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Edited by:

Professor Simeon O. Jekayinfa

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DEDICATION

This book is dedicated to the Alexander von Humboldt Foundation, Germany for its special support for outstanding African Scholars.

FROM THE EDITOR

Agricultural residues are the excesses of production that have not been utilized and currently constituting environmental problems. Finding practical and economic uses for the residues will create an opportunity for building a bioeconomy that can deliver sustainable economic growth. This may lead to job creation and social cohesion. Creating such a bioeconomy involves the substitution of fossil materials with renewable carbon. As a consequence of increasing the use of renewable resources for industrial feedstocks and for energy, the bioeconomy will bring benefits in a number of areas. These areas may include: Reduced dependence on imported fossil oil, Reductions in greenhouse gas emissions, , A bio-industry that is globally competitive, The development of processes that use biotechnology to reduce energy consumption and the use of non-renewable materials, Job and wealth creation, The development of new, renewable materials, New markets for the agriculture and forestry sectors, including access to high-value markets, Underpinning a sustainable rural economy and infrastructure., Sustainable development along the supply chain from feedstocks to products and their end-of-life disposal.

The articles contained in this book are a collection of research findings on value-added products from agricultural residues. These fields of science and technology cut across several disciplines which include agricultural engineering, chemical engineering, civil and construction engineering, microbiology, animal science & production, agronomy, agricultural economics & extension, rural sociology, food science and engineering, pharmacology and pharmaceuticals and all other allied disciplines.

Professor Simeon O. Jekayinfa

Dedication

From the Editor

AGRO-BASED ALTERNATIVES TO PETROLEUM ECONOMY[+]

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Abstract
Petroleum is a natural resource that has contributed immensely to the industrial and economic developments of many nations. It has simultaneously contributed to the ruin of such nations. While industrial activities of nations endowed with petroleum resources increased, the national technological advancement of such nations has not been significant. The discovery and exploration of petroleum has diverted focus on (Agricultural Produciton) and other sectors of national economy. The serious negative effects of the exploration of petroleum on the agrarian economy of Nigeria, as a case in Africa, are very sad. The agriculture sector which used to be the main stake of the economy of Nigeria in the pre and early independent periods, until the 1980s, was destroyed as a result of the discovery and exploration of petroleum. While Nigeria should celebrate the exploration of petroleum and properly manage the resource, this volatile petroleum resource should not be allowed to destroy the agricultural and other viable sectors of the national economy. The paper presents some viable agro-based alternatives to petroleum economy. The industries and programs that can emerge from the output of the agriculture sector are many. These include energy industry from bio Fuel and bio diesel, solar and wind; pharmaceutical industry from fruits and vegetables; tourism industry from wild life parks and forest resources; furniture and construction industries from forest resources; agro processing industry from arable and cash crops; leather industry from animal skin; textile industry from cotton; agro machinery manufacturing industry to serve agro based industries; product development and added value; and women and youth empowerment through agricultural clusters.

Key words: Agrarian economy, Agro-industry, Petroleum economy, National development

INTRODUCTION
One of the key economic forces ruling and ruining the world is petroleum. While petroleum exploration has contributed significantly to the economy of many nations, it has simultaneously led to the following serious problems:

- global pollution (land, water and air)
- deviation of focus on (Agricultural Produciton) and other sectors of national economy
- enhanced a high cost of living
- local and international disputes and wars
- youth unrest
- natural disaster
- Mass unemployment
- Increased crime and corruption rates, etc

NEED FOR A SHIFT FROM PETROLEUM ECONOMY
Any reasonable economist or scientist cannot completely relegate the roles of petroleum in the world economy, but considering the problems associated with petroleum exploration, as earlier

enumerated, it is recommendable to de-emphasis the main dependence of nations on petroleum resources. It is also essential to note that petroleum is a depletable resource.

Unlike most Western and Eastern nations, Africa and Asia are especially blessed by nature with agricultural resources (SHDI 2006). Africa has the following advantages (UNEP 2007; OAU 2003; Blaikie 1989; World Bank 2003; Kiss 1990; Frazier 1999):

- Second largest continent in the world
- 27% of the world's population
- Land area of more than 3,025.8 million hectares
- Abundant land, water, forest, mountain and coastal resources with adequate climate
- Agrarian continent extremely rich in crop, forest, fish and animal resources with agriculture as the dominant economic sector

In Africa, with Nigeria as an example, agrarian economy has been relegated because of petroleum and this has resulted in the under listed problems as identified by OAU (2003) and World Bank (2003):

- Increasing natural disasters
- Increasing under nourished population
- 25 African countries have problem of food emergencies for reasons including drought, civil strife, internal displacement, economic disruption and refugees

LESSONS FROM INDIA

India, Japan and China are striking examples of Asian countries that do not have petroleum but emerging as very strong nations because they appreciated agriculture, technology and industry. The highest percentage of GNP of Nigeria and India in the pre independence and 1960's to 80s was derived from the agricultural sector (Adewumi, 2006). Despite the economic recession experienced by India in the 1980s, the nation is back to economic stability because of the emphasis on agriculture. India, despite her large population, has drastically and consistently improved (Agricultural Produciton) both for the supply of national needs and export via viable policies. The agricultural sector in India has developed bio Fuel from Jatropha for utilization as bio diesel for energy generation and raw materials for the textile and food processing industries.

Nigeria and India were both colonized by Britain. Both nations became sovereign after independence and had similar problems to contend with after independence. In the late 1950s and up to late 1970s, both nations relied heavily on agriculture as the main sustenance of their economies with up to 80% or more of the population involved in peasant crop and animal farming. Groundnut, cocoa, oil palm, palm nut, cotton and other cash crops were produced and exported from Nigeria in large quantities as of raw materials to develop nations (IMF, 1994; Adewumi, 1998a, b & 2000). Cashew, legume grains, pulses, dairy products and other agricultural materials were produced in India and exported to countries all over the world (IMF, 1994; FAO, 1987; ILO, 1983). When the exploration of petroleum started in Nigeria, especially from the 1980s, the focus on agriculture and technological development diminished but the economy of Nigeria was booming because of the earning from petroleum but India had economic recession and many Indians have to migrate to other parts of the world amass, including Nigeria for survival. In fact there was a great influx of Indians to Nigeria during these periods.

India however overcame the economic recession because of the focus on technological development and the effect of the five - years plan policy. The planning commission of Indian, set up in March 1950, has steady 5 - years plan policy/ programme for the nation since independence to give a focus to the nation (Five years plan policy, 1950). India was classified together with Nigeria as developing nations after independence. While Nigeria remain in the group of developing nations, India is fast emerging as a global giant, especially in the last five years, consequent to her very rapid technological developments resulting in self-reliance and economic growth. India, like other Asian countries started her technological development with copy technology but now developing technologies for many other nations. India has inherent disadvantage of very large population, about ten times the population of Nigeria, yet India is becoming self sufficient because of her emphasis and priority on science and technology.

The five - years plan policy has strengthen institutional structures to guide developmental process in India. This has improved the GDP of India and positioned the nation among the 1st ten fastest growing nation toward the end of the 20th century (Five years plan policy, 2002). This planning policy takes to account all the sectors of the economy and the reforms in India (Five years plan policy, 1987).

The economic recession made India to think inwards and identify national priorities for development. Technology, agriculture and social/ human well being were given priority (Five years plan policy, 1987). India therefore started an aggressive technological growth with copy technology, like other key Asian countries such as China and Japan during this period. Indigenous or traditional knowledge approach (CSIR, 2004) was adapted for solving national problems, including technological problems. The issue of local content was also addressed early enough in India. India addressed the problem of economic recession and embanked on developing some essential sectors of their economy especially iron and steel, manufacturing, agriculture and education. India also devoted time to raw material development for industrial development during this period. The policy of India does not support indiscriminate importing of goods and services.

The effect of such actions and policies became glaring towards the end of the 20th century when India was ranked one of the 1st ten fastest growing nations (Five years plan policy, 2002). India now have fully developed automobile, aeronautical, nuclear, iron and steel, construction, manufacturing, textile, communication, railways, computer and agricultural sectors that can favorable compete with developed nations. India is also fast gaining technological recognition and becoming a global giant in science and technology. USA has recently acknowledged the potential of the nuclear power of India.

AGRO-BASED ALTERNATIVES

Agricultural products, including plant and animal materials, are not only good sources of food but basic industrial raw materials. The agricultural sector is therefore essential for the development of various industries and highly required for national development. There are several agro-based alternatives to petroleum. The industries and programs that can emerge from the output of the agriculture sector include:

- Energy industry from bio Fuel and bio diesel, solar and wind
- Pharmaceutical industry from fruits and vegetables
- Tourism industry from wild life parks and forest resources
- Furniture and construction industries from forest resources
- Agro processing industry from arable and cash crops
- Leather industry from animal skin
- Textile industry from cotton
- Agro machinery manufacturing industry to serve agro based industries
- Product development and added value
- Women and youth empowerment through agricultural clusters

ENERGY INDUSTRY FROM BIO Fuel AND BIO DIESEL, SOLAR AND WIND

There is the need to focus on alternative energy, especially solar, wind and other renewable energy sources. Methane is a bio gas derivable from agricultural Wastes such as cow dung and poultry Wastes using a digester. This can be used as cooking gas. It is convertible to other forms of energy (Ague farm is an example). Solar and wind energies are harvestable and convertible to electrical and heat energy for whatever applications (solar house in Jos is an example). Jatropha, wild caster (lapa lapa), mostly regarded as useless and Waste crop, is a ready raw material for the production of

bio diesel. Fig. 1 shows a solar incubator. Fig. 2 shows Jatropha stem, pods and seeds. Fig. 3 shows the bio diesel from Jatropha.
India is aiming at generating 40% of its energy from bio diesel using Jatropha in the next 10 years (Mangaraj et al, 2009). Sugar cane is another major source of bio Fuel utilized in Brazil. Cars are now developed using Fuel produced from sugar cane.

Fig. 1: Solar Incubator

Fig. 2: Jatropha seed & Stem

Fig. 3: Bio diesel from Jatropha

PHARMACEUTICAL INDUSTRY FROM FRUITS AND VEGETABLES
Fruits and vegetables are natural, rich and ready sources of vitamins and minerals, which are in high demand in the pharmaceutical industry. The largest concentration of fruits and vegetables are produced in the tropical regions of the world, including Africa, because of the favorable climatic conditions (Adewumi and Amusa, 2004).

TOURISM INDUSTRY FROM WILD LIFE PARKS AND FOREST RESOURCES
Nations such as India, Kenya and Qatar earn heavily through tourism. Libya has also invested much on tourism. Wild life parks inherent in forest reserves are major sources of environmental friendly national income.

FURNITURE AND CONSTRUCTION INDUSTRIES FROM FOREST RESOURCES
Wood and timber derived from the forest are the major raw materials for the furniture and construction industries. Wood has acoustic properties and are highly priced for interior decorations.

AGRO PROCESSING INDUSTRY FROM ARABLE AND CASH CROPS

The vast fertile land in the African nations favors the production of both arable and cash crops in large quantity. Many tropical crops have high international commercial values. These include cocoa, groundnut, cashew, pine apple, etc. These agro materials consequently support the establishment of different types of agro processing industry which are vibrant sources of national income and rural development. These agro processing industry however requires regular power supply to operate efficiently.

LEATHER INDUSTRY FROM ANIMAL SKIN

Leather from animal skin is used for the production of high quality thermal wears, decorations, shoes and bags. Ethiopia has a high record of national income through the leather industry. The leather industries are organized into innovative clusters to enhance their efficiency.

TEXTILE INDUSTRY FROM COTTON

The textile industry is a major sector that creates mass employment and contributes to national income. While we are busy destroying our textile industry in Nigeria, India is expanding hers. The textile industry in Nigeria MUST be revived.

AGRO MACHINERY MANUFACTURING INDUSTRY TO SERVE AGRO BASED INDUSTRIES

Agrarian nations must encourage mechanized agriculture, not by exporting agricultural machinery but by developing and manufacturing indigenous agro machinery suitable for there conditions (Adewumi, 1998a, 2000, 2004, 2005, 2007). Such nations should further graduate to become exporters of such machinery and fit into the global market. India is an example. Figs. 4 – 9 show some agricultural and food machines.

Fig. 4: Threshers and Cleaners

Fig. 5: Fruit Graders

Fig. 6: Silo Storage Structures

Fig. 7: Hand Operated Seed Planters

Fig. 8: Land Cultivating Machines and Planters

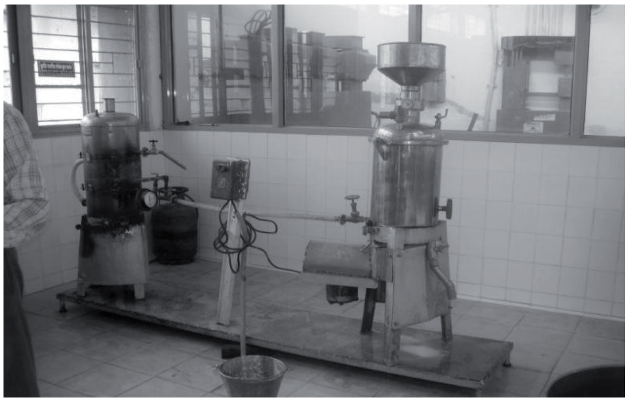

Fig. 9: Soy Milk, Cake and Cheese Machine

PRODUCT DEVELOPMENT AND ADDED VALUE

One of the greatest problems in the agricultural sector in the developing nations is the inability to develop high commercial and industrial products with added value from agricultural products. Example, the development of modified starch from cassava would add value to cassava and make it become a high commercial and export crop.

Development of a high protein based weaning food from pigeon bean (feregede) and maize for commercial production would earn more from maize and add value to pigeon bean. The commercial value of 'lesser crops' such as locust bean with high protein values could thereby be up graded. Locust bean can be upgraded from its present use as food condiment to flavoring agent, food additives and food supplement.

WOMEN AND YOUTH EMPOWERMENT THROUGH AGRICULTURAL CLUSTERS

The innovative cluster system is a proven global concept of developing national economy. The naturally occurring women and youth clusters in agriculture could be transformed into innovative clusters to alleviate poverty and empower both the women and youth. This is practiced in Uganda and Tanzania.

CONCLUSION

Petroleum economy is enviable but has a lot of terrible associated problems. Nations that rely solely on petroleum economy often slum into unforeseen fatal problems. Agro based economy is therefore recommendable because of its lasting effects, particularly for the African nations that are agrarian

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TRANSFORMING WASTE TO WEALTH: *GMELINA ARBOREA* FRUIT-PULP POTENTIALS FOR ETHANOL PRODUCTION AS BIOFUEL RESOURCE

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Abstract
Enormous amount of Biomass are Wasted annually in Africa as they are not utilized, thus their conversion to forms beneficial to man will amount to transforming Waste to wealth. The identification of Ethanol as a universal energy source has stimulated worldwide investigations in both high Ethanol yielding strains and cheaper raw materials. *Gmelina arborea* Fruit-Pulp was investigated for Ethanol yield as potential Biofuel resource. Fruits were collected six age series of Gmelina plantations at Oluwa forest reserve, Nigeria. The fermentation agents used in fermenting the fruit pulp were baker's yeast (*Saccharomyces cereviacae*) and palm wine. Distillation was carried out at 90°C, the distillate was subjected to spectrophotometry technique using Ethanol standard solution (0.5%). Mean Ethanol yield ranged from 1.45 to 9.71% and 1.21 to 9.38% for Fruit-Pulp fermented with baker's yeast and palm wine, respectively. Baker's yeast yielded a significantly higher Ethanol than palm wine. A significant effect of plantation age on Ethanol yield was obtained. However, since there was no discernable pattern of Ethanol yield with respect to plantation age, the significant effect of age could not be attributed to the effect of plantation. It was concluded that *Gmelina* Fruit-Pulp has good potential for Ethanol production and thus a good Biofuel resource. The potential is better appreciated if the huge annual *Gmelina* fruit production and large extent of *Gmelina* plantations are considered. Utilizing *Gmelina* Fruit-Pulp for Ethanol production will amount to transforming "Waste to wealth" since *Gmelina* fruits are always left to Waste as no use currently exist for them. Using Ethanol from *Gmelina* Fruit-Pulp for Biofuel could be a cheaper substitute for fossil Fuel, would produce "zero emission" since it is renewable, thus leading to less environmental pollution and contributing to climate change adaptation.

Key words: Gmelina arborea, fruit pulp, Ethanol yield, Biofuel, plantation, fermentation agent

INTRODUCTION

Recently, Ethanol has been identified as a universal energy source, which has stimulated worldwide investigations, not only with respect to high Ethanol yielding strains, but also to cheaper raw materials. The conversion of wood or Agricultural Residues to Ethanol and industrial chemicals is an attractive option for utilizing all major components of Biomass to produce a liquid automotive Fuel (Akin-Osanaiya *et al*., 2006). The search for alternative raw material for Ethanol production has led to the use of agricultural or biological residues such as wheat straw, wood Waste, sugar beets, corn cob, bitter kola Waste, etc (Doppelbauer et al.,1987; Ahmeh *et al*., 1988; Chen and Wayman, 1991; Aiello et al., 1996; Abd El-Nasser et al., 1997; Cao *et al*., 1999; Nguyen et al., 1999; Akin-Osanaiya *et al*., 2006; Nzelibe and Okafoagu, 2007; Saha and Cotta, 2007).

Biological Waste from agricultural and forestry crops could be as high as between 40 and 60% of the initial crop weight depending on the species. These Wastes are not usually utilized for any purpose and could sometimes constitute environmental hazard if not properly handled. Biological Waste could be generated from a number of sources like crop production, inedible crop parts, livestock farming, forest and forest industry operations, domestic and industrial food processing, social and commercial human activities. The effective conversion of these 'Wastes' to forms beneficial to man will demand the identification of the possible product(s) and their uses, the sources of raw materials, the quality and quantity of their supply, the quantity or quality of product derivable from them, the cost implication of the conversion, uses and demand of the products.

There is growing interest in converting biological Wastes to forms beneficial to man. The search for alternative sources of energy, especially renewable energy, should involve exploitation of the potentials of biological residues, which have long been considered as Waste and useless. Some of these "Waste" materials are always in abundance and where they are fund to be good sources of bioenergy, their utilization would amount to transforming "Waste" to wealth. The utilization of these materials would also reduce the incidence of environmental pollution and economic empowerment of poor farmers in developing countries. In addition, the dependence on fossil Fuel will be reduced and thus the incidence of global warming will to some extent be mitigated.

The investigation of Biomass raw material for Ethanol production is by no means exhaustive. Some biological Wastes from forest tree species and forest operations can also be transformed to wealth. The fruit pulp of *G. arborea* contains appreciable amount of sugar, which can be processed to Ethanol as Biofuel resource. *G. arborea* is a popular fast growing plantation tree species that is widely planted in the tropics. The species begin to fruit between 4 – 5 years after planting and yields abundant fruits every year (Onyekwelu and Stimm, 2002) and continues to do so for many years. The fruit is a fleshy and succulent drupe, with a leathery shining epicarp, a succulent, sweetish and phenolic pulp (mesocarp) and a hard stony endocarp (fruit stone). The succulent mesocarp (the fruit pulp) accounts for about 60% of the fruit weight. In Nigeria and many parts of the tropics, *Gmelina* fruit is not utilised for any purpose. After natural fall, the fruit is left to decay and Waste. Consequently, the conversion of the abundant yearly *Gmelina* fruit pulp will amount to transforming Waste to wealth. Consequently, this study was designed to investigate the potentials of *Gmelina* fruit pulp from plantations of different ages for Ethanol production as Biofuel resource.

MATERIALS AND METHODS

The fruits used for this study were collected from *Gmelina arborea* plantations in Oluwa forest reserve, Nigeria. The reserve covers an area of about 87,816 ha and lies between latitude 6° 55' and 7° 20'N and longitude 4° 32' and 4° 85'E in south western Nigeria. Over 20,000 ha of the reserve have been converted to forest plantations while the remaining area is mostly accounted for by degraded natural forests (about 27,000 ha) and arable farmland (about 31,000 ha). Large scale plantation establishment in Oluwa began in the 1970s. Currently, *Gmelina arborea* is the dominant plantation species in Oluwa forest reserve, accounting for about 89% of the total plantations (Onyekwelu et al., 2006) in the reserve.

The climate of Oluwa is tropical, comprising of two distinct seasons: rainy and dry seasons, with high mean annual temperature (26^{o}C). The rainy season lasts about 8 months (April–November), with mean annual rainfall range of 1700 to 2200 mm. The dry season lasts from December to March. Annual average daily relative humidity is about 84%. Soil type is Alfisols (Soil Survey Staff, 2003). The soil parent materials were formed from crystalline rocks of the undifferentiated basement complex of pre-cambrian series. The soils are well-drained, mature, red, stony and gravely in the upper parts of the sequence, grading into the hill wash overlying original parent material or hard-pan layers in the valley bottom (Smyth and Montgomerry, 1962). Texture of topsoil is sandy loam.

Matured *Gmelina* fruits were collected from plantations of six different ages (13, 16, 18, 21, 23 and 25 years). The fruits were bagged in the field and immediately taken to laboratory for analysis. The fruits were then thoroughly washed with distilled water, after which the fruit pulp was sliced open with the aid of a sharp knife and the fruit stones (seeds) removed.

Baker's yeast (*Saccharomyces cereviasae*) and palm wine yeast (Sedimented residues from palm wine juice) were used as fermenting agents. The yeasts were obtained from "Oja Oba" market in Akure, Ondo State, Nigeria. The reagents used for the analysis were: Dinitrosalicyclic acid (DNS), urea, Potassium di-hydrogen phosphates, Activated Charcoal, Distilled water and Sodium hydroxide (NaOH).

Extraction and treatment of wort

The extraction of *Gmelina* wort was carried out by blending the fruit and homogenizing it with minimal amount of distilled water, after which the sample was sieved with clean cheese cloth. The initial pH of the wort was taken using pH meter and then adjusted to 5.5 pH level by adding 0.1M Sodium Hydroxide (NaOH). Ten grams of urea and Potassium di-hydrogen phosphate and 2g of Potassium sulphate were added to 1000ml of the wort from the fruit pulp for each plantation age.

Fermentation of wort

To ensure the elimination of any micro-organism that may be present in the sample (wort), the wort was sterilized inside an autoclave at 121^{o}C for 45 minutes and then allowed to cool at room temperature. For the purpose of adaptation, 10g of yeast (*Saccharomyces cerevisiae*) and 10g of palm wine were added to 100ml each of wort. Adaptation was carried out for 4 hours to enable fermentation agents (yeast and palm wine) to acclimatize to the substrate to enhance growth. The medium was stirred for homogeneity, which facilitated yeast growth. The adapted yeast was poured into the wort in different fermentors (a plastic laboratory vessel with a 2 litre capacity). To ensure anaerobic fermentation, the fermentors were covered and made airtight during fermentation. Each fermentor was manually agitated daily to facilitate uniform yeast cell distribution in the wort. The fermentors were kept sterile throughout the period of the experiment by washing with detergent and rinsing with Ethanol and stain remover to prevent the growth of microbes. The CO_2 liberated during the fermentation process was eliminated daily through one of the outlets to enhance more formation of the products. Fermentation was allowed to take place for a total of seven days.

The fermented *Gmelina* worts were filtered and distilled using standard distillation apparatus. The solution (wort) was heated to vapourise the solvent, and the vapour passed through a condenser. This re-condensed the vapor into a liquid form (distillate), which was then collected in a receiver. After distillation, the distillates were subjected to spectrophotometry technique to determine the percentage alcoholic content according to AOAC (1990). A standard calibration curve of absorbance against alcoholic concentration was constructed before extrapolating for the samples.

The experiment was arranged in Randomized Complete Block Design (RCBD). Thus, two way analysis of variance (ANOVA) was used to test for significant differences between the fermentation agents and Ethanol yield of the fruits from different age series *Gmelina arborea* plantations using SPSS 13.0 for Windows. Means found to differ significantly were separated using Duncan's Multiple Range Test (DMRT).

RESULTS

The appropriate wavelength of maximum absorption was found to be at about 540 nm. This is because the Ethanol solution had the highest absorbance at this wavelength (540 nm). Consequently, the samples were read at 540 nm and the absorbance for each sample was obtained. The spectrophotometry absorbance of the samples ranged from 0.03 to 0.19 and from 0.02 to 0.18 for yeast and palm wine, respectively (Table 1). The concentration of Ethanol in the samples varied from 0.14 to 0.78 for yeast and from 0.10 to 0.81 for palm wine (Table 1). The concentration of Ethanol increased with increase in the absorbance values for both fermentation agents. With yeast as fermentation agent, the highest Ethanol concentration was obtained from the fruit pulp of 21 years plantation, followed by 25 and 16 years plantations. On the other hand, the highest concentration was obtained from 13 years plantation and followed by 21 and 25 years plantations when palm wine was used as fermentation agent. Except for 23 year old plantation, the results indicated that absorbance value and the concentration of Ethanol was generally higher in fruit pulp from older plantations than the younger ones when yeast was used as fermentation agent (Tab. 1). With palm wine as fermentation agent, the highest Ethanol concentration was obtained from fruit pulp of 13 year old plantation. However, there a trend that intends to suggest that higher Ethanol concentration was generally obtained from fruit pulp of the fruits from older plantations than from younger ones (Tab. 1).

Table 1: Absorbance of 8 ml of each sample distillate and their corresponding concentration

Age (years)	Absorbance at 540nm		Concentration (8 ml)	
	Yeast	Palm wine	Yeast	Palm wine
25	0.17	0.10	0.71	0.43
23	0.03	0.09	0.14	0.36
21	0.19	0.15	0.78	0.63
18	0.10	0.04	0.43	0.15
16	0.15	0.02	0.61	0.10
13	0.14	0.18	0.57	0.81

The Ethanol yield from *G. arborea* fruit pulp from plantations of different ages fermented with baker's yeast and palm wine is presented on Table 2. Generally, mean Ethanol yield raged from 1.45% to 9.71% for fruit pulp fermented with yeast and from 1.21% to 9.38% for fruit pulp fermented with palm wine. For fruit pulps fermented with baker's yeast, the lowest and highest Ethanol yield were obtained from the fruit pulp from 23 and 21 years plantations respectively, while the lowest and highest Ethanol yield were obtained from the fruit pulp of 16 and 13 years plantations respectively for fruit pulps fermented with palm wine (Table 2). The trend of Ethanol yield from *Gmelina* fruit pulps from the different plantations followed the same trend as that of the absorbance values of the fermentation agents and their corresponding Ethanol concentration. Thus, the plantations with the highest absorbance values and Ethanol concentration yielded the highest Ethanol while those with the lowest values yielded the lowest Ethanol (Tab. 2).

Table 2: Ethanol yield (in %) of *Gmelina* fruit pulp from plantations of different ages using yeast and palm wine as fermentation agents

Plantation age (years)	Yeast	Palm wine
25	8.88 ± 0.20	5.42 ± 0.31
23	1.45 ± 0.33	4.54 ± 0.39
21	9.71 ± 0.31	7.84 ± 0.23
18	5.42 ± 0.31	1.88 ± 0.33
16	7.63 ± 0.16	1.21 ± 0.15
13	7.13 ± 0.34	9.38 ± 0.41

Values are means of three replicates ± standard error.

Since the Ethanol yield obtained in this study ranged from about 1 to 10%, the data were not subjected to Arcsine transformation prior to statistical analysis. Akindele (1996) noted that the transformation of percentage data prior to analysis of variance is not necessary if the data falls within the range of 0 to 20%. The results of analysis of variance revealed a significant effect of fermentation agent on the mean Ethanol yield from *G. arborea* fruit pulp (Tab. 3). Except for fruit pulps from 23 and 13 years plantations, using yeast as fermentation agents resulted to significantly higher Ethanol yield than using palm wine as fermentation agent (Tab. 3). The results of analysis of variance also revealed that plantation age had significant effect on Ethanol yield. The results of mean separation revealed that *Gmelina* fruits from 21 and 13 years plantation gave the highest Ethanol yield for fruit pulp fermented with yeast and palm wine respectively, which were significantly higher than the Ethanol yield of the fruits from all the other plantations (age series) investigated (Tab. 3). The results indicated that low Ethanol yield were obtained from 18 and 23 years old plantation. Except for 23 and 18 years plantations (for fruit pulp fermented with yeast) and 23 and 13 years plantations (for fruit pulp fermented with for palm wine), older plantation generally yielded higher Ethanol than younger plantations for both fermentation agents.

Table 3: Results of mean separation for the effect of plantation age on Ethanol yield

	Plantation age (Years)					
Fermentation agent	25	23	21	18	16	13
Yeast	8.88^{a}	1.45^{b}	9.71^{c}	5.42^{d}	7.63^{e}	7.13^{e}
Palm wine	5.42^{f}	4.54^{g}	7.84^{h}	1.88^{i}	1.21^{j}	9.38^{k}

Values with different letters (superscript) are significantly different.

DISCUSSION

Most Biofuels currently in use are mostly derived from corn, palm oil, sugarcane, soybeans, rasp seeds, sun flower seeds, etc. These resources are either edible or are used in the manufacture of edible products. In fact, some of these Biofuels feedstocks are major cash crops for food, cosmetics and fodder. One of the current and contentious issues on the commercial use of Biofuels is its role in food price hikes (Cotula *et al.*, 2008), the accompanying food crises and hunger, especially in developing countries of Africa, Asia and South America. It is feared that the continued use of edible resources as Biofuel feedstocks will lead to competition with food crops and a significant negative impacts on food security, the so-called "food versus Fuel" debate (Cotula *et al.*, 2008). Though the recent world food price hikes is not primarily caused by Biofuels, the competition between Biofuels and food may increase pressures over world food prices during the next few years. Thus, significant future increase in world food prices due to demand in Biofuel feedstocks is expected (OECD-FAO, 2007). Competition between resource use as food and Biofuel feedstock will always exist. Since the use of Biofuels is expected to drastically increase in the coming decades, food scarcity occasioned by the use of edible crops as Biofuel raw material will also increase. These concerns are particularly relevant for large-scale commercial Biofuel production, which tends to consume a large amount of food crops as raw materials as well as take place on lands that would otherwise have been used for food production. Consequently, there is the need for reconsideration of current Biofuel policy.

One consideration is to use resources that are inedible, cost-effective and high yielding as Biofuel feedstock. Inedible materials that have been used as bioenergy feedstock include Jatropha, Neem and other non-food seeds. The second consideration is to source Biofuel feedstocks from Wastes from forestry and agro-food industries (e.g. wood and crop residues), domestic and industrial Waste products (e.g. Waste paper, household rubbish) (Cotula *et al.*, 2008), especially those for which no other alternative use exists. In the developed counties, there are significant advances in the exploitation of industrial and agricultural Waste primarily to reduce pollution with the realization that there are commercial gains. By exploiting Waste, the poor farmers could boost their incomes from sources other than the current practice of selling their meager food crops. The Waste exploitation in poor farming communities is sustainable and beneficial due to their abundance.

The result of study is an indication that *G. arborea* fruit pulp possess good potential for Ethanol production as a result of the relatively high Ethanol yield obtained. Utilizing *Gmelina* fruit pulp for Ethanol production will amount to transforming "Waste" to wealth since large quantity of *Gmelina* fruits are usually left on the forest floor to Waste every year. Biomass (e.g agricultural Wastes, cassava, maize, fruits, sugar cane, etc) has the potential of being the most important renewable energy option within the next 25 years (Lal and singh, 2000). The results of this investigation have shown that *G. arborea* fruit pulp contains a considerable amount of Ethanol, thus making it a potential bioenergy resource. As much as 10% Ethanol yield could be obtained from the fruit pulp of the species. If the large quantity of fruits produced by *Gmelina* trees every year (with the ability to continue doing so throughout its average 25 – 30 years life expectancy (Schneider, 1997; Onyekwelu and Stimm, 2002)), the large extent of its plantations as well as the steady increase in the area occupied by the plantations in many tropical and sub-tropical countries are taken into consideration, the potentials for Ethanol production from *Gmelina* fruit pulp will be enormous. With about 18,385.0 ha (89% of total plantations) and 24,486.0 (91% of total plantations) of *Gmelina* plantations in Oluwa and Omo, respectively, (Onyekwelu et al., 2006) the species is the dominant plantation tree species in Nigeria. With an average of 800 trees per hectare, there are 19,588,800 and 14,708,000 *Gmelina* trees in Omo and Oluwa forest reserves, Nigeria respectively that yields thousand of kilograms of seeds every year. When processed, this resource has the potential of yielding thousand of volume of Ethanol.

There was a significant effect of plantation age on Ethanol yield of *G. arborea* fruits pulp. Although the significant difference did not follow any clearly defined trend with respect to plantation age for both fermentation agents (i.e. the yield of Ethanol neither clearly increased nor decreased with plantation age), there is an indication that older plantation generally yielded higher Ethanol than younger plantations irrespective of the type of fermentation agent used, which is evident from the decreasing trend of Ethanol yield with age, with only few exception. The implication of this result is that fruits from older *Gmelina* plantations have higher Ethanol concentration than those from younger plantations. This is attributed to the generally large fruit size from older *Gmelina* plantations than from younger ones.

The Ethanol yield in our study is generally higher than the 3.97% Ethanol yield obtained for *Gmelina* by Akachukwu (1990). The lower Ethanol yield reported by Akachukwu (1990) is probably due to natural fermentation method adopted in his study. The higher results in this study is an indication that the use of fermentation agent (e.g. baker's yeast, palm wine yeast, etc) to accelerate the process of fermentation resulted in higher Ethanol yield than natural fermentation. The introduction of fermentation agents enhanced the reduction of sugar in the fruit pulp to produce Ethanol thereby increasing the percentage Ethanol yield. The presence of Urea (H_2NCONH_2) and potassium dihydrogen phosphaste (K_2HPO_4) makes the yeast activities more efficient when compared to the natural fermentation which lacks the additional nutrients.

Out of the two fermentation agents used in this study, baker's yeast gave a consistently higher Ethanol yield than palm wine, indicating that baker's yeast is a more efficient fermentation agent for Ethanol production from *Gmelina* fruits. For most plantation age, baker's yeast gave a significantly higher Ethanol yield than palm wine (Table 3), which is consistent with the reports of earlier studies. In a preliminary study on Ethanol production from *Garcinia kola* (bitter kola) pod, Akin-Osanaiye *et al*. (2006) reported optimum yield of Ethanol with bakers' yeast in comparison with brewers' yeast. Also, Nzelibe and Okafoagu (2007) observed that baker's yeast yielded significantly higher Ethanol than EMCEferm active yeast from Germany.

The increased need for Ethanol as a universal energy source has stimulated worldwide investigations, not only with respect to high Ethanol yielding strains, but also to cheaper raw materials (Ahmed *et al*., 1988; Cao *et al*., 1999; Nguyen *et al*., 1999). Consequently, several plant products and Agricultural Residues such as corn-cob, grass-straw, *Carica papaya* Waste, *Garcinia kola* pod, wheat straw, sugar beets etc, have been investigated for Ethanol content for possible use as Biofuel. The conversion of these Agricultural Residues to Ethanol and industrial chemicals is an attractive option for utilizing all major components of Biomass to produce a liquid Fuel and for environmental remediation. Also, some nuts when pressed into oil can be used to run electricity generator. A good example is *Jatropha curcus*, a plant widely found in Africa, especially in East Africa. The unrefined oil is not only suitable as a diesel substitute, but also useful as Fuel for clamps or as cooking oil, soap, candle as well as fertilizer production (Stefan, 2007). Currently, *Jatropha* oil refinery is being planned and generator that will be powered by *Jatropha* oil is being produced. More *Jatropha* plantations are being established to ensure sustainable supply of raw materials for the industry (Stefan, 2007). This can be extended to *Gmelina* fruit pulp in the light of current results.

Generally considered a Biofuel alternative to gasoline, Ethanol provides Fuel for automobiles and other forms of transportation. Currently produced from starch or sugar from a wide variety of crops, there is some debate about the viability of bio-Ethanol as a replacement for fossil Fuels. Public concerns include the large amount of arable land required for crops, and the energy/pollution balance of the Ethanol production cycle. For Ethanol to be suitable for use as a replacement to fossil Fuel, it must be distilled to at least 70-80% purity by volume. For use as an additive to petrol, almost all water must be removed, otherwise it will separate from the mixture and settle to the bottom of the Fuel tank, causing the Fuel pump to draw water into the engine, which will cause harm to the engine.

CONCLUSION AND RECOMMENDATION

This research has shown that *G. arborea* fruit pulp contains a considerable amount of Ethanol, thus making it a potential bioenergy resource. Higher Ethanol yield is obtained when the fruit pulp of the species is fermented with a fermentation agent than when it is naturally fermented. However, the Ethanol yield is dependent on the type of fermentation agent used, with baker's yeast giving higher yield than palm wine. Result did not reveal any clearly defined pattern of Ethanol yield with plantation age (i.e. Ethanol yield neither increased nor decreased with increase in plantation age and vice-versa) but there is general indication that older plantations yielded higher Ethanol than younger ones. Bearing in mind that this is a preliminary research, further research on how to improve on the extraction of Ethanol from the fruit pulp of this species is recommended. A better extraction method than what was used in this study might give higher Ethanol yield.

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BIOFUEL TECHNOLOGY AND ITS SUSTAINABLE DEVELOPMENT IN NIGERIA

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Abstract

The article reviews establishment of a thriving Biofuel industry utilizing agricultural products as a means of improving the quality of automotive fossil-based Fuels in Nigeria. The paper further highlights the current status of the use and possible application of Biofuel in Nigeria through the introduction of Jatropha plant for Biodiesel production. Rapid Research and Development investments flowing into Jatropha cultivation, processing and conversion into Biodiesel through the adoption of modern techniques which could lead to Biomass increase and food yields was also discussed. Primary issues favouring Jatropha over other crops which are its non food nature, reported ability to grow on marginal lands and the special ability to grow with limited rainfall was reported. The drivers behind the rush to Biofuels production and its sustainability were also enumerated in the paper. Detailed explanation of the potential benefits of Biofuel was given in relation to improved energy security, economic gains, rural development, greater energy efficiency, reduced Green House Gases (GHG) emissions compared to standard Fuels, the expansion of the agricultural frontier and deforestation to mention a few. Negative impacts of Bio-Fuels in terms of food security, higher economic costs compared to conventional Fuels as a result of large scale development of Biofuel technology, spread of genetically modified organism resulting in contamination of local crop varieties with its attendant destruction of biodiversity. The study concludes by pointing out that Biofuels could help mitigate climate change and reduce dependence on oil. Furthermore, the exploitable bio-energy potential of the Sub-Saharan African region is reported to be significant despite concerns over food security and land ownership in crop production. Finally, Biofuels production represents an opportunity for the African region to increase energy supply security and to give a boost to rural economies by opening markets for agricultural surpluses, creating jobs and reducing carbon emissions. But on the negative note, the recent increases in food prices have been attributed worldwide to increases in Biofuel production as farmers have switched to crops for Biofuel, which have threatened food security in the region and worldwide generally.

INTRODUCTION

Biofuels are products that can be processed into liquid Fuels for either transport or heating purposes. Global production of Biofuels has doubled in the last five years and will likely double again in the next four years, according to the UN framework (Any Reference(s)?). Burgeoning demand for Biodiesel derived from plant oils has grown significantly over the last decade (Chand et. al. 2008). The advantages of Biodiesel compared to fossil diesel Fuel include: biodegradability, it is biorenewable, has low sulfur content and toxicity, its low volatility/flammability, and storage properties and salutary atmospheric CO2 balance for production (Srivastava and Prasad, 2004).

Among the countries that have enacted new pro-Biofuel policies in recent years are Argentina, Australia, Canada, China, Colombia, Ecuador, India, Indonesia, Malawi, Malaysia, Mexico, Mozambique, the Philippines, Senegal, South Africa, Thailand, Zambia Zimbabwe and Nigeria (Annie Dufey, 2006). Biofuels production represents an opportunity for the African region to increase energy supply security and to give a boost to rural economies by opening markets for agricultural surpluses, creating jobs and reducing carbon emissions. On negative note, the recent increases in food prices have been attributed to increases in Biofuel production as farmers have switched to crops for Biofuel, which have threatened food security in the region and worldwide (Annie Dufey, 2006).

CURRENT STATUS OF THE BIOFUEL INDUSTRY IN NIGERIA

At this time, Nigeria is establishing an Ethanol industry, using Cassava and sugarcane as Biomass. The introduction of the Jatropha plant for Biodiesel and the adoption of modern techniques could increase Biomass and food yields. As well, they could also reclaim land lost to desertification and improve the standard of living. Among all the oil bearing crops, Jatropha has emerged all over the world as the focal point for the Biofuel industry with rapid Research and Development (R & D) investments flowing into its cultivation, processing and conversion into Biodiesel. With the growing emphasis on the sustainability of the Biofuels production, there have been pressures on regulators and governments to set in place sustainable models for Jatropha cultivation and use as a Biofuel feedstock (KnowGenix, 2008).

While petroleum prices are increasing exponentially across the world, it is the African people who are being affected the most, with prices reaching #200/litre in some nations. This is the case in Senegal, where high gas prices have caused daily blackouts because their electric companies can not afford Fuel. There is a similar story in Nigeria. Despite its vast petroleum supplies and per capita income of less than $1,500, there are long queues at gas stations (Reference(s)?). With oil prices rising, the cost to produce and transport crops increases. In an impoverished nation, this can have huge consequences on the well being of the population. The integration of a Biofuel economy would help alleviate the inflated Fuel prices in Nigeria by providing a steady income to their people so that the purchasing of these expensive fossil Fuels becomes bearable. It is of the utmost importance that Nigeria and other countries in Africa start implementing Biofuels into their economy before this opportunity to industrialize passes.

Cassava is a tree like plant that is the staple food for Nigeria and much of the surrounding region. Nigeria is the world's largest producer of Cassava, with 30 million tons produced annually (Osterkorn, 2000).

Recent researches have shown that Cassava can be refined to create Ethanol. This discovery has already been well received by China and Thailand where Cassava is already being used to produce Ethanol; coincidentally the Cassava being used in these nations is being imported from Nigeria. The Nigerian government has already made an agreement with the Brazilian Fuel company, Petrobras, in which Brazil will supply the Nigerian national oil company with the technology to build and sustain an Ethanol industry in exchange for a Nigerian market for Brazilian Ethanol (The New Scramble for Africa). This is a tremendous step in the right direction because the Nigerian people will be creating their own industry instead of selling their resources and labor to foreign companies. This was initially what happened with the oil resources. Nigeria did not have the technological resources to develop a petroleum industry nor did they have the capital to start such an endeavor. With poverty on the rise and no solution on the horizon, the Nigerian government was forced to allow foreign companies to start and monopolize the petroleum industry. The result is that Nigerian oil is not making its way to the Nigerian people and none of the money from the profits is beneficial to the people. With this new deal with Brazil, the average farmer will personally profit from the sales of his

crops. We must not forget about the hunger issues in Nigeria. Cassava is the main staple of this region.
If Cassava is being diverted for Ethanol production, then more people will starve. Fortunately this disaster is easily avoidable. In fact, the Nigerian National Petroleum Corporation (NNPC) has proposed agreements with the International Institute of Tropical Agriculture (IITA) that will focus on the low yield problems with Cassava. Once the agreements are made, researchers will study various Cassava varieties that could create higher yields (Osterkorn, year?). These higher yields will nullify the negative effect that Ethanol production would have on the food supply. Of course, this will not be enough. The Nigerian government will have to make sure that land is not sold in large expanse to Fuel companies. The best path for Nigeria is one in which the expansion of land dedicated to industrial Cassava farming is limited, while coupled with a set percentage of land dedicated to industrial and consumer use. The duty of a government is to provide for its people. If the land is sold to Fuel companies, then the people can not grow enough food to eat. This is why research into higher yield Cassava is so important.

THE DRIVERS BEHIND THE RUSH TO BIOFUELS

The current rush to Biofuels is due to a confluence of factors, many of them politically potent and economically appealing. One of the factors relates to Fuel security through a diversified energy portfolio. The volatility of world oil prices, uneven global distribution of oil supplies, uncompetitive structures governing the oil supply (i.e. the Organization of Petroleum Exporting Countries (OPEC) cartel) and a heavy dependence on imported Fuels are all factors that leave many countries vulnerable to disruption of supply. The need to address the growing volume of greenhouse gasses which in turn negatively influences the global weather patterns, as been internationally agreed to through the Kyoto Protocol is also another valued driver.

BIOFUELS AND THE SUSTAINABLE DEVELOPMENT DEBATE

Links between Biofuels and sustainable development are varied and complex. On one hand, Biofuels may imply improved energy security, economic gains, rural development, greater energy efficiency and reduced Green House Gases (GHG) emissions compared to standard Fuels. On the other hand, production of energy crops could result in the expansion of the agricultural frontier, deforestation, monocropping, water pollution, food security problems, poor labour conditions and unfair distribution of the benefits along the value chain. The positive impacts and trade-offs involved vary depending on the type of energy crop, cultivation method, conversion technology and country or region under consideration.

POTENTIAL BENEFITS OF BIOFUELS

The perceived benefits of Biofuels are reflected in the increasing number of countries introducing or planning to introduce policies to increase the proportion of Biofuels within their energy portfolio. If this is to be achieved, significant increases in production are required to rapidly satisfy greater global demand. The following are some of the potential benefits of Biofuels production.

PRODUCTION DIVERSIFICATION AND VALUE-ADDED

Biofuels generate a new demand for agricultural products that goes beyond traditional food, feed and fibre uses. This may reduce the problem of commodity surpluses. In addition it provides an opportunity for more value addition to agricultural output. All of these aspects are needed to support poverty reduction, especially in developing countries. Nigeria is likely to benefit because she can now add value to her sugar instead of exporting it in the raw form and this is likely to lessen her dependence on European Union (EU) where she has been coerced to enter into agreements in order to access the EU market when exporting sugar.

GREEN HOUSE GAS (GHG) EMISSIONS

One of the greatest advantages associated with Biofuels and one of the main driving forces behind worldwide Biofuel uptake are their alleged reduced GHG emissions, and hence their potential to help minimise climate change. However, there is considerable variation in GHG savings, ranging from negative to more than 100%. Estimates vary according to the type of feedstock, cultivation methods and conversion technologies. A recent evaluation of six studies on GHG reduction of corn-based bioEthanol found a variation from a 33% decrease to a 20% increase, averaging a 13% reduction in GHG emissions compared to petrol (Koonin, 2006). Estimates for wheat-based bioEthanol point to reductions ranging from 19 to 47%, while for sugar cane based bio-Ethanol estimates were around 92% in Brazil (IEA 2004). One estimate for rape based bio-Ethanol in Brazil showed a 95% reduction compared to standard Fuel (IEA, 2004). Figure 1 shows estimates of GHG reduction for different types of Biofuels.

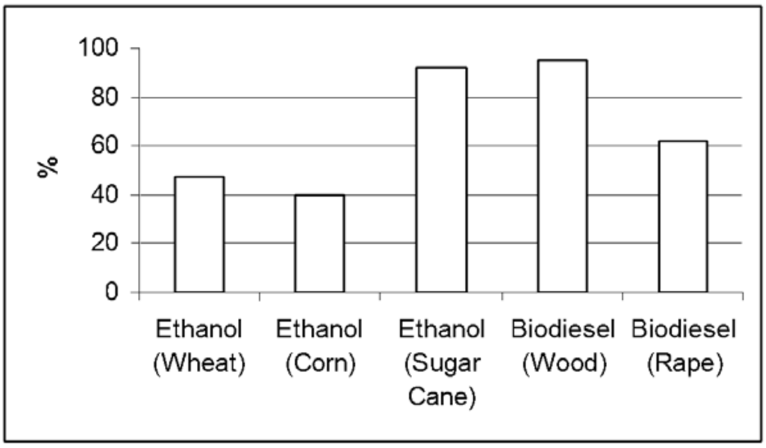

Fig. 2: GHG reductions for different Biofuels
Source: E4 Tech, et al 2005

The variation in levels of GHG emissions for different types and sources of Biofuels make it difficult to predict the achievement of GHG reduction targets for policy makers in countries that rely on various sources of Biofuels. This highlights the need to identify Biofuels with lower GHG emissions and create incentives for their production. At the same time it is important to bear in mind that Biofuels are not deemed to provide a final solution to global warming but they form an important component of an integrated approach to tackling the issue (Macedo *et al.*, 2004).

EMPLOYMENT CREATION AND QUALITY

In addition to the environmental benefits of Biofuels, a primary motivation for the promotion of Biofuels in Nigeria is rural economic development (MEPD, 2007). Biofuel production can have a positive impact on agricultural employment and livelihoods, especially when the cultivation of jatropha involves small-scale farmers and the conversion facilities are located near the crop sources in rural areas. Sugarcane plantation in Nigeria for instance, employs a lot of workers and the number is expected to grow if Ethanol production is fully entered into. BioEthanol related jobs involve low skilled and poor workers in rural areas.

IMPROVED LIVELIHOODS

In addition, Biofuel production offers opportunities for better livelihoods. As its production requires many crops as inputs, policymakers see the promotion of Biofuels as a viable option

to change the composition of agricultural output from surplus food commodities to Fuels that can be consumed domestically. This increased demand for agricultural commodities could significantly increase the price of agricultural commodities, and therefore farmers' incomes. A problem that has been highlighted in this respect relates to the potential trade-offs that might arise in terms of food security in the poorest countries.
Primary issues favouring Jatropha over other crops are its non food nature, reported ability to grow on marginal lands and the need for limited rainfall. There are also claims of Jatropha assisting in preventing deforestation and desertification, and improving soil fertility. However, experiences across the developing world have been quite varied reflecting complexities in local practices, soil, water and climatic factors (KnowGenix, 2008). Livelihoods could also improve because of the positive impacts on land restoration associated with crops such as jatropha. Becker and Francis (2005) argue that once the jatropha trees establish themselves and fertilize the soil, their shade can be used for intercropping shade-loving vegetables such as red and green peppers, tomatoes, etc, which would provide additional income for the farmers.

NEGATIVE IMPACTS OF BIO-FUELS

Most of the negative sentiments around bio-fuels, especially bio-Ethanol, are derived from concerns in the market around energy balances and the ability of the agricultural industry to produce sufficient raw material cost effectively.

FOOD SECURITY

The debate of crops for food versus crops for Biofuels remains one of the major problems yet to be resolved. There is the worry that an increase in the use of food crops such as maize, cassava and sorghum is likely to increase the food price of most staple foods in Nigeria. It has been argued in one of the articles that grain to fill a 4x4 car could feed a person for a year. Price rise will depend on whether or not oil crops are planted on arable land that could otherwise be used for growing food crops, and whether water is diverted from food crops to irrigate the Biofuel plantations. It has also been argued that increasing Biofuel development is likely to affect food aid. The United States for example, provides food aid from its surplus crops. But if the surplus is used for US Biofuels, the US will use the surplus food crops for Biofuels instead of donating it to Africa. At a consultative workshop hosted by AIPAD, it was agreed that food security is non negotiable and therefore food production should not compete with Biofuels.

HIGHER COSTS THAN CONVENTIONAL FUELS

One of the biggest barriers to large-scale development of Biofuels remains their higher economic costs compared to conventional Fuels. Some estimates show Biofuels to be twice as costly as conventional Fuels. (Petroleum Economist, 2005). Economic costs, however, tend to differ depending on the type of Biofuel, the country of provenance and the technology used.

EXPANSION OF THE AGRICULTURAL FRONTIER AND FOREST CONVERSION

Another concern associated with increased Biofuel production is the impact on the agricultural frontier. Biofuels are expected to contribute to around 20 to 30% of global energy demand by 2030. This is very likely to exacerbate the already intense competition for land between agriculture, forests and urban uses. Sugarcane production has been linked to the clearing of some of the most unique and biodiverse regions on the planet. Likewise, if the increased Biofuel demand were met by soya-based Biodiesel, this would imply further environmental pressure.

SPREAD OF GENETICALLY MODIFIED ORGANISMS (GMOS)

There is considerable concern that Biofuel development will lead to a wider spread of GMOs because of the need to improve both the economic efficiency and the energy efficiency of Biofuels. The use of GMOs will contaminate local varieties and destroy biodiversity. The main arguments against genetically modified GM technologies relate to food safety concerns, and their impacts on biodiversity and on farmers' livelihoods.

TRADE IN BIOFUEL

Currently, very little Biofuel enters international markets since the bulk of it is consumed in domestic markets. Trade in Biodiesel is at a less developed stage than trade in bioEthanol. However, it is expected that trade in Biodiesel will develop in a similar way to that of bioEthanol. There is already some evidence of increasing trade flows. The EU, for instance, currently imports about 3.5 million tonnes of refined and crude palm oil a year, mainly from Malaysia and Indonesia. In Nigeria, there is no trade in Biofuels because currently, production in most African countries is still at its infancy.

At present there is no comprehensive trade regime specifically applicable to Biofuels. Biofuels are categorised as "other Fuels" or as alcohol (in the case of Ethanol) and are subject to general international trade rules under the World Trade Organization (WTO). Energy crops are covered by the WTO Agreement on Agriculture.

FUTURE PROSPECTS OF BIOFUELS PRODUCTION IN NIGERIA

All things considered, it appears that Biofuels are indeed high on Nigeria's agenda as in all other countries, industrialised and developing are implementing or planning to implement directives to promote greater use of Biofuels. However, uncertainty still surrounds Biofuels' potential in Nigeria because climate change, energy shortages, food security, land availability and sustainability all have to be taken into consideration. The most important criteria in the long-term sustainability of Biofuels is not whether they produce enough reward, but whether the Biofuels industry is able to sustain a market. If a market cannot be sustained, supply cannot satisfy demand, and viability will then become questionable.

The potential of Biofuels production in Nigeria seems unlikely to be realized due to the concerns over food prices and environmental degradation caused by growing of Biofuels. The unfavourable economics of Biofuels also suggests that the potential of Biofuels is unlikely to be realised. Although there is hope for production costs for Biofuel feed stocks to decline as a result of improvements in yields, it is not clear that such improvements will be enough to compensate for rising prices due to production factors and the combined pressures on prices of rising demand for food, feed and Biofuels. Increasing competition with Biomass feed stocks, woody material as well as agricultural products is actually pushing feedstock prices and production costs up. Higher oil prices will have the effect of increasing Biofuel production costs while simultaneously making fossil Fuel alternatives increasingly competitive.

CONCLUSIONS AND RECOMMENDATIONS

This study pointed out that Biofuels could help mitigate climate change and reduce dependence on oil in the transport sector. They can also have a positive impact on the limited foreign exchange reserves of many African countries. When well managed, they also offer large new markets for higher priced products for agricultural producers that could stimulate rural growth and farm incomes. Biofuel production could be especially beneficial to poor producers, particularly in remote areas that are far from the consumption centres, where inputs are more expensive and prices lower, making food production, by and large,

noncompetitive. Farmers in these areas could plant crops that do not compete with production of food crops such as jatropha.
The exploitable bio-energy potential of the Sub-Saharan African region is significant despite concerns over food security and land ownership. One area of bio-energy development that offers some opportunities both for domestic markets and international markets is bio-Ethanol. The region has a fairly strong industrial base in the sugar industry. Expansion of sugar production is unlikely to be rewarding, given decisions in recent years to reduce the preferential market access to Agricultural Common Policy (ACP) countries.
Biofuels production must take into account social issues: accessibility, affordability and acceptability. Given the existence of important potential benefits associated with Biofuels, there is need for investment in research and development on Biofuels in order to assess the negative impacts against the potential benefits. The international community can also help by providing evidence on the costs and benefits of Biofuels; evidence on the impacts of different policy tools; and the development of global market incentives and financial resources for market development in the poorest countries.
In general, Biofuels that use food sources are costly to the poor and raise prices on the basic foods that already represent a large share of poor people's household spending. It should also be noted that crop subsidies that encourage the production of Biofuels from certain food sources have a welfare burden on the poor. In certain cases, the benefit to society at large of reducing carbon emissions might justify some level of producer support and price policy towards Biofuels, since simple market forces do not recognize such benefits, and fail to reflect them in market prices. If this were so, then the cost of fossil-based Fuels would be much higher, as a reflection of their true impact on the environment.

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THE POTENTIALS OF BIODIESEL PRODUCTION AS A FUEL FOR DIESEL ENGINES IN NIGERIA.

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Abstract

Current increase in petroleum prices together with increasing threat to the environment from exhaust emissions and global warming have generated an intense international interest in developing alternative non-petroleum Fuels for engines. Biodiesel is one of such non-petroleum Fuels with positive environmental benefit of reducing the dangerous exhaust emissions in diesel engines. Biodiesel is made from vegetable oils and animal fats and is presently produced and marketed in many developed countries for Fuelling diesel engines. It is relatively unknown as a Fuel in Nigeria, although there is an obvious need to conserve and/or supplement the available petroleum resources with renewable Fuels. This paper examines the methods of Biodiesel production and reviews the potential problems and prospects of its production in Nigeria.

Keywords: Biodiesel, vegetable oils, renewable Fuels.

INTRODUCTION

Energy is the essence of life on earth and is one of the most basic of human needs, not as an end in itself but as a means to numerous ends. Energy is needed to sustain technological development and the quality of life in any society. This energy comes from natural resources as fossil Fuels, such as coal and oil, living resources, such as Biomass, nuclear Fuel such as uranium, or renewable resources such as flowing water and wind and the power of the sun.

In the last century, there was concern that fossil Fuels would run out, plunging the world into an energy crisis. Today the fear is that their continued use might be wrecking the global climate by emitting carbon dioxide (CO2) as we burn carbon- containing Fuels. This anxiety has generated an intense international interest in developing alternative non-petroleum Fuels for engines. Vegetable oils have attracted attention as a potential renewable resource for the production of an alternative for petroleum based diesel Fuel. Various Biofuels derived from vegetable oils have been proposed as an alternative Fuel for diesel engines, including neat vegetable oils, mixtures of vegetable oil with petroleum diesel and alcohol esters of vegetable oil (Ma, et al., 1999). Alcohol ester known more generically as Biodiesel is the most commonly used method and appears to be the most promising alternative (Krawczyk, 1996 and Conceicaco et al., 2005).

In its most general sense, Biodiesel is any Biomass derived diesel Fuel substitute (Sheehan, et al., 1998). Most commonly, it refers to various ester-based oxygenated Fuels composed from vegetable oils or animal fats (Hobbs, 2003). Biodiesel can be used in it's pure form to Fuel any existing diesel engine, and it can be blended with petroleum diesel.

There are unfavourable cold weather flow properties of the Biodiesel Fuel leading to operatability problem of the engine in cold climate and temperate regions (Shresta, et. al., 2005). This is the reason that Rakopoulos et. al. (2006) reported that blends of not more than 10-20% Biodiesel with petroleum diesel should be used in existing diesel engine without modification. They noted that higher percentage of blends can limit the durability of engine components leading to engine malfunctioning. This problem of unfavourable cold weather flow properties of the Biodiesel Fuel is not an issue in the tropics. Therefore the Fuel is more suitable for use in the tropics. Krawczyk (1996) identified Biodiesel as a possible replacement to fossil's Fuels as the world's primary energy source.

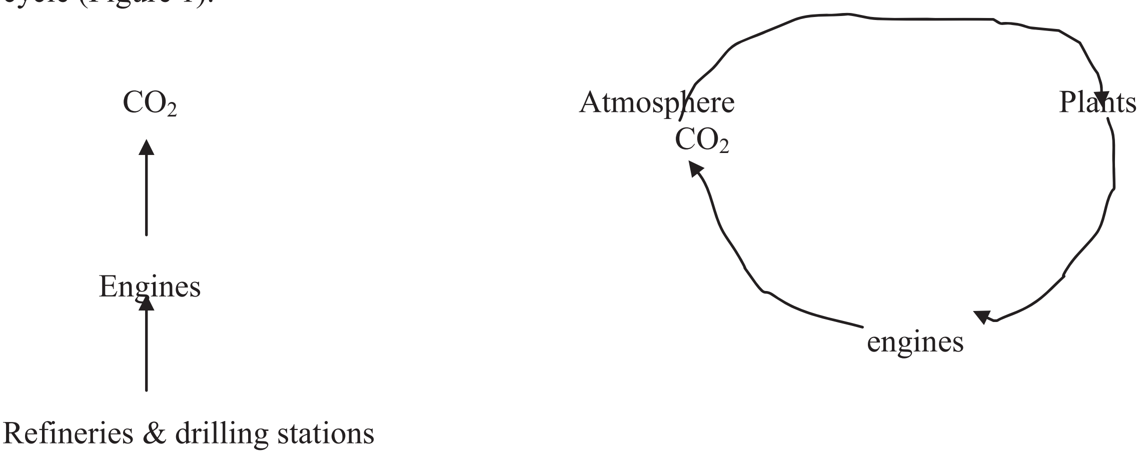
PERFORMANCE OF BIODIESEL IN COMPRESSION IGNITION ENGINES

Biodiesel has become more attractive recently as an alternative Fuel for compression ignition engines because of its numerous advantages. Hobbs (2003); Faupel and Kurki (2002); Elsebeth and Bialkowski (2003) have given a number of distinct advantages of using Biodiesel over fossil Fuel. They are stated as follows:

1. It is renewable and has positive environmental benefits. It burns up to 75% cleaner than conventional diesel Fuel made from fossils Fuels.
2. It substantially reduces unburned hydrocarbons, carbon monoxide and particulate matter in exhaust fumes.
3. It is plant based and adds no CO_2 to the atmosphere. Instead of releasing stored carbon in to the atmosphere, there is occurrence of basically cycling carbon.
4. The Fuel economy is the same as conventional diesel Fuel.
5. Sulphur dioxide emission are eliminated (Biodiesel contains no sulphur).
6. Increased Nitrous Oxide (NO_x) emissions can be reduced to below conventional diesel Fuel level by retarding engine timing.
7. It is a much better lubricant than conventional diesel Fuel and extends engine life.
8. It has a high cetane rating, which improves engine performance and efficiency.
9. Biodiesel increases safety in storage and transport because the Fuel is non-toxic. It is neither harmful nor toxic to humans, animals, soil or water.
10. It has high calorific value and high energy density.
11. It is biodegradable.
12. Increased value for our farm products, especially the vegetable oils.

One of the biggest advantages of Biodiesel compared to many other alternative transport Fuels is that it can be used in existing diesel engines without modification (Shresta, et. al., 2005 and Briggs, 2004).

It is worth mentioning that while our current energy system can be represented by an irreversible, open cycle, an energy system based on natural vegetable oil constitutes a closed cycle (Figure 1).



Natural closed cycle based natural vegetable oil
current open cycle based on petro diesel

Fig 1: Energy system based on petro-diesel and natural vegetable oil

It has been reported that petroleum diesel exhaust causes cancer and other human health problems (Faupel and Kurki, 2002). However, the use of Biodiesel in diesel engines has been found to reduce significantly the emissions (e.g carbon monoxide, carbon dioxide, hydrocarbons, etc.) which cause cancer. (Hobbs 2003; Faupel and Kurki 2002; Elsebeth and Bialkowski, 2003).
Another advantage of the use of Biodiesel is that with care and practice, Biodiesel can be produced on – farm using a variety of oils as feedstock. Farmers can produce their own Fuel for tractors and other farm equipment from their own oil seeds or from Waste fryer oil collected in neighbouring communities.

BIODIESEL – THE BEST ALTERNATIVE TO PETROLEUM BASED DIESEL FUEL

The greatest driving force for the use of Biodiesel is the need to have a Fuel that fulfills all of the environmental and energy security needs required which does not sacrifice operating performance. One of the largest roadblocks to the use of alternative Fuels is the change of performance noticed by users.
The most noted attribute of Biodiesel is the similar operating performance to conventional diesel Fuel and the lack of major changes required in facilities and maintenance procedures. (Shresta, et. al., 2005; Rakopoulos et. al., 2006).
Rakopoulos, et. al., 2006; Faupel and Kurki, 2002; Mohammed et. al., 2002 gave a number of disadvantages encountered when using Biodiesel in compression – ignition engine. They are stated as follows:

1. Biodiesel Fuels have higher viscosity, higher pour point, lower heating value and lower volatility than petroleum diesel Fuel.
2. The oxidation stability of Biodiesel Fuels is lower, and they are hygroscopic.
3. As solvents they cause corrosion of component, attacking some plastic materials used for seals, hoses, paints and coatings.
4. They showed increased dilution and polymerization of engine sump oil, thus requiring more frequent oil changes.
5. The use of vegetable oil for Fuel causes competition with the use of vegetable oil for food.
6. There is the possible concern with engine warranties.
7. Special measures must be taken to use Biodiesel, particularly B100 (i.e pure Biodiesel) in cold climates.
8. Higher per gallon cost than petroleum diesel in the current market.
9. Limited commercial availability of the Fuel, if you are not going to process it yourself.

BIODIESEL PRODUCTION TECHNOLOGIES

There are four primary ways to make Biodiesel. (Ma et. al., 1999; Rakopoulos, et. al., 2006). They are direct use and/or blending; micro emulsion, thermal cracking (pyrolysis) and transesterification.
In direct use, pure vegetable oil is used to Fuel the diesel engine, while in blending, a blend of vegetable oil and diesel Fuel is used. The main problem with the direct use of vegetable oils as Biodiesel Fuel is high viscosities (Rakopoulos, et. al., 2006). Other problems associated with the direct use of vegetable oils as Fuels were oil deterioration and incomplete combustion (Peterson, et. al., 1983; Frame, et. al., 1997). The incomplete combustion resulted in carbon deposits and lubricating oil thickening. (Ma, et. al., 1999). The purpose of blending vegetable oil with diesel Fuel is to lower the viscosity to make it thinner, so that it flows more freely through the Fuel system into the combustion chamber. (Ma, et al 1999). It is note

worthy that direct use of vegetable oils and\or the use of blends of the oils has generally been considered to be not satisfactory and impractical for both direct and indirect diesel engines because of the obvious problems associated with it as discussed earlier (Elsbett and Biakowki, 2003). However, the Elsebett engine has been developed for successful direct use of vegetable oils. (Elsbett and Biakowki, 2003).

In micro-emulsion, a colloidal equilibrium dispersion is formed by mixing vegetable oils with solvents such as mEthanol (Schwab et al., 1987). Though the performance of such micro emulsions has been reported to be as good as that of diesel Fuel (Goering et al., 1984), the problem of heavy carbon deposits, incomplete combustion and an increase of lubricating oil viscosity have been reported (Ziejewski et. al., 1984).

Thermal cracking (pyrolysis) involves heating vegetable oils or animal fats in the absence of air to produce a variety of Biofuels (Sonntag, 1979). The initial product of the pyrolysis of vegetable oils or animal fats is a crude oil (Ma, et al., 1998). The crude oil can be refined to produce diesel Fuel and small amounts of gasoline and kerosene (Ma, et al., 1998). The major problems associated with this method include the fact that the equipment for thermal cracking is expensive for modest throughput.

In addition, while the products are chemically similar to petroleum derived gasoline and diesel Fuel, the removal of oxygen during the thermal processing also remove any environmental benefits of using an oxygenated Fuel (Ma et al., 1998).

Transesterification involves the reaction of fat or oil with an alcohol to form esters and glycerol (Watt et al., 1997). Chemically, it is defined as the reaction of triglyceride molecule of vegetable oil or animal fat with a simple alcohol such as mEthanol, Ethanol, butanol or iso-propanol to form esters and glycerol. (Watts, et. al., 1997). In simpler terms transesterification is the conversion of heavy oils or fats into a less viscous fluid that is suitable for combustion in a conventional diesel engine (figure 2). The esters are used as Biodiesel Fuel. This method is generally the preferred and most probably the best option to making Biodiesel.

Biodiesel can be used in pure form, or blended with petroleum diesel for use in compression ignition engines. The physical and chemical properties of Biodiesel Fuel are similar to petroleum diesel Fuel.

similar to petroleum diesel Fuel.

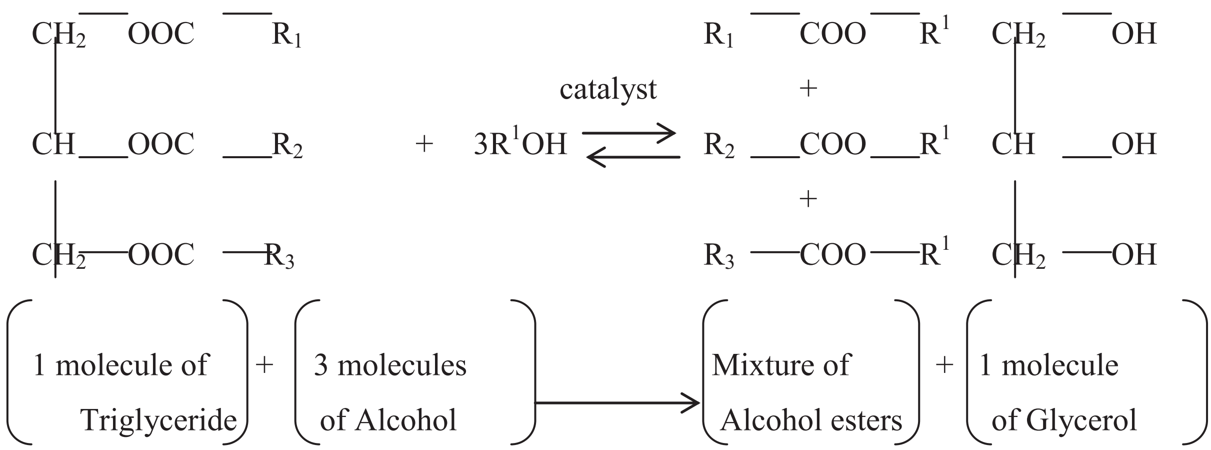


Fig 2: - Transesterification of Triglycerides (or plant oils) with alcohol (Ma et al., 1999)

COMMON FEEDSTOCKS FOR PRODUCTION OF BIODIESEL

The common feedstocks for production of **Biodiesel** are:

(a) Virgin oil feedstock such as palm oil, soybeans oil, sunflower oil, coconut oil, rapeseed oil, tung oil, mustard oil, corn oil etc. (Faupel and Kurki, 2003, Elsebeltt and Bialkowski, 2003).
(b) Animal fats including tallow, lard, yellow grease and fish oil. (Elsebett and Biaskwoski, 2003)
(c) Waste vegetable oils and restaurant grease.

Biodiesel Production in Nigeria

A number of problems in the refining and distribution sectors of the petroleum industry had led to persistent soaring of prices of the locally refined and imported products, despite the fact that there are abundant oil reserves in Nigeria which make the country a potent petroleum oil producer in the world. These price increases have become too frequent in the recent past and there is need to think of other alternatives or supplements such as Biodiesel that can be produced and used in the country. Plants with oilseeds abound in the country and the oils can be used as feedstock for Biodiesel production.

POTENTIAL PROBLEMS OF PRODUCTION OF BIODIESEL IN NIGERIA

The production of Biodiesel in Nigeria can only be possible after addressing the following problems.

A. Lack of Adequate Feedstock for Sustainable Production

Vegetable oils are mainly produced from groundnuts, cottonseed, palm kernels and sheanuts, although several oil-bearing crops exist in the country. The predominant small-scale agriculture practiced in the country had prevented self-sufficiency in edible oil production from being achieved; hence there is importation to meet demand for domestic and industrial use. Animal fats and spent or Waste frying oils, which are claimed to be unhealthy for human and animal consumption because they contain trans fatty acids are cheaper feedstock used elsewhere. However, the low income and cooking habits of most Nigerians are such that animal fats and oils used in frying are used completely leaving no Waste. Hence, this category of feedstock cannot become available for Biodiesel production in the near future.

B. Vegetable Oils are more Expensive Than Petrodiesel

The vegetable oils obtained in the local markets have average prices in the range of ₦155 - ₦250 per litre, and are more expensive than petrodiesel (Table 1). The cost of producing Biodiesel from available vegetable oils, assuming adequate feedstock supply would not be attractive at all compared to petrodiesel since production cost include cost of the feedstock. Therefore it is not economical presently to use the available vegetable oils for producing Biodiesel.

Table 1: Market prices of vegetable oils and petrodiesel in Ogbomoso in April, 2010

S/N	Commodity	Average price (₦/litre)
1	Groundnut oil	180.00
2	Palm oil	160.00
3	Cotton seed oil	155.00
4	Imported oil (Turkey brand)	250.00
5	Petrodiesel	90.00-110.00

C. **Little or no Incentive from Government for Farmers**
Farmers have little or no incentive from the government to purchase costly agricultural services and inputs such as fertilizer and other chemicals to improve local production of vegetable oils to accommodate its use for the production of Biodiesel.

D. **Abundant Petroleum Resources**.
Nigeria has abundant petroleum reserves which make petrodiesel cheaper than many alternative Fuels including Biodiesel. This will hinder the country from taking the production of Biodiesel seriously.

E. **Lack of Equipment and Facilities for Research and Development**
The essential equipment and laboratory facilities needed for the production of Biodiesel are not available in higher institutions and research centers in the country.

PROSPECTS FOR BIODIESEL PRODUCTION IN NIGERIA
The problems listed above notwithstanding, there are prospects for Biodiesel production in Nigeria listed below.

A. **Use of Non - Edible Feedstocs**
There are non-edible oils such as those of loofah and neem seeds which can be harnessed for the production of Biodiesel since they do not compete as food items. Others are castor and pumpking seed oils.

B. **Technical Feasibility**
The technology involved in the production of Biodiesel simple. There are adequate engineers and technicians in Nigeria to produce the Fuel.

C. **Conservation of Petroleum Resources**
The production and use of Biodiesel the country would conserve the available petroleum resources and provide more crude oil for export.

CONCLUSION
From a technological stand point, producing Biodiesel will help Fuel the transition to a more sustainable transportation system. Most of the current challenges facing the use of Biodiesel globally is its production cost, as the cost of Biodiesel is still higher than it's petro-diesel counterpart. This opens a golden opportunity for the use of Waste seeds such as loofah, neem, pumpking and castor seed oils as its production feedstock.

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THE POTENTIAL OF PRODUCING FUEL FROM BIOMASS IN NIGERIA

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Abstract
Biomass is available in large quantities in Nigeria. However, most of these materials are usually discarded as Waste without adequately exploiting its potential for economic use. This paper exploited the potential of some Biomass as a source of Fuel in Nigeria.
Some Biomass were selected for the study such as water hyacinth, water lettuce, vegetable materials of municipal solid Waste, corn cobs, cashew shells, agricultural residue, and oil bearing seeds. The technology of producing Fuel from these materials was considered based on their composition.
Water hyacinth, water lettuce, animal manures, vegetable materials of municipal solid Waste was processed into biogas through anaerobic digestion. Agricultural materials that can be pyrolysed into Fuel oil and char are corn cobs and cashew shells; while agricultural residue was briquetted to produce Fuel for domestic use. Vegetable oil was processed to produce Biodiesel, neat oil that reduces exhaust emissions.
Nigeria has abundant Agricultural Residues that can be tapped to produce Fuel for domestic and industrial use. Effort should be focused on exploiting this for energy use.

Key words: Biomass, biogas, anaerobic digestion, pyrolysis, Biodiesel

INTRODUCTION

Energy production and use is a vital part of modern economy. With a progressive increase in global population, there is a need to sustain the economic development and population growth. This therefore necessitated the need to consider some sources of obtaining energy as a long-term alternative to conventional energy source. Energy must be provided at moderate prices to the farmers to boost (Agricultural Produciton). Biomass is a potential in realising this desire. Biomass represents a continuously renewable potential source of energy and thus offers a partial solution to the eventual prospects of fossil Fuel depletion.
Waddle *et al*., (1990) provided a summary of the status of Biomass conversion technologies and opportunities for their use in developing countries. The paper observed that although Biomass Fuels at that time played a large and significant role in energy use worldwide, they were generally used very inefficiently. It opined that utility–scale applications, and perhaps to a lesser extent, the use of liquid Fuels and biogas digesters will play a large role in the changing complexion of Biomass energy utilization. Options for Biomass exploitation include plant materials and livestock Wastes chiefly.

SOME AVAILABLE BIOMASS IN NIGERIA

In Nigeria, energy source has been mainly fossil Fuel and hydroelectric power generation. The major areas of energy consumption in Nigeria are domestic, industry, and transportation, with little in agriculture.
Agricultural crop residues, Fuelwood and Wastes from sawmill have been used through direct burning in Nigeria for many years. These sources are called non commercial energy sources; however, Fuelwood is the primary Fuel of rural areas and the urban poor. There is a need to consider other sources of renewable energy to enhance energy production.

AQUATIC WEEDS

WATER HYACINTH

Water hyacinth is a fast growing plant that has covered Nigeria's coastal waters in recent times. Water hyacinth became a national problem in Nigeria in 1986 (Bamgboye, 1994). The weed is known for its high productivity, competitive ability and wide tolerance range as to the conditions under which it grows. The emergence of water weeds on Nigeria coastal waters has caused a lot of threat to recreational activities and severe economic difficulties, affecting the utilization of land and water resources. It is a problem to river transportation by completely taking over some water ways. It has been a great menace wherever it flourishes.

A lot of money has been spent in clearing water hyacinth from the water ways without much appreciable change. Utilization of water hyacinth as a Fuel should contribute towards reducing its nuisance value.

The energy potential of Water hyacinth was exploited by Bamgboye (1994), and found that the weed is suitable for biogas production. The weed was biodigested anaerobically; a process through which organic materials are decomposed by bacteria in the absence of air in a digester to produce biogas. Biogas is a flammable gas produced by microbes when organic materials are fermented in a certain range of temperatures, moisture contents, and acidities, under airtight condition. Water hyacinth was pre treated by chopping, grinding and blanching of chopped samples and digested anaerobically. From the chopped samples, 3.95 dm^3/kg Total Solids(TS) of biogas was produced, while with ground water hyacinth as feed stock, 4.01 dm^3 / kg TS was produced (Lucas and Bamgboye, 1998). For samples subjected to chopping and blanching, 4.27 dm^3 /kg TS of biogas was produced (Lucas and Bamgboye, 1999), while for whole blanched water hyacinth feed stock, biogas production was 3.31 dm^3 / kg TS. The results obtained suggested a great potential of producing biogas from water hyacinth and its production rate can be accelerated by pre-treatment (Lucas and Bamgboye, 2001).

WATER LETTUCE

Another prominent aquatic weed is water lettuce (Pistia stratiotes Linn.), a free flowing aquatic herb with succulent leaves. A dense cover of water lettuce increases the dissolved O_2 level of water, thereby inhibiting the survival of the aquatic animals where water lettuce is found. Converting the weeds to useful product will reduce the amount of money been spent in its clearing, one of such is its conversion into energy through anaerobic conversion.

When water lettuce was anaerobically digested, 9.83 dm^3 / kgTS of biogas was produced (Bamgboye 2000). The result indicated that biogas can be produced from water lettuce to meet domestic energy required.

BRAKERNFERN

This weed is available in abundance in swampy areas. Its potential as energy source thorough biodigestion process was exploited. Brakenfern, a terrestrial weed was biodigested to produce biogas with a yield of 2.11 dm^3 /kg TS (Bamgboye, 2002). It is however noted that more biogas was produced using aquatic weeds as substrate than terrestrial weeds. This shows that aquatic weeds can be readily digested to produce biogas; while terrestrial brackenfern may not be easily digested. Combining the weed with aquatic weeds was also exploited to find a way of enhancing its use as a substrate in biogas production.

Water hyacinth was combined with water lettuce and brackenfern in varying proportion to produce biogas. Combining the weeds in varying proportions has been found to increase the yield of biogas production during anaerobic digestion with the combination of water hyacinth and lettuce having the highest biogas yield of 12.94 litres / kg TS, while the biogas production of the other two combinations are 3.98 litres/kg TS for water hyacinth and

brakerfern, and 4.278 litres /kg TS for water lettuce and brakenfern (Bamgboye, 2000). The results show that water hyacinth can best be combined with water lettuce to produce biogas. However, the three weeds can be combined together to produce biogas. A combination of brakenfern with water lettuce and water hyacinth in ratio 1: 3: 2 were found to produce the best results with a total biogas yield of 9.29 litres/kg TS (Bamgboye and Abayomi, 2000).
The aquatic weeds that are causing problem to the use of land and water resources can be managed effectively by utilizing it as an energy source which will further helped in reducing the cost of its clearing from the water ways.

MUNICIPAL SOLID WASTES

Solid Waste has been a problem in many countries of the world up till date. The generation of these Wastes increases with increasing human activities, including industrialization (Beukering et al., 1999; and Diaz and Golueke, 1987) and urbanization (Pelling and Thomas-Hope, 1999; and Anand, 1999). Since these activities cannot be curtailed nor eradicated there is the need for the management of the Wastes. The problem of Waste generation is closely linked to the population of a particular locality and this is also an influence on the character of the Waste generated (Halla and Majani, 1999). Several studies have shown that if the Wastes are not properly managed, they will grow to such a level that they will prevent human being from carrying out their daily activities and dangerously affect human lives (Olokesusi, 1994; and Onibokun, 1996).
In a study carried out in Lagos Island, the average percentage by weight of the constituents of the MSW have been found to be 60.55 for vegetable materials, 15.38 for paper products, 6.26 for plastics/rubber, 3.79 for ferrous metals, 3.48 for textiles, 2.19 for glass and 0.36 for non-ferrous metals (Bamgboye and Ojolo, 2004). The vegetable product which is the most abundant have potential for anaerobic digestion to produce biogas, with the average yield varying from 5.15dm^3/kgTS to 5.83dm^3/kgTS (Ojolo and Bamgboye, 2005). The drier components such as plastics can be pyrolysed into pyro-oil and gas (Ojolo and Bamgboye, 2005), while the paper components can be briquetted.

LIVESTOCK

Livestock production causes environmental problems such as odour nuisance which may reduce the value of the neighbouring properties. Some odour substance, caused by a large number of chemical components produced during animal growth may present health hazards. The estimated populations of Nigeria’s cattle, sheep, goat, pigs and poultry are 18, 33.2, 53.8, 8.3 and 97.3 millions respectively (Adelekan, 2008). These livestock generate huge amount of manure daily. Presently, the manures are indiscriminately discharged to land with attendant potential for significant environmental pollution. A way of managing these manures is by converting into biogas through anaerobic digestion. Poultry, piggery and cattle Wastes were anaerobically biodigested with favourable results as energy source with biogas production of 20.8, 28.1 and 15.6 L/kg TS respectively (Adelekan, et. al., 2009).

AGRICULTURAL RESIDUES

CASSAVA

Cassava (*Manihot esculenta,* Cranz) is a very important crop grown for food and industrial purposes in several parts of the tropics. Nigeria, with the year 2006 production of 49 million tonnes of cassava, is the largest producer of the crop in the world (NPC, 2008). The ongoing encouragement of cassava cultivation by the Federal Government of Nigeria is gradually raising the profile of the crop as a significant cash crop. According to IFAD/FAO (2000), cassava is the fourth most important staple crop in the world after rice, wheat and maize. The processing of cassava results in the production of peels, chaff, fibre, and spoilt or otherwise unwanted tubers. A relatively small quantity of peels and unwanted tubers is fed directly to ruminants. However, the much larger remaining proportion of cassava solid Wastes are indiscriminately discharged into the environment and amassed as Waste dumps on sites where cassava is processed. This constitutes an enhanced risk of pollution to the environment. There is, therefore, a pungent need to find an alternative productive use of the peels. One area of possibility is the investigation of potential of cassava peels as Biomass for the production of biogas. In a recent study carried out, it was observed that biogas yield from cassava peels was small, 0.6 L/kg TS (Adelekan, 2008). To further increase biogas yield from cassava peels, mixing the peels with animal manures in varying proportion was considered. On mixing with piggery Waste, the average cumulative biogas yield increased to 35.0, 26.5, 17.1 and 9.3 l/kg-TS respectively for 1:1, 2:1, 3:1 and 4:1 mixing ratios. With cattle Waste, the average cumulative biogas yield increased to 21.3, 19.5, 15.8 and 11.2 l/kg-TS respectively for 1:1, 2:1, 3:1 and 4:1 mixing ratios (Adelekan and Bamgboye, 2009). The results show that biogas production from cassava peels can be enhanced by mixing with peels in the ratio 1:1 by mass.

SORGHUM

Sorghum ranks amongst the three major grain crops grown in Nigeria particularly the Northern states of the country. About 8.3 million hectares of the crop are cultivated yearly (FOS, 2005). Sorghum is mostly harvested and processed for food manually, leaving a large volume of residue constituting Waste on the farm, most of which are flared off in preparation for subsequent farming season. The sorghum residue like any other organic Wastes is heterogeneous varying in bulk density, moisture content, particle size and distribution depending on the mode of handling. It is usually of low bulk density with high moisture content of up to 40% when harvested from the farm in partially dried form (Bolufawi, 2008)). Work has been done in harnessing the energy potential of sorghum, one many numerous crop residue. Briquettes were produced from the sorghum residue as a way of providing energy for cooking. The heating values of the briquette produced from sorghum residues compared well with other Agricultural Residues (Bolufawi, 2008). The briquettes were kept safely for a period of six months without deterioration (Bamgboye and Bolufawi, 2009). This shows that energy trapped in sorghum residues can be harnessed to produce briquette useful as energy for cooking.

CORNCOBS

A large number of Waste products are generated in the rural areas, both on the farm, which occupied the larger portion of the land, and from household activities. Most of these Wastes are mainly deposited on the farm or burnt, with all ecological problems associated with these disposal methods. Corncobs, one of the Wastes is available in large quantities on the farm, constituting a Waste disposal problem.
A study was carried out to harness this for energy production. Pyrolysis was found to be a suitable technology for converting corn cobs into energy, producing tar oil and pyrogas (Bamgboye and Oniya, 2003)

CASHEW NUT SHELLS

The disposal of Cashew Nut Shells (CNS) has constituted serious environmental problems in the cashew nut processing industry in low technological countries where bulk of the world cashew nuts are processed.
A viable way of effectively managing CNS is by thermo-chemical conversion of CNS into Fuel products. In the recent studies on this, the heating value of the CNS was 16.69 MJ/kg, while that of tar oil produced from it was 13.17 MJ/kg. The study thus established that CNS,

a Waste in the cashew nut processing industry, is useful as a renewable energy source (Ogunsina et. al., 2009).

VEGETABLE OIL

Emissions of hazardous gases from the exhausts of heavy duty vehicles have increased tremendously over the years. This has resulted in intense air pollution, identified to be one of the reasons for climatic changes that result in frequent heavy rains, hurricanes and floods threatening lives and properties. There is a need to reduce carbon-dioxide and other hazardous emissions to the atmosphere in internal combustion engines to decrease air pollution. Added to this is the quest to reduce dependence on petroleum products as a result of the fast depletion of crude oil resources and instability in its price. This has shifted the focus on sourcing for an alternative energy from other materials than petroleum products.

Pure vegetable oils have been considered as alternatives for diesel Fuel, but the high viscosity at room temperature made them unsuitable for diesel engines. However, fatty acid methyl ester (FAME) have lower viscosity than the pure oils, and as such are promising alternatives. While the focus has been mostly on oils like soybean, rapeseed, and sunflower (Lang *et al.*, 2001), which are essentially edible in nature, Biodiesel has also been produced from non-edible sources such as used frying oil and greases (Alcantara *et al*., 2000; Canakci and Gerpen, 2001).

The Nigerian oil mill company in Kano crushes between 100 – 120 tonnes of groundnut seeds a day during their oil production season (SATRENDS, 2001). In addition, there are numerous oil mills (both large-scale and low-scale industries) which ensure the production of groundnut oil throughout the year. Therefore, the availability and abundance of the oil makes it a candidate for being used for the production of Biodiesel. Work done on this has shown potential for producing Biodiesel from groundnut oil.

CONCLUSION

Nigeria has abundant Agricultural Residues that can be tapped to produce Fuel for domestic and industrial use. Some of the available Biomass has been found to be biodegradable and can thus best be converted into biogas through anaerobic digestion. Oil can be extracted from the oil bearing seeds and use to produce Biodiesel. Effort should be focused at exploiting the Biomass for energy use.

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DETERMINATION OF BIODIESEL BLENDS SUITABLE FOR AUTOMOBILE ENGINES FROM AFRICAN STAR APPLE SEED (*CHRYSOPHYLLUM ALBIDIUM*) OIL (ASASO)

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Abstract

There is growing interest in the use of oil obtained from seed for the production of Biodiesel, which is less polluting and renewable as against the conventional diesel. Production of Biodiesel blend using *Chrysophyllum Albidium* (African Star Apple) seed oil (ASASO) through transesterification was investigated in this study. Batch transesterification of ASASO was carried out using 100mL ASASO, 42mL dehydrated Ethanol, 0.75g Potassium Hydroxide catalyst, 60 min reaction time and 65^0C reaction temperature. The Biodiesel produced was blended with 60, 70, 75, 80 and 90% of petroleum diesel to produce B40, B30, B25, B20 and B10 type of ASASO blends respective. The viscosity of the blends were 3.91, 3.64, 3.37, 3.11 and 3.00 mm2/s while their specific gravity were 0.879, 0.876, 0.870, 0.864 and 0.860 for B40, B30, B25, B20 and B10 respectively. Similarly, the pour points of the blends were 7, 1, 4, -7 about 10^0C while their cloud points were 8, 3, 1, -4, and -8^0C for B40, B30, B25, B20 and B10 respectively. The flash point of B40, B30, B25, B20 and B10, were 144, 130, 106, 99 and 90^0C respectively. The viscosity, specific gravity, pair cloud and flash points of the unblended. ASASO bodies were 4.865 mm^2/s, 0.883, 14^0C, 15^0C and 181^0C respectively. These were higher than the corresponding values obtained for the blends. The viscosity, specific gravity and pour points of all the blends fall within the ASTM (D6751-02) standard while the cloud point of B25, B30 and B40 fall within the ASTM Standard. Only the flash point obtained for B30 was very close to ASTM Standard. This shows that oil derived from African Star Apple Seed can be used as Biodiesel, unblended or blended with 30 and 70^0 % of petroleum diesel for automobile engine

Keyword: Biodiesel, Chrysophyllum albidium, blend, transesterification
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INTRODUCTION

Vegetable oils and animal fats have been sourced to produce Biofuel to replace conventional petroleum use in driving automobile engines (Ma and Hanna, 1999). These vegetable oils are renewable and possess about 80% of diesel Fuels heat content but are characterized by high viscosity, lower volatility and reactivity of unsaturated hydrocarbon, which are disadvantage to their use as direct Fuel (Ma and Hanna, 1999). The use of rapeseed, safflower, and sunflower oils, as direct Fuel in diesel engine showed poor performance due to carbonization (Bettis et al, 1982). In order to improve on this, these processed vegetable oils have been blended with various proportion of petroleum diesel and their performances in diesel engines were studied (Ma and Hanna, 1999). The viscosity of canola oil blended with diesel Fuel at ratios 75:25 and 50:50 were 40 and 19 respectively and were well above the viscosity of diesel Fuel (4) (Strayewr et al. 1983). Similarly, the viscosity of sunflower oil and petroleum

diesel blended in ratio 25:75 was 4.92 at 40oc and was fairly above the american standard for test material, astm (Ziejewski et al, 1986).
Further studies to reduce viscosity of these oils led transesterification process, which facilitates the production of fatty acid or ethyl ester from these vegetable oils or animal fats. (Felizardo et al, 2006). The ester derived from this process is known as Biodiesel (Zhang et al, 2003) and may be obtained in one or two steps. (Ramadtias et al, 2004, Veljkovic et al, 2006, Wang et al, 2006, Shashikant and Riheman, 2005). The free fatty acid (FFA) content in the vegetable oil and fat is reduced with Ethanol and acid or base catalysts in the first step known as esterification. The portion of esterification process particularly triglyceride react further with more alcohol and catalyst to form ester and glycerol and this process is called transesterification process. The Biodiesel produced is further purified and this greatly influences its Fuel characteristics as a suitable Fuel for diesel engines (Ma et al, 1998, Predojevic 2008).
Furthermore, the Fuel properties of the Biodiesel derived from vegetable source (oil seeds) were improved by blending them with conventional diesel in various ratios in order to meet the Fuel standard and even surpass those of the convectional diesel. Rapeseed oil/diesel blend (25:75) left no wear on engine components or contaminants of the lubricating oil but shorten the injector life of the engine due to carbon build up (McDonnell et al, 2000). A blend of ethyl ester derived from Waste oil with diesel Fuel in ratios 75:25, 50:50 and 25:75 were studied, but 75:25 blends gave the best performance (Al-Widyan et al, 2007). In another study (Ramadhas et al, 2005); rubber seed oil/diesel blends were produced in ratios 20:80, 40:60, 60:40, and 80:20. The efficiencies of these blends were tested with a 5.5KW single cylinder direct injector engine and it was observed that the thermal efficiency and specific Fuel composition of 80:20 met acceptable standard through heavy carbon deposits was recorded. The performances of rapeseed methylester blended with diesel in 5:95, 10:90, 20:80 and 35:65 ratios on the brake specific Fuel consumption were carefully investigated in the works of Labeckas and Slavinskas (2006).
Many studies have investigated the influence of additives like organic solvent known as microemulsion on the efficiencies of the blends for diesel engines (Ma and Hanna, 1999). Standard solvent containing 48% parafines and 52% naphthalene was mixed with soybean oil (50:50) to produce a Fuel with a viscosity of 5.12 at 38oC, which passed the 200h. Engine Manufacturer Association (EMA) Test (Goering 1984b). similarly, a blend of No 2 diesel Fuel (50%), soybean oil (25%), Ethanol (5%) and 1-butanol (20%) passed the 200h EMA test but carbon and lacquer deposits on some major parts of the engine (Goering and Fry 1984a). The EMA test was further employed to investigate the performance of blend obtained from soybean oil (52.7%); mEthanol (13.3%), 2-octanol (33.3%) and cetane improver (10%) and the result was satisfactory (Goering 1984b).The purpose of this work is to characterize the Fuel properties of the Biodiesel blends produced from Chrysophyllum albidium Biodiesel and diesel Fuel at various proportions.

MATERIALS AND METHOD

MATERIALS

The chrysophyllum albidium seed were sourced from the Araada market in Ogbomoso town (8 15N and 4 15E) in Nigeria. The seeds were obtained from the pulp of the seed, and were washed and dried in the sun for three days, thereafter the seeds shells were removed. The endocarp of the seed was further dried at room temperature for 7 days before being stored in desiccators to avoid absorption of moisture. Petroleum diesel was obtained from Oando filling station in Ogbomoso. All the reagents used in this experiment include KOH, Ethanol and distilled water were all of analytical grades.

EXTRACTION OF OIL PROCEDURE

The pre-cleaned African Star Apple Endocarp (ASAE) was milled with electric blender (MX 795N, National, Japan) and 500g of CASE was solvent extracted in Soxhlet apparatus using Ethanol as solvent. After 12h, the African Star Apple Seed Oil (ASASO) was transferred into a sample flask of a rotary evaporator (RE-52A, Shanghai, Ya Rong, Biochemistry Instrument Factory, Shanghai) to remove excess Ethanol at 65oC and 20kpa. The pale yellow ASASO obtained was started for further use.

BIODIESEL PRODUCTION

Biodiesel production from ASASO was carried through esterification process in a screw-capped bottle (250mL) according to Changkhong et al, (2007). KOH catalyst (0.75g) was dissolved completely in 42.0 mL of Ethanol at 55oC in 150mL flask at 100mL of ASASO was poured into the screw-capped bottle and preheated to 55oC after which, the mixture of Ethanol and KOH was added to it. The bottle content was stirred at 80rpm for 60min after which the mixture was poured into a separating funnel and allowed to separate into two layers. The bottom layer was carefully remove and the top ester was washed with distilled water up to 10 times until the pH became constant (averagely 6.9) (Predojevic, 2008). The ester product was further used as blends.

BLENDING PROCEDURE

The African Star Apple Seed Oil Biodiesel (ASASOB) was carefully blended with various percentage ratios (v/v %) of petroleum diesel in a steel basin at room temperature for 10 min each. The blend ratios of 10:90 (B10), 20:80 (B20), 25:75, (B25), 30:70 (B30) and 40:60, (B40) (v/v %) ASASOB to diesel were selected for investigation.

BLEND CHARACTERIZATION

The density, kinematics viscosity; pour point, cloud point as well as the specific gravity of the blends were determined using standard methods described by Predojevic (2008) and were done in duplicates and the average obtained were used for discussion.

RESULTS AND DISCUSSION

DENSITY OF THE BLENDS

The density of B10, B20, B25, B30 and B40 were 864, 866, 868, 870 and 876 kg/m3 at 15oC respectively. The values (Table 1) increased as the percentage volume of ASASOB increased in the blend. All these values fall within the a Biodiesel density standard (Chongkhong et al, 2007) as well as JUS EN 14214 (2004) which are 870-900 kg/m3, 860-900kg/m3,860-900kg/m3 respectively. They are however less than the Biodiesel derived from Palm fatty acid distillate (PFAD) (Chongkhong et al, 2007).

VISCOSITY OF BLENDS

The viscosity of the blends was 3.0, 3.11, 3.64, and 3.91 for B10, B20, B25, B30 and B40 respectively. The viscosities of the blends obtained were less than the viscosity of (4.92) of blend of sunflower oil and petroleum diesel (25:75 v/v) and petroleum diesel (4.0) (Ma and Hanna, 1999). However, the viscosities of the blends obtained met the specifications of ASTM D6751-02 (1.9-60) while the viscosities of B10, B20 and B25 were below the minimum specification of Thai Standard (3.5-500) for Biodiesel (Chongkhong et al, 2007). High viscosity of Biodiesel is a disadvantage to its use as Fuel in diesel engines (Ma and Hanna, 1999; Predojevic, 2008).

SPECIFIC GRAVITY OF THE BLENDS

The fluidity of oils in diesel engines depends on the surface gravity of the oils (Alamu, 2007). The viscosity of B10, B20, B25, B30 and B40 (Table 1) were 0.860, 0.864, 0.870, 0.876 and 0.879 respectively and this increased with increase in the percentage ratio of the ASASOB in the blend. The range of specific gravity (0.860-0.879) of the blends met the range specified by some international standards; EN 14214 (0.86-0.90) and ONC 1191 (0.85-0.89), (JUS EN 14214, 2004, Alamu, 2007).

POUR POINT OF BLENDS

The pour points of blends of CASB and petroleum diesel obtained in this study were -10, -7, -4, 1 and 7oC for B10, B20, B25, B30 and B40 respectively. As observed with other properties of the blends, the pour point of the blends increased with increased percentage ratio of ASASOB in the blends. These values (-10 to 7) fell within the range (-15 to 10) specified by ASTM D6751-02 (ASTB 1998).

CLOUD POINT OF THE BLENDS

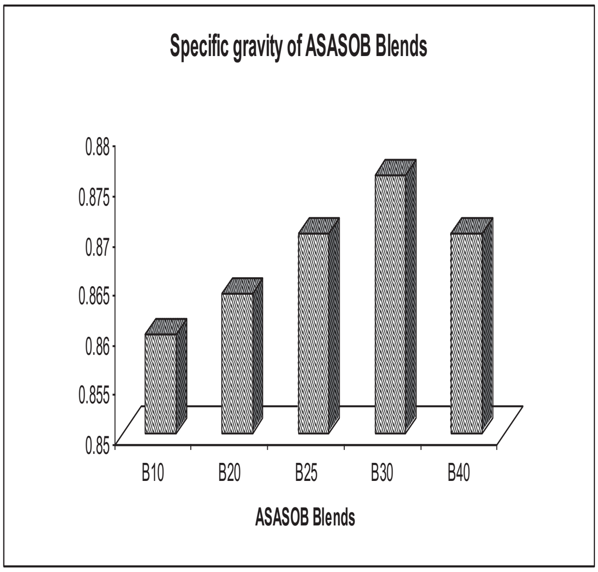
The cloud point of the blends, -8, -4, 1, 3 and 8oC generally increased for B10, B20, B25, B30 and B40 as the percentage composition (volume) of the CASB increased from 10-40% in the blends. The cloud point of B10 (-8oC) and B20 (-4oC) were below the minimum standard (-3oC) specified by ASTM (1998) and this suggests the reliability of B25, B30 and B40 as good blends (Graboski and McCormic, 1998).

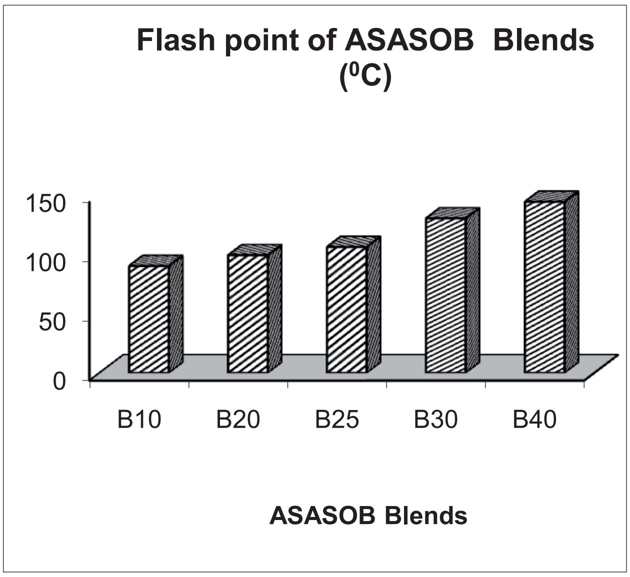
FLASH POINT OF THE BLENDS

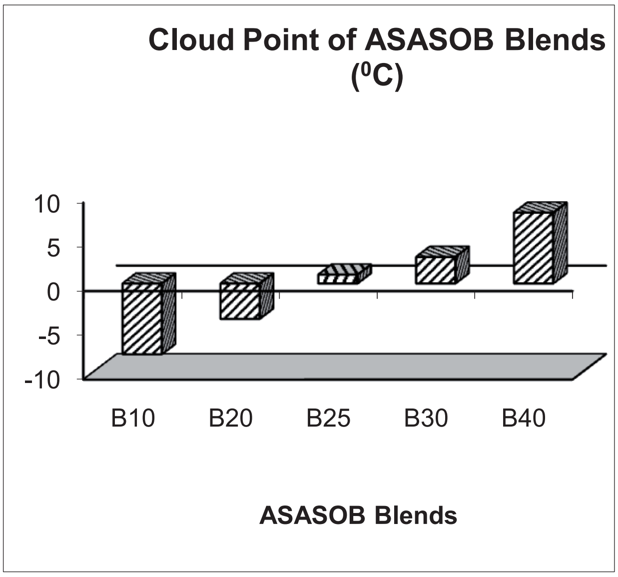
The flash point of B10, B20, B25, B30 and B40 were 90, 99, 106, 130 and 144^{o}C respectively, which show a corresponding relationship with the increasing percentage composition (volume) of the CASB in the blend. The flash points of B10 (90^{o}C), B20 (99^{o}C) and B25 (106^{o}C) were well below the standard specified in Thai standard (120) and D6751-02 (130) (Chongkhong et al, 2007, ASTM, 1998) B30 (130) meet the D6751-02 standard (ASTM, 1998) while B40 (140) is higher than the standards specified above. Moreover, the values obtained for B30 and B40 showed that the two blends are safer to handle.

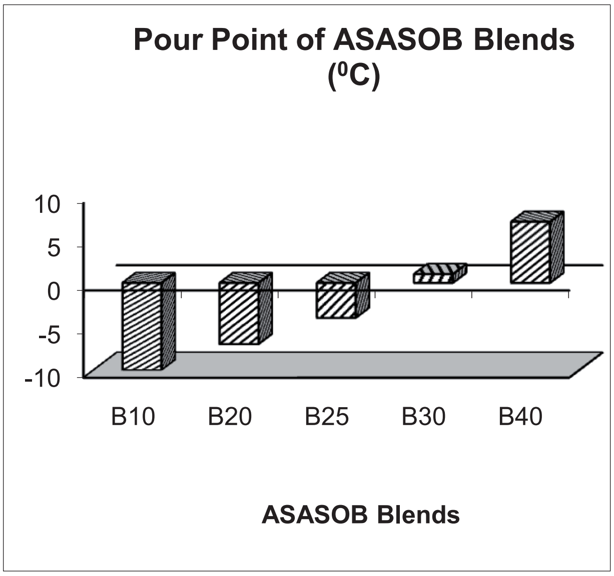
CONCLUSION

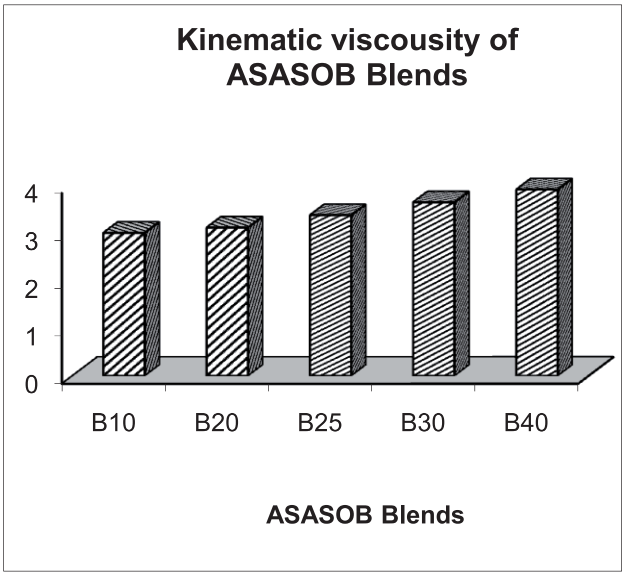
Various ratios of Biodiesel produced from African Star Apple Seed Oil (ASASO) were mixed with petroleum diesel (v/v) to produce Biodiesel blends. The Fuel properties of these blends were evaluated and compared with the Fuel standard available to determine the suitability of these blends as Biodiesel blends fit for use in diesel engines. The order of their suitability is given as B30>B40>B25>B20>B10. This study therefore showed that a blend of Biodiesel derived from African Star Apple Seed Oil (ASASO) and petroleum diesel in ratio 30:40 (v/v) can be used conveniently in a diesel engine to replace conventional petroleum diesel Fuel.

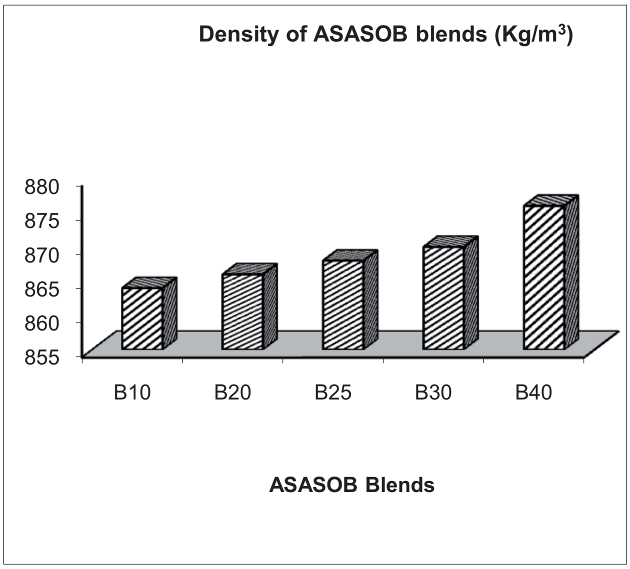

Specific gravity of ASASOB Blends
0.88
0.875
0.87
0.865
0.86
0.855
0.85
B10
B20
B25
B30
B40
ASASOB Blends


Flash point of ASASOB Blends
(0C)
150
100
50
0
B10
B20
B25
B30
B40
ASASOB Blends


Cloud Point of ASASOB Blends
(0C)
10
5
0
-5
-10
B10
B20
B25
B30
B40
ASASOB Blends


Pour Point of ASASOB Blends
(0C)
10
5
0
-5
-10
B10
B20
B25
B30
B40
ASASOB Blends


Kinematic viscousity of
ASASOB Blends
4
3
2
1
0
B10
B20
B25
B30
B40
ASASOB Blends


Density of ASASOB blends (Kg/m3)
880
875
870
865
860
855
B10
B20
B25
B30
B40
ASASOB Blends

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TECHNOLOGICAL AND ECONOMIC ASSESSMENT OF SUSTAINABLE JATROPHA BIOFUEL PRODUCTION IN NIGERIA

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Abstract
Fossil Fuels currently constitute the sole source of energy for transportation in Nigeria, with the attendant environmental and energy security consequences. The Nigerian government's Biofuels development policy focus is on blending 20% Biodiesel in national diesel demand in line with the Government's Development agenda – Vision 20:2020 & 7-Point Agenda. Jatropha Circus is recognised as a potential feedstock for this initiative. Although government target is 20% substitution, the realities of project planning make it imperative to create an acceptable range or upper-and-lower limit of substitution. This paper used 5% below and above the target. This study examines the technological and economic feasibility of jatropha resources as an alternative energy source for transportation in Nigeria which requires comprehensively addressing transportation Fuel demands into the near future. Issues such as jatropha Biofuel process technology and critical input feedstock requirements, land requirements, energy and environmental considerations are examined. Economic considerations include feedstock and processing costs. Coate's model of technology assessment and engineering economy methodology are also employed. The study showed viability results for 15%, 20% and 25% jatropha Biodiesel substitution in transport Fuel demands in Nigeria by 2020. Appropriate policy recommendations are suggested.

Keywords: Biofuels, Jatropha, Climate Change, Biodiesel, Technological, Economic

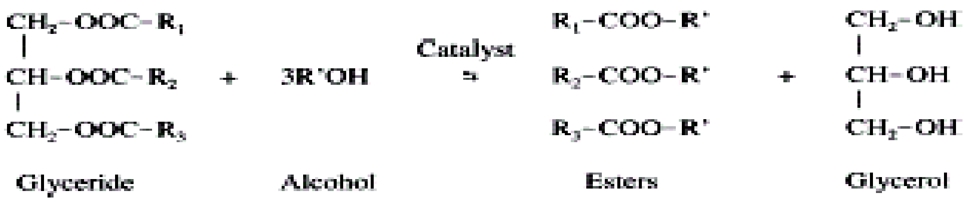
INTRODUCTION
Nigeria, a country situated in West Africa, is well endowed with energy resources such as crude oil, natural gas, coal, tar sand, and Biomass. The country is a member of the Organization of Petroleum Exporting Countries (OPEC), is the largest producer of crude oil in Africa and the eleventh largest in the world (2.45 million bpd). Nigeria also has the 10th largest proven reserves of crude oil in the world (36.22 billion barrels). The energy sector clearly dominates economic activities constituting almost 40% of GDP. Inspite of these considerable resources, Nigeria is bedevilled by energy problems and the country's refining capacity is insufficient to meet domestic demand – Nigeria's 4 state-held refineries have a combined nameplate capacity of 438,750 bbl/d, but problems including sabotage, fire, poor management and a lack of regular maintenance contribute to the current operating capacity of less than 30% of installed capacity. This shortfall necessitates the massive importation of petroleum products (Akarakiri, 2007).

Fossil Fuels constitute the major source of energy for the Nigerian economy with consumption quantities and costs in excess of 8644 thousand tonnes of petrol (₦ 654 billion), 2368 thousand tonnes of diesel (₦ 303.2 billion) and 1389 thousand tonnes of kerosene (₦ 194 billion). The country's huge population (150 million people), very poor public transport system, and extremely deplorable electricity production system (less than 4,000 MW of

electricity produced) play huge contributory roles in this situation. The global debate on Climate Change/CO_2 emissions and domestic concerns on economic, environmental and energy security implications of fossil Fuel consumption have also necessitated developing alterative energy options and created opportunities for sustainable Biofuel enterprise in the country. The Federal Government of Nigeria (FGN) in recognising the need for bio-energy alternatives set up a national Biofuels initiative under the Renewable Energy Division (RED) of the Nigeria National Petroleum Company (NNPC). This Division is coordinating the Domestic Industry programme and the national Biofuels policy. Viable feedstock plants are being reviewed for cultivation with Jatropha curcas being a strong choice for Biodiesel production. Nigeria recognises that estimated national diesel demands will be between 3600-4200 thousand metric tonnes by 2020, hence there could be an expansive opportunity for jatropha Biofuel enterprise in the country (Akarakiri, 2007, NNPC, 2007)
Jatropha curcas is an uncultivated non-food wild-species plant with great potential for bioenergy development in the country. The Jatropha plant can reach a height up to 5 m and its seed yield ranges from 7.5 to 12 tonnes per hectare per year, after five years of growth. The seeds are resistant to a high degree of aridity and contain 27-40% oil by weight basis. This oil can be processed to produce a high-quality Biodiesel Fuel, usable in a standard diesel engine.

CHEMISTRY OF JATROPHA BIODIESEL PRODUCTION

Biodiesel is produced by transesterification of large, branched triglycerides in to smaller, straight chain molecules of methyl esters, using an alkali or acid or enzyme as catalyst. There are three stepwise reactions with intermediate formation of diglycerides and monoglycerides resulting in the production of three moles of methyl esters and one mole of glycerol from triglycerides. The overall reaction is:



Alcohols such as mEthanol, Ethanol, propanol, butanol and amyl alcohol are used in the transesterification process. MEthanol and Ethanol are used most frequently, especially mEthanol because of its low cost, and physical and chemical advantages. They can quickly react with triglycerides and sodium hydroxide is easily dissolved in these alcohols. Stoichiometric molar ratio of alcohol to triglycerides required for transesterification reaction is 3:1. In practice, the ratio needs to be higher to drive the equilibrium to a maximum ester yield (Rayner and Van Dyne, 1992)

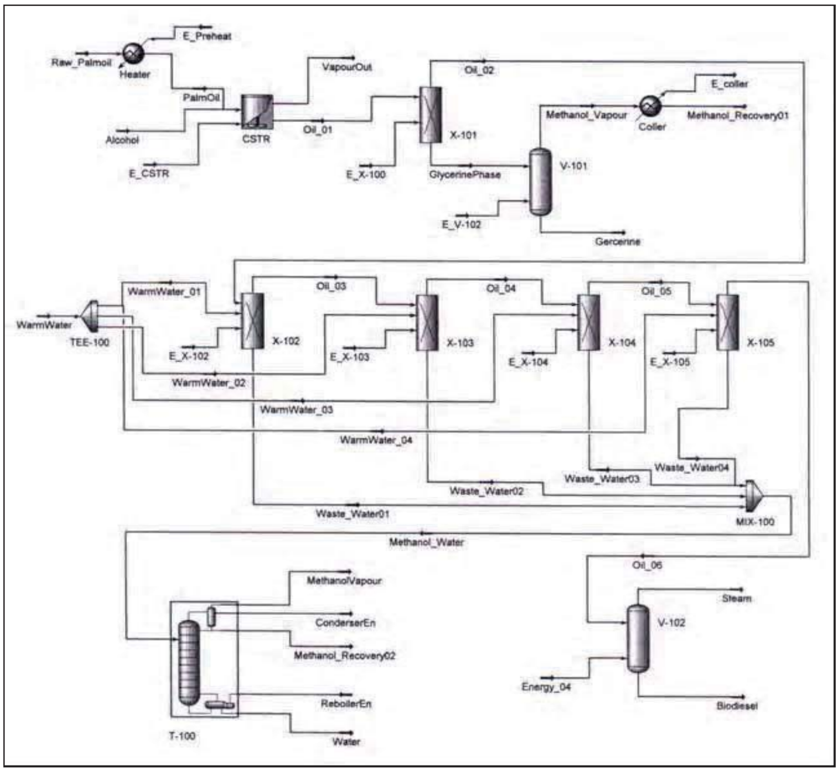


Fig. 1: Flow diagram of the preliminary Biodiesel process, PFD_1.

From Fig. 1, the PFD_1 consists of a continuous stirred tank reactor (CSTR), glycerin-oil separation tanks (X-101), an evaporator V-101 to evaporate mEthanol from glycerin and a distillation column to separate mEthanol from Waste water. The unreacted mEthanol from this unit is then recycled to the reactor. Oil from X-101 contains soap from saponification of free fatty acid and NaOH catalyst, so tanks X-102 to X-105 are washing tanks used to remove soap from methyl ester by warm water. Waste water from this washing still contains a large amount of mEthanol and then is sent to distillation column (T-101) (Kapilakarn and Peugtong, 2007; Anderson et al, 2003).

BENEFITS OF JATROPHA BIO-DIESEL PRODUCTION IN NIGERIA

- Wasteland Reclamation and Reforestation
- Income generation from previously unusable areas
- Increased demand for employment in infrastructure, logistics and Transportation
- Improved Agricultural Development and Rural Society Enhancement. This will involve the development of irrigation systems, soil preparation, Plantation maintenance, seed collection, and oil extraction.

TECHNOLOGICAL AND ECONOMIC ASSESSMENT

Project Planning Theory

Every project must start with a clearly defined statement of the objective it is intended to achieve and against which its success can be measured. This is usually called the ‘project definition’. Since ultimate success lies in the market place, the objectives must be clearly defined in terms of market need, albeit modified by an assessment of these needs in terms of what is likely to be technically achievable in practice. The project definition needs to be concise and specific, determining the planning objectives for all the tasks forming part of the project and, in particular, must lay down clear guidance on technical performance required, cost limitations, and the project duration (Akarakiri, 2009; SADC, 2005).

Developing jatropha Biodiesel enterprise in Nigeria therefore requires providing planning objectives or guidelines for successful operation. These objectives are to:

(a) determine the diesel Fuel demand projections in the country up to January 1, 2020;
(b) assess the technology and engineering economy of the possible substitution levels, and
(c) analyse Biofuel technology capability in Nigeria's universities and research institutes.

METHODOLOGY

Diesel Fuel consumption data in Nigeria from 1989 to 2005 were obtained from the Central Bank of Nigeria (CBN) and projections till 2019 estimated. Technological and economic data for jatropha Biofuel production in the country were obtained from both primary and secondary sources. The secondary sources consisted of selected national and international agencies. The primary sources consisted of three national research institutions under the Federal Ministry of Science & Technology, five universities, a civil engineering firm, a bank and an insurance firm. Technological information analysed include input feedstock requirements, environmental considerations, and land requirement for feedstock crop production, while economic information analysed include feedstock costs, processing costs, and Biofuel market potential. The biotechnology capability analysis was carried out in 10 universities and 5 research institutes spread across Nigeria using questionnaire and structured interview guide. Faculties sampled were the Natural Sciences, Engineering/Technology, and Agriculture. The data were analyzed using Coate's model of technology assessment, engineering economy and other statistical methods were also used.

RESULTS

(a) Diesel Fuel Demand Projections in Nigeria (Up to 2020)

Diesel demand in Nigeria has been rising steadily in Nigeria since 1996, and this is expected to continue till it reaches between 3600-4200 Thousand Tonnes by 2020. This steady growth is precipitated by rising transportation requirements and the industrial/domestic need for diesel Fuel to power generators in view of deteriorating services from the national electricity authority. It is pertinent to note that the high and low lines in the projection zone constitute the upper and lower limits of expected diesel Fuel demand in the country.

projection

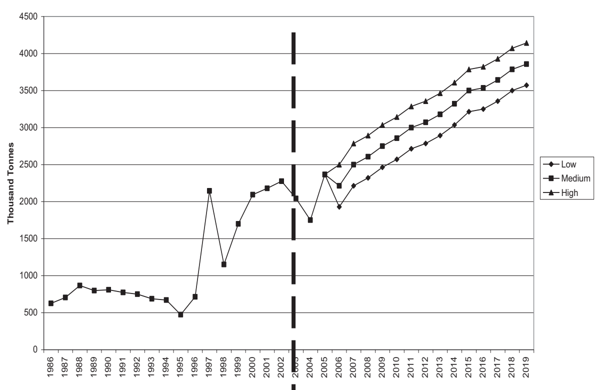


Fig 2: Domestic Consumption of Diesel (Automated Gas Oil – AGO) in Nigeria

(b) Technology Assessment and Engineering Economy of Possible Substitution Levels

(i) Bio-Diesel Substitution Requirements

The Nigerian government has a target of 20% Biodiesel substitution (B20) in national transport diesel demand. Taking into congnisance project planning realities, this B20 substitution level will serve as the midpoint for a 15%-25% substitution level planning range. It is recognized that Nigeria's capabilities in Biofuel development could create actual performance slightly less or even slightly more than the set target. Fig 3 below provides planning ranges for 15%, 20%, and 25% Biodiesel substitution levels up to January 1, 2020. As the table shows, the planning premise for Biodiesel substitution in Year 2011 under the 20% Biodiesel substitution target is between 385.71 Thousand Tonnes to 785.71 Thousand Tonnes. By the end of Y2019 (which provides information for January 1, 2020), Nigeria is expected to produce between 535.71 – 1035.71 Thousand Tonnes of Biodiesel to meet national targets.

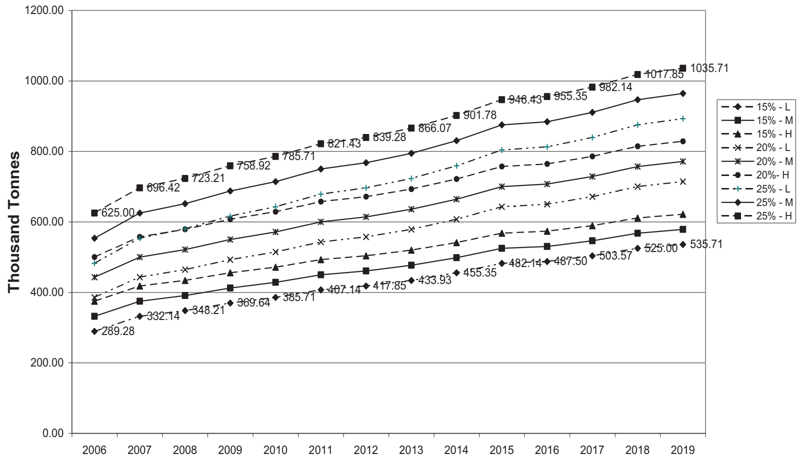


Fig 3. Biodiesel Substitution in AGO

(ii) Jatropha Oil Requirements

Fig 4 below provides the upper and lower limits to the total jatropha oil requirements necessary to meet the substitution levels determined in Fig. 3 above. By the end of 2019, planning projections would be for between 0.87 and 1.68 million tons of jatropha oil.

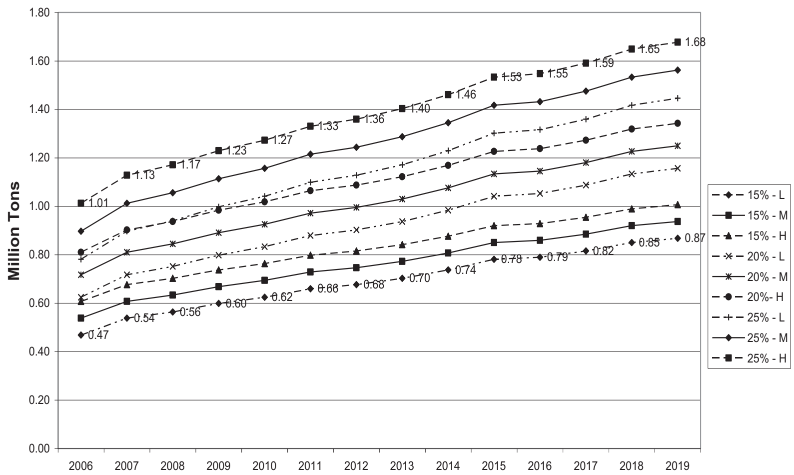


Fig 4 Jatropha Oil Utilization in Biodiesel Substitution

(iii) Landmass Requirements

It is estimated that 2.29 tons of jatropha oil can be produced from 0.01 Sq Km (1 hectare) landmass of jatropha. Fig 5 presents the total landmass requirements for the cultivation of the jatropha curcas plant. The figures for 2019 are between 3.83 and 7.41 Thousand Sq. Km. These figures are only a fraction of Nigeria's total landmass of 923. 8 Thousand Sq Km (between 0.0039% and 0.0077%).

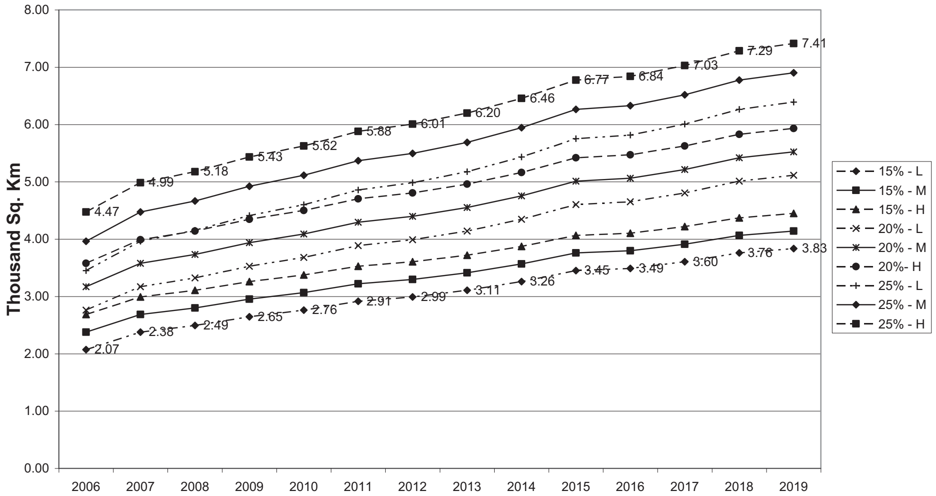


Fig 5. Landmass Requirements for Jatropha Biodiesel Substitution in AGO

(iv) Environmental Considerations

Mankind's consumption of fossil Fuels over the last 200 years has had both positive and negative effects on his development. On the positive end, the use of fossil Fuels has greatly improved human economic activities; on the negative end, fossil Fuel usage has contributed significantly to altering the chemical and physical compositions of the environment. These environmental alterations have not always been good – it is on record that acid rain and global warming are two of the most serious environmental issues related to large-scale fossil Fuel combustion (Karekezi, 2001; Peskett et al, 2007; Somerville, 2008). Other environmental problems associated with oil extraction activities in Nigeria include land degradation, land reclamation and oil spills; and public health considerations (respiratory diseases and cardiovascular-related deaths) (Akinbami, 2001).

Carbon dioxide (CO_2) is the major by-product of fossil Fuel combustion and the second most abundant greenhouse gas. Greenhouse gases are gases which absorb solar heat radiated from the earth's surface and retain this heat, keeping the earth warm and habitable for living organisms. Humans are significantly increasing the amount of carbon dioxide released to the atmosphere through the burning of fossil Fuels; at the same time, the number of trees necessary to absorb this carbon dioxide has been greatly depleted through deforestation – hence carbon dioxide is being released to the atmosphere much faster than Earth's natural processes can remove. Unfortunately, the CO_2 can remain in the atmosphere a century or more before nature can dispose of it. For example, before the Industrial Revolution began in the mid-1700s, there were about 280 molecules of CO_2 per million molecules of air. In 2007, these levels had risen to a record high of 379 ppm and are increasing at an average of 1.9 ppm per year (World Bank, 2008; Achten et al, 2008; RFA, 2008; Escobar 2009).

CO_2 induced global warming is also harmful to human health. High-temperature events are blamed for increasing the number of cardiovascular-related deaths, enhancing respiratory problems, and Fuelling a more rapid and widespread distribution of deadly infectious

diseases, such as malaria, dengue and yellow fever (World Bank, 2008). To stabilize atmospheric concentrations of carbon dioxide, global emissions would need to be cut significantly – on the order of 70 to 80 percent (Escobar et al, 2009; Brown, 2006).
Jatropha bio-diesel substitution in domestic diesel consumption will reduce CO_2 emissions and decrease these environmental concerns. Carbon dioxide (CO_2) will be produced in the substitution option, however it is estimated that all the CO_2 will be absorbed by the jatropha plants cultivated.
Table 1: Below therefore provides information on the amount of carbon dioxide reduction associated with the various substitution levels.

Table 1: $C0_2$ Reduction via Jatropha Bio-diesel Substitution (Thousand Tons)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
15% - L	0.89	1.02	1.07	1.13	1.18	1.25	1.28	1.33	1.39	1.48	1.49	1.54	1.61	1.64
15% - M	1.02	1.15	1.20	1.26	1.31	1.38	1.41	1.46	1.53	1.61	1.62	1.67	1.74	1.77
15% - H	1.15	1.28	1.33	1.39	1.44	1.51	1.54	1.59	1.66	1.74	1.75	1.80	1.87	1.90
20% - L	1.18	1.36	1.42	1.51	1.57	1.66	1.71	1.77	1.86	1.97	1.99	2.06	2.14	2.19
20% - M	1.36	1.53	1.60	1.68	1.75	1.84	1.88	1.95	2.03	2.14	2.16	2.23	2.32	2.36
20%- H	1.53	1.71	1.77	1.86	1.92	2.01	2.06	2.12	2.21	2.32	2.34	2.41	2.49	2.54
25% - L	1.48	1.69	1.78	1.89	1.97	2.08	2.13	2.21	2.32	2.46	2.49	2.57	2.68	2.73
25% - M	1.69	1.91	2.00	2.10	2.19	2.30	2.35	2.43	2.54	2.68	2.71	2.79	2.90	2.95
25% - H	1.91	2.13	2.21	2.32	2.41	2.51	2.57	2.65	2.76	2.90	2.92	3.01	3.12	3.17

(v) Engineering Economic Evaluation
Table 2 presents the net cost of jatropha Biodiesel production in Nigeria. It is important to note that the costs assumed here are estimates derived by the careful extrapolation of information obtained from literature. The current pump price of diesel in Nigeria is ₦ 110 (US$ 0.73) per litre, hence the bio-substitution option would provide for a profit margin of ₦ 26 (US$ 0.17) per litre. This profit margin could lead to the direct creation of 35,000 jobs from the bio-diesel industry by 2019. This figure has also been calculated from literature.

Table 2. Economics of Jatropha Biodiesel Production (Estimates)

Item	US$/Litre	₦/Litre
Cost of raw jatropha oil	0.44	66
Biodiesel processing cost	0.18	27
Cost of production	0.62	93
Less return from crude glycerol	0.06	9
Net Cost of Production	**0.56**	**84**

Exchange Rate: US$ 1 = ₦ 150 (2009 rates)

Using this net cost of production for analysis, it is possible to determine production costs for the jatropha bio-substitution option at its different substitution rates. This information is presented in Table 3 below.

Table 3: Production Costs for Jatropha Bio-Diesel Substitution (US$ Million)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
10% - L	189	217	227	241	251	265	272	283	297	314	207	328	342	349
10% - M	217	244	255	269	279	293	300	311	325	342	346	356	370	377
10% - H	244	272	283	297	307	321	328	339	353	370	374	384	398	405
25% - L	251	289	303	321	335	354	363	377	396	419	424	438	456	466
25% - M	289	326	340	359	372	391	400	414	433	456	461	475	494	503
25% - H	326	363	377	396	410	428	438	452	470	494	498	512	531	540
50% - L	314	361	378	402	419	442	454	471	495	524	530	547	570	582
50% - M	361	407	425	448	466	489	501	518	541	570	576	594	617	629
50% - H	407	454	471	495	512	535	547	565	588	617	623	640	663	1206

(a) Survey of National Technological Capability in Jatropha Bio-Diesel Production in Nigerian Universities and Research Institutes

This section presents a strategic consideration on the technical competences of Nigerian researchers for Biofuel development. The Education and Research sector play a key role in any country's national system of innovation. Other key players are Government, Finance, and Industry. Bearing in mind Nigeria's global aspiration to be one of the leading economies by 2020, and the national development agenda tagged '7-Point Agenda', it is necessary to analyse the technical competence level of the Education and Research sector relative to Biofuel development. 301 respondents returned their questionnaires.

Table 4 shows the distribution of respondents according to academic affiliations, gender, and qualification.

Table 4 Academic Affiliations, Gender and Qualification of Respondents

Gender	**Universities**				**Research Institutes**					
	PhD		**MSc**		**PhD**		**MSc**		**BSc**	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Male	169	88.5	69	87.3	6	66.7	13	68.4	3	100
Female	22	11.5	10	12.7	3	33.3	6	31.6	0	0

Slightly more than 50% of the respondents in Table 4 above have their specialisations closely related to bio-energy development as shown in Table 5 below. Members of staff working in Universities top this assessment.

Table 5: Specialisations Closely Related to Bio-energy Development

	Universities				Research Institutes					
	PhD		MSc		PhD		MSc		BSc	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Male	83	87.3	43	91.5	2	66.7	5	71.4	0	0
Female	12	13.7	4	8.5	1	33.3	2	28.6	0	0
Total	152 (50.4% of 301 Respondents)									

On paper, it would look like Nigeria has the technical competences for bio-energy development. However, further analysis (as shown in Table 6) reveals that less than 12% of Nigerian researchers have continuous research output in bio-energy development from 2005 to 2009. Only 36 respondents (11.99% of all respondents sampled in the study) are in this category. One can conveniently argue therefore that although Nigeria has some bio-energy development related knowledge and skills, the country lacks the critical mass of expertise required to push this skill into a buoyant industrial sector as theorised by Ogbimi (2007).

Table 6: Continuous Research Output in Bio-energy Development (2005-2009)

	Universities				Research Institutes					
	PhD		MSc		PhD		MSc		BSc	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Male	15	75	13	92.9	1	50	1	100	0	0
Female	5	25	1	7.1	1	50	0	0	0	0
Total	36 (11.99% of 301 Respondents)									

CONCLUSION

The Nigerian government's Biofuel policy focus advocates a 20% Biodiesel substitution level in national diesel demand. Using project planning premises, upper and lower levels of 25% and 15% substitution were calculated and presented in graphs. *Jatropha curcas* was the feedstock utilized for the analysis. Technological and economic analyses of the various substitution options have provided planning objectives and guidelines for sustainable bio-diesel production. These guidelines show bio-diesel substitution in AGO, Landmass requirements for cultivation, Jatropha oil utilization requirements, CO_2 reduction calculations, and production costs estimates up till 2019. With estimated national net production costs of bio-diesel (per litre) at ₦84 (US$ 0.56) and current fossil-diesel pump prices at ₦110 (US$ 0.73), the bio-substitution option could provide profits up to ₦26 (US$ 0.17) per litre for investors. Interpolating information acquired from literature on employment, it is possible to argue that jatropha Biodiesel production can create as many as 35,000 direct jobs in the bio-diesel industry by 2019. The option offers business opportunities for agricultural enterprises and rural employment. The analysis of Biofuel technological capabilities in Nigerian universities and research institutes however is worrisome – just slightly more than 50% of researchers have specialisations closely related to bio-energy development, and less than 12% have consistent, active research between 2005 and 2009. This data shows that Nigeria lacks the critical mass of expertise needed in Biofuel development enterprise. A critical challenge therefore would be to increase the number of researchers with competences in this all-important economic sub-sector.

POLICY RECOMMENDATIONS

1. The Biofuel policy has been at the planning stage since 2007, hence Government should, as a matter of urgency, develop and implement a comprehensive *explicit* Biofuel policy.
2. The broad planning premises for 20% bio-diesel substitution in national diesel demand till 2020 have been spelt out. These premises will be more detailed as more and deeper research occurs. It is therefore recommended that more intrusive techno-economic assessments be carried out for better planning guidelines.
3. The parameters for Biodiesel production show production costs which are significantly less than current prices for fossil diesel. This situation is expected to persist till 2020. Therefore, it would be economically beneficial for the nation to invest significantly in Biofuel development. The Government of Nigeria is trying to remove the subsidies given on petroleum product importation. It is a reasonable suggestion to utilize this multi-million dollar fund to provide financial cover for the bio-energy industry.
4. There is a need to strengthen the level of competence in Biofuel research in the country. Having less than 12% of national researchers actively researching in such a critical sector of the economy is unrealistic for achieving national development goals. For Nigeria to be competitive in the global Biofuel industry there is a strategic need to step-up the capabilities of the critical elements of the national innovation system in this key sector. Nigerian universities and research need to improve conditions to increase Biofuel research competence.

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DESIGN OF A LABORATORY SCALE BIOMASS GASIFIER

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Abstract
There is a vast amount of Biomass particularly in form of Agricultural Residues and there is need to use more efficient conversion processes to enable a more efficient use for the Biomass. Gasification is a thermochemical conversion process for the production of syngas or producer gas and a Gasifier is used for the purpose. This work presents the design of a laboratory scale throated down8draft Biomass Gasifier, to produce 4 kW of power. A specific gasification rate of 0.3 was selected for the design. The Biomass consumption of the Gasifier is estimated as 4.32 kg/h. The hearth and throat diameters are 238 mm and 68 mm respectively. It has five nozzles, 8 mm diameter, for the injection of air. The Gasifier is lagged using fibre glass material. The Gasifier can be easily manufactured at a machine shop and at reasonable cost.

Keywords: Biomass, dowdraft Gasifier, energy, Agricultural Residues.

INTRODUCTION

Agriculture and energy have always been tied by close links, but the nature and strength of the relationship have changed over time (FAO, 2008). Agriculture has always been a source of energy, and is a major input in modern (Agricultural Produciton) (Anil, 1986; FAO, 2008). The linkages between agriculture and energy output markets weakened in the twentieth century as fossil Fuels gained prominence in the transport sector.

Currently, most of the electrical or thermal energy consumed in the world is generated through the use of non-renewable energy sources that, in the future, will increase strongly their price due to potential shortage in the market. However, with recent price rise and scarcity of these Fuels there has been a trend towards use of alternative energy sources like solar, wind, geothermal, etc. Vegetal-type Biomass is currently being considered a promising energy source (Ramrez et al, 2008). The use of renewable resources would contribute to a country's economic growth, especially in developing countries, many of which have abundant Biomass and agricultural resources that provide the potential for achieving self-sufficiency in materials.

The world's total primary energy demand amounts to 11, 400 million tonnes of oil equivalent (Mtoe) per year; Biomass including agricultural and forest products and organic Wastes and residues, accounts for 10 percent of this total. In some developing countries, as much as 90 percent of the total energy consumption is supplied by Biomass. In most African countries, Biomass continues to be the main energy source for subsistence activities such as cooking, heating and lighting. Solid Biofuels such as Fuelwood, charcoal and animal dung constitute by far the largest segment of the bioenergy sector, representing a full 99 percent of Biofuels (Miah et al, 2008; The Need Project, 2008).

Gasification is the transformation of solid Fuels into combustible gases in presence of an oxygen carrier (air, O_2, H_2O, CO_2) at high temperatures. It is a process for converting carbonaceous materials to a combustible or synthetic gas like biomethane or producer gas (Tobias, 2004). Biomethane can be used like any other Fuel, such as natural gas, which is not renewable (Leland, 2001). The gasification process occurs at temperatures between 600-1000^{0}C and decomposes the complex hydrocarbons of wood (Rezaiyan and Cheremisinoff, 2005). The gasification process, with high temperature, produces ash and char, tars, methane, charcoal and other hydrocarbons. The corrosive ash elements such as chlorine and potassium are removed, allowing clean gas production from otherwise problematic Fuels (Cassidy, 2008).

Conversion of solid Biomass into combustible gas has all the advantages associated with using gaseous and liquid Fuels. Such advantages include clean combustion, compact burning equipment, high thermal efficiency and a good degree of control. Biomass is also economic in places where Biomass is already available at reasonable low prices or industries using Fuel wood (Leland, 2001).

Biomass Gasifiers are reactors that heat Biomass to produce a Fuel gas that contains from one-fifth to one half (depending on the process conditions) the heat content of natural gas. A Biomass Gasifier converts solid Fuel such as wood Waste, saw-dust briquettes and agro-residues converted into briquettes into a gaseous Fuel through a thermo-chemical process and the resultant gas can be used for heat and power generation applications (Chanderpur Works, 2008; Global Collaborations, 2004).

Biomass Gasifiers have been classified based on their operation principles such as gasification and product temperature, oxygen requirements, product gas composition amongst others. The major types of Gasifiers are updraft or counter current Gasifier, downdraft or co-current Gasifiers, cross-draft Gasifier and fluidized bed Gasifier (FAO, 1986). The throated downdraft Gasifier is suitable for Biomass gasification, has a low tar yield, high carbon conversion, low ash carry over and simple construction and operation. However, it has a high gas exit temperature, requires uniformly sized feed stock and limited moisture content of feed. This main aim of this work is the design of a laboratory scale downdraft Biomass Gasifier.

THEORY OF GASIFICATION

The substance of a solid Fuel is usually composed of the elements carbon, hydrogen and oxygen. In addition, there may be nitrogen and sulphur present in small quantities. Biomass gasification in air can be expressed in three stages which are oxidation or combustion, pyrolysis and reduction or gasification (FAO, 1986).

Combustion/Oxidation Reactions provide the heat energy required to drive the pyrolysis and char gasification reactions.

$$C + {}^{1}/_{2}\,O_2 \leftrightarrow CO \qquad -111 \text{ MJ/kmol}$$
$$CO + {}^{1}/_{2}\,O_2 \leftrightarrow CO_2 \qquad -283 \text{ MJ/kmol}$$
$$H_2 + {}^{1}/_{2}\,O_2 \leftrightarrow H_2O \qquad -242 \text{ MJ/kmol}$$

The Pyrolysis Reactions involve the cracking of the heavier Biomass molecules into lighter organic molecules and Carbon monoxide:

$$C_6H_{10}O_5 + Heat \leftrightarrow C_xH_z + CO$$
$$C_6H_{10}O_5 + Heat \leftrightarrow C_nH_mO_y$$

The Reduction/Gasification Reactions involve, mainly, the gasification of tar, depending on the technology used. They include:

a. *The Boudouard reaction,*

$$C + CO_2 \leftrightarrow 2CO$$

b. *The water gas reactions*

   i. *Primary water gas reaction,*

   $$C + H_2O \leftrightarrow CO + H_2$$

   ii. *Secondary water gas reaction,*

   $$C + 2H_2O \leftrightarrow CO_2 + 2H_2$$

   iii. *Water-gas shift reaction,*

   $$CO + H_2O \leftrightarrow CO_2 + H_2$$

c. *Methane synthesis reactions*

$$C + 2H_2 \leftrightarrow CH_4$$
$$2C + 2H_20 \leftrightarrow CH_4 + CO_2$$
$$CO + 3H_2 \leftrightarrow CH_4 + H_2O$$
$$CO_2 + 4H_2 \leftrightarrow CH_4 + 2H_2O$$

THE DESIGN OF THE GASIFIER

A laboratory scale Biomass Gasifier is for a micro scale application which is to produce mechanical power of about 1 to 7 kW. An average mechanical power of 4 kW is assumed and the design of the Gasifier is based on this. The design of the reactor is basically empirical, that is, implied from charts based on past experiences.

POWER CONSUMPTION OF THE GASIFIER

For an engine with a compression ratio of 9.5:1, the effeciency has been estimated to be 28 per cent (FAO, 1986). Therefore, the thermal power in the Gasifier can be estimated as

$$P_g = \frac{P_m}{\mu} \qquad \text{(FAO, 1986)}$$

$$P_g = \frac{4}{0.28} = 14.3\ kW$$

If the thermal effeciency of the Gasifier is taken at 70 per cent, the thermal power consumption at full load can be estimated as

$$P_t = \frac{P_g}{0.7} \qquad \text{(FAO, 1986)}$$

$$P_t = \frac{14.3}{0.7}$$

$$P_t = 20.4\ kW$$

BIOMASS CONSUMPTION OF THE GASIFIER

Higher heating value of Biomass (wood) having a moisture content of about 10 to 60 per cent is about 10000 to 20000 kJ/kg (Klentsch, 2001; FAO, 1986). A heating value of Biomass with 14% moisture content is taken to be 17000 kJ/kg (FAO, 1986).

The Biomass consumption of a Gasifier can be estimated as (FAO, 1986; Rathore et al., 2009),

$$Biomass\ consumption\ of\ gasifier = \frac{Thermal\ power\ consumption}{Heating\ value\ of\ biomass}$$

$$Biomass\ consumption\ of\ gasifier = \frac{20.4\ kW}{17000\ kJ/kg} = 0.0012\ kg/s = 4.32kg/h$$

THE HEARTH LOAD: SPECIFIC GASIFICATION RATE AND SPECIFIC SOLID FLOW RATE

The hearth load, B_g, is defined as the amount of producer gas reduced to normal (p, T) conditions, divided by the surface area of the throat at the smallest circumference and is expressed in $m^3/cm^2/h$ (FAO, 1986). This may be referred to as the specific gasification rate (SGR), which is the volumetric flow rate of gas per unit area based on throat diameter, the gas volume being measured at the standard conditions (Sivakumar et al., 2006; Jain, 2006).

The hearth load can also be expressed as the amount of dry Fuel consumed divided by the surface area of the narrowest constriction, B_s, and is expressed in $kg/cm^2/h$ (FAO, 1986). This may also be referred to as the specific solid flow rate (SSR) which is the mass flow of Fuel measured at throat (Sivakumar et al., 2006, Jain 2006). One kilogramme of dry Fuel under normal circumstances produces about 2.5 m^3 of producer gas (FAO, 1986; Sivakumar et al., 2006; Reed and Das, 1988). Thus

$$B_g = 2.5B_s \qquad \text{(FAO, 1986; Sivakumar, 2006)}$$

$$B_s = \frac{4.32}{Area\ of\ throat} \qquad \text{(FAO, 1986)}$$

$$B_g = \frac{2.5 \times 4.32}{Area\ of\ throat\ (S)}$$

The recommended value for B_g falls in the range of 0.30 to 1.0 (Sivakumar, 2006; Reed and Das, 1988; FAO, 1986). Taking the value of B_g as 0.3,

$$0.3 = \frac{2.5 \times 4.32}{S}$$

THROAT SIZING

The cross sectional area of the throat is thus,

$$S = \frac{2.5 \times 4.32}{0.3} = 36cm^2$$

The diameter of throat, d_t, can be calculated using,

$$S = \frac{\pi}{4} d_t^2$$

$$d_t = \sqrt{\frac{4S}{\pi}} = \sqrt{\frac{4 \times 36}{\pi}}$$

$$d_t = 6.8\ cm = 68\ mm$$

Other Gasifier dimensions, with respect to the throat diameter, are obtained from tables and experimental graphs obtained from previous experiences in Sweden by Volvo and the National Swedish Testing Institute for Agricultural Machinery, which are presented by FAO (1986).

Sivakumar et al. (2008) discovered from their model that for throat angles of about 45^0, the cumulative conversion effeciency is increased while larger angles of about 90^0 decrease the cumulative conversion effeciency because of a decreased temperature for larger throat angles due to the divergent effect and the reaction rate. Venselaar (1982) also recommended, after comparison of the design characteristics of a number of Gasifiers, that the throat inclination should be around 45^0 to 60^0. A throat angle of 60^0 is used for the design.

SIZING OF THE FIRE BOX OR HEARTH

Diameter of the fire box or hearth, d_h is a function of throat diameter and can be estimated from figure 1(a) using

$$\frac{d_h}{d_t} = 3.5 \qquad \text{(FAO, 1986)}$$

$$d_h = 3.5 \times 68 = 238\ mm$$

NOZZLE DESIGN AND AIR BLAST VELOCITY

The height of nozzle plane above the smallest cross section of the throat is a function of the throat diameter and can be evaluated from figure 1(b),

$$\frac{h_{nt}}{d_t} = 1.6 \qquad \text{(FAO, 1986)}$$

$$h_{nt} = 1.6 \times 68$$

$$h_{nt} = 109\ mm$$

The ratio between the nozzle flow area and the throat area is a function of the throat diameter and is given from figure 1(c) as

$$\frac{A_n}{A_t} = 0.07 \qquad \text{(FAO, 1986)}$$

Where A_n is the total nozzle area. It is assumed that the Gasifier will be equipped with 5 nozzles as recommended by Shrinivasa and Mukunda (1984) for operating slow two-cycle engines.

$$\frac{5 \times \frac{1}{4} \times \pi \times d_n^2}{\frac{1}{4} \times \pi \times d_t^2} = 0.07$$

$$\frac{5 \times d_n^2}{68^2} = 0.07$$

$$d_n^2 = \frac{0.07 \times 68^2}{5}$$

$$d_n^2 = 64.74\ mm^2$$

$$d_n = 8\ mm$$

Sivakumar et al. (2006) suggested optimum results are obtained when the angle of inclination of the nozzles is between 10^0 and 25^0. An inclination of 15^0 is used.

The nozzle tip ring diameter d_{nt} is also a function of the throat diameter as seen in figure 1(d). The ratio between the nozzle tip ring diameter and the throat diameter is

$$\frac{d_{nt}}{d_t} = 3 \qquad \text{(FAO, 1986)}$$

$$d_{nt} = 3 \times 68\ mm$$

$$d_{nt} = 204\ mm$$

The air blast velocity (V_b) can be estimated by equating the volumetric flow rate of the producer gas through the throat to the volumetric flow rate of air through the nozzle.

$$Q = Av$$

The volumetric flow rate of producer gas through the throat is estimated using

$$Q = 2.5\ m^3/kg\ \times 4.32\ kg/h$$

$$Q = 10.8\ m^3/h$$

Using this flow rate as the flow of air through the nozzle,

$$Q = \frac{10.8}{60 \times 60} m^3/s = 9 \times \frac{\pi (0.006)^2}{4} \times v_b$$

$$v_b = 11.79\ m/s$$

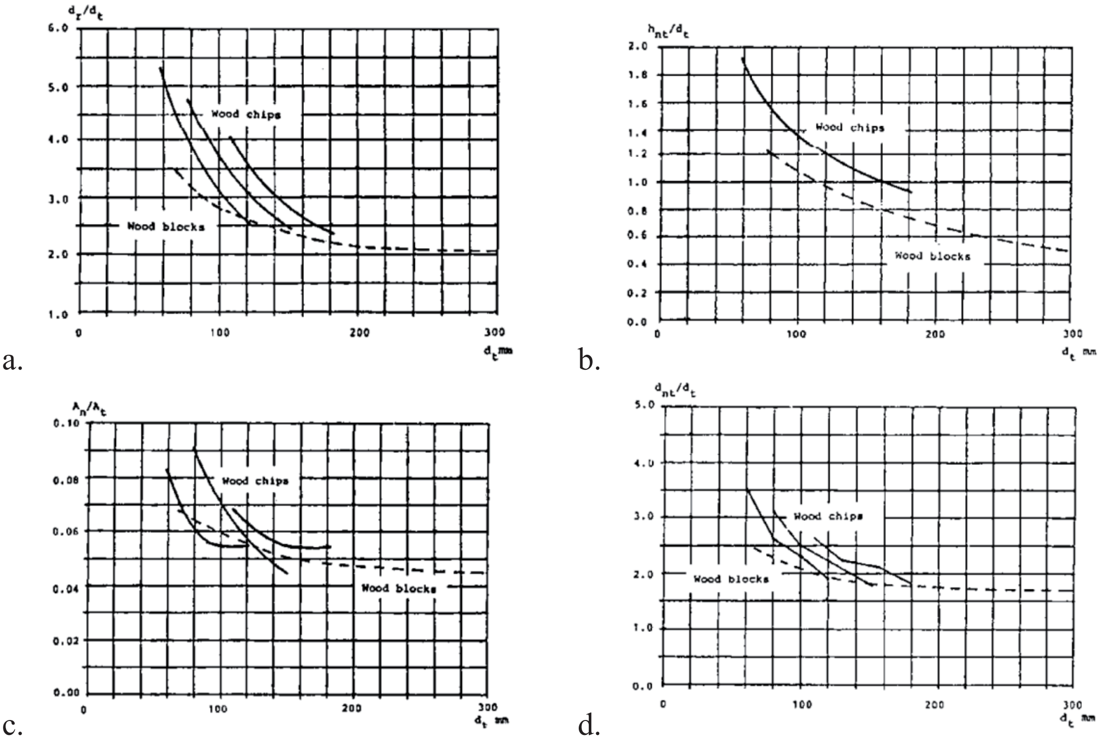

Figure 1 **a.** Diameter of the fire box, d_r, as a function of the throat diameter, d_t ; **b.** Height of the nozzle plane above the throat, h_{nt}, as a function of the throat diameter; **c.** Ratio between nozzle flow area, A_n, and throat area, A_t, as a function of the throat diameter; **d**. Nozzle tip ring diameter, d_{nt}, as a function of the throat diameter, d_t (Source FAO, 1986)

Air Inlet and Outlet

The general range for air inlet velocity is 6m/s to 10 m/s (Sivakumar et al., 2006). The dimensions for the air inlet can be obtained using the continuity equation. By taking the velocity of air to be 6 m/s,

$$Q = \frac{10.8}{60 \times 60} m^3/s = A_i \times 6$$

$$A_i = 0.0005\ m^3$$

For a circular opening,

$$0.0005\ m^3 = \frac{\pi d^2}{4}$$

$$d = 0.025\ m = 25\ mm$$

The gas inlet is taken to be 25 mm. The gas outlet is taken to be 20 mm.

Length of Reduction Zone

Sivakumar et al. (2008) proposed that for a throat diameter of about 100 mm and for a throat angle of between 45 and 90 degrees, the reduction zone with a length above 150 mm gives an optimum cumulative conversion effeciency. However, SERI (1979) proposes that the height of the reduction zone should equal the diameter of the throat. The reduction zone is designed using a length of 80 mm.

Height of the Hoper

The height of the hoper is decided on the basis of the feedstock which it will be required to hold within the period of operation. The period of operation is taken to be 2 hours since it is laboratory scale. Therefore,

The total Biomass consumption estimated to be consumed in 2 hours is

$$Total\ Biomass\ consumption = 4.32\ kg/h \times 2\ h$$

$$Total\ Biomass\ consumption = 8.64\ kg$$

The bulk density of wood is between 300 and 550 kg/m^3 depending on the moisture content. Assuming the value of the bulk density is taken to be 500 kg/m^3, the total volume of the hoper is estimated as:

$$Volume = \frac{mass}{density}$$

$$Volume = \frac{8.64\ kg}{500\ kg/m^3}$$

$$Volume = 0.01728\ m^3 = 17280\ cm^3$$

The height of a cylindrical reactor is

$$Height = \frac{Volume}{Cross-sectional\ area}$$

$$Height = \frac{4 \times 17280}{\pi \times 23.8^2} = 38.8\ cm = 388\ mm$$

A height of 400 mm is chosen.

Orthographic views of the Biomass Gasifier is shown in figure 2.

Performance Evaluation Plan

The performance evaluation of the laboratory scale Biomass Gasifier is currently being done using various Biomass and air being delivered into the oxidation zone by natural convection. Further tests on the various Biomass will be carried out by using a blower to deliver air into the combustion zone, and also a pump to create vacuum by suction to increase the intake of air at the air inlet.

CONCLUSION

The design of a laboratory scale downdraft Biomass Gasifier to produce 4kW mechanical power has been presented. The Gasifier has three regions which are the hoper, hearth or throat, and ash pit. The design of the downdraft Gasifier is largely empirical. A specific gasification rate of 0.3 was selected for the design, while Biomass consumption of the Gasifier is estimated as 4.32 kg/h and through put is 8.64 kg of feedstock. As the cost of the Biomass Gasifier is moderate and the design simple, it can be manufactured at a machine shop and at a reasonable cost.

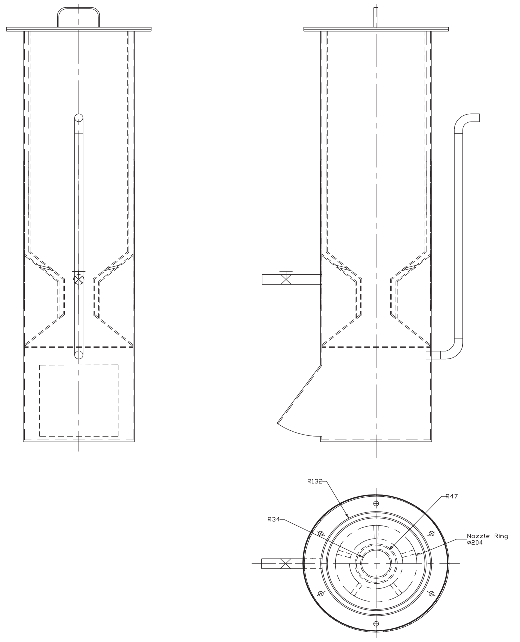

Figure 2: Orthographic views of the Laboratory Scale **Biomass Gasifier**

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ESTIMATION OF BIOMASS POTENTIAL FOR SOLVING ENERGY PROBLEM IN NIGERIA

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Abstract

Energy, electricity in particular, is required for basic developmental services and is a major input in the Nigerian economy. There is a vast amount of unexploited Biomass resource, most of which is constituted by agro-Wastes from crops and livestock in the country. The energy potential of Biomass in Nigeria was estimated considering the residues from crops being grown together with Wastes from livestock being reared. It was discovered that Biomass was capable of producing about 6.4 billion GJ of energy in 2010 and about 9.8 billion GJ of energy in 2020, which is about 16 and 20 times more than the energy estimated to be consumed at the respective periods. It is proposed that the persisting energy problem experienced in the country can be solved if Biomass energy is exploited.

Keywords: Nigeria, Biomass potential, agro-Wastes, energy.

INTRODUCTION

Energy, specifically electricity, is required for basic developmental services and its availability is one of the pointers to a progressing economy. It is the mainstay of Nigeria's economic growth and development. It plays a significant role in the nation's international diplomacy and it serves as a tradable commodity for earning the national income, which is used to support government development programmes. It also serves as an input into the production of goods and services in the nation's industry, transport, agriculture, health and education sectors, as well as an instrument for politics, security and diplomacy (Sambo, 2009; Kauffmann, 2005). With the growing concern about the epileptic power supply in Nigeria and its retrogressing economy among other factors including the effect of global warming derived from the use of fossil Fuels and the attainment of the millennium development goals, there is a need to explore alternative energy sources like solar, wind, geothermal and so on (Rabiu, 2009; Sambo, 2009). Vegetal-type Biomass is currently being considered a promising energy source (Ramrez et al, 2007). This paper aims at providing an estimate for the potential of Biomass, particularly agricultural Wastes or residues, in solving energy problems in Nigeria.

NIGERIA'S ECONOMY STRUCTURE, ENERGY AND AGRICULTURE SITUATION

Nigeria, located between longitude 3^0 and 14^0 east of the Greenwich and latitude 4^0 and 14^0 north of the equator, has a land mass area of 923,768 sq km. It is one of the ten most populous countries in the world, and the most populous country in Africa, being estimated to have a population of 138,283,240 and with a population growth rate of 2.38 percent. Nigeria economy is structured on the basis of resources generated from sectors including oil/energy, agriculture, manufacturing, forestry, general Merchandise, tourism, ocean and marine resources, and freshwater resources. The economy of Nigeria is majorly oil-based following the development of the petroleum industry between 1960 and 1970. Petroleum, natural gas, and hydroelectricity are Nigeria's major sources of commercial energy; they are slightly outpaced by the largely non-commercial consumption of Fuelwood and charcoal (Osaghae, 2009; RECIPES, 2006).

Traditional Biomass (largely woodFuels) accounts for the largest share of total energy consumption (51%) followed by petroleum products (41%), natural gas (5.2%), and electricity (3.1%). This is as shown in figure 1. Total installed electricity capacity is estimated at 5.9 GW with about 40% of the population having access to electricity (82% in urban areas and 18% in rural areas). The major thermal electrical installations are at Egbin, Afam, and Sapele which supply approximately 48% of energy generated. Hydroelectricity is generated at Kainji Dam and in lesser quantities at Shiroro Gorge on the Kaduna River, at Jebba, and at several smaller sites which cater for the remaining 52%. The nuclear and renewable energy sources are yet to be explored (RECIPES, 2006; EarthTrends, 2003; Rabiu, 2009). The energy consumption pattern by sector is presented in figure 2.

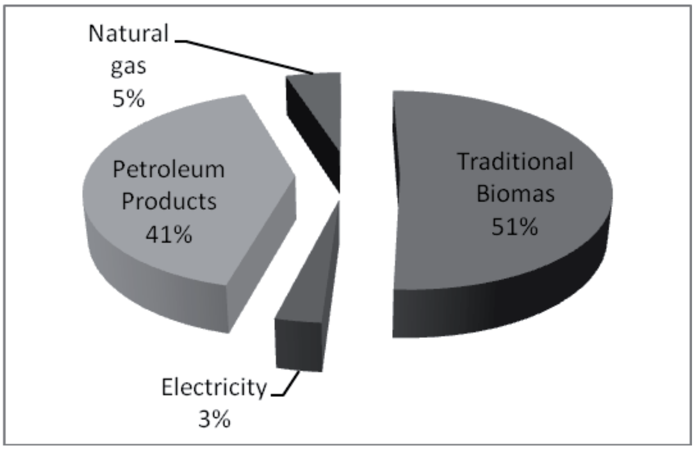

Figure 1: Energy Consumption in Nigeria (2007) (Osaghae, 2009)

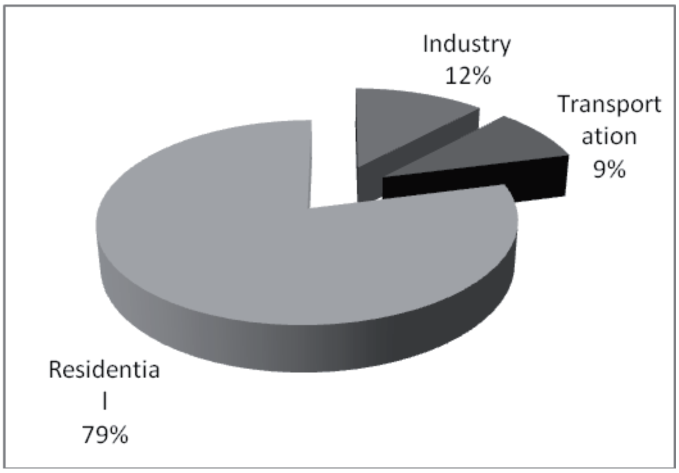

Figure 2: Energy Consumption by sector in 2005 (Source: RECIPES, 2006)

Agriculture in Nigeria, which includes farming and herding, employs 3 percent of its workforce and currently accounts for 23% of the gross domestic product. Major crops grown include palms used to produce palm oil, peanuts, rubber, cocoa, cotton, sorghum, millet, maize, yams, cassava, and timber while livestock being reared consist basically of cattle, sheep, goat, pig and poultry. Agriculture had contributed more than 75% of export earnings before 1970. By the mid-1990s, agriculture's share of exports had declined to less than 5% partly due to government neglect and poor investment, and partly due to ecological factors such as drought, disease, and reduction in soil fertility. In addition to this the percentage of workers in the agriculture sector, as at 1980, was 54% and has reduced by over 50% in 2005 (Stock, 2008). It has been recorded by the Federal Ministry of Agriculture of Nigeria that about 719000 sq km, which amounts to 70%, of its entire landmass is potentially suitable and/or used for agricultural purposes (Okoroigwe et al., 2008). However, approximately 35 percent of the entire landmass is being cultivated (Jekayinfa and Scholz, 2007; Osaghae, 2009), which amounts to about 319512 sq km.

MATERIALS AND METHODS

Data was collected from various sources covering the periods between 2000 and 2009. Statistical tools were used in evaluating the collected data to provide estimates required for determining the potential of Biomass in Nigeria. Simple ratios and certain assumptions were also made which include that the average annual crop production is constant, energy supplied and electricity generation increases with increasing population.

THE BIOMASS POTENTIAL IN NIGERIA

Nigeria possesses a vast amount of Biomass. Okoroigwe et al. (2008) stated that the total land available for agriculture and under vegetation is a measure of Biomass generation in that country. The availability of Biomass resources, thus, follows the same pattern as the nation's vegetation. The rain forest in the south generates the highest quantity of woody Biomass while the guinea savannah vegetation of the north central region generates more crop residues than the Sudan and Sahel savannah zones. Industrial effluent such as sugar cane molasses is located with the processes with which they are associated. Municipal Wastes are generated in the high-density urban areas.

Ojiako and Olayode (2008) estimated that the compound growth rate of livestock in Nigeria was 4.83% per annum and the population estimate of livestock was obtained from Mbanasor and Nwosu (2003). These were used to compute an estimated population of livestock over a five-yearly period, from 2000 to 2020. This is presented in Table 1.

The energy contents of crops and Agricultural Residues grown in Nigeria were derived from Klentsch (2001), Klass (1998), Okoroigwe et al. (2008) and Osaghae (2009). Their average annual production was obtained from Okoroigwe et al. (2008), Sambo (2009) and Osaghae (2009). As recommended by FAO (1986), a thermal effeciency of 70% is assumed to obtain the energy derivable from, or available in, each type of Biomass. The total available energy per annum for the Biomass sources, which are basically residues from agriculture, is evaluated. The results are presented in Table 2.

Table 1: 5-yearly animal population estimate in millions at 4.83 % annual growth rate

Animal Type	2000[1]	2005	2010	2015	2020
Cattle	19.6	24.8	31.4	39.8	50.3
Sheep	15	19	24	30.4	38.5
Goat	25.5	32.3	40.9	51.7	65.5
Pig	7.6	9.6	12.2	15.4	19.5
Poultry	127	160.8	203.5	257.7	326.2
Camel	18	23.9	28.8	36.5	46.2

[1]Okoroigwe et al. (2008)

Table 2: Estimation of available energy from some Biomass (crop) sources

Biomass	HHV (MJ/kg)[1,2,3,4]	Thermal energy derivable (MJ/kg)	Average annual production (10^9 kg/yr)[3,4,5]	Total available energy/ annum (10^6 GJ/yr)
Cashew nut shell	24	16.8	159	2.7
Cassava stem	19	13.3	32609	433.7
Coconut shell	19	13.3	175	2.3
Coffee husks	16	11.2	0.004	0.04
Cotton residue (gin trash)	14	9.8	135	1.3
Cotton residues (stalks)	16	11.2	224	2.5
Ground nut shells	17	11.9	6	0.07
Maize (stalk)	15	10.5	5242	55
Maize (cob)	19	13.3	5242	69.7
Peanut husk	20	14	2550	35.7
Palm oil residues (fibres)	11	7.7	837.5	6.45
Palm oil residues (fruit stems)	5	3.5	628.1	2.2
Palm oil residues (shells)	15	10.5	118	1.2
Rice husk	14	9.8	3501	34.3
Rubber	19	13.3	121	1.6
Sorghum stalk	18	12.6	7511	94.6
Fuel Wood	20	14	300	4.2
TOTAL				747.6

[1]Klentsch (2001); [2]Klass (1998); [3]Okoroigwe et al. (2008); [4]Osaghae (2009); [5]Sambo (2009)

Okoroigwe et al. (2008) gives the estimated Waste produced per animal per day. The estimated energy content of each animal Waste was obtained from Klass (2007). The total available energy per annum was obtained by assuming a thermal effeciency of 70%. The results are presented in table 3.

Table 3: Estimation of available energy from some Biomass (animal Waste) sources

Biomass	Energy content (MJ/kg)[1]	Thermal energy derivable (MJ/kg)	Average annual Waste production (kg/yr/animal)[2]	Total available energy per annum (GJ/yr/animal)	Total available energy per annum (10^6 GJ/yr)	
					2010	2020
Cattle	17.5	12.25	12410	152.0	4772.8	7645.6
Sheep	20.0	14.0	548	7.7	184.8	296.45
Goat	20.0	14.0	548	7.7	311.9	504.35
Pig	17.4	12.18	1825	22.2	270.8	432.9
Poultry	17.6	12.32	37	0.5	101.8	163.1
TOTAL				190.1	5642.1	9042.4

[1]Okoroigwe et al. (2008); [2]Klass (2007)

DISCUSSION

The total energy obtainable per annum from Biomass crop sources, which are basically agricultural Wastes and crop residues, is estimated to be 747.6 GJ/yr, out of which the traditional Fuel wood which is acclaimed to be widely used in Nigeria, as well as most developing countries, contributes just about 0.56%. The total energy available from Biomass Wastes derived from the herding of common livestock which include cattle, sheep, goat, pig and poultry is estimated to be 190.1 MJ/year per animal. Using the estimated value of the animals for 2010 and 2020, as presented in table 1, the estimated total available energy per annum for 2010 from animal Wastes is about 5.6 billion GJ which has the capacity to increase to over 9 billion GJ in 2020. Thus, the total energy that can be obtained from both sources, that is the crop and animal Wastes or residues, is estimated to about 6.4 billion GJ in 2010 and this could increase as estimated to about 9.8 billion GJ in 2020.

As at 2003, it was estimated by RECIPES (2006) that the total energy supply in Nigeria was about 93000GWh (334.8 million GJ) out of which electricity generation was 20183GWh (72.7 million GJ). From estimates given by Osaghae (2009), about 40% of the population has access to electricity from the national grid, out of which urban centres have more than 80% accessibility, while rural areas, which constitute about 70% of the total population, have less than 20%. Simple ratio shows that for the entire populace to be supplied with electricity, the required estimate of electricity generation, using 2003 estimate, is 182 million GJ. This will have to increase with increasing population which is estimated to be about 2.4%. This brings the required estimate electricity generation to 215 million GJ (59722 GWh) by 2010 and 272 million GJ (75556 GWh) by 2020. Total required energy estimate to be generated will then be 395 million GJ by 2010 and 501 million GJ by 2020.

A comparison of the energy that can be obtained from Biomass with the estimated energy consumption needed in Nigeria reveals that the total energy obtainable from Biomass is about 16 times the energy required by the populace in 2010, and could increase to about 20 times of the value of the estimated required energy by 2020. This is shown in figure 3.

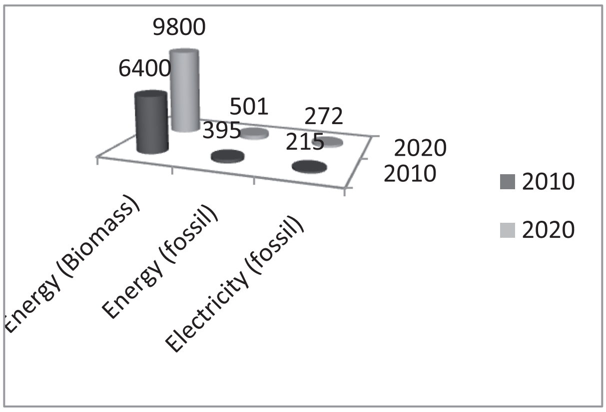

Fig. 3: Comparison of Energy and Electricity generation using Biomass and fossil Fuels (million GJ)

In addition, it can be seen that for electricity generation, use of Biomass in 2010 is estimated to give about 30 times of the electricity generated in 2003. This could increase to about 36 times by 2020.

The use of Biomass, coupled with various Biomass conversion processes can be used to offset the imbalance and insufficiency of electricity in Nigeria and particularly in the rural areas. The use of Biomass also has lesser tendency to produce greenhouse gases than fossil

Fuels, thereby contributing less to the overall negative effect of global warming and more to promote human health and quality of living.

The various known Biomass conversion processes are direct combustion processes, thermochemical processes and biochemical processes. The thermochemical conversion processes include pyrolysis, carbonization, gasification and catalytic liquefaction. The biochemical conversion processes include anaerobic fermentation, methane production in landfills and Ethanol fermentation. These processes produce Biofuels such as Biodiesel, biogas, syngas or producer gas, charcoal which can be used for various purposes such as cooking, electricity generation and transportation Fuels.

CONCLUSION

Nigeria has a large Biomass resource, particularly in Agricultural Residues, which is potentially sufficient for meeting its immediate energy needs and also for exportation. The study shows the estimate of the Biomass potential for energy supply and electricity generation in Nigeria and compares it with the existing structure. It was revealed that Nigeria has the capacity to produce above 6 billion gigajoules of energy per year and this has the tendency to increase with the increasing livestock population. Since electricity is a major input into the Nigerian economy, this being satisfied, Nigeria has a very large tendency to make Nigeria's economy one of the strongest as outlined in its vision 2020. In addition to this, the rate of unemployment could be reduced by increasing the value for the agriculture sector as against the oil and gas sector of the economy, thereby causing the employable populace to intensify on growing crops with more focus on energy crops such as switch grass. The use of land is also subject to increase.

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PRODUCTION OF BIOGAS FROM SELECTED CROPS AND ANIMAL RESIDUES IN NIGERIA

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Abstract
The concern for energy supplies in the future has stimulated various research programmes to evaluate energy potential of renewable energy sources. The massive energy crunch triggered by the oil price hike led to the revival of interest in non-conventional and renewable energy sources worldwide. Consequently, as a result of ecological-environmental problems being caused by conventional sources of energy coupled with the fast depleting rate; biogas, a clean and renewable form of energy is being researched into as a good alternative. The objectives of this work are to evaluate the energy potential of Agricultural Residues, its utilization and contributions to the energy supply needs of Nigeria. A technical survey using a well structured questionnaire would be carried out in Southwestern Nigeria to evaluate the use and contributions of bio-material to the energy supply in the region. A biodigester (500 litres capacity) would be designed and constructed for the production of biogas using cow dung and maize cob. Variations in operational parameters like pH, temperature, loading rate, agitation, hydraulic retention time etc will also be studied critically in order to establish standard models which will describe the biogas production pattern for each agricultural residue. This will enhance the utilization and proper disposal of agricultural residue thereby reducing the environmental problems and possible health hazard. This will also help in controlling pollution emanating from the use of kerosene, charcoal, Fuel wood, diesel, petrol and thereby reducing the effects of greenhouse gas emissions.

INTRODUCTION

Concern for energy supplies in the future has stimulated a large research programme to evaluate the energy potential of renewable energy sources. As the world population increases, so does the demand for chemicals and energy. The net result of this has been that the demand for energy has multiplied greatly and it can no longer be satisfied by the traditional inefficient energy technology which utilizes only a few local resources (Jebaraj and Iniyan, 2006). Energy is considered the basis for the prog0ress and prosperity of nations and social development. It is also the cornerstone of economic 0and social development. In many developing countries, energy from Biomass continues to be the main source of energy, mostly in its traditional forms designed to meet the demands of domestic use (Hall and Rosillo, 1998). The massive energy crunch triggered by the 1973 oil price hike led to the revival of interest in non-conventional and renewable energy sources worldwide. Thus along with the solar and the wind energy, the long neglected but potentially rich Biomass became the focus of intensive utilization for energy generation (Robertson, 1981). Conversion of animal Waste to biogas through anaerobic digestion processes can provide added value to manure as an energy resource and reduce environmental problems associated with animal Wastes.

Anaerobic digestion is a natural process that converts Biomass to energy. Biomass is any organic material that comes from plants, animals or their Wastes. Anaerobic digestion has been used for over 100 years to stabilize municipal sewage and a wide variety of industrial

Wastes. Most municipal Wastewater treatment plants use anaerobic digestion to convert Waste solids to gas.
The anaerobic process removes a vast majority of the odorous compounds (Lusk 1995, Wilkie 2000). It also significantly reduces the pathogens present in the slurry (Lusk 1995). Over the past 25 years, anaerobic digestion processes have been developed and applied to a wide array of industrial and agricultural Wastes (Speece 1996), (Ghosh 1997). It is the preferred Waste treatment process since it produces, rather than consumes, energy and can be carried out in relatively small, enclosed tanks. The products of anaerobic digestion have value and can be sold to offset treatment costs (Roos 1991).
Biogas (a mixture of approximately 60% methane and 40% carbon dioxide) is a well-established Fuel that can supplement or even replace wood as an energy source for cooking and lighting in developing countries. Table 1 shows some of the typical applications and equivalents for a cubic meter of biogas. During its production, any drastic change in temperature should be avoided since methanogens are very sensitive to thermal changes (Garba, 1996). At the same time, Jain et al. (1998) reported that the efficiency of methane production was more than 75% when the slurry pH was above 5.0. Furthermore, Sahota *et al.,* (1996) had observed that biogas production was only significantly affected when the pH of the slurry decreased to below 5.

Table1. Some biogas applications

Application	$1m^3$ biogas equivalent
Lighting	Equal to 60 – 100 watt bulb for 6 hours
Cooking	Can cook 3 meals for a family of 5 - 6 members
Fuel replacement	0.7 kg of petrol
Shaft power	Can run 1 hp motor for 2 hours
Electricity generation	Can generate 1.25 kW h of electricity

Source: Kristoferson and Bokalders (1991)

Currently as the fossil-based Fuels become scarcer and more expensive, the economics of biogas production is turning out to be more favourable. At the same time, Pound *et al.,* (1981) observed that biogas production units provide a decentralized Fuel supply and Waste management system, both of which are very attractive particularly in rural areas of developing countries.

AIM OF THE RESEARCH

The major aim of this research is to investigate biogas production per weight of selected crop residues.

OBJECTIVES OF THE RESEARCH

The objectives of this research are:

(i) to determine the effect of production parameters such as the digester type, temperature, hydraulic retention time, mixing, pH level, Nitrogen inhibition and pressure on biogas yield for each selected crop residues.
(ii) to determine the effect of pre-treatment of feedstock on biogas yield both in terms of the quantity and quality.
(iii) to develop Mathematical models to describe the biogas pattern for each crop residue for specific production parameters.

SCOPE OF THE RESEARCH

This research is limited to the use of Agricultural Residues for the production of biogas. Energy
crops specially planted for energy production can also be used but due competition that might set in because they are being consumed as food by human beings, this research will not be considering them.

RESEARCH QUESTIONS

The demand for energy is multiplying greatly to the extent that the traditional inefficient energy technology which utilizes only a few local resources can no longer be satisfied. The highly fluctuating oil price is also another problem that the people are faced with. This cannot just continue. The problem has to be solved by means of researching on alternative energy sources. One of these sources is biogas which this research is all about. Also, construction of biogas plants can help to create new jobs, especially in the energy sector, and thereby decrease the unemployment rate in the country and stimulate the rural economy.

JUSTIFICATION OF THE RESEARCH

The biogas produced will serve as a valuable Fuel for domestic, agricultural and industrial sector. The use of Agricultural Residues in the biogas production will help in promoting sanitation by turning Wastes that are potential public nuisances and liabilities to public health. It will also help in controlling environmental pollution through the conversion of organic Wastes into organic fertilizer (the slurry) and materials. Since the fertilizer produced is digested sludge which contains all the nutrients present in the original Waste materials, as well as in a finely processed state that is ready to be utilized by crops, it enhances good soil structure. It also helps in controlling environmental pollution by displacing kerosene, charcoal, Fuel wood, diesel and thereby reducing greenhouse gases emissions. For instance, if there is a Fuel switch from kerosene to biogas, a reasonable percentage of CO_2 into the atmosphere would be avoided. By turning solid Wastes into biogas there is a reduction in the release of methane and other gases that emanate from various refuse dumps into the atmosphere. Construction of biogas plants can help to create new jobs, especially in the energy sector, and thereby decrease the unemployment rate in the country and stimulate the rural economy.

LITERATURE REVIEW

Conversion technologies for the production of energy from Biomass can be classified as biological or thermal technology (Claassen et al, 1999). The choice of such technologies depends strongly on the material properties together with the social and economic situation. Anaerobic digestion is one of the biological technologies to produce renewable and clean energy (biogas) from Biomass (Van -Velsen, and Lettinga, 1980). Since the end of the last century onwards; anaerobic digestion has been applied in man-made environments for both energy production and as a cost effective method for Waste stabilization and Wastewater treatment (Lettinga, 1996). El-Mashad, (2003) revealed that anaerobic digestion (AD) is a microbial degradation process of organic matter in the absence of oxygen. Such process occurs naturally in soils and in the digestive tract of ruminants. AD has been applied for many decades as a key method for stabilizing Wastes like sewage, industrial and agricultural Wastes.

Ranzo, (1977) mentioned that the anaerobic decomposition of any complex organic substance is basically a two-stage process. The first stage consists of conversion of the complex organic materials into organic acids by acid forming bacteria with the production of carbon dioxide (CO_2). Bacteria known as methane formers producing methane (CH4) and carbon dioxide

(CO2) from organic Wastes act upon these organic acids in the second stage. Many factors such as the feed composition, fermentation temperature, hydraulic retention time (HRT), and stirring of slurry affect the AD process performance and its stability (El-Hadidi, 1999). The major advantages of biogas technology, besides cooking, lighting, and electricity generation is the utilization of effluent (residual slurry) obtained after digestion as a beneficial organic fertilizer (biogas manure).

The increase in greenhouse gas emissions and the resulting climatic changes have understandably caused worldwide concern. According to Watson (2001), the rise in the average temperature by the end of the next century (2100) will be between 1-3.5^{0}C. This has serious implications on the entire ecosystem. Biomass appears to be an attractive energy resource because it is a domestic and environmentally sound renewable Fuel (Bezzon and Cortez, 1999; Strehler, 1998). The use of Biomass as a source of energy is of interest world-wide because of its environmental advantages. Biomass is a renewable energy resource compared with the fossil energy resources.

Crop residues and animal Wastes are Biomass sources that have been extensively studied as Fuel sources in many experiments ranging from basic chemical studies to applications in the field. Biomass can provide energy by direct combustion, gasification, anaerobic digestion to methane (CH_4) or fermentation to Ethanol which has been demonstrated on a laboratory scale. (Cooney et al., 1978, Lipinsky, 1978; Weisz and Marshall, 1979, Flaim and Urbain, 1980, Bungay, 1981).

Anaerobic digestion is a microbiological process that produces a gas, biogas, consisting primarily of methane (CH_4) and carbon dioxide (CO_2). The use of biogas as an energy source has numerous applications Biogas is suitable for practically all the various Fuel requirements in the household, agriculture and industrial sectors. Domestically, it can be used for cooking, lighting, water heating, running refrigerators, water pumps and electric generators. Agriculturally, it can be used in small- scale industrial operations for direct heating applications such as in scalding tanks, drying rooms in the running of internal combustion engines for shaft power needs.

METHODOLOGY

Twenty litres (20l) of cow dung will first be prepared to undergo partial digestion in order to activate the methanogenic bacteria.The pre-treated substrate will then be added to 200l of cow dung-water mixtures.A little quantity of the mixture will be taken for analysis after which the mixture will be fed into the digester. The next thing is the closing up of the feed inlet of the digester. The digester will be left for about 30-40 days before harvesting the gas. The gas will be tested with a burner locally constructed.

Actual concentration of the dissolved methane can be calculated from:

$$C_m = 0.296 \times M \times (S_o - S_e) \qquad \text{..................(1)}$$

Where

C_m = Concentration of dissolved methane gas, mole/l

M = COD conversion factor

S_o = effluent substrate concentration, mg/l

S_e = influent substrate concentration, mg/l

Concentration of methane gas in gas collector will be calculated from

$$C_g = \left[K_l \times \frac{A}{V_l}\right] \times [C_{st} \times C_m] \times t_{dc} \qquad \text{...............(2)}$$

Where

C_g= Concentration of methane gas in gas collector, mole/l

K_l= Coefficient diffusion

A= interfacial gas transfer area, m^2
V_l= Volume of liquid in CSTR, m^3
C_{st}-= Saturated concentration of methane gas in the liquid, mole/l
t_{dc}= time of digestion, days

Volume of gas collector,

$$V_{gc} = \frac{1}{3} \times V_{dc} \qquad \text{.........(3)}$$

Where
V_{gc} = Volume of gas collector, m^3
V_{dc} =Volume of continuous digester, m^3

Mass of methane gas,

$$M_{mc} = C_g \times V_{gc} \qquad \text{.........(4)}$$

Where M_{mc} is then mass of methane in continuous digester (kg).

Volume of methane,

$$V_{mc} = \frac{M_m}{\rho_m} \qquad \text{.........(5)}$$

Where
V_{mc} = Volume of methane in continuous digester, m^3
M_m = Mass of methane in continuous digester, kg
ρ_m = density of methane, kg/m^3

Total volume of biogas is

$$V_{tc} = 100 \times \frac{V_{mc}}{60} \qquad \text{.........(6)}$$

SOLIDS RETENTION TIME (SRT)

The Solids Retention Time (SRT) is the most important factor controlling the conversion of solids to gas. It is also the most important factor in maintaining digester stability. Although the calculation of the solids retention time is often improperly stated, it is the quantity of solids maintained in the digester divided by the quantity of solids Wasted each day.

$$SRT = \frac{(V) \times (C_d)}{(Q_w) \times (C_w)} \qquad \text{.........(7)}$$

Where V is the digester volume; Cd is the solids concentration in the digester; Qw is the volume Wasted each day and Cw is the solids concentration of the Waste. In a conventional completely mixed, or plug flow digester, the HRT equals the SRT. However, in a variety of retained Biomass reactors the SRT exceeds the HRT. As a result, the retained Biomass digesters can be much smaller while achieving the same solids conversion to gas.

The Digester Loading

The digester loading can be calculated if the HRT and influent Waste concentration are known. The loading in (kg / m3 / d) is simply:

$$L = \left(\frac{1}{HRT}\right)(C_I) \qquad \text{.........(8)}$$

Where C_I is the influent Waste concentration in grams. Increasing the loading will reduce the digester size but will also reduce the percentage of volatile solids converted to gas.

AVAILABLE RESIDUES FOR BIOGAS PRODUCTION

Organic Wastes are known to have high energy potential, as indicated by Odeyemi (1995) who obtained biogas from palm oil effluents. Various Agricultural Residues had been used in the past in the production of biogas. According to Jekayinfa and Scholz (2009), there is availability of large amounts of non-plantation Biomass resources in Nigeria for modern energy applications. The amount of residues generated in 2004 varies from 311,000 tonnes for oil palm shells to 14 million tonnes for sorghum straw. It has been estimated also that total of more than 70 million tonnes of Agricultural Residues were potentially produced in the year 2004 out of which only 58 million tonnes are energetically available. The residue availability for 2010 is projected to be about 80 million tonnes (Jekayinfa and Scholz, 2009).
In Nigeria, identified feedstock substrate for an economically feasible biogas programme includes water lettuce, water hyacinth, dung, cassava leaves, urban refuse, solid (including industrial) Waste, Agricultural Residues and sewage (Akinbami et al, 1996). Table 2 shows the available biogas substrates in Nigeria.

Table 2: Available Biogas Substrate

Type	Source
A Animal dung	cow, Buffalo, chicken, pig, duck
B Household Wastes	Kitchen Wastes, night soil
C Crop residues (air dry)	Corn stalk, rice straw, corn cobs, peanut shells, Baggage grass trimmings.
D. Industrial	Breweries, wineries, bakeries, confectionaries, Distilleries, tea processing factories, other industrial organic Waste water.

Source: Akinbami *et al* (2001)

ANAEROBIC DIGESTION PROCESS

Anaerobic digestion involves bacteria that require an environment that is void of oxygen to survive. Converting organic Waste to methane gas by anaerobic digestion can be considered a two-step process. The first step involves a group of anaerobic bacteria-referred to as the acid formers- that produces organic acids as a by- product of the initial organic degradation. The second step involves a group of bacteria- known as methane formers. These bacteria break down the organic acids and produces methane as a by-product of the degradation. These degradations take place inside a biogas plant popularly called an anaerobic digester where farm Wastes or energy crops are treated.
Livestock manure is an option in Nigeria, where it is considered that Biomass energy can continue to be a major source of energy. (Bajpai et al, 1986). The dung from cattle can be obtained from abattoirs or cattle farms with uncovered containers in order to prevent methanogenesis before plant digestion process (Mata-Alvarez *et al*, 2000). The dung will then be mixed with water to a maximum ratio of 1:2 (Eggling et al,1979). The substrate will then be fed into a digester for ‘anaerobic’ digestion to take place. The digester must be airtight.

THE DIGESTER TANK

The bio-digester is a physical structure commonly called the biogas plant .It is an airtight container where the breaking down of organic matter takes place. It can be made of various materials and in different shapes and sizes. Construction of this structure forms the major part of the investment cost. The major types of biogas digesters in developing countries are the floating drum (very popular in India), the fixed dome and bag digesters.

PARAMETERS OF BIOGAS PRODUCTION

Biogas production depends on the amount and nature of the fermentation, temperature, type of digester, pH of the substrate, Nitrogen inhibition and the hydraulic retention time. The effects of these parameters on gas production will also be studied and a Mathematical model developed to describe the biogas production pattern.

DEVELOPMENT OF MODELS

Mathematical models will be developed which will be used to describe the biogas pattern for each crop residue.

Expected Outcome

This research aims at contributing to knowledge in terms of:

(a) establishing the effects of biogas production parameters for each selected crop residue. Such parameters include the digester type, temperature, hydraulic retention time, mixing, pH level, nitrogen inhibition and pressure.
(b) concreting the effect of pre-treatment of feedstock on biogas yield.
(c) developing Mathematical models to describe the biogas pattern for each crop residue for specific production parameters

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ADDRESSING THE CHALLENGES OF HARNESSING BIOGAS FOR NATIONAL DEVELOPMENT IN NIGERIA

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Abstract
Bioenergy resources have been identified as a long-term renewable energy sources with potential of addressing both environmental impacts and security concerns posed by current dependence on fossil Fuels by many nations of the world. It is now clear that energy cannot be affordable unless its production and availability are sustainable. Moreover, sustainability of the rural livelihood depends on accessibility to basic needs such as food security, health care services, education, affordable housing, portable water supply and sanitation. Sustainable energy plays an important role in ensuring these services. Nigeria has a lot of potentials in producing biogas from energy crops for energy generation because of their abundance. Analysis in this paper shows that biogas production may be a viable means of reducing dependence on Fuelwood use as a source of energy generation especially in the rural areas and at the same time reducing the health risk of livestock Wastes on the populace. However, challenges such as poor technical competence, lack of attention to user needs and local conditions, inability to replicate and adopt appropriate technology, lack of incentive structures, failure to demonstrate institutional and commercial viability, lack of maintenance culture, and failure to generate sustainable markets for the technologies have hampered its development. This paper critically examines these challenges, proffers solutions and suggests policy recommendations for efficient generation of biogas in the country.

Keywords: Biogas, Nigeria, energy, fossil Fuel, climate change, bioenergy resources, rural development

BACKGROUND

The impact of greenhouse gas (GHG) emission on world climate due to increasing demand and use of fossil Fuels calls for attention especially in developing country (Eguidanos et al, 2002). Many countries are now adopting Biofuel as a means of reducing GHG emission. Biogas is a type of energy that could be subsumed under Biofuel. Production of Biofuel will not only reduce the GHG but contribute to the development of rural areas (Lichtman, 1983). Biogas energy is one of the renewable energy sources, which could be generated from sewage, poultry farm, organic Waste and food industry. It can be defined as organic Fuels derived from Biomass which can be used for the generation of thermal energy by combustion or by other technology. They comprise purpose-grown energy crops, as well as multipurpose plantations and by-products (residues and Wastes) (FAO 2000). Biogas could be derived from vegetable oils (e.g. rapeseed oil, jatropha, soy or palm oil) by reaction of the oil with mEthanol which can either be burnt directly in diesel engines or blended with diesel derived from fossil Fuels. The production of biogas enables a sustainable agriculture with renewable and environmental friendly process system (Widodo and Hendriadi, 2005). It can be used for improving energy security.

Scientists have identified bio energy resources as a long-term renewable energy sources with potential of addressing both environmental impacts and security concerns posed by current dependence on fossil Fuels (Batidzirai, et. al. 2006) by many nations of the world. In Nigeria, biogas production can improve the quality of life of people and social equity, as well as provide opportunities for new income-generation; saves material, energy and resources. It can as well drastically lower environmental impact, including reduction of GHG emissions. Biogas production will reduce dependency on fossil Fuel, enhance energy security, and makes access to energy affordable (Acaroglu et.al., 2005). Increase in the prices of oil and gas in world market has made renewable energy a potential option to exploit.

Nigeria has good conditions for (Agricultural Produciton)s with about 60% of its population in rural areas. She has 924million hectares of total land area and about 91 million hectares is adjudged to be suitable for crop production (FAO, 2005), most part of this land is under cultivation. Exploiting agricultural by-products and Wastes for biogas production will create a stable base for farmers; and provide solutions to the problem of poverty and climate change as stipulated in Kyoto protocol. This will also play a major role in job creation and food security. Sequel to this, Nigeria government developed a policy entitled Nigeria Bio-Fuel Policy and incentives in 2007 with the aim of reducing the nation’s dependence on imported diesel, reduce environmental pollution and create a commercially viable industry. The mandate to create an enabling environment for the implementation of this policy and the take off of bio-Fuel industry was given to the Nigeria National Petroleum Corporation (NNPC). The bio-Fuel programme intends to integrate the agricultural sector of the economy with the petroleum sector thereby creating opportunities for job creation in the rural areas. There are lots of bio-Fuels opportunities in Nigeria that will guarantee ecologically and socially acceptable development in Nigeria. Nigeria stand a chance of leading the world in bio-Fuel production as it has all what it takes. For instance, She is the largest producer of cassava in the world and also have a huge source for Jatropha Curcas and rapeseed. Nigeria has the largest ability for oil palm plantation which serves as a source of bio-diesel. Countries like South Africa, Tanzania, Ghana, Burkina Faso and Zambia have invested a lot on bio-Fuel production with South Africa taking the lead.

Presently, South Africa has the largest Jathropha plantation in Africa. It has developed and commercialised bio-diesel using Jathropha curcas oil, this triggered the setting up of many shops by bio-energy companies in South Africa. The Nigeria communities are yet to experience the exploitation of these technologies; and maximize these renewable resources for its development. Only few countries dominate the production of Biofuel for export and domestic use. The USA and Brazil are the largest producers of bio-Ethanol by a large margin (Figure 1). The largest increases in production volumes of bio diesel are expected in Brazil, the US, the EU, China, India, Indonesia and Malaysia with annual projection of 120 billion litres by the year 2020 (Peskette et al, 2007). Many developing countries have started launching Biofuel programmes based on agricultural feedstocks available in each country for its economic development; countries like Mozambique uses sugarcane for Biofuel production. The agricultural feedstocks are available in most Nigeria rural areas awaiting exploitation, so there is need to harness Biofuel for rural development.

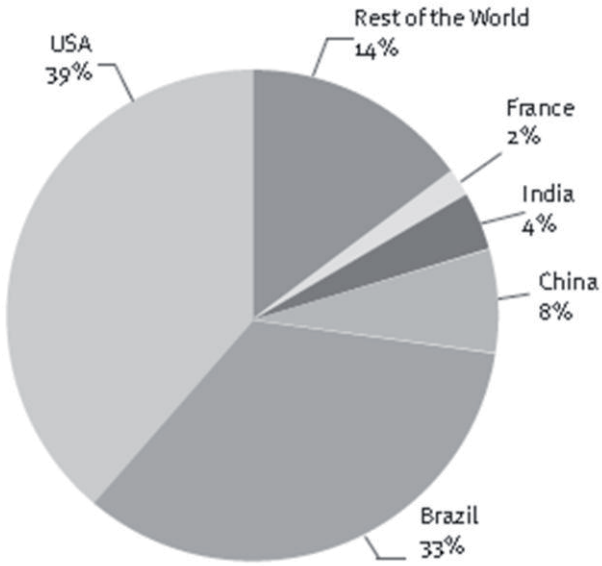

Figure 1: Top five Ethanol producers worldwide (% of global production)
Source: Adapted from Peskette et al, 2007

BARRIERS TO RENEWABLE ENERGY

The benefit of renewable energy is enormous, so are the risks and challenges. The expansion of agriculture for Biofuels, if not adequately managed, can lead to land degradation, water pollution and water scarcity, biodiversity loss, and deforestation (RFA, 2007). Rural renewable energy development is an effective way for reducing poverty and promoting sustainable development in Nigeria. However, there is a low level of awareness, particularly the characteristics and advantages of bio-Fuel development in rural areas. Government low priority and inadequate commitment to renewable energy development in term of resources allocation has been a great challenge. The low commitment from government could be a result of the huge revenue derived from fossil Fuel. There is little government supported programme on rural renewable energy development; this has been an obstacle to renewable energy development in Nigeria. The institutional framework to develop this sector is also not strengthened in providing, developing and financing rural energy technologies. The level of involvement of private organisation in bio-Fuel development in Nigeria is weak, thereby posing negative influence on renewable energy development. According to Pasqualetti (2006), the future contribution of renewable energy to the global energy mix will depend upon overcoming both technical and societal barriers. Renewable energy projects have high initial costs. Nigeria has no significant manufacturing capacity for components of renewable energy technologies. Significant supply chain constraints include long project implementation periods, high import tariffs, bottle-necks in the customs clearing of goods and the issue of corruption.

CHALLENGES OF BIOGAS DEVELOPMENT IN NIGERIA

Policy and regulatory barriers

Energy sector in Nigeria lack an enabling legislation in the implementation of renewable energy policies; this impedes the biogas development. The government over dependence on revenue from fossil Fuel has not encouraged the R&D needed for bio-Fuel production, so government should make sure they have appropriate policy that will encourage Biofuel R&D funding; for without this no meaningful progress will be achieved. Moreso, government pays little or no attention to implementation of Nigeria Bio-Fuel Policy and incentives 2007. There is need to also optimise the public-private partnership by establishing a clear legislation on

bio-energy that will create an enabling environment for its implementation and consequently provide opportunities for the bio-entrepreneurs.
Government policy is yet to provide a favourable environment for most NGOs and the private sector to effectively operate as promoters of renewable energy technologies in Nigeria. There is need for government to put a workable legislation in place that will promote the development of indigenous technologies and participation as this will ease the production bottlenecks and bring about development and sustainability. The regulatory gap in bio-Fuel production is a threat to its development; therefore, there is need to facilitate and put every mechanism in place to fill this gap. However, there is need for clearer policy and there should be links to overall sustainability development policy. Moreso, the need for concentrated efforts in formulating and implementing realistic policies and strategies is paramount in order to facilitate the development of sustainable renewable energy in the Nigeria and enhance rural development. The implementation of National Policy on Biofuels, will assist in establishing a thriving Biofuel industry.

Financing and Investment barriers
Renewable energy development in Nigeria needs a mechanism that will integrate small scale and medium enterprise in order to promote the energy sector. This cannot be achieved without adequate and proper funding from both private and public quarter. There is little or no investment system in the area of bio-Fuel production in Nigeria; because of the government lukewarm attitude towards the renewable energy development. The technologies for processing agriculture products into bio-Fuel are beyond the financial reach of many rural people; therefore it is very difficult for them to invest in the bio-Fuel production. There is need for government to appoint an investment bank to manage the funding of renewable energy in Nigeria; this bank can as well invest in bio-Fuel production. In Brazil, the investments and expenses related to bio-Fuel production were financed by the National Bank for Economic Development (Banco Nacional and Desenvolvimento Economito) and other banks (Oniemola and Sanusi, 2009). These helped in the growth of its bio-Fuel sector tremendously. The lack of rural renewable energy financing schemes and a low awareness of the existing sources of financing contributed to the slow rate of Biofuel development in Nigeria and most especially in the rural areas. Creating awareness on the benefit of adopting modern rural energy technologies will not only influence external participation in Biofuel development but also encourage banks to finance the Biofuel production. Bank of Industry and Small and Medium Enterprises Development of Agency of Nigeria (SMEDAN) should be strengthened to take up these roles.

Technological Barrier
The contribution of renewable energy to Nigerian economy depends on the available technologies for bio-Fuel production. One of the challenges facing bio-Fuel production in Nigeria is lack of technical know-how. Presently, there is no indigenous capacity in designing, fabrication and maintenance of bio-Fuel energy technologies/equipment in rural areas. There is need for indigenous production of machines/equipment for processing agricultural products into bio-Fuel; this will enhance productivity. These technologies should be adapted to make Biofuel production more efficient and affordable. In addition, Nigeria has inadequate training opportunities, facilities and infrastructure in renewable energy technologies. Meanwhile, some developing countries such as Colombia, Ethiopia, Tanzania, Vietnam, Cambodia and Bangladesh are now promoting the low-cost biodigester technology so as to reduce the production cost by using local materials (Sarwatt, 1995; Khan, 1996).

Public Awareness

The rural population in Nigeria accounts for over two-thirds of Nigeria's population and it has already been established that most of them live below poverty line. An examination of the distribution pattern exposed an uneven distribution, with rural Nigeria accounting for 73% of the poor and 95% of the "extremely poor" in 1992 (Vision 2010 Report, 1997:2). There is limited public awareness of the benefits of harnessing biogas in meeting some of the energy and development challenges facing the rural areas of the country. The inadequacy of awareness creates a market distortion which results in higher risk perception for potential renewable electricity projects. This is of concern since rural communities are critical to energy sectors in Nigeria. This is because well over 60% of Nigerians lives in the rural communities and Fuelwood is their main source of domestic energy. The rural energy problem has not changed in the past two to three decades and millions of people still lack enough energy inputs to sustain economic development (Stout and Best, 2001). Majority of this people has little or no access to information on biogas feedstock, its benefits, available technologies and standards. Hence rigorous and consistent public awareness programme that incorporates and accommodates Nigerian cultural and religious diversities in the areas should be made for proper adoption and utilization.

AWARENESS ABOUT THE BIOGAS POTENTIAL

There is no comprehensive biogas potential assessment studies carried out in Nigeria as at present. However, inference from the vegetation and organic Biomass in the country are promising. There are facts indicating that the highest biogas potential is in the agricultural sector (Widodo and Hendriadi, 2005). Okonko et al., (2009) reported that more than 20 million dry tons of Agricultural Residues per year are generated in the country. Half of this amount can be effectively used for energy and other Biomass-based production. However, the spatial distribution of biogas potential in Nigeria and where exactly the available Biomass hubs are located are not clear. Thus, the use of the identified biogas potential is complicated because of the scattered small scale farms and other biogas feedstock sources in the country. The benefits of biogas offers one possible solution to land degradation due to over-reliance on wood for Fuel, since it converts livestock Waste into a combustible gas, and also produces high-quality fertilizer, yet one more important barrier for use of biogas is the lack of statistical data, thus evaluation of biogas potential and Waste flows is complicated.

AWARENESS ABOUT AVAILABLE BIOGAS TECHNOLOGIES

Biogas in Nigeria is mainly produced in landfills and in Wastewater treatment plant, using solid Wastes and sewage sludge as feedstock respectively. Available biogas technologies are limited only to landfill gas, solid Wastes and Wastewater treatment. Biogas technologies are being used at small scale level in the country. The biogas market in the country is at an early stage of its development. At present, there is no industry for design, construction and operation of biogas plants in the country. In order to further develop biogas market, there is the need for local manufacturers and biogas experts to develop capability in the biogas technologies in Nigeria. The development of a locally-adapted prototype, the establishment of demonstration sites, training for local people on how to construct bio-digesters, and public awareness about the benefits of the model and wider use of biogas units would help reduce the demand for firewood in peri-urban areas and would supply high-quality fertilizer for local farmers. These local technologies can help overcome the challenges of adapting the foreign technologies. It is imperative that community members are also involved in the development of such technology because their inputs are very important for effective usage. Government agencies such as National Agency for Science and Engineering Infrastructure

(NASENI), Project Development Institute (PRODA), Energy Commission of Nigeria (ECN), Technology Incubation Programme, Small and Medium Enterprises Development Agency of Nigeria (SMEDAN) and Bank of Industry, Students from polytechnics, universities and technical and vocational schools should be involved in the development of the technology.

STANDARDS, QUALITY CONTROL AND BIOSAFETY

The development and quality of biogas energy must suit the purpose for which it will be utilized; as a vehicle Fuel, domestic cooking gas, purification, production of bio-methane, etc.

Procedures for biogas projects should be consistent in individual firm and among plant owners hence a standard procedures would require government agencies, as well as time and resources. Since the development of biogas is relatively new in Nigeria, there is the need to constitute a regulatory body that will be responsible for evaluation and monitoring of both the development of the energy resource and its use so as to prevent negative impacts on the environment and social-economic activities.

For instance, there are no regulations and legal bases on the technical criteria for bio-methane injection in Nigeria. This technical regulation is important because in order to inject bio-methane into the natural gas grid, it is necessary to amend the existing energy regulation and ensuring that natural gas transmission operator gives permission for appropriate quality bio-methane injection both for domestic and commercial utilization. The use of natural gas as vehicle Fuel in Nigeria is at its infant stage even though the Federal government has set the target/goal of using liquidified Natural Gas for automobile by 2015. Some of the main barriers for biogas use in transportation system in Nigeria are as follows:

i. the lack of long-term policy framework on biogas use in transportation system (e.g. tax allowances for vehicles using biogas)
ii. lack of participation by the private investors;
iii. existing gas station infrastructure is undeveloped and gas stations for natural gas are yet to be developed
iv. lack of human capabilities for modification of existing vehicles to use gas Fuel

Inadequate resource assessment

The energy that can be generated from biogas is estimated to range from 5.0 – 171 X 10^{12}J in the period 2000-2030 under a moderate biogas technology programme (Akinbami *et al* 2001), however, there is no single official national data source to evaluate organic Waste amounts that are available for biogas production. According to Akinbami *et al*, (2001), a biogas plant requires a considerable amount of residential space for effective functioning. Information on Waste flows are collected by different organizations and included in different databases. Those Waste databases only partly cover minor information to determine how much of each kind of Waste is generated and available for biogas. Analysis of the market potential regarding the availability of agricultural by-products is also not available. Only small part of agricultural by-products and agricultural Waste is collected and sorted from the total Waste stream while significant part of collected Waste materials is considered as problematic for biogas production. In case of food processing Wastes, the most challenging aspect has to do with the huge amount of unsorted household and municipal solid Wastes. Only 3.6% of household Waste is collected separately from the total Waste flow. Additional separation and treatment is necessary in order to use those Waste for biogas production. In order to use this Waste material, improvement on Waste sorting practices has to be introduced at all levels of governments. In the same light, there is no national regulation on Waste buy-back even though a particular state has initiated it. Technical conditions for optimum exploitation of biogas production must be assessed to meet the geospatial regional variability that exists in the country. A major determinant is temperature; biogas production is optimal when the internal temperature is in the range of 30 - 35^{0}C (Kharbanda *et al.,* 1985). Fermentation is inactivated when the internal temperature of the biodigester falls below 15^{0}C

Intermittency of resource availability

In Nigeria, identified feedstock substrate for an economically, feasible biogas programme includes water lettuce, water hyacinth, dung, cassava leaves, urban refuse, solid (including industrial) Waste, Agricultural Residues and sewage (Akinbami *et al*.,2001). It has been estimated that Nigeria produces about 227,500 tons of fresh animal Waste daily, and it was reported that 1kilogram of fresh animal Waste produces about 0.03m^3 of biogas, then about 6.8million m^{3}of biogas can be produced per day (Akinbami *et al*., 2001). However their production vary with seasonal weather variation, cyclical rain/dry season, geographical location and the comparatively small size of farms which have been identified as a limiting factor for biogas development in Nigeria. This and some other determinants/ factors of production in this type of energy sector makes investment in biogas projects usually very high; therefore it is very important for each project to evaluate financing options properly as the drivers for Biofuel research and development in the country (*Okonko .et al 2009)*.

CONCLUSION AND WAY FORWARD

According to the above analysis the most crucial barriers for the development of a biogas project in Nigeria are: the lack of regulations and legal bases for biogas development, biogas use in transport and injection into natural gas grid and the lack of continuous, targeted, and well-planned state support for biogas projects. Lack of official national statistical data and information on biogas potential, lack of data on spatial distribution of energy crops and other abiotic factors require urgent attention from government agencies and other stakeholders in the country. Inadequate awareness on biogas and its environmental benefits is generally low because of over-reliance on crude oil and its products. In order to continuously update existing biogas potential studies and to find new possibilities for biogas production in Nigeria, improvements in the collection of statistical data on biogas feedstock and biological Waste is necessary for effective energy security. To extend the use of biogas potential, additional investigation on a spatial distribution of biogas feedstock is also necessary. The necessity for improvement in municipal Waste sorting practices is crucial.

In order to develop biogas market in Nigeria, there is the need to develop human capability among the local technology fabricators and manufacturers and biogas experts to adapt the technology to suit the country specificity. Since biogas technologies are complex and require specific know-how. One of the ways for potential local biogas technology producers would be to make partnerships with some foreign companies which will help adapt the technology. Strengthening of local and national energy agencies is necessary to close the gap between potential biogas producers and biogas project developers and investors. A long-term policy framework on biogas use in transport (e.g. tax allowances for vehicles using biogas) is necessary. It is necessary to promote the awareness on biogas at all levels, including public in general, potential biogas producers, and decision-makers in particular.

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STARVING PEOPLE TO FEED CARS? ANALYSING THE CONFLICTS BETWEEN GREEN POLITICS AND FOOD SECURITY

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Abstract

There is no general consensus on the use of Biofuels as a means of poverty reduction in most of the developing countries. This paper seeks to analyse the frictions between environmentalism and green business. From the perspective of green business, Biofuels have the potentials of reducing poverty by increasing rural employments and reduce energy price. However, the opposing views believe that Biofuels development (especially in the developing countries) will increase the poverty level of the rural dwellers which harbour more than 50% of the population in most developing countries. The paper argues that an increase in Biofuel production in the developed countries from European Union or United States of America is likely to result in substitution for food/feed production, thereby driving up global food/feed prices and, hence, increase the potential shock for developing country producers and consumers. The paper illustrates the divergent views of the impacts of Biofuels on agricultural growth and poverty in the developing countries and strengthens the argument for the use of Agricultural Residues for energy generation. It is suggested that these sources of energy should complement other sources of renewable energy in the energy mix of the developing countries.

Keywords: Biofuel, energy, developing countries, bioenergy crops, fossil Fuel

BACKGROUND

The world today has seen the need, and is indeed taking serious steps, to move from a dependence on fossil Fuels to alternative sources of energy. Among others, the common reasons advanced for the preference for alternative energy sources are environmental friendliness and relative perpetuity of supply. There are several forms of alternative energy sources that are being presently considered, ranging from the renewable sources of solar and wind energy to the replenishable sources of Biofuels. Although some of these sources could be more expensive to harness and deploy, the long-term security that could be derived from the fact that they cannot be exhausted unannounced is considered to be a strong motivation. However, there are divergent views of the impacts of these energy sources on agricultural growth and poverty, especially in developing countries. More importantly, the macro- and micro-level implications are difficult to identify. For instance, Biofuels are subjects that have triggered sharply polarized views among policy-makers and the public. They are characterized by some as a panacea representing a central technology in the fight against climate change. Others criticise them as a diversion from the tough climate mitigation actions needed or a threat to food security and thus a key challenge to the achievement of the poverty-related Millennium Development Goals (UNEP, 2009).

There have been a lot of arguments on the development of Biofuels both on the economic and environmental grounds. Various current issues with the production and use of Biofuels are emerging and have become the subject of much research and debate in the media and scientific worlds. These cross-cutting issues include: the effect of moderating oil prices, carbon emissions levels, deforestation and soil erosion, impact on water resources, sustainable Biofuel production, human rights issues, poverty reduction potential, Biofuel prices, energy balance and efficiency, and centralised versus decentralised production models. Perhaps the most significant of these issues is the dilemma regarding the risk of diverting farmland or crops for Biofuels production in detriment of the food supply on a global scale – the so-called 'food versus Fuel' debate. The authors recognise, first and foremost, that increased Biofuels production will impact on agriculture, with serious implications for developing economies where significant proportions of the populations depend on agricultural cultivation for livelihood. Additionally, we acknowledge the emergence of a virtual 'rich versus poor' competition among developed and developed nations. For instance, demand for Fuel in rich countries is now competing against demand for food in poor countries. As noted by Brown (2006), the grain required to fill a 95-litre Fuel tank with Ethanol will feed one person for a year. This paper seeks to analyse, from the perspective of a developing economy, the frictions between environmentalism and green business on the one hand and food security on the other. It is important to state at the outset that the discussion in this paper focuses on the more advanced Biofuels such as Ethanol and biogas rather than on the traditional[1] ones such as sawdust and wood.

BIOFUELS: A BRIEF CHARACTERISATION

Biofuels are combustible materials, - solid, liquid or gaseous - directly or indirectly derived from Biomass, commonly produced from plants, animals and micro-organisms but also from organic Wastes. Although, bioenergy – energy from biological sources - includes Biofuels processed and unprocessed (or traditional) Biomass, modern bioenergy typically comprises Biofuels for transport, and processed Biomass for heat and electricity production. Recent statistics all point in the direction that Biomass, and indeed Biofuels are rising in prominence in the energy mix of today's world. Biomass contributed about 1% to the total global electric power capacity of 4,300 GW in 2006. Traditional Biomass accounted for about 13% of global final energy demand in 2006, the largest contribution to all renewable energies. Investment into Biofuels production capacity exceeded $4 billion worldwide in 2007 and is growing. World Ethanol production for transport Fuel tripled between 2000 and 2007 from 17 billion to more than 52 billion litres, while Biodiesel expanded eleven-fold from less than 1 billion to almost 11 billion litres. Altogether Biofuels provided 1.8% of the world's transport Fuel in 2008. Recent estimates indicate a continued high growth. From 2007 to 2008, the share of Ethanol in global gasoline type Fuel use was estimated to increase from 3.78% to 5.46%, and the share of Biodiesel in global diesel type Fuel use from 0.93% to 1.5% (UNEP, 2009).

REASONS FOR PROMOTING BIOFUEL

The reasons in favour of Biofuels as alternative energy sources are not far-fetched. For instance, making and burning Biodiesel contributes to a less extent to atmospheric CO_2. As noted by UNEP (2009),

> *Climate change, together with an increasing demand for energy, volatile oil prices, and energy poverty have led to a search for alternative sources of energy that would be economically efficient, socially equitable, and environmentally sound. One option that has raised enormous public and private interest is Biofuels. Farmers seek additional income and Biofuels may have the potential to promote rural development and access to energy in poorer countries. As a 'readily available' alternative, Biofuels offer to*

[1] Traditional biomass means unprocessed biomass, including agricultural waste, forest products waste, collected fuel wood, and animal dung, that is burned in stoves or furnaces to provide heat energy for cooking, heating, and agricultural and industrial processing, typically in rural areas (UNEP, 2009).

continue business as usual in the transport sector. Encouraged by research indicating that Biofuels could provide substantial energy while mitigating climate change, governments have supported production aimed at increasing Biofuel use in many countries. Industry has invested significantly in production and technology development.

DEVELOPING COUNTRY PERSPECTIVES ON BIOFUEL: SOME SUCCESS STORIES

In spite of the apparent issues that trail the development of Biofuels in developing economies, a number of such countries can be identified where significant successes have been achieved in developing and deploying bioenergy towards economic development. In this section, we discuss the cases of Brazil and China.

ETHANOL PRODUCTION FOR VEHICLES IN BRAZIL

Brazil is among the world's leading producers of Ethanol fuel and probably the world's largest exporter. Brazilian Ethanol production increased to almost 18 billion litres in 2006, nearly half the world's total (REN21, 2007). In 2008 however, she produced 24.5 billion litres which represents 37.3% of the world's total Ethanol used as Fuel (RFA, 2008; World Bank, 2008). It has been reported that Brazil and the United States accounted for 89% of the world's production in 2008. This remarkable achievement has made Brazil to be one of the foremost countries of the world to have sustainable Biofuels economy (Sperling and Gordon, 2009; Inslee and Hendricks, 2007; Rother, 2006; Budny and Sotero, 2007). As a matter of fact, her policy model has been adapted by other countries (Friedman, 2008). Her success is attributed to a 36-year-old "ProAlcool" program which is based on cheap sugar cane as feedstock and the most efficient agricultural technology for sugarcane cultivation. The result of this approach is a very competitive price for sugarcane production and high energy balance (output energy/input energy) (Rother, 2006). Important achievements were recorded because of the breakthroughs in scientific and technological advances in agriculture and industry. For instance, traditional breeding techniques were used to produce varieties adapted to different soil and climate conditions, with shorter production cycles, better yields, and tolerance to water scarcity and pests (Almeida, 2007). Also new grinding systems were developed and the fermentation process adapted to use different microorganisms and enzymes to produce more Ethanol faster.

Most of the vehicles in Brazil now use both pure Ethanol and gasohol, a 25 percent Ethanol/75 percent gasoline blend. Besides the fact that Biofuel reduces air pollution and contributes to mitigate global warming by reducing greenhouse gas emissions, one other fact that increase the demand for Ethanol Fuels, compared to gasoline, was the introduction of so-called "flex-Fuel" vehicles by automakers in Brazil. All Fuelling stations in the country are required to sell both gasohol (E25) and pure Ethanol (E100). Some of the supporting policies that help the "ProAlcool" program include retail distribution requirements, production subsidies, and tax preferences for vehicles that use both E25 and E100 (REN21, 2007). In recent years, significant global trade in Fuel Ethanol has increased tremendously and the high demand for sugar cane has allowed the country her productive land efficiently.

BIOENERGY IN CHINA

China's desire for alternative Fuels is traceable to some factors such as the need to cover the national demand of her fast growing economy, solutions to reduce the dependency on imports and high oil prices, pressure to reduce CO_2 and sulphur emissions from transport and agricultural machinery (GTZ, 2006). Among developing countries, China has a new long-term renewable development plan, of 15 percent of primary energy by 2020. Her individual technology targets include 300 GW of hydro, 30 GW of wind, 30 GW of Biomass, and 1.8 GW of solar PV. It is estimated that meeting these targets would almost triple China's renewable energy capacity by 2020 (Martinot and Li, 2007). However, the capability to meet this goal would be influenced by competing uses of inputs which include corn, wheat, sugar, cassava, sweet sorghum, and oilseeds. The long-term development plan is necessitated because of the rising energy demand and the urge to develop rural agricultural sector of the economy. Besides the national government, several other stakeholders are involved in the programme. Some of these institutions include the Asian Development Bank and China's Ministry of Agriculture. China is the world's third-largest producer of Ethanol, after Brazil and the United States (RFA, 2008). The central government has been able to encourage Biofuel development through subsidies and other financial mechanisms. The Biofuel development in China has not only improved the health of the environment by reducing the GHG emissions but also increased the number of clean development mechanisms projects registered (GAIN Report, 2006). The National Development and Reform Commission (NDRC) is saddled with the responsibility of guiding future energy production and consumption in China while the National Ethanol Promotion Team is the committee that promotes Biofuel development, particularly E-10 (Fuel made up of 90 percent gasoline and 10 percent Ethanol) for automobiles (Latner et al., 2006). Chinese Ethanol's production in 2005 was approximately 920,000 metric tons (MT), with a production capacity of 1,020,000. Biodiesel production totalled between 100,000 and 200,000 MT. Her policy objective is to produce 12 million MT of Biofuels, including Ethanol and Biodiesel, annually by 2020 (GAIN Report, 2006).

SITUATING AGROFUEL WITHIN FOOD SECURITY: THE PARADOX

At present, production of Biofuel, the countries producing it and the number of Biofuel industries are rapidly increasing. It was estimated that global production of liquid Biofuels amounted to 0.8 EJ in 2005 (Rossi and Lambrou, 2008) where USA, Brazil, and the EU are the main Biofuels producers. However, developing countries such as Indonesia and Malaysia are currently expanding the frontiers of Biofuels production in the developing countries.

There is no general consensus on the use of Biofuels as a means of poverty reduction in most of the developing countries. From the perspective of green business, Biofuels have the potentials of reducing poverty by increasing rural employments, reducing/stabilising greenhouse gasses, diversifying agriculture, reducing energy imports and provide security against the depleting conventional energy sources and increasing energy prices (IPCC, 2007; Ackom and Ertel, 2005).However, the opposing views believe that Biofuels development (especially in the developing countries) will increase the poverty level of the rural dwellers which harbour more than 60% of the population (Monbiot, 2004). They argue that for Biofuels development to be profitable, it has to be on a large scale. Meanwhile, most of the farmers in the rural areas that produce most of the energy crops in these countries do not have the capacity and capability for such level of the mechanised farming. In addition to this, agricultural productivity in most developing countries is confronted with a lot of challenges which could be biotic (arthropods, nematodes, diseases, weeds, rodents, birds); abiotic (drought, soil fertility, mineral toxicity); and infrastructural (low price to farmers and inability to compete with subsidized imports, high price of pesticide and fertilizer inputs, poor transportation and storage systems) (Gressel, et. al. 2004). Besides these challenges, it is usually difficult to have access to large hectares of land in rural Sub-Saharan Africa and other developing countries required for the cultivation of energy crops due to the complex situations of land ownerships. Even when these lands are available, the level of production is always very low without adequate agricultural inputs which are difficult to access by the local farmers. Other factors that affect development of Biofuels production in developing countries include different feedstocks/ production systems; varying downstream (transportation) costs; existing (non-Biofuel) crop production and processing patterns; and patterns of land holding (Peskett, et.al., 2007). Other negative environmental and socioeconomic impacts that make investment in the production of Biofuel in large scale more difficult include destruction of forests to expand land for feedstock production, loss of wildlife habitats, competing uses of land, and human and ecological toxicity impacts from chemicals and fertiliser (Blottnitz and Curran, 2006). In the same light, Pimentel and Patzek (2005) has also raised the issue of low agricultural yield and the high energy consumption of the process that attains the production of Biodiesel out of sunflower and soybeans (energy crops for Biofuel) as one of the main reasons that makes the production of this Biofuel unfavourable.

The irony of this analysis is that an increase in Biofuel production in the developed countries from EU, USA or other OECD states is likely to result in substitution for food/feed production, thereby driving up global food/feed prices and, hence, increase the potential shock for developing country producers and consumers (Peskett, et.al., 2007). In other words, origins and supply of agroFuels are highly relevant to the developing countries for human and food security while its production is of great concern to energy-conscious groups around the world, most especially the developed countries. The implication is that while the developed countries are filling their car tanks, the developing countries that produce bioenergy crops are starving. For instance, there are some concerns over the increase in the number of distilleries being built by the largest exporters of corn in the United States of America (Dodic, 2010) most especially from the food manufacturers that depend on these grains. This is because as the oil prices go up, the production of Biofuels out of agricultural products is more profitable and as a result, the price inequality between the price of a raw material used for Biofuel production and the price offered by the food industry could prompt this raw material to be converted into Biofuel (Dodic, 2010). Example of this could be seen in Europe where the production of Biodiesel out of vegetal oil led the margarine producers to seek help from the European Parliament because of price inequality between them and the owners of Biodiesel refineries (Brawn, 2006). Moreover, there are indications that the inflation rate of 8.6% experienced in Nigeria in January 2008 in the food sector (FAO, 2008) could be as result of increase in demand for food crops as Biofuel feedstock.

Some of these concerns about balancing increase in food prices, reduction in greenhouse gas emission and poverty have been aggravated by the scale and extent to which governments in the developing countries are willing to go about converting food crops as well as arable lands to agroFuel production. In Nigeria, for instance, the government of Nasarawa State allocated $27 million (€18 million) to improve Ethanol processing and (Agricultural Produciton) (D-8 Secretariat, 2008). Experiences in the developed countries have also shown that production at such a large scale requires a lot of hectares of land. For instance, it has been estimated that a 10% substitution of petrol and diesel would require 43% and 38% of current cropland area in the US and Europe respectively (IEA, 2004). It is therefore not difficult to understand that substitution at this level would require in addition to existing arable land, clearing of forests and grasslands (Righelato and Spracklen, 2007). To make this matter worse, it has been reported that clearing of forest could create a large up-front emissions cost that would outweigh the net reduction in carbon emissions from fossil Fuels (Righelato and Spracklen, 2007).

Connecting the dots

The relationship between Biofuel production and reduction in poverty in the developing countries is rather complex and requires critical analysis (Escobar, et.al., 2009). Recent reports have identified the diversion of crops to the production of Biofuels as being a major factor in driving up food prices around the world. However, there is the need to connect all the dots before such conclusions can be reached. The point raised by Kunateh (2009) below (see Box 1) will help throw light on this argument and probably establish whether dots connecting high food prices could be linked to high demand for energy crops for Biofuel production or not.

Box 1: Connecting the dots

- It was reported that wheat prices increased by 126% in the period January-April 2008, as compared to the same period in 2007. However, only 1.4 percent of wheat is used for Biofuels production in the European Union and about 0.6 percent globally (Kunateh, 2009). And about this same period, there were unfavourable weather conditions in some key producing countries, such as Australia and Ukraine. ***Dots not connected***

- Maize prices increased by 23% during the period July 2007-March 2008. In the United States (the highest producer of corn), the use of maize for Ethanol production is expected to almost double between 2005/06 and 2007/08 as a result of the provisions of the 2007 Energy Bill that focuses on renewable energy. ***Dots may be connected***

- During early May 2008, rice prices were more than double their May 2007 level. The combination of export restrictions by some key rice so as to reconstitute rice prices to compensate for losses, incurred by floods has had a dramatic effect on the market of rice, especially since November 2007. Be that as it may, rice is not even used for Biofuel production, and So far globally, only small amounts of rice cropland have been shifted to producing Biofuel feedstocks. ***Dots not connected***

- The price of oilseeds went up 94% between 2007 and 2008 and 140% per cent compared to 2006. The European Commission has a proposal for a mandatory 10% minimum target for the share of Biofuels in transport gasoline and diesel consumption by 2020. ***Dots may be connected***

Source: Kunateh (2009)

- The price of sugar, a major Biofuel feedstock, reached a 25-year high in 2006, fell back later in the year and continued to decline throughout most of 2007, due to large oversupply of sugar on the market. Prices started rising again at the end of 2007, and by the end of the first trimester of 2008 had reached a level 30% higher than in November 2007, before starting to decline in April. The following factors have been used to explain the disconnection between international sugar prices and market fundamentals:

    - High energy prices,
    - The weakness of the United States dollar,
    - The potential influence of investment funds on the sugar futures markets. ***Dots not connected***

The argument above shows that the link between hike in food prices may not be directly related to the high demand of energy crops for Biofuel production or at best circumstantial (Peskett, et.al., 2007).

CONCLUDING REMARKS ON THE CONNECTED DOTS

In all, this argument shows how difficult it is to analyse the impact of Biofuels expansions on food security and poverty. The analysis in this paper shows that unless the issues of Biofuels problems are contextualized, the challenges will be difficult to overcome. This is because the Biofuels production challenges illustrated here are age-old problems that affect (Agricultural Produciton) of which bioenergy crops are not exceptions. However, be that as it may, the intensity of the global instability of energy prices, greenhouse gas emission and other air pollutions are currently increasing the importance of the development and commercialisation of Biofuel industry in Africa (Amigun et. al, 2006). World Bank (1980) analysis also revealed that considering the potential of Biomass feedstocks in Africa and some other developing countries, Biofuels industry, should have substantial environmental, economic, employment and social benefits both on a national and local scales.

Another factor that could promote the use of Biofuel in the developing countries is the decline in the unit cost of most of the renewable energy technology (most especially that of Biofuels) and this trend is expected to continue with improvement in technological development progress and market growth (Karekezi, 2001). Moreover, even though, most of the countries in Africa have abundant Biomass potential for Biofuels, yet majority of the countries have not put in place a workable policy where entrepreneurs could invest. Few countries such as Brazil, USA, Sweden and Germany have created a conducive environment for Biofuels production. For instance, in Brazil sugarcane-based Ethanol industry now produces more than 160,000 barrels (1072 GJ) of oil-equivalent a day (Amigun, 2006). Also, in Sweden, bioenergy is the second largest supply of energy where it has contributed to the reduction in emissions of carbon dioxide and improved energy supply security.

OVERCOMING THE OBSTACLES

The critical step (and more viable solution) to resolving this conflict and still support the development of Biofuels is to increase political and industrial support for Biofuel implementation from non-food crops. Biofuel produced from these non-food crops are called second-generation (2G) Biofuels. Examples of non-food crops used in the production processes for second-generation (2G) Biofuels include Waste Biomass, manure, rice husks, sewage, and food Waste, straw, forestry scrap and saw dust, the stalks of wheat, corn, and wood (cellulosic Ethanol production) and special-energy-or-Biomass crops (e.g. *Miscanthus*, or Jatropha Circus). The production of cellulosic Ethanol using non-food crops or inedible Waste products does not divert food away from the animal or human food chain. The "woody" structural material of plants used in cellulosic Ethanol production is called “Lignocellulose”, this feedstock is abundant and diverse, and in some cases (like citrus peels or sawdust) it is in itself a significant disposal problem (Akinbami, 2001, Inderwildi and King, 2009; Somerville, 2008). Second generation Biofuels use Biomass-to-liquid technology, and many of these types of Biofuels are under development such as biohydrogen, biomEthanol, DMF, Bio-DME, Fischer-Tropsch diesel, biohydrogen diesel, mixed alcohols and wood diesel (Somerville, 2008)

Producing Ethanol from cellulose in itself is a difficult technical problem to solve. In nature, ruminant livestock (like cattle) eat grass and then use slow enzymatic digestive processes to break it into glucose (sugar). In cellulosic Ethanol laboratories, various experimental processes are being developed to do the same thing, and then the sugars released can be fermented to make Ethanol Fuel (Inderwildi and King, 2009; Somerville, 2008). Scientists working in New Zealand have developed a technology to use industrial Waste gases from steel mills as a feedstock for a microbial fermentation process to produce Ethanol (Fisher, 2007; Voegele, 2009). In Nigeria, Jatropha Circus is a viable option for bio-diesel production.

Jatropha Circus is a hardy plant resistant to drought and pests, and produces seeds containing 27-40% oil. The remaining press cake of jatropha seeds after oil extraction could also be considered for energy production (Achen et al, 2007; Achen et al, 2008).
Estimates of Jatropha seed yield vary widely, due to a lack of research data on the genetic diversity of the crop, the range of environmental tolerance, and its life cycle. Seed yields under cultivation can range from 1,500 to 2,000 kilograms per hectare, corresponding to extractable oil yields of 540 to 680 litres per hectare (58 to 73 US gallons per acre). It has been recently reported that it has the potential for as much as 1,600 gallons of diesel Fuel per acre per year (Dar, 2007). Jatropha may yield more than four times as much Fuel per hectare as soybean, and more than ten times that of maize. A hectare of jatropha can produce as much as 1,890 litres of Fuel. Philippines, Brazil, and India are countries currently using Jatropha curcas for making Biodiesel Fuel. In Africa, the cultivation of Jatropha is being promoted and it is grown successfully in countries such as Mali.

CONCLUSION

Promoting sustainable energy system in developing countries like Nigeria includes developing explicit Biofuel policies that analyse the strengths and weaknesses of each country taking into consideration the underlying opportunities and threats. For instance, the United Nations Conference on Trade Development (UNCTAD) has been assisting countries in assessing the viability of including Biofuels in their energy mix since 2005. The concept of sustainability in energy development highlights the need for the system to bear in mind the necessity for economic advancement within the ambit of environmental viability. Thus the following could be considered:

- For the key consumers of Biofuels, there should be flexibility on mandated blending volumes or percentages introduced in the energy mix so as to restore the natural balance played by markets.
- Developing countries should support investment in small scale farmers so as to enhance Biofuel production
- Support investment in second-generation Biofuel such as those based on the conversion of cellulosic resources, such as grasses and fast-growing trees, into **Fuel**s
- Reassess Biofuel policies factoring in the actual or potential impact of Biofuels production on the price and availability of agricultural commodities for food production
- Support small holder Biofuel production for local use where Biofuel feedstocks are used to generate electricity and biogas for cooking.
- Bioenergy production should not take place on land that is currently used for food and feed production
- It should not require irrigation with potable water, and it must prove a significant positive greenhouse gas balance.

In conclusion, in drafting appropriate policy for effective Biofuel adoption, may be the question to ask is not what crop, or what technology, but why bioenergy and for whom?

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BIOFUEL PRODUCTION: WHAT IMPLICATIONS FOR (AGRICULTURAL PRODUCITON) AND FOOD SECURITY IN NIGERIA

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Abstract

Biofuels are organic Fuels of primary or secondary types derived from Biomass which can be used for production of thermal energy either by combustion or other technology. BioEthanol is produced from purpose-grown energy crops e.g. sugar beet, sugar cane, or corn and Biodiesel is produced from vegetable oils e.g. rapeseed oil, soy or palm oil and jathropha. The production of Biofuels is currently dominated by few countries. BioEthanol production which started in the 1970s is produced in larger volumes than Biodiesel for which production started 20 years later. The USA and Brazil are the major producers of bioEthanol with 39% and 33% of world production, respectively while the EU produces about 95% of the world's Biodiesel. Annual global bioEthanol production is expected to reach 120 billion litres by 2020 and that of Biodiesel to reach 12 billion litres. Biofuels production is expected to have effect on food and feed stock production, access to land and by implication food security. There are indications that increases in source costs for Biofuel production, has in recent years, reached at least 50% and have harmed the comparative advantage and competitiveness of individual countries. While prices of corn and other Biofuel source material can be increased due to growth in the Biofuel sector, the competitiveness of the production of the source materials can be adversely affected by the same price changes and other economic factors. The overall implication is the emergence of a linkage between food and energy markets such that fluctuations in the prices of energy will inevitably lead to changes in food prices. Nevertheless, there are on the other hand, indications that Biofuel production can impact on poverty reduction when viewed on a country-by-country basis and taking into consideration differences in production systems. With rising oil prices, there will be increase in global demand for Biofuel crops and for farmlands, putting upward pressure on world prices of Biofuels, food and feed. The effect of this will be to increase incomes of producers and countries in net supply and reduce incomes of those of consumers and countries that are net importers. This scenario will play out both between and within countries. With regards to poverty and food security, Biofuels production show that economies of scale is important especially for processing than feedstock production, a significant labour force is required and production can be complimentary to other types of (Agricultural Produciton) and create linkages and multipliers. Comprehensive international and national policy frameworks can lay the foundation for pro-poor environmentally sustainable Biofuels that also achieve energy security.

INTRODUCTION

Biofuels are organic Fuels of primary or secondary types derived from Biomass which can be used for production of thermal energy either by combustion or other technology. BioEthanol is produced from purpose-grown energy crops e.g. sugar beet, sugar cane, or corn and Biodiesel is produced from vegetable oils e.g. rapeseed oil, soy or palm oil and jathropha. The production of Biofuels is currently dominated by few countries. BioEthanol production which started in the 1970s is produced in larger volumes than Biodiesel for which production started 20 years later. Growing concern about fluctuations in prices of petroleum products, energy independence, and the environmental ramifications of fossil Fuel use have drawn attention to Biofuels as an alternative to the world's growing demand for energy. Supply and demand of these alternative bioenergy are expected to rise dramatically as both developed and developing countries attempt to carve out a place for themselves in the emerging Biofuels market. However, developing countries face different situations than do developed countries. They must address the issue of food security when they develop Biofuels. The rapid global expansion of Ethanol production has affected food markets and prices in both domestic and international markets, ranging from the allocation of acreage among crops to exports and imports. As more food grains will be used to produce Biofuels, food grain carryover stocks will remain tight, and average grain prices will increase. Moreover food price increase also increase feed cost for livestock. Consequently, most food prices are affected. As production of Biofuels and food are closely related, the overall implication is the emergence of a linkage between food and energy markets such that fluctuations in the prices of energy will inevitably lead to changes in food prices. As production of Biofuels and food are closely related what then are the implications for food security of global bioenergy production for a developing economy as that of Nigeria?

WORLD PRODUCTION OF BIOFUEL AND BIODIESEL

Biofuels have emerged in just a few years as a transport Fuel with the aim to contribute to addressing the challenges of climate change, energy security and rural development. The interest in Biofuels has been accelerated by adoption of governments of policies and support measures like time bound targets for Biofuel consumption. This opportunity has been embraced by commercial agriculture which based upon assured government support have responded with investments and efforts to increase production to meet the market demand for Biofuels feedstocks. This has resulted in increased national and world market prices of current first generation Biofuels feedstocks which are also important food and feed crops.

At present Ethanol represents 85% of the world's production of liquid Biofuel, with Brazil and USA being the main producers. These two countries alone account for 90 percent of global production. Other countries such as Canada, China, France and Germany in the EU and India produce most of the remainder. Biodiesel production is based mainly in the EU, which makes about 60 per cent of the total world production (Table 1).

Table 1. Biofuel Production by Country,

COUNTRY/COUNTRY GROUPING	ETHANOL		BIODIESEL		TOTAL	
	(Million litres)	*(Mtoe)*	*(Million litres)*	*(Mtoe)*	*(Million litres)*	*(Mtoe)*
Brazil	19 000	10.44	227	0.17	19 227	10.60
Canada	1 000	0.55	97	0.07	1 097	0.62
China	1 840	1.01	114	0.08	1 954	1.09
India	400	0.22	45	0.03	445	0.25
Indonesia	0	0.00	409	0.30	409	0.30
Malaysia	0	0.00	330	0.24	330	0.24
United States of America	26 500	14.55	1 688	1.25	28 188	15.80
European Union	2 253	1.24	6 109	4.52	8 361	5.76
Others	1 017	0.56	1 186	0.88	2 203	1.44
World	52 009	28.57	10 204	7.56	62 213	36.12

Note: Data presented are subject to rounding.
Source: based on F.O. Licht, 2007, data from the OECD–FAO AgLink-Cosimo database.

Energy security has been one of the main drivers for production of Biofuels and the concern over access to fossil Fuels, the reduction in greenhouse gases and carbon gain or credit have also been cited as major reasons for their production. According to FAO (2008), different crops have different yields in terms of Biofuel per hectare. Wide variations also occur in terms of energy balance and greenhouse gas emission reduction across feedstocks, locations and technologies. The FAO has also measured the amount of energy it takes to produce new Biofuels, giving each feedstock a "fossil energy balance". The FAO reported that a fossil energy balance of one means that an equal amount of energy has been used to make Fuel as it gives. The higher the balance number, the more energy is received from the Fuel and the less it takes to produce. There is a wide variation in the estimated fossil energy balances across the different feedstocks and Fuels. For example, Biodiesel from rapeseed or soybean has a balance of one to four, while the estimated balance for biosel from palm oil is around nine (Figure 1). For Ethanol, the balances ranged from less than two for maize to between two and eight for sugar cane. The range for cellulosic feedstocks is even wider than that for sugar cane, which represents the variety of raw material feedstock, the different production methods and uncertainty surrounding the technology at present. Cellulosic Biomass is the most abundant biological material on earth, and according to the FAO, the successful development of commercially viable second-generation cellulose-based Biofuels could significantly expand the amount and variety of feedstocks that can be used. Cellulosic Wastes including agricultural Waste products such as straw, stalks, leaves and forestry, Wastes generated from processing such as nut shells, sugar cane bagasse, sawdust, and organic parts of municipal Waste, could all be potential sources.

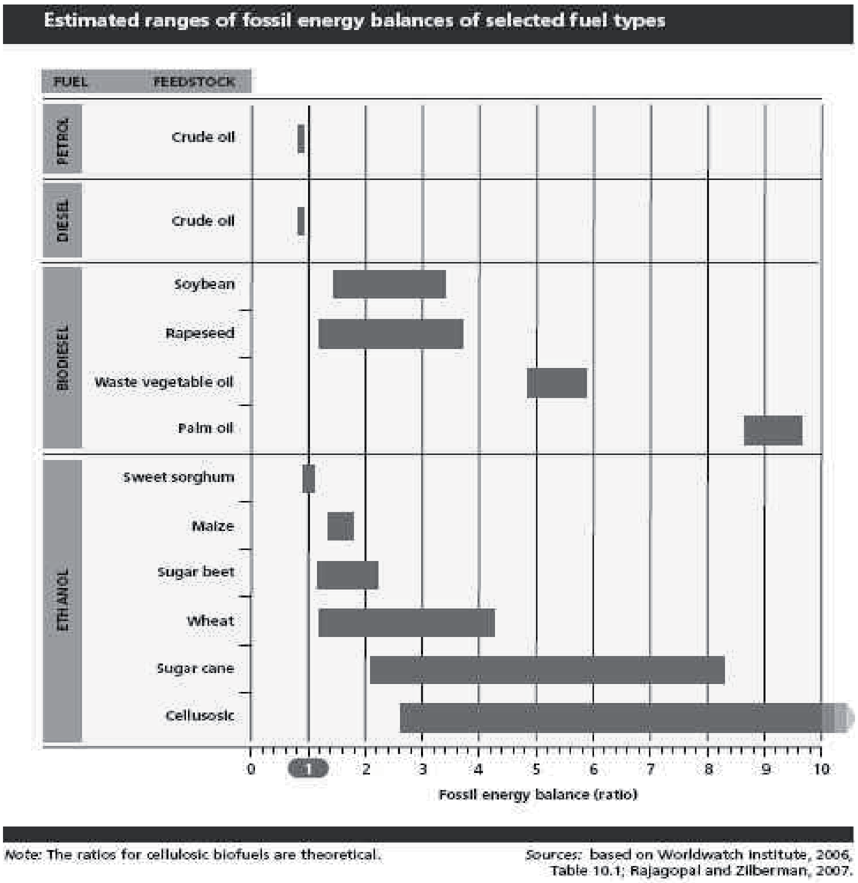

Fig. 1: Estimated fossil balance for different sources of Biofuels

The implementation of Biofuels targets by governments in developed and developing countries will result in an increase in the share of Biofuels in transport Fuel from about 1.5 per cent on the average today to 8 percent in the developed countries and 6 percent in the developing countries in 2020. The corresponding shares in 2030 are respectively 12 percent and 8 percent. With regards to second-generation Biofuels, they will with gradual deployment contribute 4 percent in 2020 and 18 percent in 2030 of the Biofuels in the developed countries. In developing countries second-generation Biofuels come into play only after 2030 and contribute some 4 percent share in 2030. Annual global bioEthanol production is expected to reach 120 billion litres by 2020 and that of Biodiesel to reach 12 billion litres. The estimated Biofuels from second-generation Biofuels is derived from the estimated value of second-generation feedstocks which is put at an increase of 33 percent and 51 percent in 2020 and 2030 for developed countries and 3 percent and 19 percent respectively for developing countries in the corresponding years.

BIOFUELS PRODUCTION AND FOOD PRICES

World food prices gradually halved in the period from the late 1970s to the early 1990s and then stagnated until 2002. The long term trend in declining food prices has been the result of several drivers including demographic changes, technological developments such as the Green Revolution and agricultural support policies maintaining relatively inelastic supply. Between 2002 and 2007, world food prices increased by some 140 percent due to a number of factors including, increased demand for Biofuels feedstocks and rising agricultural Fuel and fertilizer prices. The world market price increases for food and feed cereals, oilseeds and vegetable oils triggered a number of countries around the world to implement policy measures to protect their domestic markets. It has been reported by OFID (2009) that due to Biofuels demand the impact on crop prices in 2020 is very substantial, of the order of 30 percent compared with a scenario without Biofuels. With accelerated introduction of cellulosic Ethanol, the price impact on cereals would be halved to 15 percent. The impact on non-cereal crops (in particular vegetable oils) is stronger than for cereals. The pattern of price impacts for 2030 remains similar to 2020. The largest price increase will be for coarse grains with an increase of about 50 percent. Maize, a major biofules feedstock in the USA, is a staple food crop in many developing countries, particularly in Africa and high world market prices as projected for coarse grains are of concern with regard to the implications for food security. In the case of protein feeds, prices decline by 30 to 40 percent in comparison to a reference run without Biofuels. This is caused by biofules by-products entering the market in large volumes, such as livestock feeds from starch-based Ethanol production or protein meals and cakes from crushing oilseeds. Access to cheaper feed sources results in only modest increased of livestock product prices. Biofuels development scenarios indicate a strong relationship between agricultural prices and the share of first-generation Biofuels in total transport Fuels. For example the cereal price index increases by 20 percent with biofules share of 4 percent and by 40 percent with a 7 percent Biofuels target. Biofuels development policies should give serious consideration to food price impact as higher prices will profoundly affect food security.

BIOFUELS PRODUCTION AND HUNGER

In the 1970s about 900 million people in the developing world, a third of the total population was chronically undernourished. Four decades after the number of undernourished in the world totaled about 923 million in 2007. The food price crisis in 2008 added a further 100 million to the world's undernourished. The higher food prices resulting from expanding Biofuels production would consequently reduce food consumption in developing countries, which in turn would result in increased undernourishment. From simulated regional distribution of additional people at risk of hunger in different Biofuels scenarios, there is a large impact in particular in South Asia. In the Biofuels target scenario, about 140 million additional people are threatened by hunger. Even relatively swift deployment of second-generation technologies, reduces the projected figure only by about 40 million. For the range of simulated global shares of first-generation biofules in total transport Fuels of 0 to 8 percent in 2020 and 0 to 10 percent in 2030, the resulting impact on the expected number of undernourished people is substantial, up to about 200 million. South Asia and Africa are the most affected regions with a third and a quarter of their total population undernourished. The Millennium Development Goals put a time bound target to reduce world hunger by half in the period to 2015 and it is estimated that this would require public funding of some US$ 50 to 80 billion annually. Putting this in perspective, the OECD agricultural subsidy budget amounts to over US$ 300 billion annually. According to a report by IFPRI (2007), based on the current Biofuel investment plans, the international price of maize and oilseed will increase by 26 percent and 18 percent respectively. If the investment plans double, the report estimated a price increase of 72 percent from corn and 44 percent for oilseeds. In both scenarios, increasing crop prices go hand in hand with decreasing availability of, and access to, food. Poor people spend a much bigger share of their budgets on food than they do on energy, about 50-70 percent on food and 1-10 percent on energy. With high prices, they will likely spend less on food, exacerbating poor diets and micronutrient malnutrition. The report estimated that calorie consumption will decrease across whole regions, with consumption increasing the most in Sub-Saharan Africa

BENEFITS OF BIOFUELS PRODUCTION

In the developed countries, less than 5 percent of the populations are economically dependent on agriculture for their livelihoods, yet the agricultural lobby in these countries is politically influential. In contrast, in the developing countries, rural populations derive their livelihoods directly or indirectly from agriculture and yet the rural agricultural community often has no political voice. It is the urban poor, subsistence farmers and landless in food insecure developing countries where livelihoods and food security will be most affected by food-feed-Fuel competition. Biofuels development has been seen as a means to diversify (Agricultural Produciton) and-especially in developed economies-has shaped agricultural support policies. According to the report of OFID (2009), the agricultural sectors in developed countries benefit relatively more than developing countries in terms of percentage gain. For example, the increase by 2020 would be 2.3 percent for developed compared with only 1 percent for developing countries. While Africa and Latin America achieve gains of about 1.3 percent, the gains achieved for Middle East & North Africa region and Asian regions are only 0.6 to 0.9 percent. The value added to (Agricultural Produciton) as a result of Biofuels production is projected at US$ 31 billion and US$ 51 billion in the developed countries in 2020 and 2030 respectively. The corresponding values for the developing countries are US$ 27 billion and US$ 41 billion respectively. These results highlight that the increase in agricultural value added induced by first-generation Biofuels production is relatively small and this puts into perspective the scope to be viewed in the context of substantial Biofuels subsidies in developed countries that will distort and constrain Biofuels export opportunities for developing countries.

About 1.6 billion ha of land are currently used for crop production, with nearly 1 billion ha under cultivation in the developing countries. During the last 30 years the world’s crop area expanded by some 5 million ha annually, with Latin America alone accounting for 35 percent of this increase. The potential for arable expansion exists predominantly in South America and Africa where 7 countries alone account for 70 percent of this potential. There is relatively little scope for arable land expansion in Asia, which is home to about 60 percent of the world's population.

Three factors are related to how agricultural supply responds to increasing demand for first-generation Biofuels feedstocks: a) expansion of cultivated land; b) reallocation of agricultural resources to producing more profitable commodities due to relative price gains, and c) intensifying production per unit of cultivated land by increasing multi-cropping and possibly reducing fallow periods. It is estimated by OFID that the additional use of cultivated land is about 35 million ha in 2020: 13 million for developed countries and 22 million ha for developing countries. The impact of the Biofuels production is to increase the net expansion of cultivated land during 2000-2020 by 20-40 percent, and by 15-30 percent during 2000-2020. In the period 2000-2030, nitrogen fertilizer use will with about 40 million tons from 83 million tons. The Biofuels target scenario will require additional use of about additional 10 million tons of nitrogen fertilizer in 2030 representing an increase of 8 percent.

BENEFIT OF SECOND-GENERATION CONVERSION TECHNOLOGIES

Current first-generation Biofuels production on cultivated land is not tenable as world's limited arable land resources are essential to meet rising food demand. It is there imperative and important to make a fast transition to producing second-generation Biofuels from lignocellulosic feedstocks such as perennial grasses and tree species. Biomass residues from agricultural crops and forestry form a feedstock source as well. The key challenge for commercial second-generation Biofuels is to develop appropriate conversion technologies on industrial scale and at competitive prices. Agro-ecological assessment results by OFID indicate a substantial potential for producing lingo-cellulosic feedstocks on currently unprotected grassland and woodlands. Of the world's 4.6 billion ha of grasslands and woodlands about 10 percent is legally protected and some 50 percent has very low productivity or steeply sloped. Production of lingo-cellulosic feedstocks on some 125 million ha would be sufficient to achieve a 10 percent Biofuels target share in world's transport Fuels in 2020.

The Role of Biofuel Production on (Agricultural Produciton), Food Security in Nigeria

Nigeria has a land area of 98.3 M ha. 74 M ha is good for farming but less than half is cultivated. Population involved in agriculture is 60-70% but mainly subsistent and agriculture contributes about 41.5% to nation's GDP. There is threat of hunger and poverty with 70% living on less than US$1.00 per day. According to the Federal Officie of Statistics, Nigeria's food import bill increased from N940 million in the 1970s to the present N1.6 billion.

Food security is the ability of households to have access to good and nutritious food for healthy living such that the population should be healthy to create wealth. Absence of factors that ensure availability and enablement to have food enough for healthy living will result in food insecurity. Food security can be at the household or national level. There are two parts to food security - availability of food (supply) and access to food (demand). When there is not enough to eat the situation results in hunger and when there is insufficient nutrient intake the situation results in undernutrition. Both situations are closely related to hunger. Indicators of food security include nutrient deficiency (affect physical capacity and may cause death), malnutrition in children and adults, under weight in children, Infant Mortality Rate (IMR), Maternal Mortality Rate (MMR), wasting in children, stunting in children and life expectancy. All above indicators according to FAO (2008) point to the fact that Nigeria is a food insecure country.

Biofuel production will lead to expansion in cultivation of arable land, expansion in production of food crops and feedstocks for Biofuels, improved production technologies, fodder grass, high yielding crop varieties and second-generation feedstocks. The Biofuel production program in Nigeria is currently initiated by the Nigerian National Petroleum Corporation (NNPC). It is planned that bioEthanol will be produced from sugarcane and cassava. Nigeria is the leading world cassava producer with 30 M tons per annum. About 400,000 ha of land could support high yield sugarcane production to sustain the Biofuel production operations. It is also planned that biodiessel will be produced from palm oil. According to the NNPC projections 10% Biofuel could be blended with 90% fossil Fuel. It is also projected that through REEEP-funded project 10-20,000 ha sugarcane plantation will produce 70-80 M litres Ethanol annually, 5-10,000 ha cassava plantation to produce to produce 7 billion kg cassava and 50-60 M litres Ethanol annually. These operations will create 200,000 new jobs. Also, rural farmers will be empowered by generating greater earnings and the country will earn US$150 Million annually. The overall key objectives of the Nigerian bioEthanol program is represented in the figure below

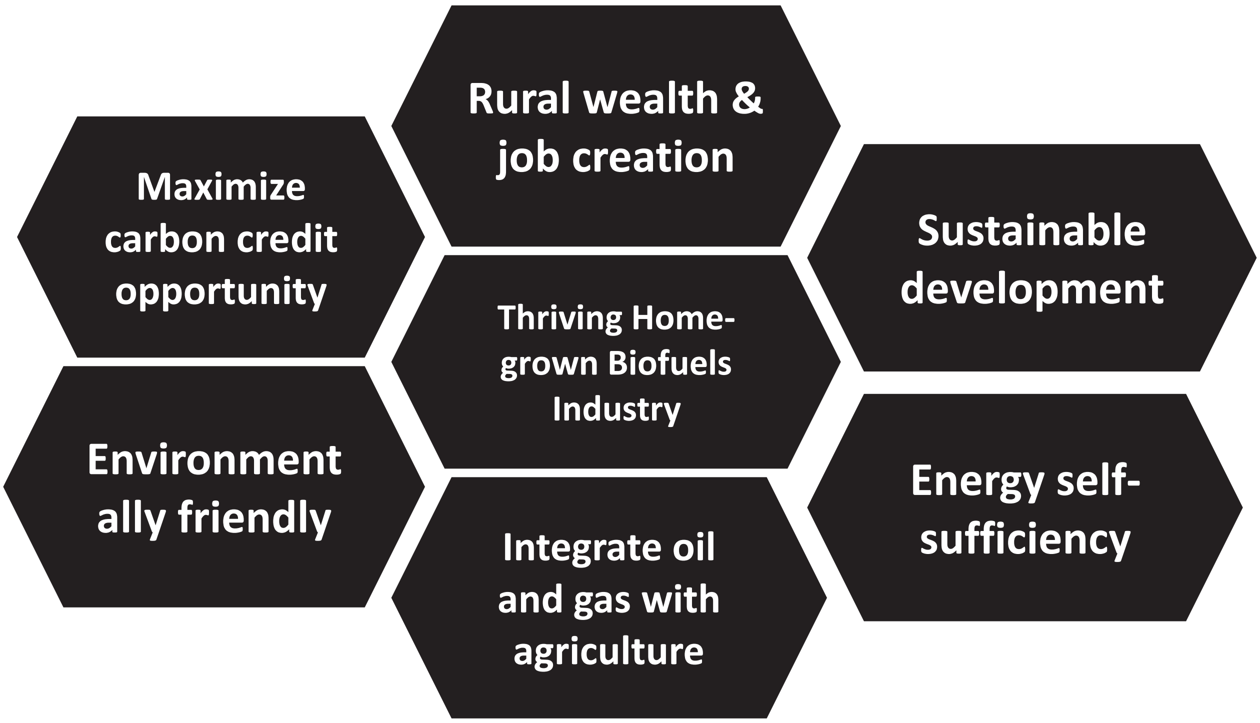

Fig. 3: Key objectives of Nigerian bioEthanol industry

CONCLUSION

Biofuels will result in less dependent on fossil Fuel and therefore contribute significantly to a cleaner environment. Expansion in Biofuel production will lead to more demand for cereals and tubers which are also used for human food. This scenario will be of advantage to countries that are net exporters of food while it will harm those countries that are net food importers. Increased food and feed crop production will increase pressure on land. However, increase crop production will lead to increase in the income of rural farmer in developing countries. Biofuel production will contribute to poverty alleviation and food security.

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BIOGAS PRODUCTION FROM BREWERY WASTE-SPENT GRAINS

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Abstract
The common GP water tank of 1000 litres volume was used as biodigester to anaerobically digest selected organic raw materials; spent grains, rice husk and poultry droppings in a ratio of 5:3:2 by mass. The result shows that the mixture indeed generated biogas of cumulative mass of 16.86g in 60 days. The temperature of the biogas and Biomass ranged from 35 to 41^0C and 20 to 30^oC respectively, while the mass of the gas generated varied daily. The minimum and the maximum mass of gas collected during the residence time were 0.14g and 0.60g respectively. The analysis of the bio-slurry showed that nitrogen, phosphorus and potassium ions present in the bio-fertilizer were 1.28, 4.22 and 0.068 mg/g respectively for evaporated process while for the filtered process the ion composition of the dried bio-fertilizer were 1.22, 3.86 and 0.052 mg/g respectively.

Keywords: biodigester, organic, anaerobic, biogas, Biomass, bio-fertilizer, bio-slurry
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INTRODUCTION

Biogas is the mixture of gas produced by methanogenic bacteria while acting upon biodegradable materials in an anaerobic condition. Biogas is mainly composed of 50 to 70 percent methane, 30 to 40 percent carbon dioxide and low amount of other gases (Da Silva, 1981). Under anaerobic conditions, the organic materials are converted through microbiological reactions into gases (Fuel) and organic fertilizer (sludge) (Dubey, 2005).
Biogas is about 20 percent lighter than air and has an ignition temperature range of 650 to 750^oC. It is an odourless and colourless gas that burns with clear blue flame similar to that of liquefied gas. Its Calorific value is 20 mega joules per m^3 and burns with 60 percent efficiency in a conventional biogas stove. Biogas production process follows three stages, which are breakdown of complex insoluble Wastes into water-soluble substances, acid fermentation by acetogenic bacteria and methane formation by methanogenic bacteria (Padmanabham, 1985).
The reaction that takes place in the process of methane production is called methanization where methanogens, a unique group of bacteria, anaerobically catabolise acetate and hydrogen to gaseous products in the absence of exogenous electron acceptors other than carbon dioxide or light energy (Karki and Dixit, 1984). The various groups of bacteria involve in methane production usually maintain a balance of their population (Yadawa and Hesse, 1981). This balance can be distorted and methane production disrupted by any or a mixture of many factors such as seeding and solid contents, loading Rate, pH , temperature, creation of anaerobic conditions, carbon/nitrogen ratio of input materials, retention time, stirring and toxic materials and elemental metal. (Singh 1971; Bell *et a*l, 1973; McCarry and Stainforth, 1978; Li, 1984; Angelidaki and Ahring, 1994; Ezeonu and Okaka, 1994; FAO, 1996)
Various types of biomaterials that can serve as feedstock for biogas plant include crop residues such as corn stover, soybean Waste, straw from maize, rice, wheat, cassava peel and saw dust (Ezehoye and Okeke, 2006, 2009). Plant materials are often shredded to facilitate

their flow into the digester and increase surface area for efficient bacteria action. Other materials that have been selected as Biomass for the production of biogas include kitchen Wastes, slaughterhouse Wastes, leaves, sewage (Singh *et al*, 1988), water hyacinth, salvinia and seaweed (Pawar, 1983, Casebow, 1987). However, these materials have been mixed in varying proportions to improve biogas yields (Pawar, 1983).

In most anaerobic digestion, inoculums are added in order to establish anaerobic microbial flora, eliminate lag phase and consequently increased biogas production (Kanwar and Guleri, 1994, Maishanu and Maishanu, 1998). These inoculums, which are biological active liquid or partially digested organic Waste medium rich in micro -organisms, may be sourced from cultured cells in the laboratory or natural sources. The natural sources include livestock droppings and dung (Ramasamy et al. 1990). Importantly cow dung and poultry dung have attracted the interest of many researchers in the production of biogas (Ramasamy et al. 1990; Preeti et al*.*,1993; Fulford, 1998) and recent findings have shown that rumen liquor are useful inoculums to optimize biogas production (Maishanu and Maishanu, 1998; Ezeonu et al, 2002; Uzodinma and Ofoefule, 2008)

Important brewery Waste is spent grains which are the solid fraction or cake obtained after filtration of the liquid-solid mixture obtained during mashing process which is the mixing of the crushed malted barley, raw and malted sorghum and maize grits with water at a given temperature, thus allow the extraction of colour and flavour from the crushed cereals. The mashing is carried out in two vessels namely mash turn and mash copper, one after the other generating useful liquid matrix (extract) which is further processed for making the solid matrix called cake. The cake is obtained as a solid fraction as the liquid-solid mixture is passed through mash filter (Plate and frame press filters) Metcalf and Eddy, (1991).

The biodigester is a physical structure, which facilitates various chemical and microbiological reactions and atimes known as bioreactor or anaerobic reactor. As a chamber, it should be air and water tight (Cortsen *et al,* 1995). It can be made of various construction materials and in different shapes and sizes. Construction of this structure, however, forms a major part of the investment cost. Some of the commonly used designs are Concrete biodigester (Thong, 1989; RERIC, 1990; FAO, 1996) which received low patronage due mainly to high cost, difficulty in installing and scarcity of spare parts for replacement.

Floating drum digester is characterized by a digester chamber made of brick masonry in cement mortar and mild steel drum on top of the digester to collect the biogas produced from the digester. It became obsolete within little time as a result comparatively high investment and maintenance cost along with other reasons that related to its design weaknesses. Fixed Dome Digester consists of an underground brick fermentation domed-chamber for gas storage as one unit (Chen, 1982). Its design eliminates the use of costlier mild steel gasholder, which is susceptible to corrosion. Other biodigesters designed in an effort to bring down the investment cost are the Deenbandhu model (Karki *et al,* 1994), Bag Digester and Plug flow digester.

Biogas is used mainly for cooking, lightning purposes as well as Fuel in Fuel-type refrigerators. It is also used in internal combustion engines to power water pumps and electric generators. The most economical benefits are minimizing environmental pollution and meeting the demand of energy for various purposes. It has a positive impact on deforestation and is an inexpensive solution to problem or rural Fuel shortage (Li, 1985). The aim of this study is to produce biogas from brewery spent-grain and rice husk using poultry Waste as natural inoculums in a relatively cheap and affordable plastic biodigester.

MATERIALS AND METHODS

Sampling

The spent grain used was obtained from Sona Brewery Plc, Sango Otta, Nigeria. Rice husks were acquired at Saja Rice Mill in Ogbomoso South Local Government Area of Oyo State, while the cattle dung was acquired from an Attendant abattoir in Ogbomoso North Local Government Area of Oyo State, both in Nigeria. The storage tank of 1000 litres capacity was purchased at Oja-tuntun Plastic Store, Ogbomoso. The project site chosen was the north of the Old Chemical Engineering Laboratory of Ladoke Akintola University of Technology, Ogbomoso. Other materials used include top loading balance (50 kg capacity, "Five goats" model no Z051599), thermometer (-10 to 110°C), welding hose pipes, water trough, cellophane gas holder, elbow joints, rubber hose, stoppers, PVC pipes, plugs, and connectors.

Modification of Storage tank

The storage tank, 1000 litres capacity, was modified to suite digestion. The cover of the plastic tank was bored in order to fix outlet pipe for the biogas. The centre of the base of the tank was also bored in order to serve as an exit for digested Biomass after the residence time. Two rubber stoppers were bored at their centres to hold thermometer that will measure the operating temperature of the digestion process. Rubber hose was cut into different sizes to connect the biodigester to the gasholder. The biodigester was completely sealed with a cellotape after the feed has been charged in order to make it airtight.

Experimental procedure

The selected materials were mixed properly with water to avoid scum formation on the surface of the liquid slurry inside the biodigester and to facilitate easy pour. The homogeneous slurry was poured through the top of the biodigester gradually and stirred after each feeding until the slurry reached marked point, 70 %, of the total digester volume. The biodigester was properly closed and the gas outlet pipe was fixed to gas line, which was properly connected to the gas collector, which was held in a position by a stand. The content of the biodigester was stirred properly for 15 min for the first five days to avoid sedimentation of the concentrate and formation of scum in the biodigester. The biodigester was carefully sealed to avoid leakages or the joints were properly tightened. The amount of gas generated per day was noticed and recorded for reference at the end of the experiment.

Analysis of Bio-fertilizer

The bio-slurry produced after the digestion process was analysed at Federal Institute of Research, Oshodi, Nigeria, to determine the elemental nutrients present. Evaporation and filtration methods were employed in the analysis. The sample was divided into two portions of 2.0 gm each. The evaporated sample (A) was placed in a water bath operating at 100^0C to remove water via evaporation while the filtered sample (B) was dewatered by filtration. The two samples were then dried in a solar dryer to constant weight. After drying, the two samples were milled to a uniform size before being digested. Then the analysis was accomplished using Atomic Adsorption Spectrophotometer (AAS).

RESULTS AND DISCUSSION

The daily quantity of biogas produced over the stated period is shown in Figure 1. The retention time of biogas production for this research work was 60days and production began on the second week after loading the biodigester. The gas produced for the first two days was expelled since it was suggested that it composes mostly carbon dioxide (Uzodinma, and Ofoefule, 2008). From figure 1, the mass of biogas generated on the first day of generation was 0.14g and was highest, 0.60 g, on the 24th day while the total mass of biogas generated was 16.86g for the 60 days retention time. Biogas generation declined from 25th to 45th day, but not as low as the gas generated within the first one week, this may be due to consumption of the substrate. Hence, biogas generation depends on retention time (Ezehoye and Okeke, 2006, 2009).

Likewise, the quantity of biogas generated per day varied with temperature of the substrates in the biodigester. The temperature rose and dropped for first few days and later became stable. This greatly influenced biogas generation as shown in Figure 2; the amount of biogas generated increased per day with low temperature and at high temperature, the amount generated reduced. Figure 3 shows variation in the temperature of the biogas generated was fluctuating and, this may be attributed to the variation in ambient temperature. The maximum temperature recorded was 41^0C while the minimum temperature recorded was 35^0C.

Figure 3 shows that maximum temperature recorded for the Biomass was 31^0C while the least temperature recorded was 20^0C. This temperature range 20^0C-31^0C is mesophilic; hence, the biodigestion process was done under a mesophilic condition. Figure 5 is showing the relationship between mass of biogas generated and biogas temperature, it was observed that highest generation was obtained at a temperature of 25^0C and the least was at temperature of 20^0C. Hence, generation is optimum only if a biodigester can be maintained at mesophilic condition. This is similar to the range of temperature (22-37oC) observed for the production of biogas from cow dung, spent grains/cow dung, and cassava peels/rice husk Wastes (Ezehoye, and Okeke, 2009)

The bio-fertilizer is in a powdery form, which can be easily handled, transported and stored for a long period. This has taking care of the problem of handling, storage, market value and other economical advantage of using the bio-fertilizer. From table 1, it was shown that the percentage of nitrogen, phosphorus and potassium in the evaporated sample was greater compared to that of filtered sample, therefore the evaporated process can be adopted to produce dry bio-fertilizer.

CONCLUSION

Biogas system is an appropriate technology solution for producing Fuel and fertilizer. From the experiment carried out on the brewery spent grains, rice husk, and poultry dropping; the biogas and bio-fertilizer made from these Wastes can be used as substitute for petroleum based gas and chemical based fertilizer. In addition, the number unit operations involved in the production of biogas is lesser than, that of natural gas and thus reducing its cost of production. Sustainable development is enhanced with biogas system as environmental pollutants are converted to useful products without further pollution of the environment from the products.

Within the limits of experimental error based on the results obtained, the following observations can be made: The quantity of gas generated was 16.90 grams. In addition, the mass of gas generated varies with optimum temperature of about 30-35^0C with no external heating but under natural condition and pH ranges of 6.5-7.5 (Alkaline or acidic medium would be lethal to the methnaogenic bacteria activities and will reduce production of biogas). The mean temperature range of the bottom and top of the biodigester are 25.30^0C and 38.50^0C because of temperature instability of the surrounding.

It can be concluded that the volume of gas obtained is inversely proportional to the temperature of the surrounding above or below the optimum temperature range. Thus, as temperature increases abnormally (about 40 - 42^0C), the mass of gas obtained decreases. In addition, the mass of gas generated is dependent on the digestion period. The volume of gas increases gradually until the peak was reached and then starts to fall again. However, the low yield of the flammable biogas generated may be attributed to lower pH of the contents of the bioreactor resulting from poor stirring (Uzodinma et al., 2007). In the treatment of the bio fertilizer, the evaporation process involves heating and thus an increase in energy cost but it gives a higher yield compared to the filtration process. There may be need for a trade off between increase production cost and maximum yield to determine which method is better suitable.

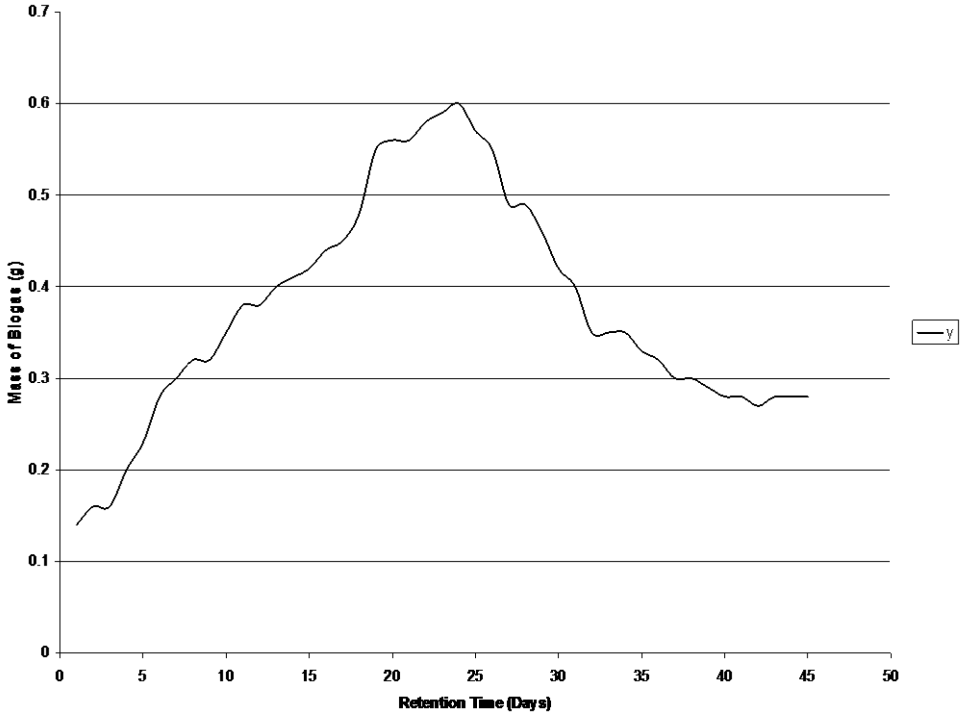

Fig. 1: Graph of mass of biogas generated against time

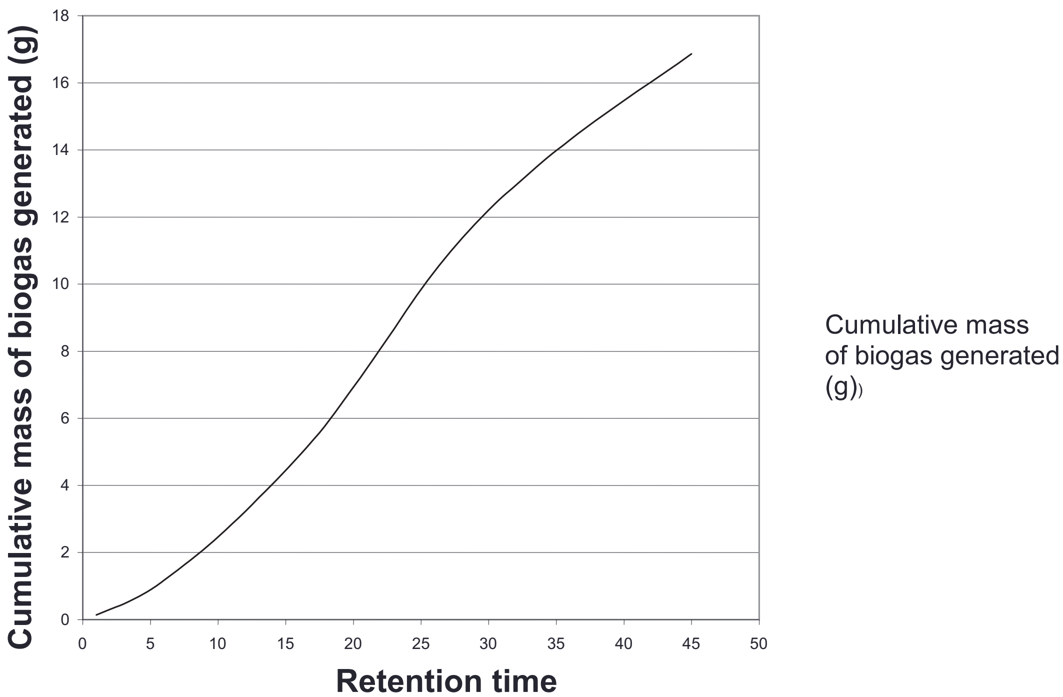

Fig. 2: Cumulative mass of biogas generated vs. retention time.

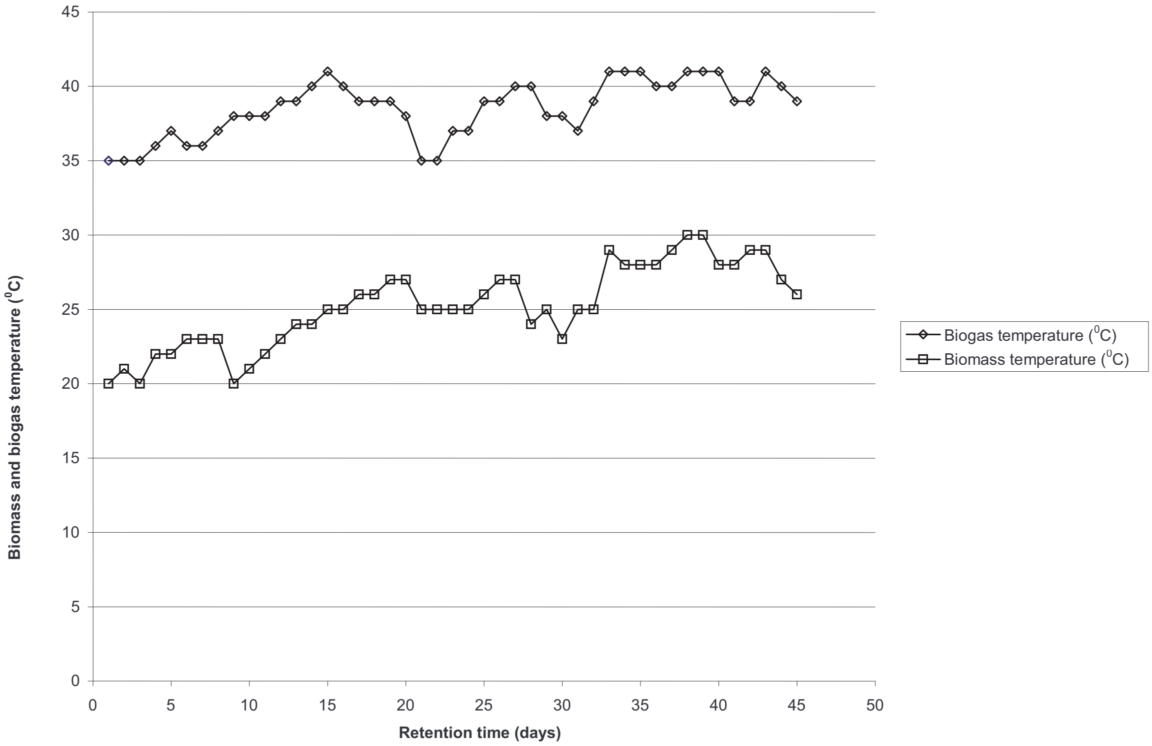

Fig. 3: Graph of biogas and Biomass temperatures against retention time.

Table 1: Analytical Result of bio-slurry

Element	Evaporated sample (A) (mg/g)	Filtered sample (B) (mg/g)
Nitrogen	1.28	1.22
Phosphorus	4.22	3.86
Potassium	0.068	0.052

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THE PYROLYSIS OF AGRICULTURAL RESIDUES FOR SUSTAINABLE ENERGY SUPPLY IN NIGERIA

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Abstract
There is rising demand for energy globally and major crude oil importers express concerns on the prices and sustainability of supplies. Biomass, which is a renewable energy source offers the potential of meeting all the energy needs on the farm. This paper discusses the use of pyrolytic technology in Nigeria, as one of the methods that can be used in converting Biomass especially Agricultural Residues into useful Fuels.
Also, the design and development of various machineries for the pyrolytic conversion of Agricultural Residues to medium – grade Fuels were discussed and their merits and their demerits were highlighted.

Keywords: Renewable energy, Sustainability, Pyrolytic, Technology, Biomass.

INTRODUCTION

Agricultural operation is an extremely energy intensive process. Energy is required on the farm at all the various stages of agricultural operations, from the land preparation to harvesting of crops and eventual processing of the crops. It is also needed in the farm for transporting harvested and processed crops from the farm to the market and urban areas. Energy is also required for power generation. The increased supply of large amount of energy inputs into the rural areas will surely lead to higher agricultural productivities.

The recent global energy crisis of the 1970s had led toward the use of alternative energy sources to replace the over-dependence on fossil Fuels (Czernik, et al. 1995). Biomass, which is a renewable energy source, offers the potential of meeting all the energy needs on the farm. It is either plant based or animal based. It can either be utilized directly as a solid Fuel, or can be converted into liquid or gaseous Fuels depending on the nature of the Biomass, especially the water content.

The methods that can be used in converting Biomass into useful Fuels include gasification, pyrolysis and anaerobic digestion (Babu, 2008). Pyrolysis as an alternative energy resource technology that could be used to supply energy has been defined as thermo-chemical decomposition of organic compounds in the absence of oxygen to produce char, condensible organic liquids (tar oils and acids) and non-condensible gases (Bridgwater, 2002; Babu, 2008).

Various pyrolysis technologies that have been developed around the world include the fixed bed system, gravitating bed system, fluidized bed system and the entrained bed system. Pyrolytic conversion can occur in batch process such as in fixed bed system or in continuous process such as in gravitating bed system. (Sabra, 1981).
The factors affecting the product yields during pyrolysis include important parameters such as temperature, pressure, time, reaction conditions and added reactants or catalysts (Bridgwater, 2002; Demirbas et al., 1997).Other factors affecting the products and their

yields in a pyrolysis process are condition and method of pyrolysis, feedstock type, heating rate, mineral matter, and the presence or absence of air in the reaction vessel (Soltes and Elder, 1978; Reed et al, 1983). Wang et al., 2007 have found out that the kinetic function of pyrolysis mechanism of seaweed is different from woody Biomass.
The products of pyrolysis have different chemical and Fuel properties. The heating value of char produced from the George Tech-Air process have been obtained to be between the values of 25.52 MJ/Kg and 30.16 MJ/Kg (Barnerd, et al 1985), and it is used both as domestic and industrial Fuels (Fuwape, 1982). The heating value of tar oil is given in general as being about 24.7 MJ/Kg (Anon, 1983). It had been fractionated into gasoline and diesel Fuels to run engines (Rajvanshi, 1986; Soltes, 1986). The heating value of pyrogas has been obtained as 1.510 MJ/Kg (Anon, 1983). Theorectically, pyrogas could be used on a farm as heat source, but in practice, its burning needs special installation (Hobson, et al 1977). Also, it is used to Fuel internal combustion engines in some agricultural establishments (Rajvanshi, 1986).
The products of pyrolysis from various Biomass materials have similar chemical composition (Soltes, 1986), but different physicochemical properties (Babu, 2008). The chemical composition of tar oils is very complex (Soltes, 1986). It is a multicomponent mixtures containing various groups of organic compounds such as sugars, aldehydes, acids and phenolics (Czernik, et al. 1995). Tar oil has been found to contain approximately 200 chemical constituents (Rajvanshi, 1986). Pyrogas was found to consist of carbon dioxide, carbon monoxide, methane, ethylene and ethane (Drummond, et al. 1996). When pyrogas was analysed by gas chromatography, it was found out that the volume of it depend on the temperature at which the pyrolysis reaction takes place (Shuller,1980). The pyroligneous acid contains a mixture of mEthanol, acetone, acetic acid and other chemicals (Sabra, 1981). Also, it has been found out that pyroligneous acid can be used as a preservative for embalming purpose in the rural areas (Oniya, 2000). Tar oil has a density of approximately 1.2 g/ml; a PH in the range of 2.5 –3.7, and a viscosity of 20 –80 cp. (Rajvanshi, 1986).
According to Rajvanshi (1986), the physical property of tar depends on temperature range and heat rate. He also stated that the appearance ranges from brown and being watery when it contains 60% water to black and being highly viscous when it contains 7% water.
The use of pyrolytic technology has received a lot of attention in the developed nations, whereas there is little work on its use in developing nations such as Nigeria. This paper examines the use and mode of operation of pyrolytic technology in Nigeria, as one of the methods that can be used in converting Biomass especially Agricultural Residues into useful Fuels.

DESIGN AND DEVELOPMENT OF PYROLYSIS PLANTS FOR THE PRODUCTION OF MEDIUM GRADE FUELS IN NIGERIA.

Most types of pyrolysis plants available in Nigeria are based on the design of a fixed bed system and were constructed using locally available materials. The plants consist of a pyrolytic retort which is heated directly in a furnace or by an electrical heating element.

Direct heated pyrolysis plant:- A pyrolysis plant to meet rural energy needs was developed by **Bamgboye and Oniya (2003)** for the thermochemical conversion of Biomass materials into a variety of Fuel products and chemicals, and it consists of a furnace, pyrolytic retort, condensate receiver unit, gas storage unit, the burner and pipelines connecting the units together (see Plate 1 & Fig 1). The pyrolytic plant was evaluated to determine its efficiency in converting corncobs to Fuel products. Also, an energy balance was drawn up between input Fuelwood, corncobs as feedstock for pyrolysis and Fuel products of pyrolysis.

The results showed that the pyrolysis plant has an energy conversion efficiency of 44.70%, while corncobs have a high potential of about 91.49% conversion efficiency to Fuel products of pyrolysis (Table 1). Although the process is not efficient, the products of pyrolysis were higher grade Fuels than the feedstock.

Advantages of direct heated pyrolysis plant.
(a) The technology is simple and easily adaptable to the rural areas.
(b) The materials of construction are cheap and locally available.
(c) It does not need high skilled professional to operate it.

Disadvantages of direct heated pyrolysis plant.
(a) The labour involved in operating the furnace that supplies the heat needed for pyrolysis is high.
(b) The inital cost of operation is high.

Plate 1: THE PYROLYTIC RETORT

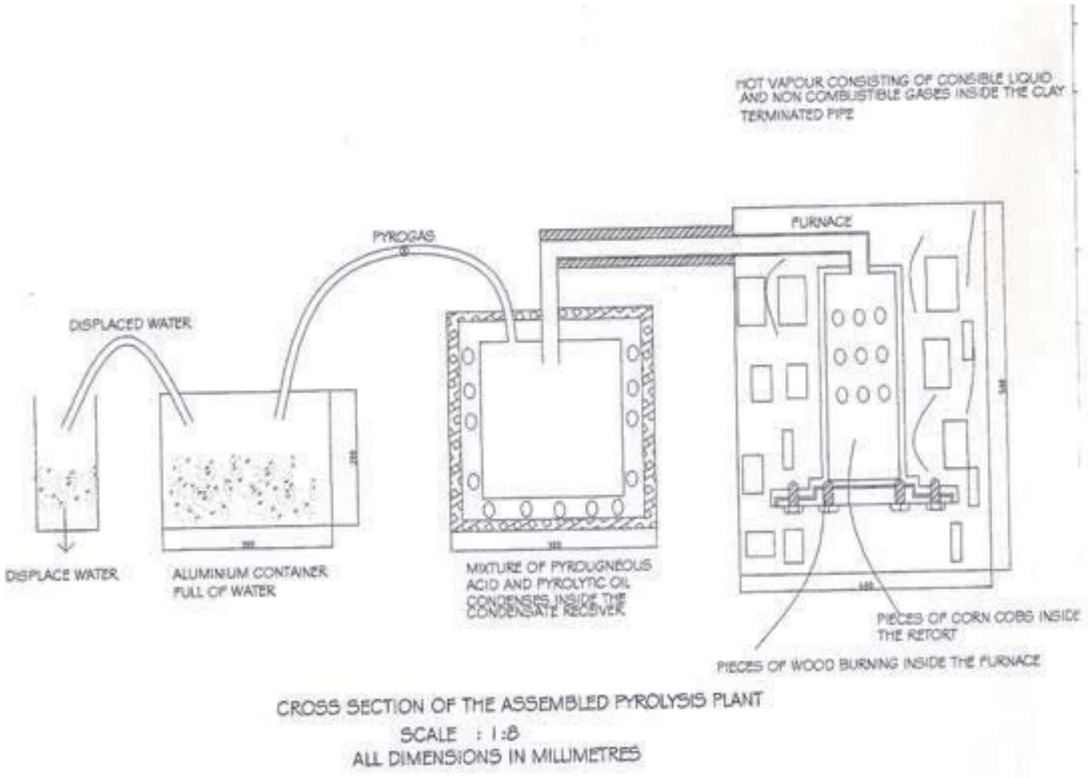

Fig 1: Cross-section of the pyrolysis plant developed by Bamgboye and Oniya (2003).

Table 1: Energy balance between input Fuelwood, feedstock and the Fuel products of pyrolysis.

Experi-Ment *No.*	**Energy Content *of tar, E_t* (KJ)**	**Energy content of *Pyrogas, E_g* (KJ)**	**Energy content of *char, E_{ch}* (KJ)**	**Total Energy *content of Fuel,* $E = E_t + E_g + E_{ch}$ (KJ)**	**Conversion efficiency *between Fuel products and* Feedstocks $\mu_e = \frac{100E}{E_c}$ (%)**	**Conversion efficiency *between products &* wood input in furnace $\mu_{eff} = \frac{100\mu_e}{E_f}$ (%)**
1.	666.90	53.56	1046.32	1766.78	98.51	44.70
2.	308.75	37.03	535.92	881.7	90.96	47.08
3.	209.95	24.30	280.72	514.97	84.99	42.31
Mean					**91.49**	**44.70**

KEY

E_c =Energy content in the corncob used for pyrolysis.

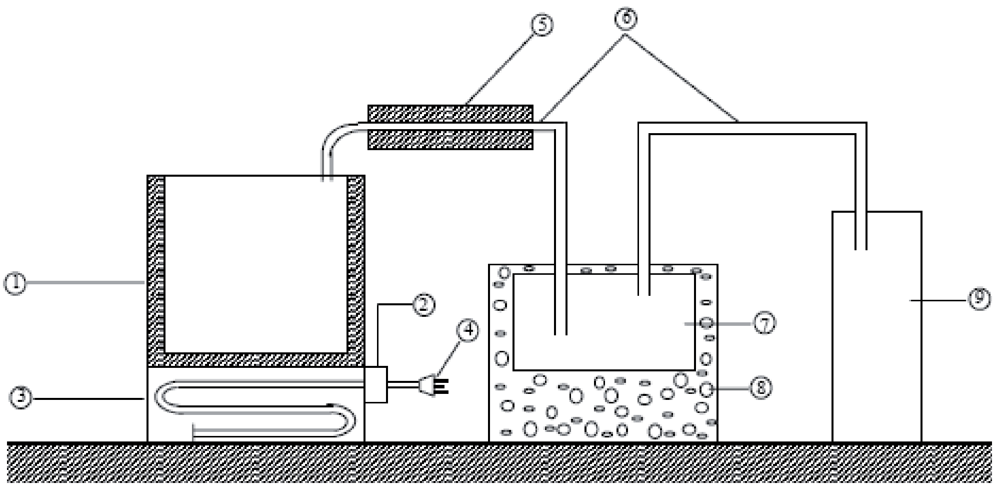

FIGURE 2:- Cross-section of electrically heated pyrolysis plant developed by Ojolo and Bamgboye (2005).

Electrically heated pyrolysis plant:- A 250 dm^3 pyrolysis reactor was designed, fabricated and tested for performance by Ojolo and Bamgboye (2005). The pyrolytic reactor consisted of a furnace which enclosed a retort, a gas holder, and the condensate receiver (Figure 2). The retort was connected to the condensing unit with copper pipes for easy handling. The cylindrical retort was constructed from 1.6mm thick mild steel. It was sealed at the bottom and had an air- tight cover to prevent emission of gases to the atmosphere and air entrance. A 3500W capacity heating element was placed at bottom of the retort. The heating compartment was well lagged with fibre glass to prevent heat loss to the atmosphere. A 12000C thermostat was used to control the temperature. The thermostat determines the feedstock residence time and the rate of heating. The connecting copper pipes used for the flow of the pyrogas were adequately lagged to ensure that the products were well condensed. The reactor has a capacity of pyrolysing 12kg dried Biomass residues. The temperature of pyrolysis was between 5000ºC and 6500ºC. The products of the pyrolysis were tar oil, pyrogas and char. The average yields of tar oil, char and pyrogas are 52.2%, 25.2% and 22.6% respectively. A Waste volume reduction of about 65% on the average was achieved after pyrolysis which is an advantage over land filling. Pyrolytic oil of between 5.27kg and 6.85kg was obtained which showed that the process has a potential for the treatment of Biomass residue and municipal solid Waste and is a good technology for resource recovery. The mean energy contents in char, tar oil and pyrogas are 89.89MJ, 151.66MJ and 4.03MJ respectively. This shows that the products of pyrolysis are higher grade Fuels than the Biomass feedstocks.

Advantages of electrically heated pyrolysis plant.
(a) The labour involved in operating the plant is low because electricity is employed in supplying the heat needed for pyrolysis.
(b) The materials of construction are cheap and locally available.

Disadvantages of electrically heated pyrolysis plant.
(a) It needs high skilled professional to operate it.
(b) The inital cost of operation is high.
(c) It cannot be operated in rural areas with no electricity.

CONCLUSIONS

Pyrolysis technology has the potential of being applied to the management of Agricultural Residues which is a cost-effective supply of feedstock for renewable energy generation. Pyrolysis can greatly reduce the Waste and odour emissions while producing energy.

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PRODUCTION OF PARTICLE BOARD FROM SAWDUST AS AN ALTERNATIVE TO SAWDUST INCINERATION

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Abstract
In recent years, there has been a growing interest in alternative use of sawdust against the use of open burning which constitute environmental pollution. Production of particle board from sawdust which permit efficient utilization of sawdust was examined as an alternative in this study. Sawdust powder and flex were carefully mixed, dried and blended with zinc chloride (0.5 - 2.5 Lt) and glue (100-150g). The strength test on the particle board was conducted at 99^0 C under accelerated –aging exposure which include vacuum- pressure soak plus oven-dry (VPS-OD), vacuum- pressure soak plus steam plus oven-dry (VPS-S-OD), hot water plus oven-dry (HW-OD) and steam plus oven- dry (S-OD) which all form part of the ASTM D1037 Six –Cycle Test. The ranges of in-plane shear strength for particles subjected to VPS-OD, VPS-S-OD: HW-OD and S-OD were 11-18, 8- 18.5, 8.25-17.5 and 11.5 -20 mpa respectively while the ranges of their modulus of rupture (MOR) were 0.3 – 3.9, 0.25 – 3.4, 0.2 – 4.2, and 1.0 – 4.8 mpa respectively. It is believed that using sawdust to produce particle boards will help to conserve the environment.

Keywords: Sawdust, Particle board, Modulus of Rupture, Shear strength, Environment.
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INTRODUCTION

Sawdust and related wood by-products from sawmills are traditionally incinerated at most sawmills as economical means of disposal. However the common open pit incineration has adverse environmental implications, particularly generation of pollutants like polyaromatic hydrocarbons (PAHs) which are carcinogenic and oxide of some elements like nitrogen oxide (NOx) and sulphur oxide (SOx) (Currie *et al.*, 1999; Mastral *et al.*, 1999; Liu *et al.*, 2001; Crisafully *et al.*, 2007). Furthermore, the open pit incineration has been identified to be more harmful to human health than previously thought and increases the risk of heart disease as well aggravate respiratory ailments such as asthma and emphysema, and cause rashes, nausea, or headaches (EPA, 2006).

However with the large amount of this solid Waste produced by the industry and which demand effective disposal then called for their use for the production of value-added products (Fuwape, 2001; Erakhrumen, 2006). Such use include production of composite comprising these sawmill by-products and other vegetal materials such as cement-bonded particleboard (Ajayi, 2002; Almeida et al., 2002; Wang and Sun, 2002; Mo et al., 2003; Winandy et al., 2003; Okino et al., 2004; Pan and Cathcart, 2004; Olorunnisola, 2006; Bamisaye, 2007; Zheng et al., 2007). It has, however, been reported that Agricultural Residues are renewable and environmentally friendly alternative Biomass resources for domestic and industrial high demand for woody materials (Sampathrajan et al., 1992; Kozlowski and Helwig, 1998).

Particleboard is generally considered as type of reconstituted wood product manufactured from lignocellulosic materials. It is primarily in the form of discrete particles combined with a suitable binder and bonded together under influence of heat and pressure. The raw material for particleboard normally consists of wood particles, primarily wood chips, sawdust, and planer shavings. Other forms of reconstituted wood products include, such as waferboard, oriented strandboard, medium density fiberboard, and hardboard (Haygreen and Bowyer, 1989)

It is commonly sourced for structural applications in the construction industry, for bracing walls and flooring (EST, 2006) and there is an increasing demand of this material especially for housing construction and furniture manufacturing (Youngquist, 1999; Sellers, 2000). Particleboard is produced in densities ranging from around 590 - 800 kg/m^3. The general steps for producing particleboard from include size classification, drying, blending with resin, forming the blended material into mat, hot pressing, and finishing. The six-cycle accelerated aging test is on of the recommended test for mat-formed panel products derived form wood source (ASTM 1993). It consists of six repetitions of the combined treatments consisting of immersion in water at 49^{0}C for 1h, steaming at 93^{0}C for 3h, freezing at -12^{0}C for 20h, drying at 99^{0}C for 3h, steaming at 93^{0}C for 3h, and drying at 99^{0}C for 18h.

It has however been considered time consuming particularly for in-plant quality control procedure (ANSI, 1993). In this wise some studies have shown the possibility of shortening the exposure without significantly altering the test results (Kajita et al, 1990; George et al, 1992). Thus the applications of cyclic vacuum-pressure soak and drying (VPSD) treatment which correlated well with the ASTM six-cycle test is proposed for the boards. Vacuum pressure soaking and drying (VPSD) consists of a vacuum pressure soaking and drying procedure. It involves soaking the material under a vacuum for 0.5h, soaking under a pressure of 290 kPa for 1h, and drying at 60^{0}C for 22h. (Karlsson et al,. 1996). The aim of this study is to produce particle board from Waste sawdust as an alternative to usual open-pit incineration and to investigate its properties using Vacuum pressure soaking and drying (VPSD) test method.

MATERIALS AND METHODS

Materials

Red wood saw residues were obtained from Apake Saw Mill (Industry) in Ogbomoso, Oyo State, Nigeria and were transported to the L.A Gbadamosi Chemical Engineering Laboratory in Ladoke Akintola University, LAUTECH, Ogbomoso. These materials were sun dried to constant weight to remove moisture content. Furthermore, non-wood materials in the mixture were carefully removed with hand and the wood saw residues were screened into sawdust and flex. These were further air dried at room temperature for three days.

Methods

Different percentage of sawdust to flex (0/100; 20/80; 40/60; 60/40; 80/20; 100/0 % w/w) were blended with various volume of glue and zinc chloride, as additives, in an aluminum batch reactor. Each mixture was stirred continuously for 30min to obtain homogenous mixture. The mat forming process was carried out manually using a wooden box (mold) of dimension 350 x 350 x 6 mm (figure 1) (Bamisaye, 2007; Erakhrumen et al., 2008). The mold was placed on a metal caul plate and covered with a polythene sheet. The mixtures were then spread uniformly with plastic hand trowel on the mat in these boxes. After the mat had been formed, another sheet of polythene sheet was placed on the top of the mat in order to prevent the mat from sticking to the platens and to obtain smooth board surface during the pressing process (Zaido et al, 1998). The mat was then flat-pressed manually to obtain a uniform shape before being hot-pressed at 125°C for 270s (Zaido et al, 1998). The properties of the particle board were further improved with sand after which they were hot conditioned in the oven at 60^{0}C for 5h. The particle boards were checked for defects and those that were defective were repeated in order to meet experimental design. Finally, the boards were further conditioned in a room (65± 5% RH and 20±2°C) for one week before (Zaido et al, 1998), and edge defects were eradicated by trimming the edges of the boards before being subjected to test for Moduli of rupture and elasticity (MOR and MOE) and six-cycle test ASTM D 1037-96a (1998).

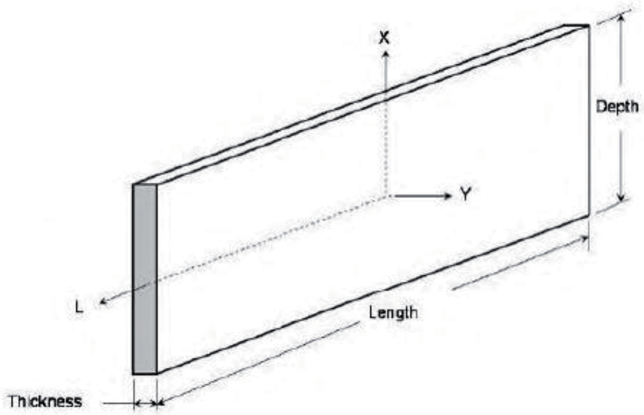

Fig. 1: Typical shape of particle board

The test study consisted of five cyclic accelerated-aging exposures of the wood-based products followed by a determination of selected properties. The five accelerated-aging exposure methods were vacuum- pressure soak plus oven-dry (VPS-OD), vacuum- pressure soak plus steam plus oven-dry (VPS-S-OD), hot water plus oven-dry (HW-OD) and steam plus oven- dry (S-OD). A common temperature of 100^0C was applied to all. In the VPS exposures, the samples were submerged in water in a pressure vessel (88-kPa vacuum-pulled) for 30 minutes in which the initial value of the samples were noted. Then the 345-kPa pressure was applied for 1 hour, after which the specimens were re-measured and tested in accordance to ASTM D 1037. The pressure vessel has been programmed to for the in-plane shear strength and modulus of rupture (MOR) as well as thickness swelling. These values were recorded for the all the samples.

RESULT AND DISCUSSION

Physical and Mechanical Properties of the Particleboard

Table 1 shows compositions of the composite mixture produced for the mat making process while the average in-plane shear strength and modulus of rupture (MOR) of the particle board samples before the test were presented in figure 2. The modulus of rupture is the magnitude in which the particle board sample can be easily break or bend and it is considered to determine the strength of each particle board sample. Particle board sample with 100% flex has the highest MOR (33.3 mPa) followed by particle board sample with 100% sawdust (28.7 mPa). The values of the other Particle board sample various percentages of flex and sawdust, S2F8, S4F6, S6F4 and S8F2 were 20.9, 20.0, 22.7, and 20.8 mPa and were lower than values obtained for S0F1 and S1F0. This shows that particle size variation affect the modulus of rupture (MOR) of the particle board samples. The in-plane shear strength of the particle board samples ranged from 2.5 – 6.6 mPa. S8F2 had the highest value (6.6 mPa) while S6F4 had the lowest value (2.5 mPa). The densities of the particle board sample produced ranged from 0.43to 0.55 g/cm^3 (table 1) which is les than usual density range for commercial particle boards (0.59 – 0.8 g/cm^3) and that may be linked to the type of wood type selected for the experiment.

Table 1: composite mixture of particle board

Sample	Sawdust (%wt)	Flex (%wt)	Glue (g)	ZnCl (ltr)	Density (g/cm^3)
S0F1	0	100	100	0.5	0.47
S2F8	20	80	110	0.7	0.43
S4F6	40	60	115	1.0	0.46
S6F4	60	40	120	1.5	0.55
S8F2	80	20	125	1.6	0.47
S1F0	100	0	150	2.5	0.45

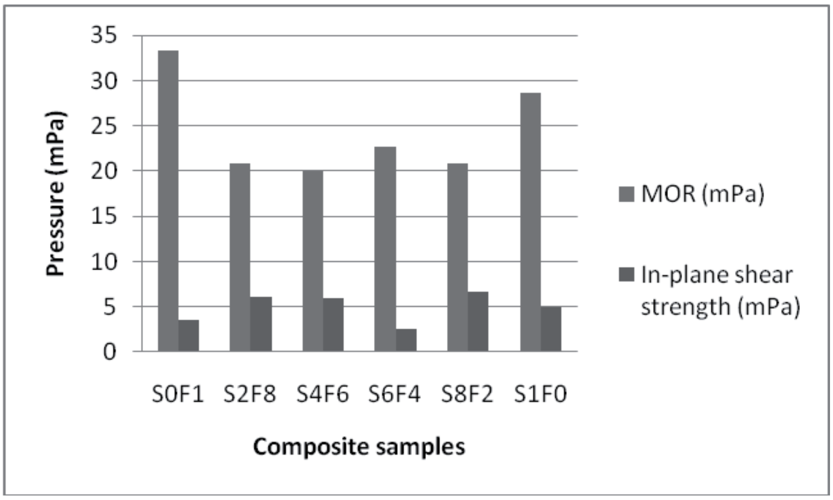

Fig. 2: Initial properties of composite mixture of particle board

Result of accelerated-aging exposures test of the particle board samples

The values of modulus of rupture (MOR) of the particle board subjected to accelerated aging exposure test are shown in table 2. The values of modulus of rupture (MOR) for the ASTM method (7 - 17 mPa) were compared with values obtained for the vacuum- pressure soak plus oven-dry (VPS-OD) (11- 18 mPa), vacuum- pressure soak plus steam plus oven-dry (VPS-S-OD) (8 – 18.5 mPa), hot water plus oven-dry (HW-OD) (7.5 – 17.5 mPa) and steam plus oven- dry (S-OD) (11.5 – 20 mPa) for all the particle board samples produced. The values of VPS-OD, VPS-S-SOD, HW-OD and S-OD obtained for the particle board samples are slightly high than the ASTM values except for S1F0. The order of strength for the VPS-OD test is S0F1>S8F2>S2F8≡S4F6>S6F4. Similarly, the values of in-plane shear strength of the particle board obtained for ASTM test (0.2 – 3.8 mPa) were compared with values obtained VPS-OD (0.3 – 3.9 mPa), VPS-S-OD (0.25 – 3.4 mPa), HW-OD (0.2 – 4.2 mPa) and S-OD (1.0 – 4.8 mPa) of all the particle board samples produced (table 3). The values of VPS-OD obtained for the particle board samples are above the corresponding values for ASTM test. The order of in-plane shear strength of the particle board for the VPS-OD test is S2F8>S0F1≡S8F2>S4F6>S6F4.

Table 2: Modulus of rupture (MOR) of accelerated-aging exposures test of the particle board samples (mPa)

	Exposure methods (mPa)				
Sample	ASTM	VPS-OD	VPS-S-OD	HW-OD	S-OD
S0F1	17	18	18.5	17.5	20
S2F8	9	12	10.5	11	11.5
S4F6	9	12	8.5	8.25	13
S6F4	7	11	8	7.5	12
S8F2	11	13	10	9	-
S1F0	17	-	-	-	19

Table 3: In-plane shear strength (MOR) of accelerated-aging exposures test of the particle board samples (mPa)

	Exposure methods (mPa)				
Sample	ASTM	VPS-OD	VPS-S-OD	HW-OD	S-OD
S0F1	2.2	2.3	2.2	2.1	2.8
S2F8	3.8	3.9	3.4	4.2	4.8
S4F6	0.3	0.8	0.6	0.4	1.0
S6F4	0.2	0.3	0.25	0.2	1.0
S8F2	2.2	2.3	1.3	1.3	-
S1F0	2.8	-	-	-	3.0

CONCLUSION

The accelerated-aging test was carried out on the particle boards produced from the mixture of wood sawdust and flex in various weight percentages. The physical and mechanical properties of particleboard produced in this study are affected by the composite mixtures of the sawdust and flex with the additives. These particle boards were subjected the applications of cyclic vacuum-pressure soak and drying (VPSD) treatment which correlated well with the ASTM six-cycle test is proposed for the boards. The VPSD test shows that qualitative particle board can be produce from sawmill wood Waste in form of sawdust and flex rather than environmentally adverse incineration process they are traditionally subjected to.

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PROCESSING AND UTILIZATION OF AGRICULTURAL RESIDUES AND FOOD SCRAPS FOR ENERGY GENERATION IN NIGERIA

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Abstract
Million tonnes of Agricultural Residues and food scraps otherwise regarded as bioWaste are increasingly being generated in Nigeria on daily basis with little or non-utilization. These constitute environmental hazard, and often times result to health problems. However, emerging technologies revealed that bioWastes could be used for combustion and non-combustion purposes. Combustion uses could generate energy for the nation in the form of Biofuels and biogas for domestic cooking, industrial Fuel, and heat generation of about 800^0C temperature and calorific value of 5,650kcal/m^3 of gas. Non-combustion uses include production of building material, composting, animal feeds and bedding, chemical, paper and board etc. BioWastes therefore have great potential for energy generation to ameliorate the erratic nature of energy production and supply in Nigeria and thereby enhance the income generation of the country.
Two things will be achieved through the economic utilization of bioWastes; (i) the environment is rid of offensive materials to the barest minimum (ii) the economy of the nation is enhanced through non-oil export goods.
This paper gives insight into potential energy generation from bioWastes through the uses classification.

Keywords: Agricultural Residues, Food Scraps, Combustion, Non-Combustion, Biowastes, Biogas.

INTRODUCTION

Although Nigeria is an oil-producing country and operating a monopolistic economy driven by petroleum but it is on record that over 75% of the country population is involved in (Agricultural Produciton) activities. This include cultivation of different crops such as; maize, rice, cowpea, cassava, groundnut, cotton, cocoa, oil palm etc, and rearing of livestock such as; poultry, pigs, cattle, goat, sheep, fishes etc. Apart from the production of food and fibre for the use of mankind, significant quantities of Agricultural Residues and food scarps are produced as by-products of (Agricultural Produciton). Although detailed statistical records of the generation and disposal of these are not readily available in Nigeria, but it could be assumed that million tonnes of these residues are increasingly being generated on daily basis with little or non-utilization. And because bulk of these materials remain non-utilized, their disposal becomes a major problem due to their scattered and seasonal availability, bulky nature, low density, and physio-chemical characteristics. Further to the problem of disposal is the fact that bioWastes obviously constitute environmental hazard which often times result to health problems.
However, with new and proven technologies it should be noted that 'Wastes' are fast being turned into 'wealth' through the provision of raw materials for production of economic goods and job creation for teeming unemployed population.

Definition of Agricultural Residues and Food Scarps

Agricultural Residues can be defined as crop residues remaining in fields after harvest (primary residues) and processing residues generated from the harvested portions of crops during food, feed and fiber production (secondary residues). Agricultural Residues include; straw, stalks, husk, cobs, shells, sticks, peels, animal dung, refuses etc. Food scraps, broadly defined, include both the portion of harvested crops and livestock that does not enter the retail market and the portion of food discarded by retailers and consumers. These include those that are produced through spoilage, removal of unusable portions, discard of excesses and substandard products, and packaging failure.

Combustion Uses of Agricultural Residues and Food Scarps

Combustion is simply the chemical combustion of the constituents of a Fuel (which could be in form of solid, liquid, gaseous) with oxygen, usually accompanied by the evolution of heat. In its broad definition, combustion includes fast exothermic chemical reactions, generally in the gas phase but not excluding the reaction of solid carbon with a gaseous oxidant. Flames produced represent combustion reactions that can propagate through space at subsonic velocity and are accompanied by the emission of light. (Encyclopedia of Science and Tech. (4), 2007). In the course of the chemical reaction, energy is released in the form of heat, and atoms and free radicals, all highly reactive intermediates of the combustion reactions, are generated. The main combustion use of Agricultural Residues and food scraps is for Fuel. USEPA report No. AP-42, 1995 observed that approximately one-third of California's Biomass energy plants were built in the state's agricultural regions in order to use their residues as Fuel, and also that Agricultural Fuels currently provide about 20 percent of the state's Biomass Fuel supply. Agricultural Residues suitable for Fuel use in solid-Fuel Biomass energy plants include; food processing residues, such as; pits, shells, and hulls, field straws and stalks, orchard and vineyard removals and pruning. Table 1.0 presents energy content of various Agricultural Residues and their suitability for Fuel.

Table 1: Energy Content of Various Biomass

S/N	Agric. Residues	Moisture content (wb)%	Ash content %	Calorific value Kcal/kg
1.	Paddy straw	10.6	21.0	3000
2.	Rice husk	9.6	15.5	3440
3.	Mango leaves	9.8	18.0	3390
4.	G. nut straw	12.1	1.3	4200
5.	G. nut shell	12.0	1.3	4200
6.	Cow dung	8.5	21.7	3290
7.	Bagasse	15.0	1.0	3800
8.	Cow dung cake	4.3	33.2	3240
9.	Wheat straw	18.0	18.0	3800
10.	Cotton sticks	12.0	13.5	3300
11.	Maize stalks	11.5	14.2	4700
12.	Maize cob	8.0	13.8	3500
13.	Grain straw	9.2	13.2	3950
14.	Mash straw	7.8	13.4	3920
15.	Coconut shell	6.0	-	4350
16.	Oil seeds residue	-	-	4775
17.	Bamboo cane	10.5	-	3925
18.	Buck wheat husk	10.0	-	3925
19.	Fire wood	-	-	5000
20.	Oak wood	13.0	-	3810
21.	Oak bark	7.0	-	4310

Source: T.P. Ojha and A.M. Michael (2006). Principle of Agricultural Engineering Vol.1 Jain Brothers (New Delhi)

Traditionally, many of Agricultural Residues are directly burn as Fuel for cooking by people in rural area and this represents direct combustion. However, adoption of appropriate technology can be used to convert these Wastes into a value-added Fuel. In this paper, some of these technologies shall be discussed for production of Biofuels.

a. Pyrolysis

Pyrohsis is defined as the destructive distillation of organic material heated to more than 200^0C in the absence of oxygen. (Ojha and Michael, 2006). The products of pyrolsis include solid char, liquid tar, gaseous fractions and organic liquid. Liquids products contain oils and chemicals while, the gaseous fractions are the hydrogen, CO_2, CO, CH_4, other hydrocarbons, and nitrogen. The nature and quantity of each of these products of pyrolsis is determine by some factors such as; rate of temperature changes, chemical composition of residues, processing time (duration). The products of pyrolytic process, especially liquids and gases can be useful as Fuel for I.C.E, industrial Fuel, domestic Fuel etc. (Kerdsuwan and Suthum, 2007).

b. Gasification

Gasification process is another combustion uses of Agricultural Residues to produce value-added Fuel. This involves the combustion of bioWastes (Agricultural Residues and food scarps) in a controlled atmosphere. This involves burning of tightly packed organic matter with a limited air supply at temperature above 1100^0C. This gives producer gas which has an energy content of about one sixth of petroleum gas (Sahay and Singh, 2001). With abundant availability of bioWastes in Nigeria, these can be converted to useful gases and thereby reduce overdependence on fossil Fuel and at the same time diversify the mono-economy type of the nation.

c. Biogas Production Technology

Biogas is an important renewable source of energy that could be derived from bioWastes. Biogas production processes produce a clear and odourless combustible gas mainly methane (50-70%) and carbon dioxide (30-40%). It burns with a clear blue flame without smoke which is non-polluting. The temperature of the heat generated through burning of biogas is about 800^0C and has a calorific value of 5,650Kcal/m^3 of gas (Ojha and Michael, 2006). The biogas can be used for cooking, lighting, heating of simple domestic appliances.

Raw material for the production of biogas are bioWastes such as; cattle dung, human excreta, crop residues like leaves, stems, grasses, kitchen Wastes etc. which could have created filthy and polluted environment.

The process of biogas production involves a decomposition of bioWastes anaerobically in an air tight drum otherwise called ‘digester’. A gas holder collects the gas produced which could be used for domestic purposes. The digested mixture of slurry can be used on the land as a soil conditioner or organic fertilizer.

Biogas plant is common in several countries of Asia today. It is estimated that India has over. 10,000 plants in operation, Korea has about 29,000; Taiwan 7,000; China 80,000; etc. (Joshua M. et al, 2000).

Among factors that improve the biogas production include; temperature range of 26^0C-35^0C, slow agitation/mixing of slurry, pH value of 7-8, type of basic organic material etc. (Sahay and Singh, 2001).

Further to utilization of bioWastes for heat and biogas production, there is untapped potential for the production of Ethanol and Biodiesel through fermentation of some Biomass such as; jathropha, Cassava, castor oil etc. Considering the fact that over 75% of Nigeria population is involved in agricultural activities (both crop and livestock production), it can be deduced that large quantity of residues (bioWastes) are being generated. And having identified these Wastes as high energy potential and highly combustible materials, therefore they could serve as alternative sources of energy, especially in rural areas. These technologies could also be exploited to the advantage of our nation's economy and at the same time rid the environment of pollution-causing materials.

Non-Combustion Uses of Agricultural Residues and Food Scraps

Non-combustion uses of bioWastes include any other uses different from generation of heat. Some of these uses are hereby discussed;

a. Building Material

According to Sahay and Singh (2001), it was reported that in India, mixture of rich husk, red mud, fly ash, and some clay soil can be suitably processed to make an inexpensive cement-like binders. The binder can thus be used for structure works such as; masonry, flooring, non-structural concrete. They further mentioned that rice husk can be used to produce ash bricks. The process involves burning of the rice husk, then grind the resultant ash and mix it with 10% lime. This mixture is moisture with water and the bricks cast in suitable moulds and later cured.

Bamboo is another useful building material which when properly cured could be used for building suitable structures, construction of bicycle frame, turning bamboo pulp into soft-texture paper etc.

b. Composting

Food scraps and other organic Waste can be used for composting. Composting is the biological decomposition of organic substances available in the Waste under controlled conditions. Rotting and putrefication are natural processes that take place in a controlled manner. Composting converts the organic content of refuse into a soil conditioner which can improve the fertility and structure of agricultural soils. Composting involves the laying of alternate layers of sort and putrescible material such as; night soil, animal dung, garbage, household refuse, crop residues etc. The compost can be produced both anaerobically and aerobically.

Shrivastava (2004), reported that the sale of compost to farmers can help to offset the running costs of a town's Waste disposal system as the practice in India and China.

Certain Agricultural Residues can also be spread upon farmland and plough into the soil as nutrients for the soil. It has also been discovered that removal of residue could result in erosion and loss of soil nutrients. But a blend of suitable proportion of some Agricultural Residues such as; dry poultry Wastes and dry organic matters would produce organic fertilizer which is more beneficial to the cropland than inorganic fertilizer.

c. Feeds

Some Agricultural Residues and food scraps could serve as feeds for livestock. Primary Agricultural Residues such as; maize stalks, straws, groundnut shells are good feeds for ruminant animals. However, rice bran, wheat oval, brewery Wastes, palms kernel cake (after oil extraction from the palm kernel) are economic feeds that can be commercialized.

Sahay and Singh (2001), reported that animal Wastes contain considerable amount of energy and nutritive value, almost 50% higher in crude protein than the conventional feeding ration. And that farm Wastes such as poultry droppings, cattle dung and other fine textured cellulose materials have been identified as potential alternative feed sources especially for ruminants.

Rice bran is a good source of oil proteins and high grade edible oil is extracted from raw bran, which when refined it is rich in vitamin E and other nutrients and has advantageous effects in lowering blood cholesterol level.
Among other non-combustion uses of Agricultural Residues and food scraps include provision of animal bedding, pulp, paper and boards.

CONCLUSION

With entire world desiring to have an alternative source of energy to fossil Fuel due to the effect of its combustion on ecosystem in terms of pollution, climate change and possible depletion in the future, bioWastes could be an alternative source of energy. And being a renewable form of energy could make it more reliable.
The production of economic products from bioWastes is an opportunity which the nation-Nigeria could exploit to enhance foreign earning. This will reduce overdependence of the nation on oil and its products.
The collection and processing of bioWastes is a job creation opportunity for the large number of unemployed population of Nigeria. It will stem the crime rate and leave our environment clean.

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POTENTIALS OF BIOGAS FROM AGRICULTURAL RESIDUES AS A SOURCE OF ENERGY

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Abstract

The demand for energy has increased in the country due to population increase but the supply has been greatly hampered due to inefficient electricity supply and shortage of petroleum products. This has resulted in an energy crisis which is more severe in the rural areas. Biogas as an alternate energy source is receiving a lot of attention because it is renewable. Biogas production from agricultural residue, a major by-product from farming activities, will help reduce the environmental and health hazards these residue dumpsites constitute while providing a clean and particulate-free energy source. Few units of biogas digesters have been in use both in the urban and rural segments of the country for various activities but the level needs to increase in order for it to provide a solution to the energy supply deficiency in the country. This paper examines the potentials of benefits and limitation of the use of biogas as an energy source. Recommendations on how to overcome the limitations are also made.

INRODUCTION

Energy utilization in the country varies according to its use which majorly includes electricity and energy for heating. However the energy sector in the country has been plagued with a lot of problems. This is because the increase in population has resulted in a higher demand for energy and fulfilling this demand is one of the aspects of the Federal Government's MDG and 7 point agenda. The major sources of energy in the country include Biomass, hydro, natural gas and petroleum oil. Fuelwood is the primary source of Biomass, derived from natural forests, plantations, woodlots and trees around the homestead (Agarwal, 1998). Conventional energy from fossil Fuels (coal, petroleum and gas) is depleting due to total dependence on it by man and yet it is non-renewable. There is therefore the need for development of technologies using new and renewable sources of energy like solar, wind, hydropower, and Biomass. Advantages of these renewable energy sources include pollution free, unlimited, and cheap; preservation of the ecosystems and retardation of environmental degradation.

The depletion of fossil Fuels and shortage of petroleum products in the country has resulted in an energy crisis (both commercial and traditional energy resources) occurring in both the urban and rural areas. However a greater shortage has been experienced in rural areas where it is assumed that 75% of populace in the country lives presently (Akinbami et al., 2001). This has made the recurrent national energy crisis to have a more deepening impact on the rural areas than the urban areas. The energy crisis has thus led to a general dependence of poor urban and rural households on Biomass for their energy needs. Thus the lion's share of the total Biomass use in the country is by the rural households. This dependence on Biomass has resulted in depletion of forest reserves which have a negative effect on the environment. This has also resulted in increasing scarcity of the more desirable types of wood which has led to greater use of lower quality wood. The use of lower quality wood will require a greater quantity of wood to produce similar energy supplies as previously supplied by good quality wood. This implies that it will become harder and harder for the Biomass, especially

Fuelwood, to meet energy requirements of the populace as the population increases. This has its own attendant socio–economic impacts which include less light, less warmth, less cooked food and of course health problems. Furthermore, some environmental problems have been observed to be associated with intensive and inefficient use of wood for Fuel. This has led to the need for alternate energy sources especially in the rural areas which have culminated in research on biogas (energy from plant/animal origin) production.

Use of Agricultural Residues as biogas sources

Biogas is produced by the biodegradation of organic material under anaerobic conditions. Thus biogas arises from the bacterial decomposition of organic matter in the absence of air. Waste disposal is a serious issue in the country since most Waste is dumped on solid Waste dump sites especially in areas inhabited by the poorer segment of the society who lacks access to proper infrastructure to maintain even the minimum level of hygiene. Waste management practices are however targeted at municipal Wastes rather than agricultural Wastes. Most agricultural Waste are dumped indiscriminately by the roadside or farm site or abattoir sites in the country since it is assumed to decompose to become soil. This poor agricultural Waste management results in an increase in environmental pollution which causes harm to human health. The large quantities of environment degrading solid Waste dump sites which are generally located in areas inhabited by the poorer segment of the society can therefore be utilized for biogas production. Some of the common biogas producing materials (substrates) ranges from animal dung to household, agricultural and industrial Wastes. In Nigeria, identified feedstock substrate for an economically feasible biogas programme includes water lettuce, water hyacinth, dung, cassava leaves, urban refuse, solid (including industrial) Waste, Agricultural Residues and sewage (Akinbami et al., 1996). The use of Waste especially agricultural Waste for biogas production will reduce environmental pollution as well as provide a source for energy production in the country. The use of agricultural Waste for biogas production in rural areas will also go a long way in solving the problem of energy unavailability in these areas because of the abundance of agricultural Waste as compared with other sources of Waste within the localities. It has been estimated in 1982 that Nigeria produced about 227,500 tons of fresh animal Wastes daily thus 6.8 million m^3 of biogas can be produced each day, since 1 kilogram (kg) of fresh animal Wastes produces about 0.03 m^3 gas (Matthew, 1982).

Biogas production and its success as an energy source has been reported in many countries and countries which have developed biogas plants include Phillipines, Taiwan, China and India (Akinbami et al., 2001). In China and India at least about 6.5 million and 1.8 million biogas plants respectively are already in use (Kharbanda and Qureshi, 1985; Tomar, 1994; Akinbami et al., 2001). Biogas production has been reported in a number of African countries including Botswana, Egypt, Ethiopia, Ghana, Morocco, Rwanda, Senegal, Sudan, South Africa, Swaziland (Rubindamayugi and Kivaisi, 1993). In Nigeria however substantial work has been done on biogas production and work is still in progress on it (Dangogo and Fernando, 1986; Adeoti 1998; Itodo et al., 2007). Common Agricultural Residues identified in the country are shown in table 1.

Table 1 Available biogas substrates from agricultural residue

	Type	Source
A	Animal dung	Cow
		Buffalo
		Chicken
		Pig
		Duck
B	Crop residues (air dry)	Corn stalk
		Rice straw
		Corn cobs
		Peanut shells
		Baggage
		Grass trimmings

Source: Akinbami et al., 2001

Benefits of utilization of biogas as an energy source.
The use of biogas as an energy source from agricultural residue has a lot of benefits which can be examined either as benefits in general regardless of whether is being used in the urban and rural areas or those benefits that are particular to its utilization in rural areas.

General benefits of biogas
Biogas is a profitable means of reducing or even eliminating the menace and nuisance of agricultural Waste especially livestock Waste since organic Wastes are converted into useful organic fertiliser and feed material. Anaerobic digesters used for biogas production can also function as Waste disposal systems thus preventing potential sources of environmental contamination and the spread of pathogens (Lichtman, 1983). Biogas production enhances environmental sanitation and helps control environmental pollution and other health related issues that arise from environmental pollution. The residue obtained after anaerobic digestion of organic Waste during biogas production has superior nutrient qualities over the usual organic fertilizer, cattle dung, as it is in the form of ammonia (Sasse et al, 1991). The residue produced contains all the nutrients present in the original Waste materials, thus can be readily utilised as fertiliser by crops and it also enhances good soil structure.
Biogas is useful as a Fuel substitute for firewood, dung, Agricultural Residues, petrol, diesel, and electricity, depending on the nature of the task, and local supply conditions and constraints (Lichtman, 1983). It can be used for practically all the various Fuel requirements in the household (ie for cooking, lighting, water heating, running refrigerators, water pumps and electric generators), agriculture (used on farms for drying crops, pumping water for irrigation) and industrial sectors. Replacing the traditional Biomass based Fuels, notably wood with biogas may reduce significantly the dependence on wood from forests thus reducing deforestation which will have a beneficial effect on the environment. Increased energy services can also be obtained form biogas since it has a higher heating value than producer gas and coal gas. The use of biogas as a Fuel to displace kerosene, charcoal, Fuelwood, and diesel will reduce tons of greenhouse gases emissions into the atmosphere annually. Also turning of Wastes dumpsites into biogas will reduce the release of methane and other gases emanating from the refuse dumpsites into the atmosphere. These will have beneficial potential environmental impacts
The use of biogas also has some health benefits. Biogas unlike producer gas and coal gas contains little or no levels of toxic carbon monoxide. This results in no danger of health hazards or offensive odour. The likelihood of chronic diseases that are associated with the

indoor combustion of Biomass-based Fuels, such as respiratory infections, ailments of the lungs; bronchitis, asthma, lung cancer, and increased severity of coronary artery disease (Banerjee, 1996) are also reduced with utilization of biogas because it is a clean and particulate-free energy source. Biogas also burns with a clean bluish, sootless flame thereby making it non-messy to cooking utensils and kitchens.

The benefits of biogas production to rural communities

The use of biogas systems in an agrarian community can increase agricultural productivity. This is because the use of organic Waste residue from biogas production results in an increase in land fertility which causes an increase in (Agricultural Produciton). The benefits of this increased (Agricultural Produciton) include improved subsistence / standard of living of the rural populace, increased local food security and income generation for the farmers.

The use of Agricultural Residues for biogas technology makes it possible for rural communities having difficulties or no access to commercial Fuels to produce biogas to meet their Fuel needs since the substrate is abundant in the locality. This increases the reliability of Fuel supply and enhancing energy security to the rural areas. This energy security will help raise the standard of living of the rural populace. Also the use of agricultural residue will ensure that the biogas plants are operated by the rural dwellers by themselves for themselves which will enhance its utilization.

Biogas equipment/plants are simple and easy to construct from readily available materials and its operation does not require special skills. The construction of biogas plants can help to create new jobs, thus decreasing the unemployment rate in the rural areas and stimulating the rural economy.

Biogas production also has a positive impact on rural women's lives since the utilization of biogas for energy needs will reduce time spent by rural women on production of energy for household chores. It will eliminate the drudgery of women and reduce energy spent on household activities especially the daily task of Fuelwood gathering. This frees up energy and time for a woman for other activities, some of which may be income generating.

Limitations to the use of biogas

Due to the level of research on biogas production the technology is relatively out of reach of the majority of its intended users—the poor urban and rural households because of its high or initial investment cost. Most Nigerian rural households practice subsistent farming and hence are not able to afford the capital investment in a biogas plant. This can be overcome by access of rural dwellers to appropriate loans and grants. However in some cases the loans or grants available and accessible to the rural communities may affect the correct choice of equipment / plant. Another problem affecting utilization of biogas in terms of cost is that the rural communities may consider the change from the existing free source of energy, such as wood and crop residues to biogas which is more expensive unnecessary (Moulik, 1983).

The lack of available technical support for operation and maintenance of the plants in the villages where the plants are being utilized is a serious limitation (Sudhakar and Gusain, 1991). The lack of these supports may result in plants falling into disrepair because their functioning depends upon adequate maintenance skills, which are not available in the village where it is being utilized.

Another limitation in the utilization of biogas plant is the installation of too large a capacity plant, either by accident or design. It was discovered that householders generally constructed over-sized plant, even when they were only used for cooking purposes and not applied to wider energy demands (Nag et al., 1986). This results in under-feeding which leads to the eventual failure of the plants to produce gas. Under-collection of dung may also result in

under-feeding especially in rural areas where the animals are allowed to roam in the fields. This makes dung collection difficult and makes the dung availability to vary.
Reluctance to adopt different cultural behaviour / practices by the rural dwellers may particularly limit the utilization of biogas (Singh, 1988). An example of such is that the method of rearing livestock in rural areas will probably have to change due to the need for collection of livestock Waste if it is to be used for biogas. The use of biogas for cooking may also require that traditional cooking practices are altered (Moulik, 1983).

RECOMMENDATIONS

Biogas from Agricultural Residues can be effectively utilized in rural areas to meet the energy requirements particularly because of the inefficient supply of electricity and shortage of petroleum products in the areas. However for an effective and result oriented utilization of biogas, some of the limitations discussed above need to be overcome. This can be done through effective selection processes for the technology, and proper extension and support services. The technology for biogas production for rural dwellers and farmers should be selected such that it will be cultural acceptable and user friendly. The operation and maintenance of such plants/equipment should be carried out by the rural dwellers themselves through technical education and appropriate support which should be established during installation of the equipment.

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APPLICATION OF AGRICULTURAL RESIDUES AS PHARMACEUTICAL EXCIPIENTS

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Abstract

Pharmaceutical drugs usually contain an active material and various other components which are termed excipients. The number and types of excipients used in a drug formulation depend on the desired properties of the drug and the intended use. These excipients are used as thickeners, gelling, bulking and water retention agents, fillers (or diluent), binders, disintegrants lubricant, and/or a glidant, colours, flavours and sweeteners.

One of the major features of the pharmaceutical industry in Nigeria and indeed, the whole of tropical Africa is the high dependence on imported materials. Both production and quality control facilities including excipients and consumables are imported because of non availability in Nigeria. Africa is home to many agricultural plants, most of which grow with little or no artificial inputs. Most of these agricultural products are processed for food and non food uses and large amount of Wastes and residues are generated from them annually. Disposal of these solid Wastes is becoming a major problem. For instance, traditionally, farmers harvest grain and burn or otherwise dispose the residues (stalks, husk, etc.). Burning Agricultural Residues causes environmental problems such as air pollution, soil erosion, and a decrease in soil biological activity. Therefore, utilizing Agricultural Residues not only prevents air pollution due to residual burns which adversely affect air quality and human and environmental health, but also becomes economically profitable for farmers who can now earn a second income from the sale of these residues. Agricultural Residues are excellent alternative materials for development as pharmaceutical excipients because they are widely available and easily accessible. Conversion of Agricultural Residues into pharmaceutical excipients will help reduce environmental problems and eliminate the problem of their disposal.

Thus in recent times, attention is now being focused on the development of Agricultural Residues as pharmaceutical excipients. Some of the local Agricultural Residues that have been evaluated include as coconut shells, sugar cane bagasse, jute, soybean husk, rice straw, sorghum and maize stalk, cotton stalks, bleached pulps, maize cobs, and groundnut husk. Some of these materials have been modified by both physical and chemical methods to extend their properties. This has resulted in materials with excellent properties and in some cases possessing superior properties to the existing excipients which are imported. For instance, microcrystalline cellulose, a very important directly compressible excipient widely used in pharmaceutical formulations have been prepared from local Agricultural Residues, namely, textile Waste, rice straw, cotton stalks, maize cobbs and groundnut husk. There is however the need to fully develop these excipients from Agricultural Residues to meet pharmacopoeial standards. This will encourage the local pharmaceutical industries to adopt them for industrial production.

The wide industrial application of excipients from Agricultural Residues will lead to increased conservation of foreign exchange earnings due to reduced importation of

pharmaceutical raw materials. It will also provide cheaper and more readily available materials for the local pharmaceutical industries in the region. This will also lead to economical and technological advancement of local farmers.

INTRODUCTION

The International Pharmaceutical Excipients Council (IPEC, **http://www.ipec.gov/**) has defined an excipient as any substance other than the active drug or prodrug that is included in the manufacturing process or is contained in a finished pharmaceutical dosage form. They are inert substances used as a diluent or vehicle for a drug. Excipients are used in virtually all drug dosage forms and they are essential to product performance. The right choice of the excipient/s makes the product more stable, safe, effective and superior than other products. Product performance and functionality of excipient are inter-dependable. Thus the excipients used in the formulation of many drugs are in many cases is considered a trade secret. A very diverse collection of materials are used as pharmaceutical excipients. About 1200 ingredients are in use currently as excipients in marketed pharmaceutical products and about 250 documented in the European Pharmacopoeia. Excipient selection in the drug product–development phase focuses on the desirable characteristics (*e.g.,* functionality, material consistency, regulatory acceptance, cost, availability, and sources).
Functional categories of excipients include fillers (diluents), binders, disintegrants, lubricants, glidants (flow enhancers), compression aids, colors, sweeteners, preservatives, suspending/dispersing agents, film formers/coatings and flavors. Commonly used excipients are magnesium stearate, lactose, microcrystalline cellulose, starch (corn), silicon dioxide, titanium dioxide, stearic acid, sodium Starch Glycolate, gelatin, talc, pregelatinized starch, hydroxy propyl methylcellulose, croscarmellose, hydroxy propyl cellulose, ethylcellulose, calcium phosphate (dibasic), crospovidone, shellac, sucrose, calcium stearate and povidone.

Excipient Origin

Excipients have been obtained from different origins including:
a. Minerals and Natural origin (soil) e.g. silicon dioxide, talc, kaolin
b. Crude oil to refined stage e.g petrolatum, poly-glycols
c. Biological materials like bones e.g. gelatin, calcium carbonate (Oyster shell)
d. Synthetic chemistry e.g. hydroxy propyl methylcellulose, croscarmellose
e. Agriculture materials like wheat, corn, sugar cane, sotton e.g. starch, dextrins, cyclodextrins, sorbitol, glycerin

The process of extracting excipients range from very simple processes such as the production of talc which involved mining, drying followed by milling, to complex processes such as the production of sorbitol from maize which involve about twenty (20) steps, and the production gelatin from animal bones which involve several and much more steps.

Agricultural Residues

One of the major features of the pharmaceutical industry in Nigeria and indeed, the whole of tropical Africa is the high dependence on imported materials. Both production and quality control facilities including excipients and consumables are imported because of non availability in Nigeria. Africa is home to many agricultural plants, most of which grow with little or no artificial inputs. Most of these agricultural products are processed for food and non food uses and large amount of Wastes and residues are generated from them annually. Disposal of these solid Wastes is becoming a major problem. For instance, traditionally, farmers harvest grain and burn or otherwise dispose the residues (stalks, husk, etc.). Burning Agricultural Residues causes environmental problems such as air pollution, soil erosion, and a decrease in soil biological activity. Therefore, utilizing Agricultural Residues not only prevents air pollution due to residual burns which adversely affect air quality and human and environmental health, but also becomes economically profitable for farmers who can now earn a second income from the sale of these residues. Agricultural Residues are excellent alternative materials for development as pharmaceutical excipients because they are widely available and easily accessible. Conversion of Agricultural Residues into pharmaceutical excipients will help reduce environmental problems and eliminate the problem of their disposal.

Practically, biodegradable materials can be degraded by enzymatic reactions of living organisms, such as bacteria, fungi and algae (Mothe´ and Tavares, 1997). These biodegradable materials are designed to be easily degraded and finally mineralized in natural environments such as soils, sediments, and landfill sites. For instance, partially biodegradable plastics have been obtained by blending biodegradable and non-biodegradable polymers and this has effectively reduced the volume of plastic Waste because they are partially degradable. Some of the local Agricultural Residues that have been evaluated include as coconut shells, sugar cane bagasse, jute, soybean husk, rice straw, sorghum and maize stalk, cotton stalks, bleached pulps, maize cobs, and groundnut husk.

Cellulose is one of the most abundant naturally occurring biopolymer (Hinterstoisser and Salmen, 2000; Bochek, 2003). It is an ubiquitous, renewable and biodegradable material. Various natural fibres such as cotton and higher plants, and Agricultural Residues such as maize stalk, have cellulose as their main constituent (Myasoedova, 2000; Gross and Scholz, 2000). Cellulose consists of long chains of anhydro-D-glucopyranose units (AGU) with each cellulose molecule having three hydroxyl groups per AGU, with the exception of the terminal ends (Figure 1). Cellulose is insoluble in water and most common solvents (Bochek, 2003). The poor solubility is attributed primarily to the strong intramolecular and intermolecular hydrogen bonding between the individual chains (Hinterstoisser and Salmen, 2000). In spite of its poor solubility characteristics, cellulose is used in a wide range of applications including composites, netting, upholstery, coatings, packing, paper, etc. Cellulose has good mechanical properties and is widely used in pharmaceutical tablets as directly compressible excipients and diluents in tablets (Peterson and Oksman, 2006). Chemical modification of cellulose is performed to improve process ability and to produce cellulose derivatives (cellulosics) which can be tailored for specific industrial applications (Akira, 2001). This has resulted in materials with excellent properties and in some cases possessing superior properties to the existing excipients. For instance, microcrystalline cellulose (MCC), a very important directly compressible excipient widely used in pharmaceutical formulations have been prepared from local Agricultural Residues.

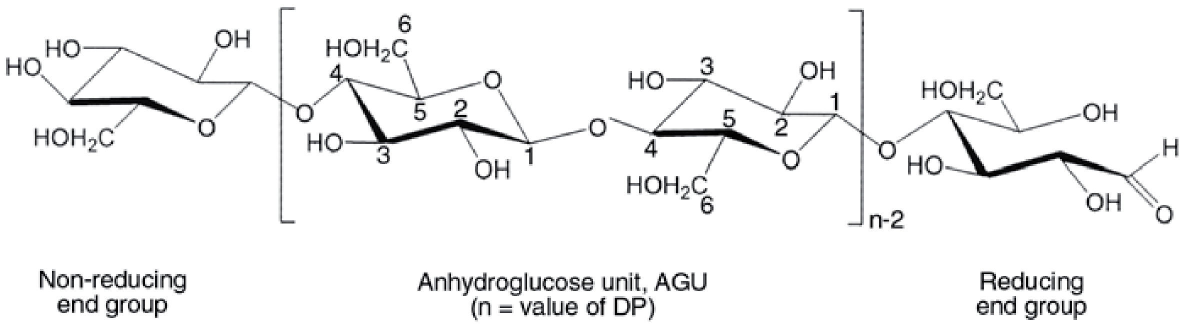

Fig. 1: Molecular structure of cellulose

As shown in the molecular structure represented in Figure 1, the hydroxy groups of β-1,4-glucan cellulose are placed at positions C_2 and C_3 (secondary, equatorial) as well as C_6 (primary). The CH_2OH side group is arranged in a trans-gauche (*tg*) position relative to the O_5–C_5 and C_4–C_5 bonds. As a result of the supramolecular structure of cellulose, the solid state is represented by areas of both high order (crystalline) and low order (amorphous). The degree of crystallinity (DP) of cellulose (usually in the range of 40 to 60%) covers a wide range and depends on the origin and pretreatment of the sample. The morphology of cellulose has a profound effect on its reactivity. The hydroxyl groups located in the amorphous regions are highly accessible and react readily, whereas those in crystalline regions with close packing and strong interchain bonding can be completely inaccessible (Conner, 1995). Cellulose that is produced by plants is referred to as native cellulose, which is found in two crystalline forms, cellulose I and cellulose II (Sjostrom, 1993). Cellulose II, generally occurring in marine algae, is a crystalline form that is formed when cellulose I is treated with aqueous sodium hydroxide as shown in Figure 2. Among the four different crystalline polymorphs cellulose I, II, III, and IV, cellulose I is thermodynamically less stable while cellulose II is the most stable.

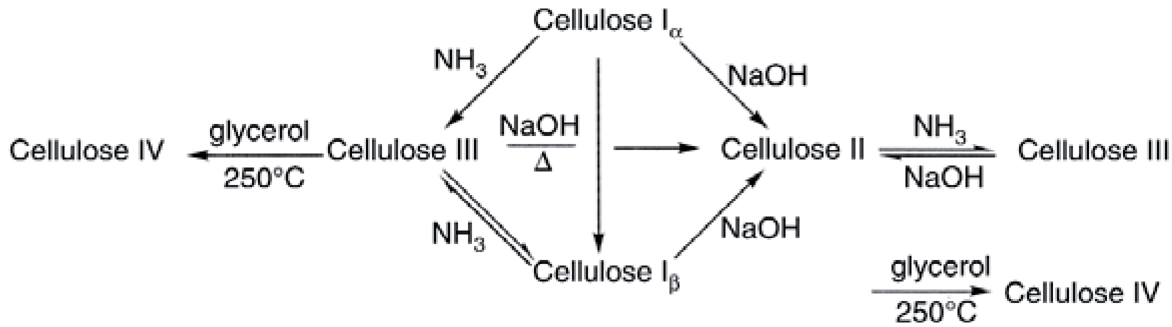

Fig. 2: Transformation of cellulose into its various polymorphs

Microcrystalline cellulose (MCC) is an important ingredient in pharmaceutical, food, cosmetic has been prepared by the hydrolysis of cellulose with mineral acids (El-Sakhawy and Hassan 2007). In tableting technology, MCC is described as a filler/binder in that it is usually added to formulations to enhance compactibility. MCC is characterized by a high degree of crystallinity in which the values are typically ranging from 55 to 80%, depending on the origin of the cellulosic sources and processing variables, such as reaction temperature and duration, mechanical agitation of the slurry, and drying conditions (Wei, et al., 1996). Being semi-crystalline, cellulose has ordered (crystalline) and disordered (amorphous) regions. The hydrolysis reaction removes amorphous cellulose and reduces the degree of polymerization (level-off degree of polymerization, LODP) of the cellulose chain (Battista, 1950), thus making cellulose consist of a large size distribution of particles (mostly in the mm range) (Kumar et al., 2002). MCC has been prepared from materials such as water hyacinth (Gaonkar and Kulkarni, 1987), coconut shells (Gaonkar and Kulkarni, 1989), sugar cane bagasse (Padmadisastra and Gonda, 1989; Shah, et al., 1993), jute (Abdullah, 1991), and soybean husk (Uesu et al, 2000). MCC is currently commercially available in different grades; it can be obtained at an industrial scale from wood and cotton cellulose (El-Sakhawy and Hassan 2007).

SOME AGRICULTURAL RESIDUES USED FOR THE PRODUCTION OF PHARMACEUTICAL EXCIPIENTS

Cassava bagasse

Cassava (*Manihot esculenta* Cranz) is considered an important source of food and dietary calories for a large population in tropical countries in Asia, Africa and Latin America.

Industrial processing of cassava is done mainly to isolate flour (which generates more solid residues) and starch (which generates more liquid residues) from the tubers. Solid Wastes include the peels and bagasse. Processing of 250±300 tons of cassava tubers results in about 1.6 ton of solid peels and about 280 ton of bagasse with high moisture content (85%) (Pandey et al, 2000). Liquid Wastes include Waste water (about 2655 m^3) with about 1% solids. Solid Wastes are generally discarded in the environment as landfill without any treatment. Their disposal is a serious concern to the environment.
Cassava bagasse is the fibrous materials remaining after starch has been extracted and is the by-product of the cassava-processing industry. They contain about 50% starch on a dry weight basis (Carta et al., 1999). Cassava bagasse does not show any cyanide content. Due to its rich organic nature and low ash content, cassava bagasse can serve as an ideal substrate for microorganisms and does not require any pre-treatment and can be easily attacked by micro-organisms. Cassava bagasse has been used as substrates for flavours and aroma (including fragrance) compound which are used in the food; feed, cosmetic, chemical and pharmaceutical industries (Bramorski et al. 1998a). This is mainly due to an increasing preference by the consumer for natural food additives and other compounds of biological origin. Cassava bagasse was hydrolyzed using HCl and the hydrolysate was used for the production of xanthan gum using a bacterial culture of *Xanthomonas campestris*. A strain of the yeast *Kluyveromyces marxianus* was used for the production of a fruity aroma in SSF using cassava bagasse as substrate (Medeiros, 1998). Cassava bagasse has been used for citric acid production with *A. Niger,* giving a yield of 41.78% (Kolicheski et al. 1995). Under improved fermentation conditions, the citric acid production increased to 27 g/100 g dry substrate, which corresponded to 70% yield (based on sugars consumed). Other bioprocesses involving cassava bagasse are shown in Table 1.

Table 1: Bioprocesses involving cassava bagasse

Micro-organism	Process	Application	Reference
A. niger LPB 21	SSF	Citric acid	Kolicheski et al. (1995)
A. niger NRRL 2001	SSF	Citric acid	Vandenberghe et al. (1999)
A. niger CFTRI 30	SSF	Citric acid	Shankaranand and Lonsane (1994)
Candida lipolytica	SmF	Citric acid	Vandenberghe et al. (1998b)
C. ®mbriata	SSF	Aroma compounds	Christen et al. (1997)
C. ®mbriata	SSF	Aroma compounds	Bramorski et al. (1998a)
K. marxianus	SSF	Aroma compounds	Medeiros (1998)
L. edodes	SSF	Mushroom	Beux et al. (1995)
P. sajor-caju	SSF	Mushroom	Barbosa et al. (1995)
Rhizopus sp	SSF	Biotransformation	Soccol et al. (1995a,b,c)
R. arrahizus	SmF	Fumaric acid	Carta et al. (1999)
R. ciricians	SmF	Fumaric acid	Carta et al. (1999)
R. delemer	SmF	Fumaric acid	Carta et al. (1999)
R. formosa	SmF	Fumaric acid	Carta et al. (1999)
R. oligosporus	SmF	Fumaric acid	Carta et al. (1998, 1999)
R. oryzae	SmF	Fumaric acid	Carta et al. (1999)
R. oryzae	SSF	Aroma compounds	Bramorski et al. (1998b)

a SSF: solid-state fermentation, SmF: submerged fermentation.

Sugar cane bagasse

Sugar cane is a major commercially grown agricultural crop in the vast majority of countries in Africa. Sugar cane bagasse is the fibrous residue remaining after sugarcane stalks are crushed to extract their juice (Encyclopedia Britannica). Sugarcane bagasse, once a worthless residue is now an important co-product used for the generation of energy and production of Ethanol, among other things._It is currently used as an annually renewable resource in the manufacture of pulp and paper products and building materials. The chemical composition of cassava bagasse are cellulose-45%-55%, hemicelluloses - 20%-25%, lignin - 18%-24%, Ash - 1%-4% and waxes <1%. Sugar cane bagasse fiber is similar to cotton fiber in its length and morphology (Padmadisastra and Gonda, 1989; Shah, et al., 1993). Research work has shown that cellulose obtained is excellent diluent and disintegrant pharmaceutical tablet formulations (Shah, et al., 1993).

Jute

Jute is the cheapest natural fibres. It is the long, shiny vegetable fiber that can be spun into coarse, strong threads. Jute is composed primarily of the plant materials - cellulose and lignin (major components of wood fibre). It is thus a ligno-cellulosic fibre – partially a textile fibre and partially wood. Both jute production and manufacture of jute-based products are highly labour intensive, concentrated mostly in Eastern India. For each tonne of jute, 2-3 tonnes of jute sticks are produced. Chemically these resemble hardwood. The sticks are traditionally used as Fuel wood and low cost structural material. Jute sticks yield excellent particle boards and the technologies are now fully commercial. Jute sticks are a good feedstock for paper pulp. The sticks can also be used as Fuel for steam and power generation. Jute is an excellent source of cellulose comparable to hard wood (Abdullah, 1991).

Rice hulls (or **rice husks**)

Rice husk is the hard protecting coverings of grains of rice and accounts for approximately 20% by weight of the harvested grain (paddy) (Mahin, 1990). The hull is made of hard materials, including opaline silica and lignin. In the majority of rice producing countries much of the husk produced from the processing of rice is either burnt or dumped as a Waste. Cellulose obtained from rice husk has excellent tablet disintegrant properties when compared with a standard disintegrant such as maize starch (Okhamafe et al 1988, 1989, 1992, 1995). Because of its high silica content, rice straw/husk MCC tablets showed better tensile strength and cohesiveness than those made from bagasse and cotton stalks MCC. Rice straw MCC also showed the highest resistant toward the negative effect of wet granulation on cohesiveness of tablets. Co-processing of bagasse pulp with rice straw pulp to prepare SMCC having different silica contents produced SMCC that had better resistance to the negative effect of wet granulation but did not significantly affect the tensile strength of tablets. Rice straw MCC tablets have better tensile strength than bagasse and cotton stalks MCC (El-Sakhawy and Hassan 2007).

Maize cob

Maize cobs accrue as an agricultural by-product can be used for a core material of light weight panels with good material properties and insulation characteristics (Saw and Datta, 2009). Maize is a major source of starch, cooking oil (corn oil) and of maize gluten. Maize starch can be hydrolyzed and enzymatically treated to produce syrups, particularly high fructose corn syrup, a sweetener. It is fermented and distilled to produce grain alcohol. Pharmaceutical grade cellulose has been extracted from maize cob (Okhamafe et al 2003). The cellulose obtained had excellent diluent properties which proved to be very useful in the production of tablets by direct compression without the need to add any other ingredient to facilitate the production of good quality tablets.

Groundnut husk

Groundnut shell, a Waste generated in local vegetable oil processing plants. The potential of using groundnut husk, as a low cost Adsorbent in removal of oil spilled on water has been reported (Nwokoma and Anene, 2010). MCC have been prepared from the *alpha* cellulose content of groundnut husk (Ohwoavworhua et al., 2009). MCC was prepared from groundnut husk by sodium hydroxide pulping and multistage pulping. Complete pulping could not be achieved using sodium hydroxide alone. Multistage pulping resulted in a homogeneous white pulp (cellulose) with a yield of 15%. This was further hydrolysed in aqueous hydrochloric acid to obtain groundnut husk MCC. GH MCC was odourless tasteless, white and granular in texture which showed comparable physicochemical properties to Avicel PH 101. The duration of bleaching affected the polymeric form of the processed alpha cellulose. Groundnut husk MCC showed higher proportion of amorphous cellulose than Avicel PH 101. The MCC conformed to official specifications for MCC and indicates that ground nut husk MCC are good potential tablet excipients.

Coconut shells

Coconut tree is widely distributed in the tropics. The roots are used as a dye, a mouthwash, and a medicine for dysentery. A frayed-out piece of root can also be used as a toothbrush. The shell and husk also are burned for smoke to repel mosquitoes. Coconut husk and shells can be used for Fuel and are a source of charcoal. Coconut husk consist of cellulose 33.61%, lignin 36.51%, pentosans 29.27% and ash 0.61%. Pharmaceutical grade cellulose has been obtained from coconut shell (Gaonkar and Kulkarni, 1989). This led to substantial reduction in the cost of tablets made with the cellulose.

Cotton stalks

Cotton stalks are the Waste generated from the processing of cotton. Microcrystalline cellulose has been prepared by hydrolyzing cotton stalk with hydrochloric acid and sulphuric acid (El-Sakhawy and Hassan 2007). The results showed that the kind of acid used was found to affect particle size, thermal stability, tensile strength, and cohesiveness of the tablets made from the different MCC samples. Cotton stalk MCC was found to possess higher bulk and tapped densities than Avicel, and produced tablets with higher densities. Tablets made with cotton stalk MCC showed the presence of large amount of pith (non-fibrous material) which decrease the fibre-fibre bonding and thereby the mechanical properties of the tablets.

Textile Waste

Large volumes of textile Waste are produced annually by the manufacture of clothing and other textile products. Disposal of these solid Wastes is becoming a major problem for the apparel industry as the rising cost, reduction in available space, and environmental issues are concerned, burning the textile Waste and dumping to landfill sites are dwindling options. Annually, solid Waste of cotton fabric from a garment factory is produced in large volume and recent studies have reported the preparation of cellulosic materials from this type of Waste. Microcrystalline cellulose (MCC) has been prepared by the hydrolyzing of Waste cotton fabric with 2.5N hydrochloric acid at $100^{o}C$ for 30 min. (Chuayjuljit, et al., 2009).

Microcrystalline cellulose prepared by acid hydrolysis of the Waste-cotton fabric when viewed under the SEM, revealed a fibrous structure and the X-ray powder diffraction pattern of MCC showed characteristic peaks of cellulose type I. The prepared MCC when used as biodegradable filler for natural rubber was found to decrease the tensile properties and elongation at break of the matrix and causes stress concentration. Water absorption and biodegradability of natural rubber were enhanced as the amount of MCC was increased. The results indicated that MCC promote the biodegradability of natural rubber and reduce the capability for strain-induced crystallization (Chuayjuljit et al., 2009).

CHALLENGES

Impurities in Excipients

a. Organic impurities: e.g. Gluten and protein. Ingredients derived from natural animal sources (*e.g.,* gelatin, starch) have raised concerns of transmissible spongiform encephalopathy/bovine spongiform encephalopathy/genetically modified organism (TSE/BSE/GMO).
b. Inorganic impurities e.g. Heavy metals in minerals and hydrogenated fats. Sulfites are usually used as processing aid for starches and refined sugars. Extraction process must be able to remove these inorganic impurities.
c. Residual solvents used during the extraction of the excipients: Special instructions should be given to remove on ethylene oxide residues and other residual solvents used during the extraction of the excipients.
d. Pesticides used for the plant may remain in the derived excipients. Thus the extraction process should include processes that will remove residual pesticide from the Agricultural Residues.
e. Microbial contamination: Microbial contamination can become a big problem because the biomaterial could act as a good substrate for the growth of microorganisms. Therefore excipients should be stored under conditions that will retard the proliferation of microorganisms.
f. Quantity in formulation: The FDA require the data demonstrating that the excipient is safe in the amount it will be used or consumed in the finished drug throughout the product's recommended or prescribed duration of use by those who will take the product.
g. Purity / Grade: Pharmaceutical excipients should be free of impurities. Many excipients for pharmaceutical use are available in different grades. Pharmaceutical grades frequently are differentiated by means of physical characteristics (e.g., the different grades of lactose and microcrystalline cellulose). They may also be chemically different (e.g., sodium starch glycolate and polysorbate esters). Particularly for excipients for which grade differentiation is determined by means of one or more physical characteristics, the reason for the grades is to change the performance characteristics of the excipient.
h. Interactions with other excipient/s: Excipients should not adversely affect the bioavailability and performance of the active drug; and should be manufactured in accordance with appropriate standards of good manufacturing practice suitable to that kind of excipient.
i. Degradation during shelf-life of the product.

CONFORMITY WITH PHARMACOPOEIAL STANDARDS

Pharmaceutical excipients from Agricultural Residues must meet the pharmacopieal standards. These non pharmacopoeial excipients should compare with well known substances and must meet the stringent regulatory requirements for approval by the International

Pharmaceutical Excipients Council (IPEC). They should be free of impurities related to starting materials and fulfil the requirements in terms of quality, safety and functionality.
For new pharmaceutical excipients, data supporting the safety and functionality of an excipient in a drug product is usually included in the data and clinical reports submitted to support a new drug application (NDA). In addition, the substance must meet applicable compendial standards where they apply should performs its intended function in the product. It should be noted that there is no FDA regulatory approval system that is exclusively applicable to pharmaceutical excipients. Thus, the scope and amount of necessary data to support a substance or its use always must be negotiated with FDA and will be determined on a case by case basis.

CONCLUSION

Agricultural Residues have great potential as pharmaceutical excipients. The wide industrial application of excipients from Agricultural Residues will reduce importation of pharmaceutical raw-materials. It will also provide cheaper and more readily available materials for the local pharmaceutical industries. This will lead to economical and technological advancement of local farmers.

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KINETICS AND EQUILIBRIUM STUDIES OF THE REMOVAL OF CADMIUM FROM SIMULATED WASTEWATER USING A NOVEL ADSORBENT PREPARED FROM MELON HUSK

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Abstract
Removal of cadmium from simulated Wastewater (aqueous solution) using melon husk (an agricultural residue) modified with concentrated sulphuric acid was investigated at room temperature. Adsorption studies were carried out to determine the influence of contact time, initial cadmium ion concentration, Adsorbent dosage and particle size on removal efficiency. Removal efficiency was observed to decrease with increasing initial cadmium ion concentration (2mg/l-10 mg/l), but increases with decreasing particle size (45-355 μm), and increasing Adsorbent dosage (0.05-0.3 g). The data obtained were well fit into three equilibrium isotherms in the order: Freundlich > Langmuir > Temkin. Modeling of kinetic results showed that the adsorption process is best described by Pseudo-second order model with regression coefficients (r^2) higher than 0.9984.

INTRODUCTION

Though heavy water are natural components of the environment, their levels have undergone dramatic increase with increasing population and sophistication in human activities, especially since the beginning of industrial revolution (Nriagu, 1979). At least twenty metals have been classified as toxic, and 50% of these are being emitted into the environment in amounts that pose risks to human health (Korthukamp et al, 1996).

Cadmium is one of the heavy metals that have been classified by the World Health Organisation (WHO) to be of serious health concern (1998). In fact, this metal together with Pb and Hg are reffered to as “the big three” because of their significant negative impact on the environment (Volesky, 1994). Apart from the “itai-itai” disease which is a manifestation of cadmium toxicity in humans, kidney dysfunction, hepatic damage and hypertension are also other health implications of cadmium (Klaassen, 2001). It also causes cancer and genetic changes (Hill.1984).

A major source of heavy metals in the environment is the discharge of untreated industrial effluents from industries such as paints, plating, fertilizers, mining, textile dyeing and processing, automobile manufacturing and metal processing (Habib-ur-Rahman et al, Harrison and Laxen, 1980; Low and Lee 1991 in; Sumanjit).

Besides their toxicity, heavy metals are of utmost concern because, unlike organic pollutants which are mostly biodegradable, they do not degrade into non-toxic end products [Nasim et al (1)]. They persist in the environment and even bioaccumulate in the food chain (Ceribasi and Yetis, 2001 in: Abia and Asuquo).

Several conventional methods such as coagulation/flocculation (Amuda etal, 2004), Oxidation process (Marrtinez et al, 2003; Peres et al, 2004) reverse osmois, chemical precipitations, ion exchange and the use of activated charcoal. (Poon 1986 in: Sumanjit) have being in use over the years for the removal of toxic heavy metals from Wastewater.

However, some of these technologies cannot effect complete removal of the pollutants, or are too expensive. There is therefore the need to develop more effective and economical

technologies for the removal of heavy metals from effluents. This has led to the search for non-conventional low-cost materials for this purpose.
The current trend is to investigate the possibility of employing various agroWastes and biological materials that are available in commercial quantities for Wastewater remediation by adsorption (Abdel-Ghani et al., 2007).This is a better alternative to the conventional techniques not only because it is cheap to process, but also because it is highly efficient and the materials are readily and abundantly available.
Various agricultural by-products in their raw and modified forms have been studied; these include sugarcane bagasse, rice husk, soybean hulls, Waste tea leaves, peanutshells and saw dust (Johns et al., 1998: Ahluwalia and Goya, 2005b; Taty-Costodes et al., 2003; and Amuda et al., 2006). However, more work and investigations are still required to be carried out on some other locally available agricultural materials. This work is therefore undertaken to contribute to the search for low-cost Adsorbents and the possibility of utilizing various agroWastes, which are in many cases also pollution sources.

Experimental

Preparation of Adsorbent

Collection, sorting and washing of melon husk;
Drying and grinding of the washed husk;
Chemical treatment using Concentrated H_2SO_4
The melon husk–acid mixture in ratio 1:1 (w/v) was kept in an electric oven at 150 – 160^oC for 24 hours. The black mass obtained was washed with distilled water, and soaked in 5% $NaHCO_3$ solution overnight to remove residual acid. This was washed again with distilled water to remove any free $NaHCO_3$. It was then dried at 150^oC for 24 hours, ground, sieved and then stored in air – tight container (Habib–ur–Rehman et al., 2006 and Raghuvanshi et al., 2004).

Preparation of Sorbate

Stock solution (1000mg/L) of Cd(II) was prepared by dissolving accurately weighed analytical grade Cadmium sulphate ($3CdSO_4.8H_2O$ in deionised water. Various standard solutions of different concentrations, as required, were prepared from the stock by dilution process.

Adsorption Experiment

Batch adsorption experiment were carried out in which 20cm^3 of each metal ion of different cncentrations was mixed with a definite mass (0.05-0.30g) of the Adsorbent in 150cm^3 plastics bottles and were agitated in a horizontal mechanical shaker at 100rpm for pre-determined period of time and temperature at natural pH. The mixture was filtered through whatmann filter paper, and filtrate analyzed for it residual metal content using atomic absorption spectrophotometer (model…) all experiment were carried out in duplicate and mean values determine were presented.
The amount of Cd(II) adsorbed, $q_{,}$(mg/g) was evaluated thus:

$$q_e = \frac{(C_o - C_e)\ M}{V} \qquad (1)$$

$$q_t = \frac{(C_o - C_t)\ M}{V} \qquad (2)$$

$$\text{Percentage Removal, } R\ (\%) = \frac{(C_o - C_t)}{C_o} \times 100 \qquad (3)$$

RESULTS AND DISCUSSION

Since adsorption is affected by physical and chemical variables, the influence of initial Cd(II) concentration, dose of Adsorbent and contact time are investigated in this study.

Effect of Adsorbent Dosage

Effect of the Initial Concentration of Methylene Blue

Adsorption Isotherms

An adsorption isotherm model gives the equilibrium relationship between the sorbate in the fluid phase (solution) and the sorbate sorbed on the sorbent at constant temperature. (Ali Riza et al., 2007; Binupriya et al., 2009). They are very useful for obtaining the adsorption capacity so as to facilitate the evaluation of the feasibility of the adsorption process for a given application and for selection of the most appropriate sorbent at the optimum experimental conditions (Ali Rija et al., 2007; Ngada and Ghole, 2008).

In this work, adsorption isotherms were carried out at initial concentrations of 2-20 mg/l .The Langmuir, Fruendlich and Temkin isotherm models were employed to interprete the sorption process in order to understand the mechanism of methylene blue adsorption on RMH. The experimental data were fitted to the aforementioned equilibrium isotherm models.

The Langmuir isotherm equation is given as :(Ho, 2005)

$$q_e = \frac{q_m k_a C_e}{1+K_a C_e} \quad (4)$$

where q_e is the amount of dye adsorbed per unit mass at equilibrium(mg/g);

q_m is the maximum possible amount of dye that can be adsorbed per unit mass of Adsorbent (mg/g);

C_e - Concentration of sorbate (in the solution at equilibrium (mg\l);

K_a - Sorption equilibrium constant.

The linearised form of equation (1) is:

$$C_e/q_e = 1/K_a q_m + Ce/q_m \quad (5)$$

A plot of C_e/q_e versus C_e should give a straight line of slope $1/q_m$ and intercept $1\backslash k_a q_m$

The essential characteristics of Langmuir Isotherm can be expressed in terms of a dimensionless constant KR, the separation factor or equilibrium parameter, which is defined as

$$K_R = 1/1+K_a C_o \quad (6)$$

Where K_R is dimensionless separation factor

K_a - Langmuir constant (l/mg)

C_o – initial concentration of sorbate (mg/l)

The Freundlich isotherm is an empirical model which indicates the surface heterogeneity of the Adsorbent. The equation is given as:

$$q_e = K_f C_e^{1/n} \quad (7)$$

The linear form of the equation is:

$$\log q_e = \log K_f + 1/n \log C_e \quad (8)$$

where q_e- amount of sorbate adsorbed to thread sorbet at equilibrium mglg)

C_e – equilibrium concentration of surbate in the solution

K_f – empirical constant which indicates the adsorption capacity of the Adsorbent

n – Constant indicating the intensity of adsorption.

A plot of log q_e verses log C_e gives a straight line of slope1\n and intercept log K_f from which n and K_f can be evaluated.

If $1/n < 1$, then the adsorption is favourable and the adsorption capacity increases with the occurrence of new adsorption sites. But if $1/n > 1$, the adsorption bond becomes weak and unfavourable adsorption takes place, leading to a decrease in adsorption capacity (Lain-chuen et al., 2007).

The Temkin isotherm model is given by the following equation

$$q = a + b \ln C_e \qquad (9)$$

where q = amount of adsorbate adsorption per unit weight of Adsorbent
C_e = concentration of adsorbate in solution at equilibrium (mg/c)
a = constant related to adsorption capacity
b = constant related to adsorption intensity

A plot of q verses ln C_e gives a straight line from the intercept and slope of which the constants a and b can be evaluated respectively (Lain-chum-Jang, et al., 2007).

Temkin isotherm assumes that the more energetic adsorption sites are occupied first, and that the adsorption process is chemisorption i.e. the particles of the adsorbate get attached to the Adsorbent through valent bond formation (Lain-Chun-Thery et al., 2007).

The Langmuir plot of the experimental data is given in figure 3. It was observed that the isotherm fits quite well the data, as the correlation coefficient, R^2, obtained was 0. 9999. This suggests that the sorption of the dye on raw melon husk was monolayer coverage. The Langmuir model is based on the assumption that there is a finite number of binding sites which are homogeneously distributed over the Adsorbent surface, and adsorption takes place at these homogeneous sites within the sorbent. It also assumes that the sites have the same affinity for the adsorption of a single molecular layer, with no interaction between the adsorbed molecules (Langmuir, 1918).

The maximum sorption capacity, q_m, is the appropriate parameter to consider when assessing the capacity of any Adsorbent (Ngada and Ghole, 2008). The q_m of the Adsorbent is calculated to be 47.39 mg/g while K_a is 0.0.9906 1/mg.

The K_R values obtained for the various concentrations of methylene blue (5-500 mg/l) in this study fall between 2.09 x 10^{-3} and 1.6798 x 10^{-1}.These values indicate that the sorption is favourable as they fall between 0 and 1. For a favourable adsorption, the value should be in the range $0 < K_R < 1$ (Namasivayam et al., 2001).

A plot o f K_R verses C_o (Ho et al., 2005) shows that the sorption process was more favourable for higher initial concentration than for the lower ones.

The Freundlich plot for the data is diplicted in figure 4, with a repression factor R^2, and Freundlich parameters n and k_f of 0.0.8732, 3.2113 (i.e. 1/n = 0.3114) and 12.5775 respectively.

The Temkin isotherm plot is shown in figure 5. Its correlation coefficent, R^2,is 0.983. Comparing the levels of the applicabity of the isotherm models using the R^2 values obtained, the trend of fitness is Langmuir (0.9999) > Temkin (0.983) > Freundlich (0.8732). This implies that the sorption of MB on untreared melon husk is mainly monolayer.

Adsorption Kinetics

The study of the adsorption kinetics of a sorption process is very important as it describes the rate of adsorbate uptake, which in turn evidently controls the residence time of the solute uptake at the solid-solution interface or the sorption reaction (Arivoli and Thenkuzhali, 2008; Igwe and Abia, 2007; Oladoja and Asia, 2008). It is an important characteristic in defining the efficiency of sorption (Arivoli and Thenkuzhali, 2008). The data obtained from the study of adsorption dynamics are necessary to understand the variables that affect the sorption of solutes, and the rate of sorption observed can also be used to develop predictive models for column experiments (Oladoja and Asia, 2008).

The most important thing when searching for an appropriate sorption mechanism, therefore, is to choose a mathematical model which not only fits the data with satisfactory accuracy but also complies with a reasonable sorption mechanism (Oualid and Mahdi, 2007).

Generally, sorption of adsorbate by an Adsorbent consists of several steps which include:

(i) Transport of sorbate (solute) from the solution to the film surrounding the sorbent particles. This is called bulk diffusion.

(ii) Diffusion of the sorbate from the film to the external surface (external diffusion).

(iii) Diffusion from the surface to the internal sites i.e. intraparticle transport within the particle.

(iv) Sorption of the sorbate on the interior surface of the sorbent (i.e. pore diffusion). This can involve several mechanisms including reaction kinetics at phase boundaries (Oualid and Mahdi, 2007; Malatvizhi and Sulachana, 2008; Igwe and Abia, 2007).

Various kinetic models have been proposed and used to study and describe the mechanism of a solute uptake by an Adsorbent from aqueous solution (Ngada and Ghole, 2008; Oualid and Mahdi, 2007). These include:

(i) The Lagergren pseudo-first order model based on solid capacity (Lagergren, 1918),

(ii) A pseudo-second order equation by Ho (Ho and Mckay, 1999).

(iii) A second order model by Lagergren,

(iv) External diffusion model of Spahn and Schlunder (Spahn and Schlunder, 1995),

(v) Intraparticle diffusion equation of Weber and Morris (1963),

(vi) The Elovich equation

(vii) Natarajam and khalat equation (Arivoli and Thenkuzhali, 2008); and

(viii) Mass transfer model.

Several of these kinetic models have been applied in the interpretation of the kinetics of the adsorption of methylene blue on different Adsorbents (Namasivagam et al, 2001a; Annadurai et al., 2002; Aksu, 2001; Butzias and Sidiras, 2001; Batzias and Sidiras, 2006). In this study, however, the kinetic equations employed to investigate the kinetics and mechanisms of methylene blue adsorption are:

In this study, however, the kinetic equations employed to investigate the kinetics and mechanisms of methylene blue adsorption are:

The Pseudo-first order by Lagergren (1898) given as:

$$dq_t/dt = K_1(q_e - q_t) \qquad (10)$$

Where q_e and q_t are the adsorption capacities at equilibrium and at time t (mg/g) respectively.

K_1 = rate constant of pseudo-first order adsorption ($1min^{-1}$)

After integration and applying boundary conditions t = 0, to t = t, and $q_t = 0$ to $q_t = q_e$, equation (1) becomes;

$$\log (q_e - q_t) = \log q_e (K_1/2.303)t \qquad (11)$$

which is the linear form of the Lagergren pseudo-first order equation.

A plot of $(q_e - q_t)$ versus t gives the slope = K_1, and intercept = $\log q_e$

The Pseudo-second or der equation is given as: (Ho and Mckey, 1998)

$$dq_t /dt = k_2 (q_e - q_t)^2 \qquad (12)$$

Where k_2 is the rate constant of pseudo-second order adsorption (g mg^{-1} min^{-1}), and other symbols have their usual meanings. After integration, equation (14) becomes

$$1 / (q_e - q_t) = 1/q_e + k_2 \qquad (13)$$

Equaton (4) is linearised to give:

$$t / q_t = 1/k_2 q_e^2 + (1 /q_{e)}\, t \qquad (14)$$

if $$k_2 q_e^2 = h \qquad (15)$$

combining equations (5) and (6) gives

$$t / q_t = 1/h + (1/q_e)\, t \qquad (16)$$

A plot of t/qt verses t gives a straight line.

If the sorption process follows pseudo-second order, h, is described as the initial rate constant as t approaches zero.

The Elovich equation is: (Chien and Clayton, 1980; Spark, 1986; Okeimen and Onyega ,1989).

$$dq_t / dt = \alpha \exp(-\beta q_t) \quad (17)$$

Where α - initial adsorption rate ($mg.g^{-1}.min^{-1}$)

β - adsorption constant ($g.mg^{-1}$)

To simplify the Elovich equation, Chien and Clayton (1980) assumed $\alpha\beta t >> t$; then applying the boundary conditions $q_t = 0$ at $t = 0$, and $q_t = q_t$ at $t = t$, equation (8) becomes

$$q_t = 1/\beta \, 1n(\alpha \beta) + 1\backslash \beta (1n\, t) \quad (18)$$

A plot of qt versuss 1n t gives a straight line with intercept $1/\beta \, 1n(\alpha \beta)$ and slope $(1/\beta)$

An intraparticlee diffusion model is presented as: Wweber and Morris, 1963; Srivastava et al., 1989).

$$R = K_{id}(t) \quad (19)$$

In linear form it is:

$$\log R = \log K_{id} + a \log t,$$

Where R is percentage adsorption, t contact time and K_{id}, the intraparticle diffusion rate constant (h^{-1}), which can be taken as a factor i.e. percentage adsorbed per unit time.

A plot of log R versus log t gives a straight line with slope ‘a’.

Other intaparticle diffusion models tried in the interpretation of the experimental data are given by the following equations:

$$\ln(1 - \alpha) = - K_p t \quad (20)$$

A plot of $\ln(1 - \alpha)$ against t gives a straight line with $- K_p$ as its slope.

The intraparticle diffusivity equation is:

$$q_t = K_i t^{0.5} + X_i \quad (21)$$

where X_i depicts the boundary layer thickness and K_i, the initial rate of sorption controlled by intraparticle diffusivity (McKay and Poots, 1980).

K_i and X_i can be obtained from the slope and intercept of a plot of q_t against $\sqrt{t}$ respectively.

The Mass transfer model:

$$C_o - C_t = D_{exp}(K_o t) \quad (22)$$

where D is a fitting parameter and K_o is a constant which is the mass transfer adsorption coefficient

$$\ln(C_o - C_t) = \ln D + K_o t \quad (23)$$

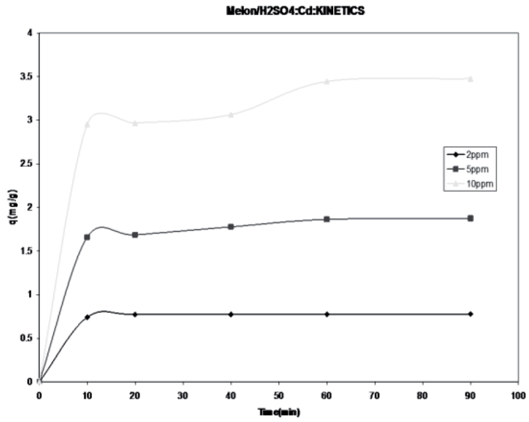
A plot of $\ln(C_o - C_t)$ versus t is made giving a slope of K_o and an intercepf of ln D

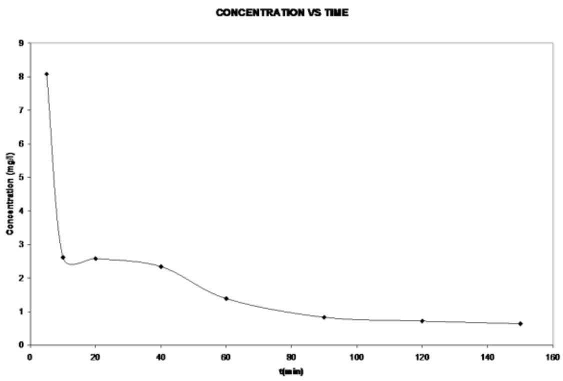
When the linearised forms of the equations are used to plot the graphs, high coefficients of linear correlation is an indication of the applicability of any of the kinetic models

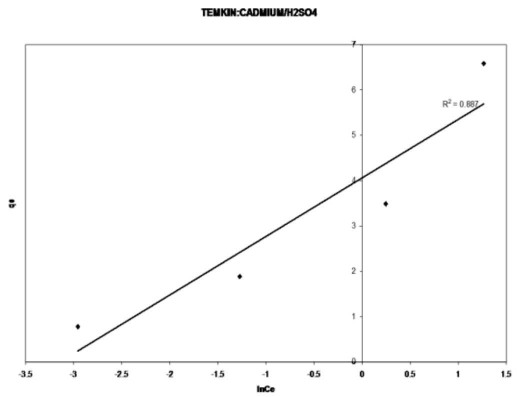
CONCLUSION

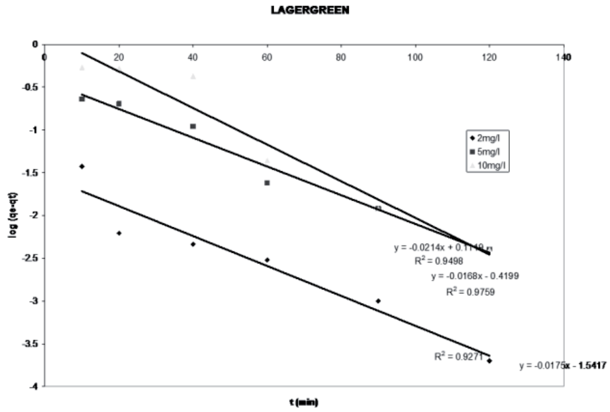
The present study was carried out to investigate the ability of melon husk in the removal of methylene blue from aqeous solution. The results obtained showed that the equilibrium time for the adsorption of the dye onto raw melon husk (RMH) was 120 minutes. The sorption process followed pseudo-second order kinetics, though there are evidences to suggest intraparticle diffusion and boundary layer effects on the sorption kinetics. The data obtained fitted all with Langmuir isotherm model ($R^2 = 0.9999$). The monolayer adsorption capacity,q_m, obtained from Langmuir isotherm was 47.39 mg/g, which is comparable with the values reported in the literature for some agroWastes and biological materials (Table 6). The adsorption is highly influenced by parameters such as contact time, Adsorbent dosage and initial concentration of the dye.

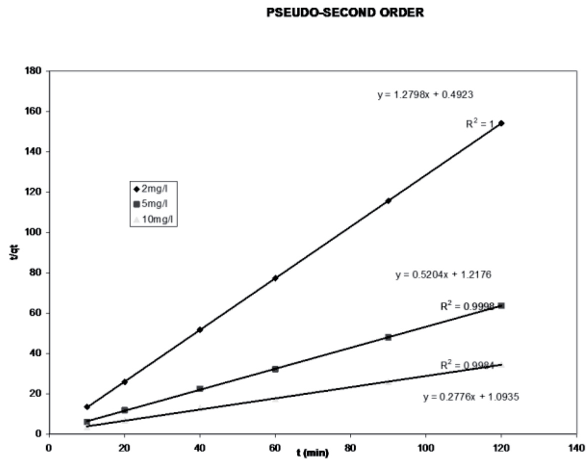
The study has shown that melon husk which is abundantly available but generally considered useless,has a considerable potential as an effective sorbent for the removal of methylene bluefrom aqueous solutions. It can therefore have a place in the treatment of effluents from textile and allied industries, thereby reducing the level of water pollution.

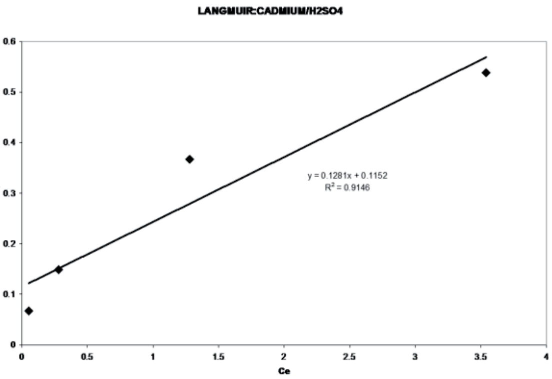

Melon/H2SO4:Cd:KINETICS
q (mg/g)
Time(min)
2ppm
5ppm
10ppm

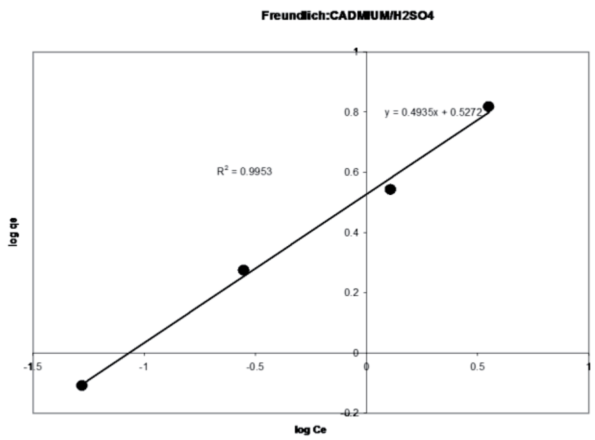

CONCENTRATION VS TIME
Concentration (mg/l)
t(min)

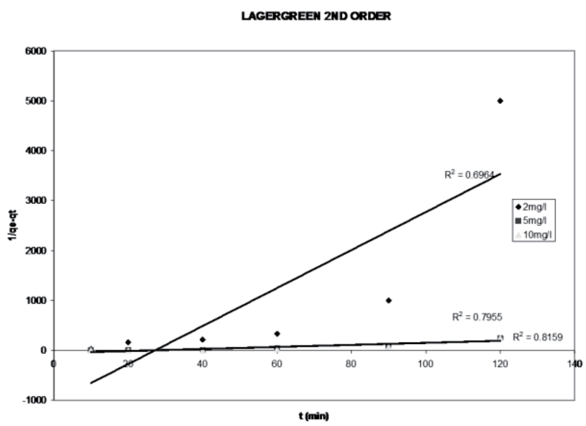

TEMKIN:CADMIUM/H2SO4
qe
lnCe
R² = 0.887


LAGERGREEN
log (qe-qt)
t (min)
2mg/l
5mg/l
10mg/l
y = -0.0214x + 0.1119
R² = 0.9498
y = -0.0168x - 0.4199
R² = 0.9759
R² = 0.9271
y = -0.0175x - 1.5417


PSEUDO-SECOND ORDER
t/qt
t (min)
2mg/l
5mg/l
10mg/l
y = 1.2798x + 0.4923
R² = 1
y = 0.5204x + 1.2176
R² = 0.9998
R² = 0.9984
y = 0.2776x + 1.0935


LANGMUIR:CADMIUM/H2SO4
Ce/qe
Ce
y = 0.1281x + 0.1152
R² = 0.9146


Freundlich:CADMIUM/H2SO4
log qe
log Ce
y = 0.4935x + 0.5272
R² = 0.9953


LAGERGREEN 2ND ORDER
1/(qe-qt)
t (min)
2mg/l
5mg/l
10mg/l
R² = 0.6964
R² = 0.7955
R² = 0.8159

MELON/H2SO4:Cd:
CONC EFFECT

CONC	%R
2	97.4
5	94.4
10	87.2
20	80.2

nMelon/H2SO4:Cd:Dosage

Dosage(g)	%R	q
0.02	92.9	7.432
0.1	93.4	7.472
0.15	93.6	7.488
0.2	93.8	7.504
0.25	94.2	7.536
0.3	95.6	7.648

PSEUDO 1ST ORDER

Co	R	slope	intercept	k1	qe,1
2	0.9271	0.0175	1.5417	0.040303	34.80968
5	0.9759	0.0168	0.4199	0.03869	2.629662
10	0.9498	0.0214	0.1119	0.049284	1.293898

2ND ORDER

R	K2=slope	intercept	qe=1/intc
0.6964	38.096	1035.7	0.000966
0.8159	2.0389	49.972	0.020011
0.7955	2.0698	56.919	0.017569

PSEUDO 2ND ORDER

R	slope	qe=1/slope	qe(sqr)	intercept	1/intercept	K2	h
1	1.2798	0.781372	0.610542	0.4923	2.031282	3.327012	0.4923
0.9998	0.5204	1.921599	3.692542	1.2176	0.821288	0.222418	1.2176
0.9984	0.2776	3.602305	12.9766	1.0935	0.914495	0.070473	1.0935

PRELIMINARY STUDIES ON PHYTOCHEMICAL AND ANTIMICROBIAL INVESTIGATION OF PLANTS (IRAWO-ILE) MITRACARPUS VILLOSUS, EUPHORBIA HIRTA AND SPERMACOCE OCYMOIDES

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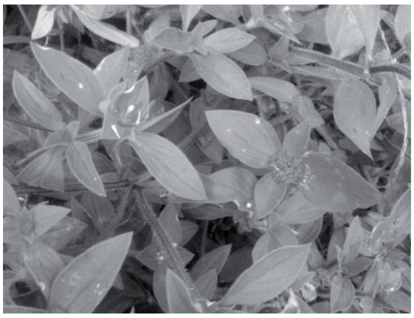
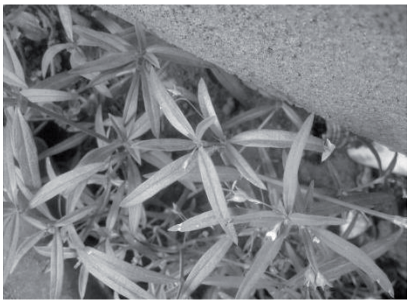
Abstract
Mitracarpus villosus, Euphorbia hirta and Spermacoce ocymoides are three plants that are called by the same local name (Irawo-Ile) in South-western part of Nigeria. These plants were investigated for some of their components and antimicrobial activities of their leave extracts against bacteria and fungi.
Phytochemical analysis revealed that the three plants contain saponins, tannins and volatile oils. They do not contain steroids. Infrared and ultraviolet-visible (U.V) analysis suggested that the plants contain Benzene ring, hydroxyl group and aniline in their structure.
It was found from antimicrobial analysis that the plants extract exhibited antimicrobial activities at a concentration of 25mg/ml. The zone of inhibition of the plants extract against fungi and bacteria ranges between 10 – 35mm with minimum inhibitory concentration (MIC) ranges between 25 – 50mg/ml for fungi while that of bacteria ranges between 25 – 100mg/ml with S. Ocymoides less effective against bacteria. The Ethanolic extracts of both dried and fresh leaves of the plants show more antimicrobial activity against the tested organisms than n-hexane extracts of the plants.

INTRODUCTION
Mitracarpus villosus, Euphorbia hirta and Spermacoce ocymoides are called Irawo-ile in south-western, Nigeria because of their similar antifungal and antibacterial properties. Irawo-ile is called African Borreria or Green Borreria in English. They belong to family known as Rubiaceae. Mitracarpus villosus fresh leaves are green in colour with the characteristic mild odour, bitter and peppery taste (Jegede et.al, 2005). The matured leaf size is 3.5cm (length) and 0.8-1.3cm (breath). Euphorbia hirta stem is slender and cylindrical often reddish or white covered with yellowish bristly hair especially in the younger parts. Its leaves are oppositely arranged lanceolate and up to 5cm long, they are greenish or reddish underneath asymmetrical and of rounded base in the axis which appears very dense. Spermacoce ocymoides leaf is partly fused at base, small, puberulous, margin not hairy. The fresh leaves are green in colour, semi-leathery and about 13cm long, 0.21cm wide, linear- lanceolate or ovate to elliptic.(Cabral et al, 1996 and Alejandro et al., 2002) These plants grow to about a height of 40-50cm. The plants are useful in curing gonorrhea, dysentery and skin diseases (Hutchinson et al., 1963)
Much study has not been carried out on these plants. Jegede et al, 2005 investigated the pharmacognostic properties of the leaves of mitracarpus villosus.
Mostly, the importance of these plants are not known and so it is normally cut off as Waste material as a result of this, we embark on this study to consider some of the components and anti-microbial effects of the leave of these plants on some micro-organisms.



Euphorbia hirta

Spermacoce ocymoides



Mitracarpus villosus

Figure 1: Picture of Euphorbia hirta, Spermacoce ocymoides and Mitracarpus villosus

MATERIAL AND METHODS

Sampling

The three plants samples; Mitracarpus villosus, Euphorbia hirta and Spermacoce ocymoides were collected in July, 2008 at Ogbomoso, Oyo state, Nigeria. The plants were identified at Botany department, University of Ibadan and Department of Pure and Applied Biology, LAUTECH, Ogbomoso. The samples were air dried for ten days, ground into powder and stored in a colourless plastic bottle.

Extraction: Three solvents were used for these extractions namely Ethanol, n-hexane and water. 20.0g each of the powdered samples were weighed into three labeled conical flask containing 200ml of Ethanol each. The mixtures were left for four days and then filtered. The filtrates were put in the round bottom flask, heated with water bath and connected to coil condenser through which cold water flows to condense the vapour from the solvent of the extract which is collected in a receiving flask. This was done in order to concentrate the extracts.

The above procedure was used for the extraction with n-hexane except that the samples were soaked for two days instead of four days.

With distilled water extraction: 20.0g each of fresh leafs of the plants were weighed and rinsed with water. The rinsed samples were ground; more water was added for extraction and then filtered.

Infrared, Ultra-Violet, phytochemical and antimicrobial screenings were carried out on the filtrates.

Phytochemical Screening

Phytochemical screening for some constituents of the plant extracts was done using standard qualitative methods as described by various authors (Trease et al., 1989 and Edeoga, 2005). The plants were screened for Saponins, Tannins, Volatile oil and steroid as follows:-

Saponins Test

5ml of each of the extracts were vigorously shaken for two minutes with 10ml of water in a test tube. Frothing which persisted on warming was taken as an evidence for the presence of Saponins.

Emulsion Test for Saponins

5 drops of Olive oil was added to $3cm^3$ of the extract in a test-tube and the mixture was shaken vigorously. A stable emulsion which formed indicates the presence of saponins

Test for Tannis

To a small quantity of the plant extracts, were added 4ml of water and a drop of ferric chloride. Green precipitate indicates the presence of tannins.

Test for Volatile oil

The extract of each of the plants were dissolved in 90% alcohol and drops of ferric chloride were added. Green colouration, indicate the presence of volatile oils.

Test for steroids: Salkowski Test

5 drops of concentrated H_2SO_4 was added to $1cm^3$ of the Ethanolic extract of each plant. Absence of red colouration indicates absence of steroids in the extracts.

Infrared Spectroscopy analysis: Small portion of the extracts were used for the IR analysis on Nicolet Avatar 330FT-IR by thermo Electron Corporation using KBr disc

Ultraviolet-Visible-analysis: This was done using Genesys 10 scanning machine

PREPARATION OF THE ANTIMICROBIAL DISCS

Filter papers were punched to produce paper discs. The paper discs were then sterilized in an autoclave at 150^oC for 2hours.

The isolate used for the determination of the anti microbial property of the extracts were taken from nutrients agar slants and subcultures on nutrients agar plates. The plates were incubated in an incubator at 37^oC for 18hours to get young cultures of the isolates.

After the sub culturing, the young cultures were then inoculated on fresh nutrient agar plates using sterile cotton swabs. With a sterile forceps, the extract soaked-paper discs were introduced on each inoculated plates, the plates were incubated at 37^oC in an incubator for 18hours. At the end of the incubation period (18hours), the plates were brought out and the zones of inhibitions around each disc were noted and measured in millimeter (mm) using measuring ruler and the results recorded.

The extracts from fresh mitracapus villosus was also applied to the scrape part of a body that has eczema (a fungi causing skin disorder). The scrape eczema part was also culture on nutrient agar and found to grow. The extracts of M. villosus was found to inhibit its growth

RESULTS AND DISCUSSION

Phytochemical Analysis

The result of phytochemical analysis for the extracts of the three plants is shown in Table 1. It can be seen from the table that the plants extracts contain saponin, tannin, volatile oils. Spermacoce ocymoides does not contain tannin. They do not contain steroid. The presence of tannin and volatile oil show that the plants can be used as purgative and herbal medicine respectively. (Gills, 1992).

Results for Antimicrobial Test

The crude extract of Mitracarpus villosus, Euphorbia hirta, and Spermacoce ocymoides were obtained using Ethanol and n-hexane on both fresh and dried leaves of the plants and were tested for their in-vitro antibacterial and antifungal activities using agar diffusion techniques.

Ethanolic extracts of both fresh and dried leaves produced definite antibacterial and antifungal activities against; Staphylococcus aureus, Candida albicans, Aspergillus Niger and Fusarium flocciferum. Ethanolic extract of dried Mitracarpus villosus is the most effective against C. albican followed by E. hirta (Table 2) .E. hirta is the most effective inhibitor of Aspergillus niger, fusarium flocciferum and staphylococcus aureus. The same trend is followed by n-hexane extract except that the M. villosus is the most effective inhibitor of Staphlococcus aureus. Extracts from dried samples of the plants is more effective compared to the extracts from fresh samples of the plants (Table 3)

Also, n-hexane extracts of both fresh and dried leaves show some antibacterial and antifungal activities against Staphylococcus aureus, Candida albicans and Aspergillus niger while the fresh leaves in n-hexane of the three plants does not posses any definite action against Fusarium flocciferum.

The zone of inhibition produced by both the Ethanolic extracts and n-hexane extracts of the dried and fresh leaves of the plants on S. aureus ranges from 10 – 30mmm while that of Ethanolic and n-hexane extracts of dried leaves ranges 10 – 35mm (Table 2). The minimum inhibitory concentrations (MIC) of the extracts are in the range 25mg/ml – 50mg/ml while the minimum bacteriocidal concentrations (MBC) is in the range 25mg/ml – 100mg/ml. The crude extracts of mitracarpus villosus which was applied directly on skin disorder, eczema was found to cure the disease within 3days. It can be seen that the plants will be an effective cure for a fungi skin disorder.

Infrared Analysis of the Plants Extract: The infrared spectroscopy of the samples show major peaks at 1635.62, 1635.54 and 1636.06 cm^{-1} for M.villosus, E. hirta and S. ocymoides respectively which is typical of compound that contain carbonyl group (C=O), C=N. Absorption at 3565.31, 3573.70 and 3568.15cm^{-1} are also observed for the three plants extract which is typical of O-H, N-H stretching frequency. Absorption at 2068.68cm^{-1} is common to the three plants samples; this shows the presence of CLC or CLN. The three plants have similar activities due to nearly identical functional group obtain from their extracts.

Ultraviolet (UV) Analysis: The three plants, M. villosus, E. hirta and S. ocymoides absorb at 229 and 322nm, 217nm and 265nm respectively. There are many compounds with different conjugation that fall into these categories i.e para-nitroaniline, chloroaldehyde, chlorobenzene, phenol and butadiene. These three plants will contain one or more of these groups of compounds.

Table 1: Summary of Phytochemical analysis Results

Extracts	Saponins	Tannins	Volatile oils	Steriods
Mitracarpus Villosus	+	+	+	-
Euphorbia Hirta	+	+	+	-
Spermacoce Ocymoides	+	-	+	-

Keys: + = Present - = Absent

Table 2: Comparative antimicrobial activities of Dried samples of M. villosus, E. hirta and S. ocymoides

Plant extracts in Ethanol	M.villosus			E. hirta			S . Ocymoides		
Concentration mg/ml	25	50	100	25	50	100	25	50	100
Organisms	**Zones of inhibition (mm)**								
C. albicans	35	35	35	20	20	30	10	12	20
Aspergillus niger	12	16.25	20	25	30	35	15	20	25
Fusarium flocciferum	10	12	15	20	25	18	20	15	20
Staphylococcus aureus	12.5	15	20	19	20	30	11	15	20
Plants extract in n-hexane	M.villosus			E. hirta			S . Ocymoides		
Organisms	**Zones of inhibition (mm)**								
C. albicans	18	20	30	25	25	30	20	30	30
Aspergillus niger	10	12	25	30	30	30	25	30	30
Fusarium flocciferum	15	18	25	25	35	35	25	30	30.5
Staphylococcus aureus	20	25	30	15	15	18	15	20	20

Table 3: Comparative antimicrobial activities of Fresh samples of M.Villosus, E. hirta and S. ocymoides

Plant extracts in Ethanol	M.villosus			E. hirta			S . Ocymoides		
Concentration mg/ml	25	50	100	25	50	100	25	50	100
Organisms	**Zones of inhibition (mm)**								
C. albicans	10	20	25	18	10	10	20	20	25
Aspergillus niger	18	20	25	20	20	30	20	30	35
Fusarium flocciferum	30	25	10	10	12	15	20	25	30
Staphylococcus aureus	11.5	15	15	15	15	20	10	12	15
Plants extract in n-hexane	M.villosus			E. hirta			S . Ocymoides		
Organisms	**Zones of inhibition (mm)**								
C. albicans	18	20	25	15	18	15	10	12	15
Aspergillus niger	18	20	20	10	18	18	NA	15	20
Fusarium flocciferum	NA	NA	NA	NA	NA	NA	NA	NA	NA
Staphylococcus aureus	20	25	30	10	10	10	18	10	10

CONCLUSION

Phytochemical analyses reveal that the three plants contain similar constituents which are useful for medicinal purposes. Infrared and ultra-violet spectrophotometric analysis suggested the presence of carbonyl, Chlorobenzene, phenol within the extracts. More analysis such as tin-layer chromatography, GC-MS, H-NMR C^{13}- NMR, needed to be done to ascertain the actual component of the plants. The three plants extract can be used as antifungal as well as antibacterial.

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POTENTIALS OF TWO UNCULTIVATED PLANTS IN NUTRITION AND INDUSTRIAL DEVELOPMENT (*ARTOCARPUS HETEROPHYLLUS* AND *PARKIA BIGLOBOSA*)

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Abstract

The major component of Wastes from uncultivated plants that constitutes environmental problems is seed. Artocarpus heterophyllus seed and Parkia biglobosa seed pulp were investigated for proximate composition, chemical and antibacterial properties of their oils with a view to exploiting their nutritional and industrial potentials. The crude protein, crude fibre and crude fat content were 14.02, 5.25; 1.23, 12.00; 26.5, 18.00 g/100g respectively. The high iodine value of the fixed oils; 1788, 1425 g iodine kg^{-1} oil respectively compared favourably with edible oils, while the high saponification values of 296.14 and 193.12 g KOH kg^{-1} suggested they are good feedstock for the soap industry. The seed and seed pulp essential oils could also find application as antibacterial agent to extend the shelf life of easily perishable food products.

Keywords: uncultivated plants; fixed oils; essential oils; nutrition and industrial potentials.

INTRODUCTION

In developing nations, numerous types of edible wild plants which remain uncultivated are exploited as sources of food; hence they provide an adequate level of nutrition to the inhabitants (Aberoumand, 2009). Recent studies on some lesser known Nigeria fruits indicated that these plant resources play a significant role in nutrition, food security and income generation (Bello et al., 2008). In addition to the renewed interest in wild edible plant species as sources of food, there has been an increased awareness of their potential use in industries as a viable alternative to the non- renewable petroleum based Fuels and lubricants (Falade et al., 2008, Jekayinfa and Waheed, 2008). Most of these wild edible species remain uncultivated and most times go to Waste and create environmental problem. Such type of these plant species are Artocarpus heterophyllus (jackfruit) and Parkia biglobosa (African locust bean) seed pulp.

The jackfruit, (*Artocarpus heterophyllus* Lamk) Family:Moraceae; is a fruit bearing tree that contains seeds (between 100 and 500 per fruit) embedded in the pulp (Morton, 1987). In Southwestern Nigeria where the plant abounds, children used to collect and eat the seed boiled. However, this practice has stopped and the seeds now substantially go to Waste. Also, *Parkia biglobosa* (Jacq.) Benth Family: Leguminosae is a savannah forest plant. The fermented seed is a protein and oil rich condiment locally known as iru (Omafuvbe *et al.*, 2004) while the fruit pulp serves as a fodder for livestock (Alabi, 2005). The bark, leaves, seeds and pulp are also known to have medicinal value and credited for the treatment of more than 40 ailments (Lemmich *et al.*, 1996; Quedrago, 1999). The pulp, which is the subject of this investigation, is mostly Wasted despite its economic importance, because the *P. biglobosa*, is uncultivated (Amoo and Ayisire, 2004) and the seeds are extracted wherever they are found leaving the pulp scattered.

These two uncultivated edible plants were therefore investigated for proximate compositions, chemical properties of their fixed oils and anti-bacteria properties of their essential oils with a view to finding practical and economic uses for them.

MATERIALS AND METHODS

Sample collection: Ripe samples of jackfruit and African locust bean fruits were collected at and around the Ladoke Akintola University of Technology (LAUTECH), Ogbomoso. Voucher specimens (number 13535 and 3356 respectively) were deposited at the herbarium of the Department of Botany, Obafemi Awolowo University, Ile-Ife.

Preparation of samples: Seeds of *Artocarpus heterophyllus* were removed from the ripe pods, shelled and diced into pieces while *Parkia biglobosa* pod was carefully opened, the yellowish pulp scraped from the seed, both samples were separately dried at 50^o C and ground in a laboratory mortar and pestle and further ground to a fine powder using a Moulinex Turbo Blender Model D70, Cologne Germany.

Proximate analysis was determined by AOAC (1990) method. Carbohydrate was determined by difference while nitrogen was converted to protein by multiplying it by a factor of 6.25.

Oil extraction: The fixed oils were extracted with petroleum spirit (40 – 60 ^{o} C boiling range, BDH, UK) using the soxhlet apparatus (Soxtherm 2000 automatic, Gerhardt Germany) (AOAC, 1990). The essential oils were extracted by hydrodistillation of the pulverized dried samples in an all glass Clevenger apparatus for 4hrs in accordance with the British pharmacopoeia specifications (1980).

Analysis of extracted oils: The refractive index of the oils was measured at room temperature using the Abbey refractometer (Prince Optical Works, Malka Ganj Delhi)while the chemical properties of the fixed oils were determined using AOAC (1990) methods.

Anti- bacteria activities of the essential oils and antibiotic sensitivity test: The anti-bacterial activities of the essential oils were determined using the paper disc method as described by Oloke (2000). The essential oils were dissolved in DMSO to obtain graded concentrations ranging from 6.25 to 50 %v/v. Sterile paper discs were dipped into different concentrations of the oils and then aseptically layered on nutrient agar plate already seeded with an 18hr-broth culture each of the test organisms (Staphylococcus aureus, Escherichia coli, Bacillus subtilis and Micrococcus luteus) in duplicate. Each plate was incubated at 37^0C for 24hrs and then examined for zones of inhibition. The lowest concentration of each test material, which inhibited growth, was taken as the minimum inhibitory concentration (MIC).The sensitivity of the bacterial to antibiotics was tested by means of M2-A6 disc diffusion method recommended by the National Committee for Clinical Laboratory Standards (NCCLS) using nutrient agar. The resistance of the test organisms to commonly dispensed antibiotics in Nigeria was evaluated as previously described (Lateef et al., 2005) using commercial disc (Abtek Biologicals Ltd, Liverpool) containing the following: Augmentin(Aug), 30µg; Amoxycillin (Amx), 25µg; Tetracycline (Tet),10µg; Cloxacillin (Cxc), 5µg; Gentamicin(Gen), 10µg; Cotrimoxazole(Cot), 25 µg; Erythromycin (Ery), 5µg; and Chloramphenicol, 30µg. The plates were incubated at 37^0C for 24hrs, after which the zones of inhibition were examined and interpreted accordinly (Chortyk et al., 1993) as resistant (< 10 mm), mild susceptibility(11- 15 mm) and susceptibility (> 15 mm) considering the appropriate breakpoints (Andrews, 2005).

RESULTS AND DISCUSSION

Table 1: Proximate Composition of the Samples

Species name	Moisture	Ash	Crude protein	Crude lipid	Crude fibre	Carbohydrate
Artocarpus heterophyllus	8.25 ± 0.10	2.83 ± 0.10	14.02 ± 0.32	26.5 ± 1.20	1.23 ± 0.03	65.44 ± 0.35
Parkia biglobosa pulp	4.00 ± 0.22	3.88 ± 0.23	5.25 ± 0.04	18.00 ± 2.60	12.00 ± 1.20	60.75 ±0.48

The proximate composition of the seed and seed pulp of Artocarpus heterophyllus and Parkia biglobosa were reported in Table 1. The moisture content were low thus suggesting they could have longer shelf life; the crude protein content in A. heterophyllus was higher than that of P. biglobosa and thus could be a good source of amino acids. According to the Food and Nutrition Board (2001), food plants that provide more than 12 % of their calorific value of protein are a good source of protein therefore A. heterophyllus seed could complement protein from other conventional plant foods. Lipids are essential because they provide the body with energy approximately twice that of carbohydrate, the crude lipid compared favourably well with those reported for conventional oils such as cotton seed (14.1 %); soybean oil (19.1 %), locust bean (20.3 %); (Ayodele at al., 2000).This showed that these samples could be sources of vegetable oil if well annexed, hence could complement conventional vegetable oils, which are very expensive. Crude fibre content of A.heterophyllus seed is low, this may be desirable in its incorporation in weaning diets as emphasis has been placed on the importance of keeping fibre intakes low in the nutrition of infants and pre- school children (PAG, 1978) however the higher fibre content of P. biglobosa is desirable in incorporation into adult diet, high fiber food expands the inside walls of the colon, easing the passage of Waste, thus making it an effective anti-constipation, it also lowers cholesterol level in the blood, reduce the risk of various cancers, bowel diseases and improve general health and well being (Eromosele and Eromosele, 1993).

Levels of antinutrients like tannin, phytate, trypsin inhibitor and oxalate reported earlier for A. heterophyllus and P. biglobosa were low to be of any nutritional importance (Bello et al., 2008) thus they could be good supplements to scarce cereal grains as sources of energy in feed formulations.

Table 2: Properties of the Fixed Oils

Species name	Refractive index	Iodine value g iodine Kg^{-} oil	Saponification value (mgKOH/g)	Peroxide value (meq/kg)	% Free fattyacid as oleic
Artocarpus heterophyllus	1.475 ± 0.007	1780.00 ± 6.52	296.15 ± 1.44	13.05 ± 0.22	8.88 ± 0.06
Parkia biglobosa pulp	1.457 ± 0.007	1424.00 ± 1.10	193.71 ± 1.24	7.16 ± 0.13	6.76 ± 0.12

The properties of the fixed oil were reported in Table 2. The refractive index of the oil samples ranged between 1.457 and 1.475. This range was in close agreement with the values reported for some conventional oils such as palm oil (1.449 – 1.451), soybean oil (1.466 – 1.470) (De Bussy, 1975) and acacia oil - an unconventional oil (1.473 – 1.474) (Falade *et al.,*

2008). The high refractive index of these oils showed that the fatty acids in the oils will contain a high number of carbon atoms (Rudan-Tasic and Klofutar, 1999).
Iodine value ranged from 1424g iodine / kg oil for P. biglobosa seed pulp oil to 1780 g iodine / kg oil for *A. heterophyllus* seed oil. The degree of unsaturation of the oil, expressed as its iodine value, serves as an indicator of the uses to which it can be put. The iodine values of the oils compared favourably with those of cotton seed oil, sunflower seed oil and passion fruit seed oil with a range of 1050 - 1440, 1100 – 1430, and 1330 – 1410 g iodine / kg oil respectively (Nyanzi *et al.*, 2005)and higher than 1093 g iodine / kg oil reported for groundnut oil (Falade *et al.,* 2008). In this respect, the oils presently under investigation seem to be superior to the conventional oils from nutritional and health view points. Oils rich in unsaturated fatty acids have been reported to reduce the risk of heart diseases associated with cholesterol (Law, 2000). The high iodine value also indicates that the oils from these samples can be utilized in coating industries because they will have high drying property (Marvin, 1979).
Peroxide value (PV), used as a measure of oil quality, ranged between 7.2 meq / kg for *P. biglobosa* pulp oil and 13.1 meq / kg for *A. heterophyllus* seed oil. High peroxide values are associated with higher rate of rancidity. For oil to have acceptable storage stability, its PV should be less than 5 meq / kg (Rudan-Tasic and Klofutar, 1999); hence, both oils reported can be stored for too long unless they are adequately processed or preserved with antioxidant. However, 10.9 meq / kg PV has been reported for groundnut oil which is a conventional oil (Falade, *et. al.,* 2008), this may therefore indicates that these oils will be less liable to oxidative rancidity at room temperature compared to this conventional oil.
Saponification values ranged between 193.7 g KOH / kg oil for *P.biglobosa* seed pulp oil and 296.2 g KOH / kg oil for *Artocarpus heterophyllus* seed oil. The results compared favourably with saponification values of palm oil (196 – 205 g KOH / kg oil), olive oil (185 – 196 g KOH / kg oil), soya bean oil (193 g KOH / kg oil), cottonseed (193 – 195 g KOH / kg oil), butter (220 – 233 g KOH / kg oil) and linseed oil (193 – 195 g KOH / kg oil) (Baumer,1995). The value obtained for *P. biglobosa* agreed well with 198 g KOH / kg oil reported for groundnut oil (Falade, *et. al.,* 2008). This indicated that the oils under investigation could be used as a substitute for these established oils for instance in soap making. High saponification implies that the fatty acids in the oil have high number of carbon atoms (Rudan-Tasic and Klofutar, 1999). The high saponification value of oil of the samples would therefore suggest a preponderance of high molecular weight fatty acids.
Free fatty acid value ranged between 6.76 and 8.88 % in P.biglobosa pulp and A. heterophyllus seed oil respectively. These values were higher than 0.4 % reported for groundnut oils (Falade *et al.,* 2008). Since free fatty acids are more prone to lipid oxidation than the glycerides, it is then expected that all these oil samples will become rancid more easily and faster compared to some of the conventional oils (FAO / WHO, 1993).

Table 3: Antibacteria Activity of the Essential Oils and Antibiotic Resistance Pattern Among the Bacterial Isolates.

Bacterial Isolates of Antibiotics	Zone of inhibition (mm) 6.25* 12.5* 25* 50* Artocarpus heterophullus	6.25* 12.5* 25* 50* Parkia biglobosa	Resistance Pattern
S. aureaus	11 13 **18 20	**15 18 22 25	Aug Amx Ery Tet Cxc GenCot
E. coli	- - - 10	- 11 13 15	Aug Amx Ery Tet Cxc CotChl
B. subtilis	- - - 11	11 12 18** 20	Aug Amx Ery Tet Cxc Cox
M.luteus	13 15 18** 22	-- 16** 18 18	Aug Amx Ery Tet Cxc Cot

* - % (v/v) using DMSO as diluent ** MIC for each bacterium. MIC – Minimum inhibitory concentration (lowest concentration of each test material which inhibited growth) resistant (< 10mm), mild susceptibility (11-15mm) and susceptibility (> 15mm) (Chortyk et al., 1993).

The antibiogram of the essential oils of the seed of Artocarpus heterophyllus and seed pulp of Parkia biglobosa as well as the resistance pattern of the tests organisms were reported in Table 3. The minimum inhibitory concentration in % volume of essential oil of P. biglobosa pulp (6.25 %) is lower than that of A.heterophyllus (25 %) against S. aureaus while this organism shows resistance against seven tested antibiotics. E.coli is resistant to essential oil of A.heterophyllus but showed mild susceptibility to essential oil of P. biglobosa at 50 % concentration. 7 tested commercial antibiotics were however resistance to E. coli. P. biglobosa pulp essential oil at 25 % concentration showed susceptibility to B. subtilis meanwhile five commercial antibiotics were resistance to the microorganism. At 6.25 % and 12.5 % concentration of A. heterophyllus and P. biglobosa respectively growth of M. luteus was inhibited but five commercial antibiotics showed resistance to the organism.

It could be seen from these results that the test bacteria in this study showed various degree of resistance to commercial antibiotics, while showing appreciable susceptibilities to the essential oils. It could be inferred that these essential oils could find application as antibacterial agent to extend the shelf life of easily perishable food products when incorporated.

CONCLUSION

The data reported show that these wild edible species which remain uncultivated and most times go to Waste thus creating environmental problem could be harnessed as food supplements and preservatives, raw materials in soap and cosmetics industries and thus components of the much- needed agro- based industrial revolution in Nigeria.

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ADSORPTION OF NAPHTHALENE ONTO CARBON ADSORBENT PRODUCED FROM AGRICULTURAL RESIDUE (*DELONIX REGIA*)

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Abstract
Polycyclic aromatic hydrocarbons (PAHs) are widespread environmental pollutants of health concern in humans. In this study, activated carbon was developed by carbonization of flamboyant (*Delonix regia*) bark at temperatures of 300, 500 and 600^{0}C, before activation with phosphoric acid (H_3P0_4). Naphthalene (50 – 150 mg/L) was adopted as a model contaminant in aqueous solution to examine the adsorption efficiency of the activated carbon. Freundlich and Langmuir isotherm models were used to pit the experimental data. The maximum adsorption capacities of the carbon produced at 300, 500 and 600 ^{0}C were 3.996, 4,082 and 4,391mg/g respectively. Removal efficiencies of the carbon obtained at 500^{0}C 54.42-55.51%) and 600^{0}C (58.55-5971%) decreased as the initial concentration of naphthalene increased from 50-150 mg/L, however efficiency increased from 51.48 to 53.28% for carbon obtained 300^{0}C. Similarly, the adsorption equilibrium data of naphthalene unto the carbon obtained at 500^{0}C and 600^{0}C were well fitted for Freundlich isotherm while carbon obtained at 300^{0}C showed slight deviation. Similar, trend was observed for Langmuir isotherm. This study showed that carbonization temperature and initial concentrations of naphthalene influenced adsorption capacity and removal efficiency of the activated carbon developed from flamboyant bark.

Key word: PAHS, flamboyant pod back, Freundlich, Langmuir, adsorption capacity,
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INTRODUCTION

The search for the removal of organic pollutants using alternatives Adsorbents is now on the rise by many researchers (McKay, 1995; Mackay and Gschwend, 2000; Grupta *et al.,* 2002; Boving and Zhang, 2004; Zheng *et al.*, 2004).Numerous carbonaceous materials, particularly, those of agricultural base, are being investigated as sources for activated carbon. Those suitable have minimum amount of organic material and a long storage life. Similarly they consist of hard structure to maintain their proprieties under usage conditions and be obtained at a low cost. Some of the materials that meet the above conditions have been used to produce activated carbon and have been subjected to uses that substantiate their suitability (Warhurst *et al.,* 1996).

Agricultural by–products like rice straw, soybean hull, sugarcane baggasse, peanut shell, pecan shell and walnut shells were used by John *et al.,* (1998) to produce granulated activated carbons (GACs). Johns *et al.,* (1999) produced granular activated carbon from pecan shell chars by applying three different activation techniques; the steam, carbon dioxide and phosphoric acid. Resulting activated carbons from these processes have surface areas that compare fairly above some commercial activated carbons. They also proved more effective in

the adsorption of organic contaminants and metals, particularly copper from aqueous solution.
Mameri *et al.,* (2000) produced a high quality activated carbon from solid olive mill Waste at temperature ranging from 800 to 900 ^{0}C and the effectiveness of the activated carbon on phenol indicates an adsorption capacity of about 11.24 mg of phenol per gram of the activated carbon produced. Another effective activated carbon was produced from oil–palm shells by Guo and Lua (2000),
Efficient activated carbons were produced from hazelnut, pistachio shells and apricot stones by Kazemipour *et al.,* (2008). These agricultural Wastes were preheated in an oven at 100 ^{0}C before being powdered to 180 µm sizes. They were then pyrolysed and activated in a vertical stainless–steel reactor which was placed in an electrical heating furnace. The surface areas of these materials range from 635–1208 m^2/g.
The choice of a particular material for the production of effective Adsorbent (activated carbon) is based of cheapness, high carbon and low inorganic content (Tsai *et al.,* 1997). Agricultural materials have attracted the interest of researchers for the production of Adsorbents because of their availability at large amount and at a low price (Ioannidou and Zabaniotou, 2007).
The selected materials employed in this study was flamboyant (*Delonix regia)* pod back are untapped agricultural produce that attracted the interest of this research. Flamboyant (*Delonix regia*) is an ornamental tree which belong to the *Fabaceae* family. It is characterised by its fern-like leaves and flamboyant display of flowers and as such given the name Flamboyant. It usually grows to a height ranging between 5 and 12 m with its dense foliage spreading widely to provide full shade. The plant's seed pods are usually dark brown and can be up to 60 cm long and 5 cm wide in a plantain shape. The seed pods contain small bullet-like seeds weighing around 0.4 g on the average.
The selected adsorbate considered in this study is naphthalene. The adsorption of the selected PAHs in this research can provide useful information on the effective treatment of Wastewater containing polyaromatic hydrocarbon (Long *et al.*, 2008). Some properties of naphthalene are listed in Table 1. Its adsorption has been studied using non-agricultural based activated carbon in such as silica gel (Tozuka *et al.,* 2002) zeolite (Chang *et al.*, 2004), modified clays and organo-based materials (Nzengung *et al.*, 1996; Lee and Kim, 2002; Bonczek *et al.*, 2002). Long *et al.*, (2008) equally investigated the suitability of Waste ion exchanged as Adsorbent for naphthalene.

METHODOLOGY

MATERIALS

The natural precursor be used in the production of the Adsorbent include flamboyant pod bark which was sourced from the campus yard of Ladoke Akintola University of Technology, Ogbomoso. The reagents used during the course of the experimental activities include sodium bicarbonate ($NaHCO_3$), phosphoric acid (H_2PO_4 58 %), acetone (BDH Chemicals Ltd, mw 58.08g , spg 0.789 - 0.791 g/^{0}C), distilled water, polycyclic aromatic hydrocarbon (PAHs) of 2-rings, Naphthalene (100 g , Merck, Mw 128.18 g).

METHODS

Sample processing

After the collection, material was sorted to remove the stones, shaft and debris. Thereafter, the backs of the flamboyant pod were removed mechanically and kept separately. These back were then washed with distilled water, to remove surface impurities (Bulut and Tez, 2007) and later dried in the oven at a temperature of 105^{0}C overnight (Amuda and Ibrahim, 2006) to constant moisture level. The dried materials were crushed using milling machine so as to reduce their sizes to pellet-form and increase their surface area (Bulut and Tez, 2007) and then stored in dry containers prior to carbonization.

Carbonization

1 kg of the agricultural material was charged into the furnace (Vecstra, Model 184A, Italy) which was then heated to the desired temperature (300 ^{0}C), the resulting charred material was collected and cooled at room temperature. The procedure was repeated for temperatures of 300 ^{0}C, 500 ^{o}C and 600 ^{o}C. The domain of variation of these factors is defined according to Bornemann *et al.,* (2007). The resulting cooled charred materials obtained from the above process were weighed to determine the yield of each material at different carbonization temperatures (Bornemann *et al.,* 2007). The percentage yield for each charred material was determined using equation 3.1.

$$\text{Percentage Yield (\%)} = \left[\frac{W_F}{W_I}\right] \times 100 \qquad (1)$$

Where W_I = Initial weight before carbonization and W_F = Final weight after carbonization

Preparation of simulated water

All the glassware used were washed with detergent, rinsed with distilled water and allowed to dry in the oven before being used. Calculated amount (50 mg/L) of the desired PAH was weighed and added to 300 mL of acetone in 1dm^3 standard flask. The mixture was carefully swirled together for 10 min to allow proper dissolution. Then, 700 mL of distilled water was added to the mixture and properly shaken to facilitate thorough dissolution of the adsorbates as well (Crisafully *et al.*, 2008), thus a stock solution of 50 mg/L of PAH was produced. The above procedure was repeated for the preparation of 75, 100, 125 and 150 mg/L of naphthalene respectively.

Determination of adsorption capacity

Weighed amount (1g) of each activated carbon was added to 50 mL of the 50 mg/L stock solution 250mL conical flask. The mixture in the flask was covered and placed on magnetic stirrer at 150 rpm for 2 h (Lemic *et al*, 2007) at ambient temperature ($28\underline{+2}$ ^{0}C) and pH 7.5 (Crisafully *et al.*, 2008). After which the content was allowed to stand for 1hr and the supernatant solution was filtered with Whatman filter paper (15mm) into sample bottles (Crisafully *et al.*, 2008). Starting with 50 mg/L of the simulated Wastewater prepared, the process was repeated for 75, 100, 125 and 150 mg/L of naphthalene respectively. Furthermore this procedure was repeated for same activated carbon produced at various temperatures. The resulting filtrates were subjected to analysis.

Analytical measurement

The unadsorbed concentration of polyaromatic in the filtrate was quantified using gas chromatography coupled with flame ionization detection (GC – FID) (Crisafully *et al.*, 2008; Bornemann *et al.*, 2007). A HP-5 capillary of 30m with internal diameter of 0.25mm and film thickness of 0.25µm was used. The column temperature was set to 60^{0}C for 2 min and then ramped to 320^{0}C programmed at 10^{0}C/minn. Nitrogen was used as carrier gas at a constant pressure of 35psi while hydrogen and air flow rate pressure were 22psi and 28psi respectively. Injector port and detection temperature were 250^{0}C and 320^{0}C respectively while 1.0µL of sample was injected before analysis calibration standard was run to check column performance peak height and resolution and the limits of detection of the compound was identified mainly by its retention time. The abundance of quantification of analyte with respect to authentic PAH standard detection limits was derived from replicate procedure.

Quantification of adsorption capacity

The adsorption capacities of the materials carbonized at different temperature were determined using equation 3.2 (Crisafully *et al.*, 2008)

$$q_e = \frac{\left(C_0 - C_e\right)}{w} V \qquad (2)$$

Where q_e is the adsorption capacity of Adsorbent (mg/g), C_o is the initial concentration of the adsorbate in the solution (mg/L); C_e is the final concentration of the adsorbate in the solution quantified with GC – FID (mg/L); V is the volume of the solution (mL) and w is the mass of the Adsorbent (g).

The removal efficiency RE (%) of each activated carbon at different concentration of selected adsorbate was calculated according to equation 3.3 (Kazemipour *et al.*, 2008).

$$RE(\%) = \frac{\left(C_0 - C_e\right)}{C_0} \times 100 \qquad (3)$$

Where C_o and C_e are as defined above.

Adsorption isotherm models

Adsorption Isotherm equations applicable to single – solute were used to describe the experimental sorption data obtained in this study and the parameters of the isotherm models were obtained from graphical plotting of the experimental data. The best fit of the isotherm equations were further determined using linear regression and the suitability of the selected isotherm models to this work was validated with values of the correlation coefficients (R^2). .models used in this study includes Freundlich and Langmuir, isotherm models.

Langmuir Isotherm Model

The linearized form of the Langmuir Isotherm equation is expressed as:

$$C_e \big/ q_e = \frac{1}{Q_L K_L} + \frac{1}{Q_L} C_e \qquad (4)$$

Where C_e (mg/L) is the equilibrium concentration of the adsorbates, q_e (mg/L) is the amount of adsorbate adsorbed per unit mass of Adsorbent. Q_L and K_L are related adsorption capacity and rate of adsorption respectively and were determined by plotting C_e/q_e against C_e.

Importance of Langmuir isotherm is often investigated with dimensionless separation factor (R_L) (Hameed and Rahman, 2008) which is expressed in the form (equation 5)

$$R_L = \frac{1}{1 + K_L C_o} \qquad (5)$$

Where K_L is the Langmuir constant and C_o is the highest concentration of adsorbate (mg/l) in the solution.

The value of R_L obtained indicates Langmuir isotherm to be unfavourable ($R_L > 1$), linear ($R_L = 1$) and favourable ($0 < R_L < 1$) or irreversible ($R_L = 0$) (Hameed and Rahman, 2008)

Freundlich Isotherm Model

The Freundlich Isotherm equation is an empirical equation expressed in linear logarithmic form (Cheung *et al.*, 2009) as

$$In q_e = In K_F + \frac{1}{n} In C_e \qquad (6)$$

A plot of In q_e against In C_e is used to determine the Freundlich constants, K_f and 1/n respectively.

RESULTS AND DISCUSSION

Effect of carbonization temperature on yield

The resulting chars obtained after carbonization at 300, 500 and 600^{0}C, respectively, and their corresponding percentage yield (%) were determined from equation 3.1. The yield of chars obtained from FB300, FB500 and FB600 are 15, 20, and 20 % at carbonization temperatures of 300, 500 and 600 ^oC respectively. The percentage washed-off of the Adsorbents obtained in this study after acid activation using H_3PO_4 for FB300, FB500 and FB600 are 11.00, 7.36, and 8.50 % and decreased as the carbonization temperature increased from 300, 500 and 600 ^oC respectively. The overall results show that the activation process has effect on the yield of activated carbon obtained from Flamboyant pod back (FB), this may be due to decomposition of Biomass portion of these material at high temperature (Ioannidou and Zabanoitou, 2007).

Influence of carbonization temperature and initial concentration on adsorption capacities of the activated carbons

The minimum adsorption capacities of FB300 FB500 and FB600 are 1.287, 1.388 and 1.492 mg/g for the adsorption of naphthalene from Wastewater. Their corresponding maximum adsorption capacities are 3.996, 4.082 and 4.391 mg/g. This shows that adsorption capacity of the activated carbon increased as the initial concentrations of naphthalene increased from 50 – 150 mg/L. Bornemann *et al.*, (2007) equally observed that carbonization temperature influenced the sorption behaviour of aromatic hydrocarbon on charcoals prepared from grass and wood. Similarly, carbonization temperature influenced the adsorption of organic compound like phenol and methylene blue unto activated carbon produced from hazelnut (Ioannioudou and Zabaniotou, 2007).

Influence of carbonization temperature and initial concentration on removal efficiencies of the activated carbons

Figure 1 shows the removal efficiencies, RE (%) of the three activated carbons produced for the adsorption of naphthalene under the influence of increasing carbonization temperature (300 – 600 ^{0}C) and initial concentration (50 - 150 mg/L) of the adsorbates. The removal efficiencies of FB300 used for the adsorption of naphthalene increased from 51.49 – 53.28% as the initial concentration increased from 50 – 150 mg/L. Furthermore, the removal efficiencies of FB500 and FB600 decreased from 55.51 – 54.42% and 59.71 – 58.56% as the initial concentration of naphthalene increased from 50 – 150 mg/L. This then suggests that the activated carbon produced from flamboyant pod back will be larger removal efficiency at carbonization temperature lower than 300 ^{0}C used in this study. However, the maximum removal efficiencies; 53.28, 54.42 and 59.71% obtained for FB300, FB500 and FB600 respectively showed that the removal efficiencies of Flamboyant pod back is proportional with increasing carbonization temperature.

Effect of carbonization temperature on Freundlich Isotherm Model

Figure 2 shows the plots of Inq_e (adsorption capacity) versus InC_e (equilibrium concentration of adsorbate) used for determining the Freundlich isotherm parameters for naphthalene adsorption onto activated carbons produced. Freundlich isotherm parameters obtained for the adsorption of naphthalene onto the Adsorbents produced from agricultural raw materials are shown in Table 1. The Freundlich exponent 'n' for the adsorption of naphthalene unto FB300, FB500 and FB600 are 0.94, 1.04 and 1.05 respectively.

Furthermore, the Freundlich exponent 'n' obtained in this study are less than values obtained for Adsorbent derived from resin (Long *et al.*, 2008). However, these values satisfy the condition, $1<n<10$, which indicate that the adsorption of naphthalene unto the activated carbon produced from the selected agricultural materials is favourable (Rao *et al.*, 2009) except for the adsorption of naphthalene unto activated carbon produced from flamboyant pod back carbonized at 300 ^{0}C. The high values of R^2 (0.995 – 1.000) showed that the Freundlich model is good for describing the adsorption process of naphthalene unto carbon derived from the agricultural raw materials investigated in this study (Crisafully *et al.*, 2007).

Effect of carbonization temperature on Langmuir Isotherm model

Figure 3 shows the plots of C_e/q_e (ratio of equilibrium concentration of adsorbate to adsorption capacity) versus q_e (adsorption capacity) using linear method and this was used to determine the Langmuir isotherm parameters for the adsorption of naphthalene onto the Adsorbents produced at carbonization temperatures of 300, 500 and 600^{0}C. The monolayer capacity, Q_L, obtained from the Langmuir isotherms are -35.714, 294.118 and 63.291mg/g for FB300, FB500 and FB600, respectively, for the adsorption of naphthalene (). The negative value of Q_L (-35.714 mg/g) obtained for FB300 shows deviation and its corresponding value of R_L (1.27) which is greater than one ($R_L>1$) shows that Langmuir isotherm is unfavourable (Hameed and Rahman, 2008) and therefore unfit for adsorption of naphthalene unto the activated carbon. Generally, the correlation coefficients (R^2) of these activated carbons are high (0.9172 - 0.9437) and such high degree of R^2, particularly for the Langmuir isotherm model, suggests that these activated carbons exhibit monolayer coverage with constant activation energy (Han *et al.*, 2009).

CONCLUSION

This study was conducted to determine the suitability and the performance of activated carbon produced from flamboyant pod back for the effective removal of naphthalene from simulated Waste water under the influence of carbonization temperature and initial concentration. Carbonization temperature and acid activation affect the yield of activated carbon produced. The adsorption capacities of the activated carbons obtained is influenced by increasing carbonization temperature. The removal efficiencies of the investigated Adsorbents generally rank above 40% and the removal efficiencies obtained in the study decreased as the initial concentrations of the adsorbate increased from 50 – 150 mg/L of naphthalene in the simulated Wastewater.

Table 1: Properties of naphthalene

Parameter	Naphthalene
Chemical formula	$C_{10}H_8$
Molecular weight	128.16
Colour	White
Physical state	Solid
Melting point	80.28 ^oC
Boiling point	217.95 ^oC
Specific gravity	NA
Solubility in water	3.0mg/L
Partition coefficient	
Log k_{ow}	3.36
Log K_{oc}	2.97
Vapour pressure at 25 ^oC	$8.2x10^{-2}$
Henrys low constant	$4.27x10^{-4}$
Infrared band	NA
Density	1.145g/mL

NA – Not Available

Source: Toxprobe, 1995; ATSDR, 1995; MOE 1997

Table 2: Freundlich isotherms model parameters for naphthalene adsorption onto activated carbons produced

Adsorbent	Naphthalene N	K_f (mg/g)	R^2
FB300	0.94	0.043	0.9999
FB500	1.04	0.071	1.0000
FB600	1.05	0.084	1.0000

K_F and n are Freundlich parameters while R^2 is the correlation coefficient

Table 3: Langmuir isotherms model parameters for naphthalene adsorption onto activated carbons produced from flamboyant

Adsorbent	Naphthalene			
	Q_L (mg/ g^{-1})	K_L ($Lmol^{-1}$)	R^2	R_L
FB 300	-35.714	-0.0014	0.9084	1.27
FB 500	294.118	0.0002	0.0791	0.97
FB 600	63.291	0.0012	0.9226	0.85

Q_L, K_L and R_L are Langmuir parameters while R^2 is the correlation coefficient

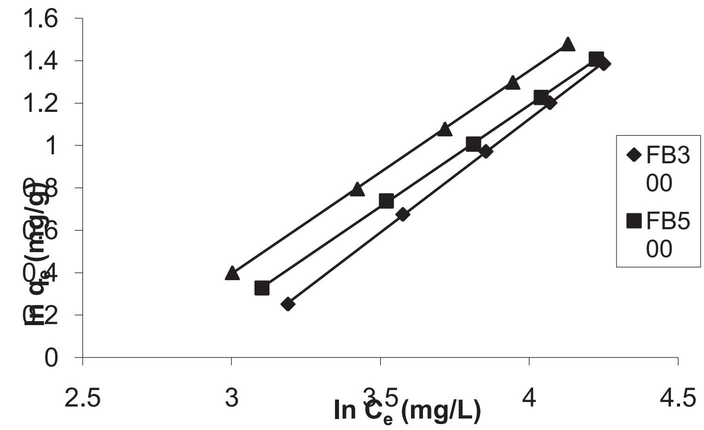


Fig. 1: Freundlich isotherm curve for the adsorption of naphthalene unto activated carbon derived from flamboyant pod back

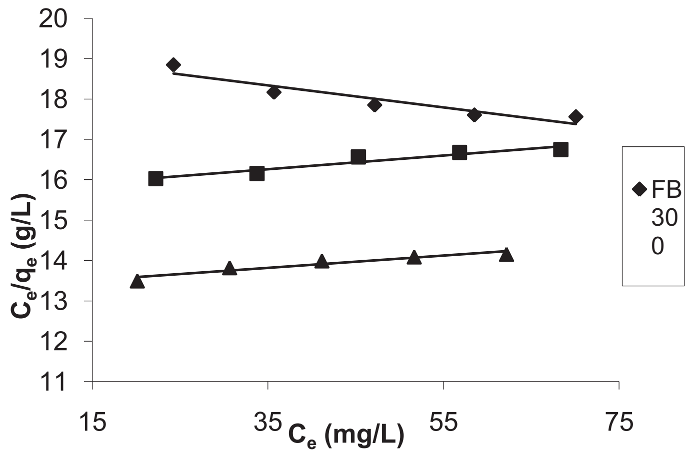
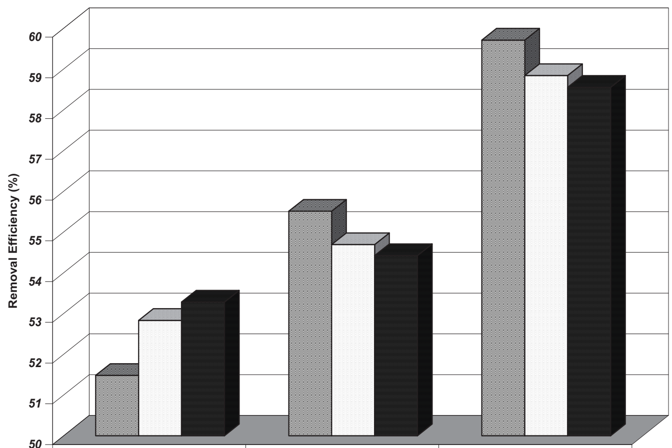


Fig. 2: Langmuir isotherm curve for the adsorption of naphthalene unto activated carbon derived from flamboyant pod back



	FB 300	FB500	FB 600
50mg/L	51.48	55.51	59.71
100mg/L	52.83	54.69	58.84
150mg/L	53.28	54.42	58.55

Activated Flamboyant pod bark

Fig 3: Removal efficiency (RE %) of flamboyant pod bark at different concentrations of Naphthalene in Wastewater

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KINETIC, EQUILIBRIUM AND THERMODYNAMIC STUDIES OF THE ADSORPTION OF EOSIN DYE FROM AQEUOUS SOLUTION USING GROUNDNUT HULLS (*Arachis hypogea*)

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Abstract
Groundnut hulls, an indigenous agricultural Waste, were tested for its efficiency in removing eosin dye without any pretreatment from its aqueous solution. Kinetic, equilibrium and thermodynamics studies of the adsorption of eosin dye on groundnut hulls were also examined at different temperatures (30°- 60°C). The adsorption parameters studied include agitation time, initial dye concentration and temperature. The isotherms used to test the adsorption data are: Freundlich, Langmuir, Temkin and Dubinin Radushkevich isotherms, the adsorption capacity (Q_m) obtained from Langmuir were 68.97, 63.29, 58.82 and 44.84 mg/g respectively at 30, 40, 50 and 60°C. It was also found that the biosorption of eosin dye followed second order kinetics. Thermodynamic parameters showed that the adsorption is endothermic and spontaneous with increased randomness at the solid solution interface. The mechanism of reaction was also found out to be physisorption.

Keywords: Adsorption, Eosin dye, Groundnut hulls and Adsorption isotherms

INTRODUCTION

In recent years, increasing awareness of water pollution and its far reaching effects have prompted concerted effort towards pollution abatement (Domez *et al*., 1999). Much of the treatment on-going within industries are focused toward treating water contaminated with organic pollutants, because organics are common Waste constituents. The fact that synthetic dyes are largely used in many industries presents certain hazards and environmental problems. Today there are more than 10,000 dyes with different chemical structures available commercially (Banat *et al*., 1996). Colour in water body is not only aesthetically unpleasant but also interferes light penetration and reduces photosynthetic action as many dyes or their metabolites have toxic as well as carcinogenic, mutagenic and teratogenic effects on aquatic life and humans. This urges an intensive search for the best available technology for dye removal. Some physico-chemical methods (such as advanced oxidation and biological process, coagulant, oxidizing agent, membrane, electrochemical and adsorption techniques) have been proposed to have satisfied the above requirement. Amongst the methods, adsorption has been found to be more efficient and economical in the removal of dyes especially in developing country and in the pursuit of an eco-friendly method.

Numerous studies have been devoted to dye adsorption using different Adsorbents such as activated carbon (Purkait *et al.,* 2005), Waste rubber (Knock *et al.,* 1981), Biomass (Tunali *et al.,* 2006) and some agricultural by-product (Dang *et al.,* 2009). Agricultural by-products are considered to be low value products due to its low utilization ratio; most of these biomaterials are arbitrarily discarded or set on fire. These disposal results in resource loss and environmental pollution. Therefore the exploitation and utilization of this biomaterial will bring obvious economic and social benefits to mankind.

MATERIALS AND METHODS

Preparation of sorbent

Groundnut hulls, *A.hypogea,* collected from a local market in Odo Oba, Oyo, Nigeria, was used as a biosorbent.The collected biomaterial was washed thoroughly with tap water to remove soil and dust, and them dried overnight at 50°C. Dried groundnut hulls was ground and sieved to 355µm.

Preparation of Eosin dye solution

Stock solution of Eosin dye was prepared by dissolving given amount of the dye in distilled water. Solutions of different concentrations used in various experiments were obtained by serial dilution of the stock solution.

Adsorption dynamic Experiments

Batch equilibrium method

Batch adsorption process of Eosin dye from its aqueous solution was carried out by agitating 2.0g of the 355µm particle size of Adsorbent with 20ml of various concentrations of Eosin dye solutions, in a sample bottle. This was done by setting up the samples into the bath shaker and shaken for hours ranging from 0-48 hours at 30^0C, 40^0C, 50^0C, 60^0C until equilibrium was reached. 10ml of the supernatants were extracted from each of the suspensions using hypodermal syringes after 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 hrs respectively. At each point in time, supernatants were filtered and 5ml of the filtrates were withdrawn and analyzed using the UV-Visible spectrophotometer (Model AAnalyst 800, Perkin-Elmer) to know the amount of adsorbate adsorbed on the Adsorbent as follows.

$$q_e = \frac{(C_o - C_e)V}{W} \quad \text{.................. (i)}$$

and $$\%R = \frac{(C_i - C_e)}{C_i} \times 100 . \quad \text{.......... (ii)}$$

Where q_e is the dye adsorbed (mg/g) at equilibrium, V the volume of solution (L), C_i and C_o are the initial concentrations, C_e equilibrium concentration of dye remaining in the solution (mg/L) and W is the dry weight of the Adsorbent (g)

Batch kinetic studies

The procedures for kinetic experiments were as identical to those of equilibrium tests. The aqueous samples were taken at preset time intervals and the concentrations of Eosin dye were determined similarly. The amounts adsorbed at time t i.e q_t (mg/g) were calculated using the equation below.

$$q_t = \frac{(C_o - C_t)V}{W} \quad \text{...... (iii)}$$

Where q_t is the dye adsorbed (mg/g) at time t, V, the volume of solution (L), C_t &C_o are, concentration at time and initial concentration of dye (mg/L) and W is the dry weight of the Adsorbent (g). Each experiment was duplicated under identical conditions.

RESULTS AND DISCUSSION

Effect of contact time and initial dye concentration

The experimental results of adsorption of eosin dye unto groundnut hulls at various concentrations (10, 20, 30, 40, 50 and 60 mg/L) with contact time are shown in Figure 1. However, the equilibrium data collected in Table 2 reveals that, percent adsorption decreased with increase in initial dye concentration, but the actual amount of dye adsorbed per unit mass of carbon increased with increase in dye concentration. This means that the adsorption is highly dependent on initial concentration of dye. This is because at lower concentration, the ratio of the initial number of dye molecules to the available surface area is low subsequently the fractional adsorption becomes independent of initial concentration. Thus, at high concentration the available sites of adsorption become fewer and hence the percentage removal of dye therefore will be dependent upon the initial concentration (Arivoli *et al*., 2008)

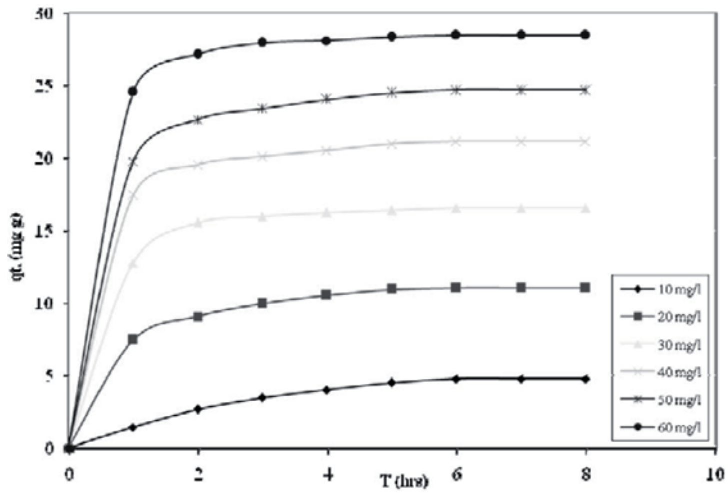

Fig. 1: Effect of agitation time and initial dye concentration on the adsorption of eosin dye on groundnut at 30^0C

The effect of agitation time and initial concentration on the uptake of the dye by groundnut hulls is shown above for various concentrations at temperature 30°C. The uptake increased with an increase in the agitation time for all initial dye concentration and attained equilibrium after 5hrs for all the concentrations studied. Thereafter, the increase became gradual until a point where there is no change in the amount adsorbed that is a constant value when the amount of desorbed dye is proportional to the amount adsorbed on the Adsorbent, inferring a dynamic equilibrium. The adsorption capacity at equilibrium increases from 4.78 to 28.47 mg/g with an increase in the initial dye concentration from 10 to 60 mg/l. Therefore, it is evident that the groundnut hulls could be used in adsorbing eosin dye from aqueous solution, the process attaining equilibrium gradually.

Adsorption Kinetics

The sorption kinetics was investigated for better understanding of the dynamics of adsorption of Eosin dye onto groundnut hulls and to obtain predictive models that allow estimations of the amount adsorbed with respect to time.

The pseudo first order kinetic model

The pseudo first order equation is generally expressed as follows (Lagergren S, 1898)

$$\ln (q_e - q_t) = \ln q_e - k_1 t. \qquad \text{...... (iv)}$$

Where q_e and q_t are the adsorption capacities at equilibrium and at time t respectively (mg/g). k_1= rate constant for pseudo first order adsorption (hr^{-1}). A plot of ln (q_e-q_t) against t at various concentrations and temperatures will give graphs with negative slopes. k_1 and q_e are calculated from the intercept (Fig.2).

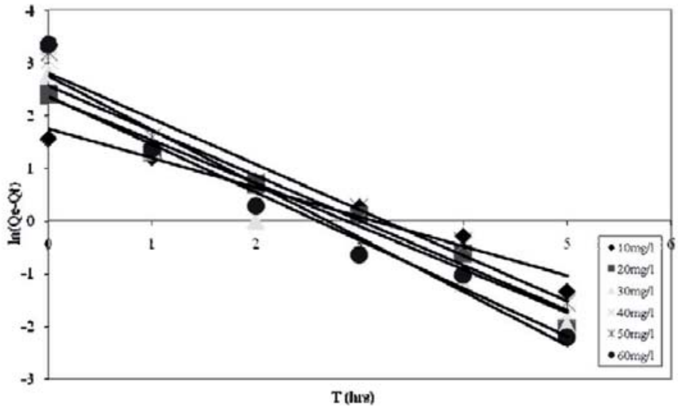

Fig. 2: Pseudo first order kinetic plot of the adsorption of eosin dye unto groundnut hulls at 30^0C.

Although, the correlation coefficient was high but on comparison of the q_e calc. to the q_e exp., the value do not to agree. The results are presented in Table 1. Therefore the adsorption of eosin dye using groundnut hulls does not follow the first order kinetics.

The pseudo second order kinetic model

The pseudo second order equation is expressed as (Ho Y.S, 2004).

$$\frac{dq_t}{dt} = k_2(q_e - q_t)^2 \qquad \text{..... (v)}$$

Where k is the rate constant of pseudo second order adsorption ($gmg^{-1}h^{-1}$). For the boundary conditions t=0 to t=t and q_t=0 to q_t= q_t, the integrated form of the equation becomes

$$\frac{1}{q_e - q_t} = \frac{1}{q_e} + k_2 t \qquad \text{.... (vi)}$$

Rearranging this equation, we have a linear form:

$$\frac{t}{q_t} = \frac{1}{k_2 q^2{}_e} + \frac{1}{q_e} t \qquad \text{..... (vii)}$$

If the initial adsorption rate, ho (mg. g-1 min-1) is

$$h = k_2 q^2{}_e \qquad \text{..... (viii)}$$

Then Equations above becomes:

$$\frac{q_t}{t} = \frac{h}{1 + k_2 q_e t} \qquad \text{... (ix)}$$

Plots of t/q_t versus t gave linear graphs from which q_e and k_2 were estimated from the slopes and intercepts of the plot (Fig.3). The correlation coefficient was as high as 0.99 and there were good agreement between $q_{e,\ cal.}$ and $q_{e,\ exp}$ data obtained. The results are presented in Table 1. The good agreement shows that the pseudo second order kinetic equation fits the adsorption data well.

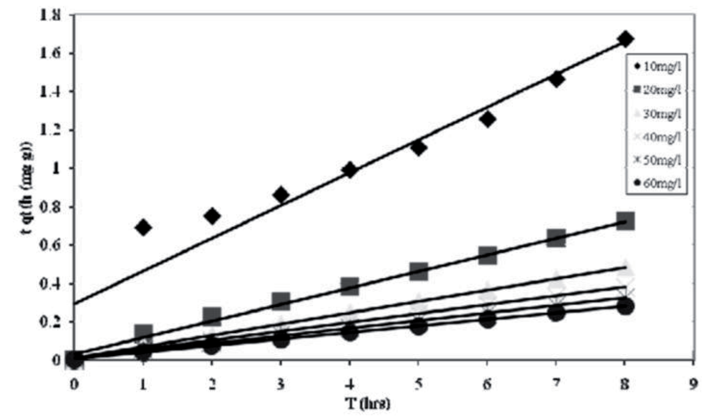

Fig 3: Pseudo second order kinetic plot of the adsorption of eosin dye onto groundnut hulls at 30^0C.

Test of kinetic models

In order to complement R^2, the applicability and validity of each kinetic model was verified through the sum of square errors (SSE %) given by

$$SSE(\%) = \sqrt{\frac{\Sigma(q_e, \exp - q_e, cal)^2}{N}} \quad \text{….. (x)}$$

Where N is the number of data points. The higher the value of R^2 and the lower the value of SSE; the better will be the goodness of fit. From Table 1, it was found that the adsorption of eosin dye on groundnut hulls can be best described by the second order kinetic model. Similar findings were reported by other researchers' (Mehmet *et al*., 2004; Bello *et al*., 2008).

Table 1: The pseudo first and second order adsorption kinetics model rate constants for the adsorption of Eosin dye onto groundnut hulls (*Arachis hypogea)* at various temperatures (30-60^0C).

			Pseudo 1^{st} order					**Pseudo 2^{nd} order**			
	C_o (mg/L)	$q_{e,exp}$ (mg/g)	K_1 (hr^{-1})	$q_{e,calc}$ (mg/g)	R^2	SSE (%)	K_2 (g/mg/hr)	$q_{e,\,calc}$ (mg/g)	R^2	h_o	SSE (%)
30^0C	10	4.78	0.5589	5.76	0.9637	0.4	0.1007	5.84	0.9169	3.44	0.43
	20	11.08	0.8168	10.43	0.9767	0.27	0.2401	11.59	0.9961	32.26	0.21
	30	16.55	0.912	10.55	0.9613	2.45	0.3769	16.89	0.9991	107.53	0.14
	40	21.14	0.8532	13.03	0.9471	3.31	0.2991	21.55	0.9993	138.89	0.17
	50	24.72	0.8651	16.52	0.9653	3.35	0.2341	25.25	0.9991	149.25	0.22
	60	28.47	1.0245	15.64	0.9536	5.24	0.3762	28.82	0.9997	312.5	0.14
40^0C	10	5.19	0.5697	6.5	0.9507	0.22	0.0757	6.57	0.8822	3.27	0.56
	20	11.49	0.7344	9.78	0.9829	0.29	0.2145	12.05	0.9952	31.15	0.23

	30	16.99	0.7833	11.04	0.9503	0.99	0.2817	17.42	0.9987	85.47	0.18
	40	21.55	0.8984	12.47	0.9413	1.51	0.3466	21.93	0.9994	166.67	0.16
	50	25.14	0.8848	18.79	0.9696	1.06	0.1981	25.77	0.9988	131.58	0.26
	60	28.88	0.8152	14.56	0.9117	2.39	0.2853	29.24	0.9996	243.90	0.15
50^0 C	10	5.97	0.5202	7.92	0.8856	0.8	0.0429	8.16	0.7987	2.856	0.89
	20	11.88	0.8395	12.37	0.9895	0.2	0.1811	12.56	0.9935	28.57	0.28
	30	17.41	0.8681	13.96	0.9792	1.41	0.2334	17.95	0.9982	75.19	0.22
	40	22	1.1928	19.72	0.9752	0.93	0.2956	22.47	0.9991	149.3	0.19
	50	25.55	0.7817	18.37	0.9564	2.93	0.1649	26.25	0.9984	113.6	0.29
	60	29.29	1.0006	18.18	0.9674	4.54	0.2823	29.76	0.9995	250	0.19
60^0 C	10	5.99	0.5092	7.7	0.8923	0.7	0.0423	8.2	0.7966	2.85	0.9
	20	12.31	0.6505	11.19	0.9934	0.46	0.1433	13.11	0.9915	24.63	0.33
	30	18.8	0.4607	11.98	0.8861	2.78	0.1208	19.53	0.9932	46.08	0.3
	40	22.38	0.8076	14.5	0.9575	3.22	0.2034	22.99	0.9986	107.53	0.25
	50	25.98	0.6363	16.71	0.9387	3.78	0.1385	26.74	0.9977	99.01	0.31
	60	29.63	0.9047	18.7	0.9670	4.46	0.2345	30.12	0.9994	212.77	0.2

Table 2: Equilibrium parameters for the adsorption of eosin dye onto groundnut hull (*Arachis hypogea)* at different initial concentrations and temperatures.

Temp °C / C_o (mg/L)	**C_e (mg/L)**				**Dye Removal (%)**				**Q_e (mg/g)**			
	30^0C	**40^0C**	**50^0C**	**60^0C**	**30^0C**	**40^0C**	**50^0C**	**60^0C**	**30^0C**	**40^0C**	**50^0C**	**60^0C**
10	5.22	4.81	4.03	4.01	4.78	5.19	5.97	5.99	47.8	51.9	59.7	59.9
20	8.92	8.51	8.12	7.69	11.08	11.49	11.88	12.31	55.4	57.45	59.4	61.55
30	13.45	13.01	12.59	11.2	16.55	16.99	17.41	18.8	55.17	56.63	58.03	62.67
40	18.86	18.45	18	17.62	21.14	21.55	22	22.38	52.85	53.88	55	55.95
50	25.28	24.86	24.45	24.02	24.72	25.14	25.55	25.98	49.44	50.25	51.1	51.96
60	31.53	31.2	30.71	30.37	28.47	28.88	29.29	29.63	47.45	48.13	48.82	49.38

Adsorption Isotherms

The adsorption isotherm indicates how the adsorbed molecules distribute themselves between the liquid phase and the solid phase until the adsorption process reaches an equilibrium state. This is basically important in describing how solutes interact with Adsorbents and is critical in optimizing the use of the Adsorbent (Dang *et al*., 2009). The analysis of equilibrium adsorption isotherm data were than carried out by fitting them to different isotherm models so as to find a suitable model to describe the experimental data (Ahmet *et al*., 2008; Arivoli *et at*., 2008). The adsorption isotherm studies were carried out using the following models.

Langmuir isotherm

Langmuir isotherm assumes monolayer adsorption into a surface containing a finite number of adsorption sites of uniform sites of adsorption with no trans-migration of adsorbate in the plane of surface (Weber W.J 1972). The linearized form of Langmuir adsorption model is expressed as

$$C_e / Q_e = C_e / Q_m + 1 / Q_m b \qquad \text{..... (xi)}$$

Where C_e is the dye concentration in the solution at equilibrium(mg/L), Q_e is the dye concentration on the Adsorbent at equilibrium (mg/g), Q_m is the monolayer adsorption capacity of biosorbent (mg/g) and b is the Langmuir biosorption constant (L/mg). A plot of C_e/Q_e versus C_e gave a straight line with a slope $1/Q_m$. The higher values of Langmuir isotherm when compared with Freundlich isotherm indicate that the adsorption of the dye fits the Langmuir isotherm better (Fig.4). Values of Q_m and b are calculated and reported in Table 3.

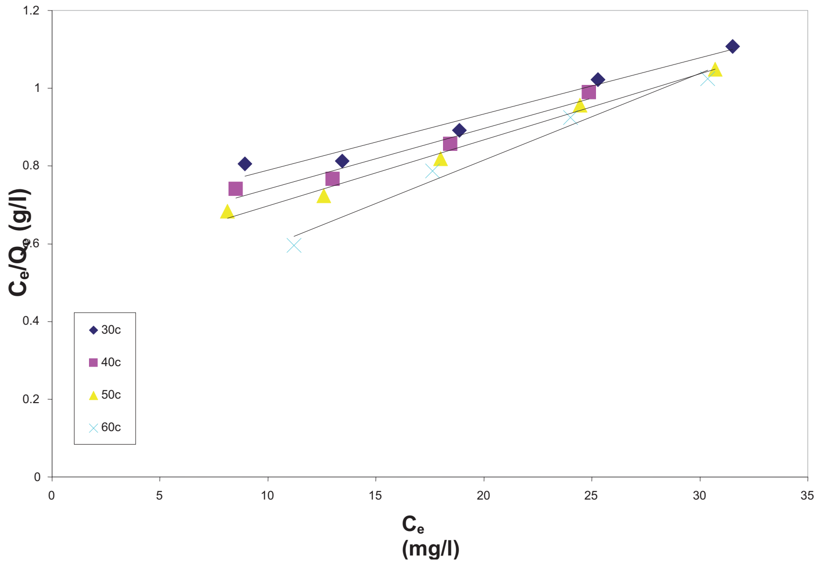

Fig. 4: Langmuir Isotherm for adsorption of eosin dye onto groundnut hulls at different temperatures

Table 3: Adsorption isotherm model parameters for the adsorption of eosin dye onto groundnut hulls at different temperatures.

Temp (^{0}C)	Langmuir Parameters			Freundlich Parameters			Temkin Parameters			Dubinin-Radushkevich Parameters			
	R^2	Q_m	B	R^2	K_f	n	R^2	A_T	b_T $*10^3$	R^2	$\beta * 10^{-6}$	Q_m	E (kJ/Mol)
30	0.9643	68.97	0.0225	0.9542	1.179	1.043	0.9982	0.2679	0.1924	0.9579	0.2679	0.1924	0.24
40	0.9813	63.29	0.0272	0.9611	1.5011	1.1203	0.9975	0.3018	0.2063	0.9433	0.3018	0.2063	0.27
50	0.9887	58.82	0.0323	0.9828	2.2024	1.2847	0.9902	0.3801	0.2330	0.8960	0.3801	0.2330	0.346
60	0.9805	44.84	0.0604	0.9518	2.4077	1.3063	0.9921	0.4095	0.2394	0.9295	0.4095	0.2394	0.353

From the results, it is clear that the value of adsorption affinity b, for the Langmuir isotherm of the Adsorbent increases on increasing the temperature and from the values it can be concluded that the maximum adsorption corresponding to a saturated monolayer of adsorbate molecules on Adsorbent surface with constant energy and no transmission of adsorbate in the plane of the Adsorbent surface was obtained at 60^{0}C, the observed b values shows that the Adsorbent prefers to bind best at higher temperature.

To confirm the favourability of the process, the dimensionless equilibrium parameter (R_L) defined by

$$R_L = \frac{1}{(1+bC_o)} \qquad \text{...... (xii)}$$

Where C_o is the highest initial dye concentration in solution, is used to confirm the favourability of the adsorption process, that is ($0< R_L<1$) favourable, R_L=1 linear, R_L=0 irreversible or R_L>1 unfavourable. (Arivoli *et al*., 2008).

Table 4: Dimensionless separation factor (R_L) for the adsorption of eosin dye onto groundnut hulls at different temperature.

C_o (mg/L)	**Temperature, ^{0}C**			
	30°C	**40°C**	**50°C**	**60°C**
10	0.8163	0.7862	0.7559	0.6234
20	0.6897	0.6477	0.6075	0.4529
30	0.597	0.5507	0.5079	0.3556
40	0.5263	0.4789	0.4363	0.2927
50	0.4706	0.4237	0.3824	0.2488
60	0.4255	0.3799	0.3404	0.2163

The values of R_L obtained at various temperatures were less than one, indicating that the adsorption of eosin dye unto groundnut hulls is favourable.

Freundlich Isotherm Model

This assumes heterogeneous surface energies, in which the energy term in Langmuir varies as a function of the surface coverage. The linearized form of Freundlich model is represented by (Freundlich, 1906).

$$\log q_e = \frac{1}{n}\log C_e + \log k_f$$ ..... (xiii)

Where q_e is the amount adsorbed at equilibrium (mg/g), C_e is the equilibrium concentration of the adsorbate (mg/L), K_f and n are constants incorporating the factors affecting the adsorption capacity and the degree of non-linearity between the solute concentration in the solution and the amount adsorbed at equilibrium respectively. Plots of log q_e versus log C_e gave linear graphs (Fig.5) with high R^2 indicating that the adsorption data fits the Freundlich isotherm. The parameters are presented in Table 3.

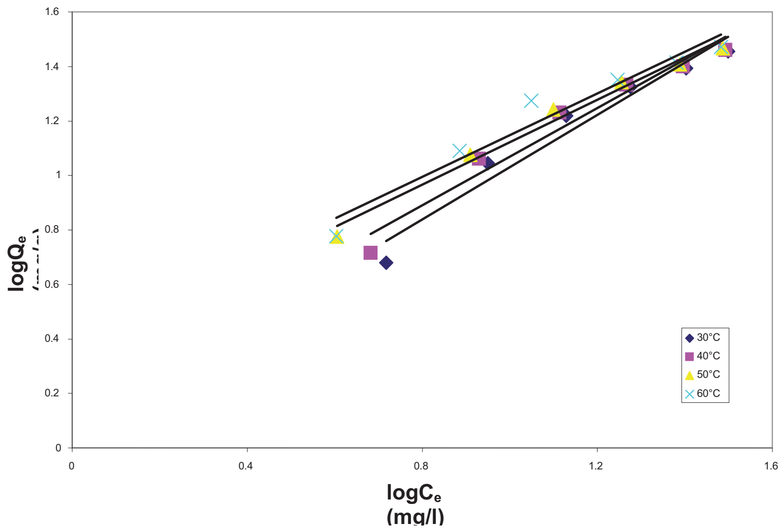

Fig. 5: Freundlich isotherm plot for the adsorption of Eosin dye onto groundnut hulls at different temperatures

The values of K_f and n from the graph are reported in Table 3, it shows the heterogeneity of the material as well the possibility of multilayer adsorption of eosin dye through the percolation process and the values of n greater than one indicates that the adsorption is favourable (Arivoli *et al*., 2008).

Temkin Isotherm Model

In order to consider the effect of the adsorbate interaction on the Adsorbent, Temkin isotherm model was tested on the experimental data. It is expressed as (Tunali *et al.,* 2006).

$$q_e = \frac{RT}{b_T}\ln(A_T C_e)$$ .... (xiv)

Where A_T and b_T are constants, R is the gas constant and T is the temperature. A plot of q_e versus $\ln C_e$ gave a straight line graph where b_T and A_T values were calculated and presented in Table 3. This shows the applicability of Temkin isotherm as having a better fit to the experiment data indicated by the high values of the correlation coefficients than any of the models tested and b_T, A_T increases as the temperature increases thereby inferring that the adsorbate interaction with Adsorbent increased with increasing temperature hence, higher rate of sorption was observed as energy increases.

Dubinin-Radushkevich Isotherm Model

The D-R model, which does not, assumes a homogeneous surface or a constant biosorption potential as the Langmuir model, is used to estimate the characteristic porosity of the

Biomass and the apparent energy of adsorption. It was also used to test the experimental data. It is written as (Dubinin *et al*., 1947)

$Q_e = Q_m e^{-\beta\varepsilon^2}$ ………………………………………………………………… (xv)

Where β is the free energy of sorption per mole of the sorbate as it migrates to the surface of the Biomass from an infinite distance in the solution (mol^2J^{-2}), Q_m is the maximum adsorption capacity and ε is the Polanyi potential ($Jmol^{-1}$) that can be written as

$\varepsilon = RT\ ln\ (1+1 / C_e)$ ………………………………………………………………… (xvi)

A plot of ln Q_e versus ε^2 gave a linear plot where β and Q_m are obtained from the slopes and intercepts respectively. The values are presented in Table 3. However, the β obtained is then used to estimate mean free energy of biosorption and the result presented in Table 3.

$E = 1 / \sqrt{2\beta}$ ……………………………………………………………………………. (xvii)

The values of E above were found to be between the ranges 0.24 - 0.353 KJ/mol over the range of temperatures used in this study. This result shows that the biosorption mechanism is physical in nature. (physisorption), since E < 8 KJ/mol (Helfferich, 1962).

THERMODYNAMIC STUDIES

Effect of Temperature on Biosorption

The adsorption capacity of Groundnut hulls increased with increase in the temperature of the system from 30-60°C as the percentage of dye removed from the solution at equilibrium increased. Thermodynamic parameters ΔG°, ΔH°, and ΔS° were determined using the following equations.

$K_0 = Q_e/C_e$ ……………. (i)

$\Delta G° = -RTlnK_0$ ……….. (ii)

$lnK_0 = \Delta S°/R - \Delta H°/RT$ ………. (iii).

Where K_0 is the equilibrium constant, Q_e amount removed at equilibrium (mg/g), C_e concentration at equilibrium (mg/L), T is the temperature in Kelvin and R is the gas constant. A plot of lnk_o against 1/T gave linear plots from which ΔH ° and ΔS° values are obtained from the slopes and intercepts. The results are presented in Table5.

Table .5: Equilibrium constant and Thermodynamic parameters for the adsorption of Eosin dye onto groundnut hulls at different initial concentrations and temperatures.

C_o (mg/L)	Temperature K_0				$\Delta G^o *10^3$(kJ/Mol)					
	30°C	40°C	50°C	60°C	30°C	40°C	50°C	60°C	$\Delta H^o *10^3$ (kJ/Mol)	ΔS^o (J/Mol/k)
10	0.9157	1.079	1.4814	1.4938	0.2219	-0.1979	-1.0553	-1.1111	14.8422	48.3783
20	1.2422	1.3502	1.4631	1.6008	-0.5464	-0.7813	-1.022	-1.3026	6.9929	24.8713
30	1.2305	1.3059	1.3828	1.6786	-0.5225	-0.6945	-0.8704	-1.434	8.2225	28.6367
40	1.1209	1.168	1.2222	1.2701	-0.2875	-0.4041	-0.5388	-0.662	3.4952	12.4843
50	0.9778	1.0113	1.045	1.0816	0.0566	-0.0292	-0.1182	-0.2177	2.7893	9.0174
60	0.9029	0.928	0.9538	0.9756	0.2573	0.1945	0.127	0.0684	3.3904	10.2653

From Table 5 above, the low values of ΔH^o which falls between the range of 1-93KJ/mol signifies that the mechanism of adsorption follows physisorption (Arivoli *et al.,* 2008). While the positive values of ΔH° affirms the endothermic nature of adsorption (Arivoli *et al.,* 2008) .This low ΔH° values depicts that dye is physisorbed onto groundnut hulls. The positive values of ΔS° show the increased disorder and randomness at the solid/solution interface of eosin dye on the Adsorbent. The negative values of ΔG^o show that the adsorption is highly favourable and spontaneous but becomes less spontaneous/non-spontaneous as initial dye concentration increases. Moreover, the enhancement of adsorption capacity at higher temperatures can be attributed to the enlargement of pore size as temperature increases (Liu *et al.*, 2005) hence the significant effect of temperature on the adsorbed amount indicates that the adsorption of eosin dye on groundnut hulls follows physical adsorption.

CONCLUSIONS

From the study, the adsorption of eosin dye onto groundnut hull was investigated in batch experimental system and the following results were obtained.

- The adsorption data followed the second-order kinetic model.
- The Temkin isotherm exhibited the best fit for the adsorption data than any of Langmuir, Freundlich, and Dubinin-Radushkevich isotherms.
- The low value of mean energy (< 8KJ/mol) obtained from D-R isotherm pave the way for physisorption of eosin dye.
- The negative value of ΔG° shows that the process is spontaneous from 30 to 50^0C but becomes non spontaneous as concentration increases.
- The positive and low values of ΔH° show that the process is endothermic in nature and equally suggests that the adsorption follows a physisorption mechanism (1-93KJ/mol).
- The positive ΔS° shows that there was increased disorder and randomness at the solid/solution interface of eosin dye and the Adsorbent.
- The removal efficiency increases as temperature increases while the adsorption capacity decreases as initial dye concentration increases.

This work has shown that utilization of groundnut hulls will be useful in the treatment of eosin dye from industrial Waste effluents and possibly other anionic/acid dyes from their aqueous solution; it will also eliminate various ecological problems these Waste effluents could cause.

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COMPARISON OF DAILY URINARY EXCRETION OF THORIUM IN EXPOSED AND UNEXPOSED SUBJECTS WITH THEIR BIOKINETIC MODEL PREDICTION

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Abstract

In view of the increasing population pressure and malnutrition in spite of the enormous wealth from long year dependence on oil export in Nigeria, effort should be geared toward harnessing sustainable agricultural products. However, the safety of such products is a major issue of great environmental concern. Ionizing radiation from radionuclides in such products especially foodstuffs results in deleterious health effect in internal organs of the body. The estimation of daily intake of radionuclides and the amount getting to the systemic circulation are very crucial to the determination of internal dose to the various organs/tissues of the body. The extent to which human subject is exposed to thorium and the related risk can be deduced from its daily excretion. In this work, daily urinary thorium excretion of 19 adult subjects living and working in different locations have been measured in Nigeria using high resolution sector field inductively coupled plasma mass spectroscopic (HR-SF-ICP-MS) analytical method. The subjects included 12 adults occupationally exposed to thorium and its compounds and 7 adults living in normal areas without radionuclides exposure besides what is assumed as background values. The mean daily thorium excretion values are 15 ng and 4 ng for the exposed and un-exposed, respectively. These values were within the normal range of 3.4 ng and 34 ng obtained in literatures in spite of the high intake scenario considered. The predicted excretion rates using bioassay model of thorium given by the ICRP was also presented and compared with the measured data.

Keywords: urine, excretion, human subjects, thorium, model,

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INTRODUCTION

Thorium is a primeval radionuclide and it is ubiquitously occurring element with several radioactive isotopes. The average activity concentration of ^{232}Th is in the range 25 – 50 Bq kg^{-1} and can concentrate in certain rocks like granites and alkaline igneous rocks (UNSCEAR, 2000). Thorium, along with it progenies, emits six alpha particles and is therefore considered as one of the highly radiotoxic elements. The health hazards associated with these radionuclides stem from their ability to accumulate in human tissues, especially bone surface (ICRP, 1993). During the decay process, highly penetrating gamma rays are emitted, thereby causing intensive damage to the tissues where they are localized. The element (^{232}Th) has many industrial applications like the production of gas mantle, welding rods, thermisters, crucibles, alloying, etc. Improper handling of thorium materials can lead to occupational exposure and hence, radiation hazard. Apart from the occupational exposure, population in the vicinity of the numerous applications of thorium element and its compound can also be exposed. Environmental exposure to a population stems from constant daily inhalation and ingestion of thorium from natural, air borne particulates and dietary sources.

In order monitor and ensure the radiation protection of occupationally exposed person, it is important to have reliable information on the bio kinetic behaviour of thorium in humans by considering the natural intake scenarios and the body content. Monitoring of occupational incorporation of thorium should preferably be carried out by analysis of its urinary excretion since the quantity lost per day via urine is related to the systemic body content (Höllriegl et al, 2002). However, for a reliable estimation of the occupational uptake of workers, baseline data of daily urinary excretion in subjects non-exposed occupationally is needed. In Nigeria, the activity of thorium from natural environmental sources in human bodies and its excretion of both exposed and unexposed subjects are yet to be studied. In fact, studies on urinary excretion of these radionuclides from Africa are not available.
The International Commission on Radiological Protection (ICRP) provides guidelines to assess the exposure to thorium using the daily urinary excretion data (ICRP, 1997). In response to this, daily urinary thorium excretion data are now available from studies conducted in many countries (Höllriegl et al, 2005a&b; Roth et al, 2005). However, data on daily urinary excretion of thorium are not available in Nigeria, and to the best of are knowledge, little or no data are available from African countries for comparison. This work is a pioneering effort in Nigeria, especially through the ingested pathway in the determination of internal contribution to the overall radiation body burden. In this study, the concentration of thorium in urine samples of unexposed and exposed subjects was quantified and its daily urinary excretion determined. The daily urinary excretion values were compared with the bio kinetic model prediction of thorium using the dietary intake values for the same population recently reported (Arogunjo et al, 2009). The excretion values were also compared with values from literature.

MATERIALS AND METHODS

Sample collection

Twenty-four hour urine samples were collected from four different groups of subjects, which include six mine workers in Bisichi mining site, five processing workers from tin processing company in Jos, four members of the public living in the city of Jos and four members of the public in Akure about 900 km away from Jos Plateau as control. The occupational (mining and tin processing workers) groups have age range of 24 – 52y including a subject in Akure who by virtue of his job might have been occupationally exposed to radionuclides. The public group around the mining and processing sites but are not exposed occupationally has age range of 34 – 44y. The public group used as control has age range of 37 – 40y that are not exposed to any artificially higher levels of thorium and its compounds. The 24-h urine samples were collected from both the occupational group and the public group around the mining and processing sites between 14th and 15th September 2006. The public control group 24-h urine samples were collected between 22nd and 23rd September 2006. The 24-h urine was collected starting early in the morning. After wake-up, the subjects emptied their bladder in the toilet noting the time, and all urine thereafter was collected in a graduated 3000 ml pre-cleaned polyethylene container until the following morning, and for the last time at the exact time the bladder was emptied the previous morning. The first void collected at the start of the sampling was acidified with 0.5 ml HCL to prevent decomposition. Thirty (30) ml aliquots of the total urine collected from each subject was put into a plastic vial, which was placed inside a plastic cylinder and stored at 4 ^{0}C until analysis.

Sample Preparation and measurement

All the samples were measured at the Central Analytical Service of GSF, using high resolution sector field ICP-MS Model ELEMENT 1 (Finnigan MAT, Germany). The instrument parameters and the method applied have been described elsewhere (). Prior to measurement, all the urine samples were removed from the storage site and allowed to defrost at room temperature. The acidified samples were diluted into ratio 1:2 by the addition of 0.25 ml of concentrated HNO_3, 0.5 ml of concentrated HCL and 4.5 ml of H_2O to 5 ml of the sample. Thorium standards were used to calibrate the instrument for its direct measurement and reagent blanks using deionised water were also measured at intervals during the entire measurement process.

Biokinetic modelling of the radionuclide

Radionuclides transport in the human body can be investigated using deterministic model. This process involves model simulation of the linear transfer processes represented by sets of linear differential equations governed by first order kinetics. In order to be able to compare the measured urinary excretion rates with that predicted by the ICRP biokinetic models for thorium and uranium, expected excretion rates through lifetime were simulated using the age dependent biokinetic transfer coefficients for the six age groups given by the ICRP Publication 69 (ICRP 1995). For the purpose of simulating the behaviour of the radionuclides between compartments after ingestion, the systemic model was coupled to the gastrointestinal (GI) tract model. The ICRP age-dependent transfer rates in the GI tract and the transfer rate from the small intestine to blood was calculated according to ICRP (1995). According to the dietary intake values for the same adult population recently reported, the annual ^{232}Th intakes of 6.1 mg y^{-1} (24.7 Bq y^{-1}) was obtained for the unexposed population (Arogunjo et al, 2009) in Nigeria. This value was added to the intake value for milk and meat given by UNSCEAR (2000), which were not included in the study to represent the adult population. The resultant value (45.0 µg d^{-1}) was age-adjusted according to the respective food consumption rates ratio for the different age groups namely: infant, child and adult given by UNSCEAR (2000) to 16.0 µg d^{-1}, 29.0 µg d^{-1} and 45.0 µg d^{-1}, respectively. The age adjusted intake values for the exposed population are 24.5 µg d^{-1}, 29.0 µg d^{-1} and 71.9 µg d^{-1}, respectively. In modelling the lifetime excretion rates, the biokinetic transfer coefficients governing the distribution and retention of thorium in the various compartments of the systemic and the GI tract models during the integral time course were performed using age-dependent linear interpolation. The distribution and retention of the radionuclide in the various compartments is governed by linear transfer processes represented by sets of linear differential equations. The transfer between the various compartments therefore, follows a system of first-order kinetics. To solve these sets of linear differential equations, different software packages are available for solving multi-compartmental systems and one of such packages is the SAAM II computer program. The SAAM II software package version 1.2.1 was used to perform the biokinetic modelling.

RESULT AND DISCUSSION

Baseline data of the daily thorium excretion of un-exposed subjects is very crucial to the overall emergency response in case of gross contamination and the assessment of subjects exposed occupationally. In order to determining the extent of radiation health hazards to the exposed and non-exposed population, the results of the daily urinary thorium excretions measured in 37 samples including their ages and weights are presented in Table 1. The Table included two groups of subjects namely the exposed and the un-exposed groups. The range of excretion values along with the mean (±SD), median (95% confidence interval), geometric mean (±GSD) for both the exposed and the un-exposed groups were also shown in Table 1. Thorium daily urinary excretion varies from 1.2 ng to 41.8 ng in the exposed group and from 0.78 ng to 8.9 ng in the un-exposed group.

In the test for significance between the urinary excretion of thorium for the exposed and the unexposed group, statistical test of the Mann-Whitney U-test was employed. The results show that the exposed group excrete more thorium ($p < 0.01$) than the unexposed group (Z: 2.897, $p = 0.00377$). This result is expected in view of the risk of exposure associated with the daily routine work in an elevated activity area. The mine workers are not only exposed via ingestion through food and water, but also via inhalation and dermal contact at workplace. In spite of the notable differences in the excretion of thorium between the exposed and the unexposed groups considered in this work, the data still fall within the normal range obtained in literatures. Figures 1 show the mean urinary thorium excretions in unexposed populations from different studies. The figure suggested that the daily urinary thorium range between 1.5 ng and 15.5 ng although the authors used different statistical parameters and units. The values were converted to the same units by assuming daily urinary volume of 1.4 l d^{-1} proposed by the International Commission on Radiological Protection (ICRP) for adult male and female (ICRP, 2003).

Comparison of urinary thorium excretion with its model data

The expected daily urinary excretion of thorium was determined for adult male using two different intake scenarios for the unexposed and the exposed groups in Nigeria by applying the current ICRP biokinetic model discussed earlier. The urinary excretion rate for thorium during lifetime was simulated using the age dependence intake given earlier for the unexposed population as shown in Figure 2. The excretion rates for the exposed group were also calculated using the intake values given earlier for this group. The default ICRP f_1 values of 5×10^{-4} for thorium, was initially used for the calculations as presented in the Figure. The figure also included all the individual excretion values plotted to show the large variability in the measured data and the discrepancy with the model prediction. In the figure, the model prediction was obtained using the default f_1 value for thorium and by applying the unexposed intake (long dash line) and the exposed intake (solid line). The model predictions fall in the range of the measured data, however, it overestimated the excretion rate value at the mean age (38 y) for the unexposed data set by more than 100 % and that of the exposed data set at the mean age (31 y) by about 24 % when compared with the geometric mean values plotted at these ages. This result clearly disagrees with the report of similar study conducted with German subjects, which indicated an underestimation of urinary thorium excretion using the default f_1 value. The default value multiplied by a factor of 10 was then proposed to fit their data (Roth et al, 2005). The general observation from the results of the present work and that of the study reported for German subjects, although the subjects are from different geological, ethnic and environmental backgrounds, is that the disagreement between the measured data and the model predictions could be traced to the assumption of a default f_1 values for all unspecified compounds by the ICRP (ICRP, 1997). The need to specified f_1 value for all dietary incorporated radionuclides can be clearly seen in view of the present discrepancies in the application of the bioassay models. The f_1 value should also take care of situation with high intake scenarios, which is currently lacking as observed in the present study.

In view of the above, it then suggest a question as to whether the f_1 value proposed by the ICRP should be applied uniquely in all situation especially when using the bioassay model as a monitoring tool in an emergency response programme. In order to fit the model to the median values of the measured urinary thorium excretion data at the mean ages for the two groups of subjects considered in this work, new f_1 of 4.0×10^{-4} was proposed for both the unexposed (dash-dot-dot line) and the exposed groups (dash-dot line) as shown in the figure.

CONCLUSION

The urinary thorium excretion rates have been calculated for the exposed and the unexposed populations in Nigeria using ICP-MS analytical method. The predicted excretion rates using bioassay model of thorium and uranium given by the ICRP (1997) were also presented and compared with the measured data. The results show that the median values for the exposed and un-exposed groups are 10.8 (1.0) ng d^{-1} and 4.0 (1.3) ng d^{-1} for thorium daily urinary excretion, respectively. The predicted urinary excretion rates simulated using the default ICRP f_1 value at the mean ages of 31y and 38 y for the daily thorium excretion are 11.48 ng d^{-1} and 6.10 ng d^{-1} for the exposed and the unexposed population, respectively. The difference between the predicted excretion values and the measured values suggested the need for the reconsideration of the use of the default ICRP f_1 values for the dietary incorporation of the radionuclide for different intake scenarios. The application of a new f_1 value proposed in this work for thorium however predicted the daily excretion values of 9.18 ng and 4.88 ng for the exposed and unexposed group, respectively.

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Table 1: Daily urinary excretion of ^{232}Th in unexposed and exposed adult subjects in Nigeria

Subject	Age	Weight (kg)	U excretion values (ng d^{-1})
		Unexposed Group	
PAC1	39	91	0.78; 4.28
PAC2	40	71	1.45; 7.61
PAC3	37	67	0.84; 4.37
PJS1	34	70	3.77; 8.19
PJS2	37	91	0.99; 5.29
PJS3	38	84	2.64; 8.94
PJS4	44	70	1.35; 7.28
Number of samples			14
Range			0.78 – 8.94
Mean (SD)			4.13 (2.94)
Median (95 % confidence interval)			4.03 (1.26)
Geometric mean (GSD)			3.01 (2.44)
		Exposed Group	
TPJ1	27	70	1.95; 27.10
TPJ2	26	70	21.45; 33.93
TPJ3	36	64	1.62; 15.18
TPJ4	26	88	8.58; 11.08
TPJ5	24	72	33.54
TMB1	30	58	41.78; 41.70
TMB2	34	66	4.32; 4.83
TMB3	35	58	1.20; 6.65
TMB4	26	64	2.03; 15.37
TMB5	28	60	10.76; 7.00
TMB6	32	70	1.45; 8.28
PAC4	52	84	23.98; 32.12
Number of samples			23
Range			1.20 – 41.78
Mean (SD)			15.47 (13.57)
Median (95 % confidence interval)			10.76 (1.00)
Geometric mean (GSD)			9.30 (3.00)

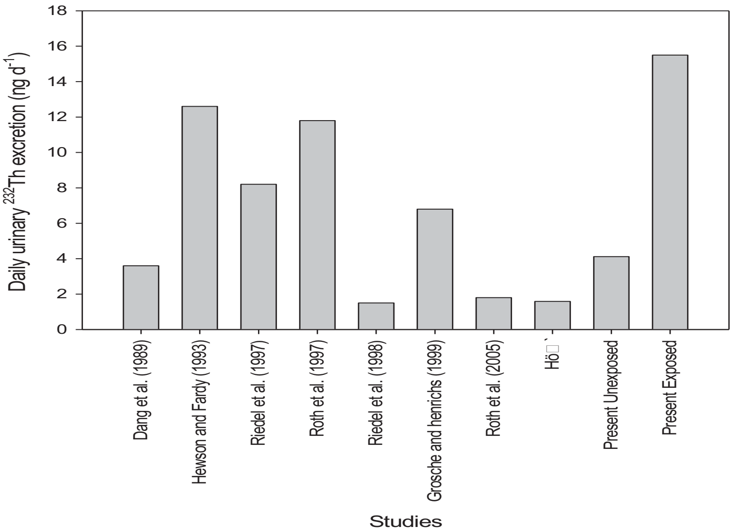

Fig 1: Comparison between the present and other studies on the daily urinary ^{232}Th excretion

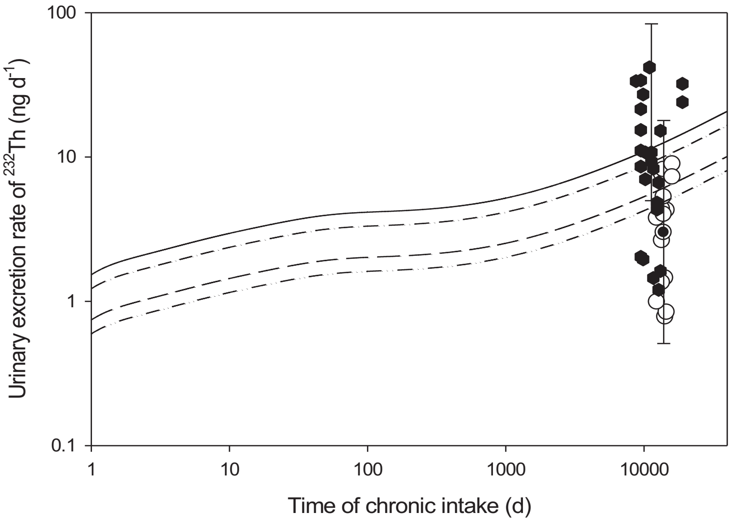

Fig. 2: Predicted urinary thorium excretion during lifetime and the measured excretion values. Solid line: ICRP biokinetic model (ICRP 1995) using the default f_1 value and thorium intake for the exposed; Long dash line: Model prediction using the default f_1 value and daily intake for the unexposed; Dash dot line: Model prediction using the modified f_1 value and daily intake for the exposed; Dash dot-dot line: Model prediction using the modified f_1 value and daily intake for the unexposed. Open circle symbol represent individual excretion values for the unexposed group; Closed Hex symbol represent individual excretion values for the exposed group. Error bars are the upper and lower bound at 95 % confidence interval of the GSD for the two groups.

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EFFECT OF A NEODYMIUM MAGNET WATER IONIZER ON MAIZE PLANT DEVELOPMENT

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Abstract
A neodymium magnet water ionizer designed and constructed to increase the hydroxyl ions in different samples of water collected from different sources in Ladoke Akintola University of Technology Ogbomoso Oyo State, Nigeria. Changes in pH of +0.48, +2.60, +0.36, and +0.57 were observed for rain, borehole, pure and well water respectively. The water ionizer has improved the quality of the water samples by increasing the hydroxyl ions necessary for keeping the pH of water in the region appropriate for maize plant development.

Keywords: Water ionizer, Neodymium magnet, Hydroxyl ions, Maize plant and pH
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INTRODUCTION
Water is the most abundant natural resources of our planet. The human body comprise of about 70% of water and the brain about 80%, even a large portion of our body functions are regulated by water. Water, as it's an essential solvent for human is also very important to living organism and plant to carry out their vital chemical reactions, it is also an important product or reactant of these reactions (Sagingw, 2005).
Ionized water is a powerful antioxidant, it contains negative oxidation reduction potential (ORP) which retards the aging process. Ionized water assist to flush out toxic Waste from the body cells. Ionization of water could be via electrolysis or by potable dipole magnet (Frasetto, 2007). The pH of water which should be consumed should fall between a pH range of 7.0-7.8 without a drop of any chemical compound. Any consumed food or drink with a pH range less than 7 leaves the body in an acidic state. Initial signs of body tissue acidity include; Feeling weak, tiredness, having low energy, skin problem, Diarrhea, Chronic digestive problem, Kidney disease, Heart problem, and Cancers. (Food Coach, August 2005).
All the above listed diseases resulting from body acidity could be averted by keeping the body alkaline which could only be achieved by drinking a lot of ionized water which has a pH range of 7.0-7.8 (Ramsey, 1998).

MATERIALS AND METHODS
Materials
The following materials were used for the design of the water ioniser
- Neodymium Magnet
- Reflector
- Yoke (Figure 2)

Neodymium Magnet

A Neodymium Magnet or neo magnet (also, but less specifically called a rare-earth magnet) is a powerful magnet made of combination of neodymium, iron, and boron i.e. Nd_2, Fe_{14}, B (NdfeB neodymium magnets 2008).

Fig. 1: Neodymium Magnet

Neodymium Magnets as shown in Figure 1 are found in the hard drive of computer. Neodymium Magnets are very strong in compassion to their masses, but are also mechanically fragile, like other Ferro-magnetic materials, Neodymium Magnet lose their magnetism above a temperature known as CURRENT POINT. However, the most powerful grades lose their magnetism at relatively low temperature of about 80 degrees Celsius, (176 degree Fahrenheit) and above.

Reflector

The reflector in the magnetic water ionizer is a hollow shaft within which the water flows through via a pipe. The reflector contact the cell, reflect the electron from the two opposite Neodymium Magnet and shut out electric flux.

Yoke

The yoke on the other hand help box in the magnetic flux from the 'neo' magnet, transfers the poles, and converge the magnetic flux within the box.

The reflector and yoke are best made from stainless steel material due to its suitable properties (e.g. corrosive resistance).

Fig. 2: Construction of the water ionizer showing the magnet, the Yoke, and the reflector.

Method

The design of the magnetic water ionizer consist of two Neodymium Magnets affixed at the exterior surface of the reflector, the water is exposed to the magnetic field as it flow through the stainless steel shaft in the reflector between the magnet. The reflector help concentrate the magnetic field by avoiding leakage of magnetic induction, the magnetic field in turn ionizes the water. As the water move through the induce magnetic field, the static charge on the water molecule is changed from negative to positive due to current being generated by the moving water (Faraday's law). The current produce by the flow also causes some water molecule to ionize (dissociate) forming hydrogen ion (H^+) and hydroxyl ion (OH^-) as follows:

$$H_2O \rightarrow H^+ + OH^-$$

Magnets have two poles, North and South; magnetism works because it enhances conductivity as well as the process of ionization or dissociation of atoms and molecules into electrically charged particles (New Scientist, June 1992).

Physics shows that chemicals change weight under the influence of magnetic field so does water, more hydroxyl ion (OH^-) are created; it is this molecule?? (change to ion) that reduces acidity.

Design

The project is a unit construction of a water ionizer therefore the major features to be analyzed are;

- The mass flow rate of water
- The volume flow rate of water
- The velocity of flow of water
- The time require to ionizer the capacity of the reservoir
- Outlet reservoir and ionizer unit height.

Mass Flow Rate

This is the rate at which the working liquid (water) is discharged into the ionizer unit, which is a function of the discharge outlet at the reservoir which is 0.033kg/sec using a valve of □12mm outlet (density of water 1000kg/m^3). Mass flow per second of water.

Volume Flow Rate

This is the volume flow of water per seconds through the ionizer unit. Given in m^3/sec, which is 0.000033m^3/sec.

Velocity of Flow

The velocity of flow is derived from;

Capacity of reservoir - 4 litres

1000 litres - 1m^3

Capacity of reservoir - 0.004m^3

$$\text{Volume flow rate} = \frac{volume\ of\ reservoir}{time\ taken} = \frac{0.004}{120}$$

Mass flow rate = volume flow rate x density of water

= kg/sec (unit)

= 0.000033m^3/sec x 1000kg/m^3

= 0.033kg/sec

Volume flow rate = Area of exist x Velocity

$$\text{Area} = \frac{\pi d^2}{4}$$

d = diameter = 12mm

$$\text{Area} = \frac{\pi \times \left(12 \times 10^{-3}\right)^2}{4}$$

$$\text{Velocity} = \frac{volume\ flow\ rate}{Area} = \frac{0.000033}{1.132 \times 10^{-4}} = 0.293 m/\text{sec}.$$

Time of Flow

This could and was obtained experimentally which is 120sec.

Height of Outlet Reservoir and Ionizer Unit

The outlet reservoir which contains the water to be ionized and the ionizer unit are fixed at the same height to ensure steady flow of water. In the cause of this project experiment both were placed at a height of 2 feet.

Fabrication

Framework

The frame of the ionizer unit is a square of 30mm height. It contains the Neodymium Magnet (23mm x 56mm x 11.5mm). It is made of 1mm thick stainless steel sheet, of 54mm length, 30mm width. The two ends were covered by stainless steel sheet and joined by electric arc welding using stainless electrode. The framework was made in two numbers.

The Reflector

The reflector was rolled into shape and was made of stainless steel sheet of 1mm thickness, 54mm length, 30mm width, has a diameter of 15mm and 7.5mm radius (height) from the top of the Neodymium Magnet.

The reflector was joined on both sides to the frame work by electric arc welding using stainless electrode.

The reflector was also made in two numbers one for each frame work.

The assembly of the two halves of reflector and frame work forms the water ionizer unit (Dipole Assembly). The type of joint between the framework and the reflector should not release excessive heat energy which could raise the temperature of Neodymium Magnet above the Current Point (Current Point 150^0c is the temperature at which Neodymium Magnet lose its magnetic strength). The advisable type of joint are joints which does not release heat energy such as; rivet, adhesive joint, etc.

Hollow Shaft

The hollow shaft was made from stainless steel solid shaft. The hollow shaft has a length of 120mm and was recessed on the lathe machine from □14mm through 80mm length and □12mm through 20mm length on either side of the shaft. The internal diameter of the hollow shaft is 10mm.

Reservoir

The reservoir is a plastic container of 4 litres capacity. Two reservoirs were procured, one of which contains the water to be ionized and has a valve outlet of □12mm while the second reservoir which contains the ionized water and has an inlet of □10mm to admit the ionized water from the ionizer unit and a valve outlet from the reservoir of □12mm to dispense the ionized water.

Pipe

The pipe used to link the reservoir to the ionizer unit and from the ionizer unit to the second reservoir provide a leak proof passage is a PVC pipe of internal and external diameter of 12mm and 14mm respectively.

Assembly

The reservoir which contains the water to be ionized is linked with the hollow shaft inside the reflector of the ionizer unit via the PVC pipe as shown in Figure 3 the other end of the hollow shaft from where the ionized water is dispensed from the ionizer unit was connected to the second reservoir which contains the ionized water by the PVC pipe.

Fig.3: Assembly of the water ionization unit.

Inside the hollow shaft the water is exposed to magnetic field which energizes the water with negative electrons thereby increasing the hydroxyl ion (OH^-) content of the water from the exit (ionized water).

TEST FOR pH

To determine if water has undergone, pass through water ionizer or truly ionized we make use of the pH detector.

pH is defined as a measure of the concentration of hydrogen ions in a solution, while p^{OH} is the measure of the concentration of hydroxyl ions in a solution. The pH scale ranges from (0-14). Low pH values are associated with solution with high concentration of hydrogen ions (0-7), while high pH value occurs for solution of low hydrogen ion (having high hydroxyl ion).

Pure water has a pH 7 (concentration of hydrogen ion equals that of hydroxyl ions) pH of other solutions are described with reference to that of pure water. Acids are defined as those solutions with pH less than 7 while basic solution are defined as those solution that have pH greater than 7 (i.e. less hydrogen ions which are ionized water).

3.5.1 Mathematical expression of pH

$$pH(x) = pH_{(s)} + \frac{(Es-Ex)F}{RT\ In\ 10}$$

- X = solution of unknown pH
- S = solution of known pH
- Es = Electro motive force of the galvanic cell (s)
- Ex = Electro motive force of the galvanic cell (x)
- R = molar gas constant
- T = Thermo dynamic temperature
- F = Faraday constant

OR $pH = -\log_{10}[H^+]$

Where $[H^+]$ = Hydrogen ion concentration.

$pOH = -\log_{1=0}[OH^-]$

$pH + pOH = 14$

$\underline{pOH = {}^-\log_{10} -AOH^- = 14 + \log_{10} AH^+ = 14 - pH}$ (remove)

$pOH = 14-pH$

Measurement of pH

The pH detector used to test water samples after ionization through the water ionizer unit was 350pc pH metre. pH testing was done in the Food Engineering Laboratory in Ladoke Akintola University of Technology, Ogbomoso as shown in Figure 4.

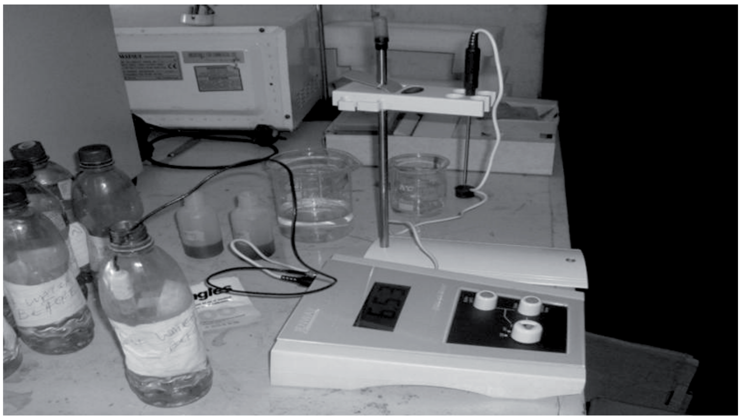


Fig. 4: Testing and measurement of the pH of the Different water samples.

The pH metre was buffered with buffer 7 and buffer 4 to make the metre ready to detect the pH level of the samples. Each sample was put into the beaker and the electrode of the pH metre inserted into the beaker which contains the sample to be tested. The pH reading was read on the monitor of the pH metre. This process was repeated for each sample tested and the corresponding pH was recorded.

Four different plots of maize were cultivated as the control group label Ia to IVa and each watered till germination with rain, borehole, sachet and well water respectively.

A similar test group labeled plot Ib to IVb were set up with the same soil sample and the maize plant watered with the same volume of their respective ionized water (5litres) twice a week and the plants measured twice a week on the days that they are watered. Fertilizers were added to maintain constant nutrition for the plants to avoid signs of stunted growth due to lack of proper nutrients.

Finally, by the sixth week, which is long enough to show accurate results, the results of each group were measured and compared with one another. The same person did the measurement to ensure accuracy. Measured are the plants height, the leaves and root lengths the average results recorded.

RESULT AND DISCUSSION

Result

Test were carried out on four types of water available which are Rain water, Borehole water, Pure water and Well water.

Each of these types of water mentioned above was filled into the reservoir which contains the water to be ionized and the outlet valves opened to run the water through the ionizer unit via the hollow shaft. In the process, the water were expose to magnetic field which in turn energize the water with negative electron thereby rising the hydroxyl ion (OH^-) level, to give ionized water in each case. The resulting pH could be seen in the

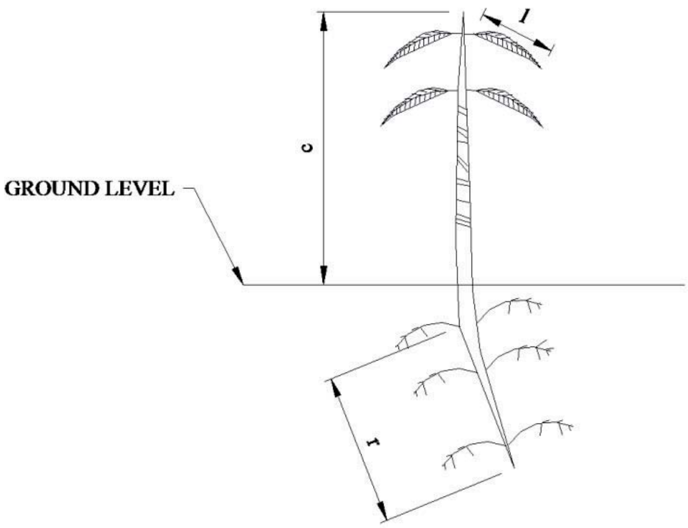
Table below;

Table 1: pH Reading

Before Ionization			After Ionization			
Water	pH	H^+ Conc.	Water	pH	H^+ Conc.	Change in pH (Δ pH)
Rain	6.75	1.78 *10^{-7}	Rain	7.23	5.89 *10^{-8}	+ 0.48
Borehole	7.44	3.63 *10^{-8}	Borehole	7.70	2.00 *10^{-8}	+ 0.26
Pure	6.84	1.45 *10^{-7}	Pure	7.20	6.31 *10^{-8}	+ 0.36
Well	6.53	2.95 *10^{-7}	Well	7.10	7.94 *10^{-8}	+ 0.57

Table 2: Maize Seedlings Germination Rate with Unionized and ionized water

	Unionized water			Ionized water			Growth Difference (%)		
Water Source	c	l	r	c	l	R	C	l	r
Ran	8.3	9.0	6.3	9.6	9.8	7.3	15.7	8.89	15.9
Borehole	8.2	9.3	5.9	9.0	10.0	6.5	9.75	7.53	10.17
Sachet	7.1	6.2	5.8	8.7	7.3	6.1	22.84	17.74	5.17
Well	7.9	9.0	5.6	10.0	9.5	6.4	26.58	5.58	16.07



Where c is plant height, l is length of the leaves and r is root length

DISCUSSION

The pH obtained after ionization falls on the alkaline scale of the pH metre. The U.S Environmental Protection Agency recommends that public water system maintains a pH between 6.5-8.5 before it could be consumed. However, any pH level which falls between 0-7 is acidic which implies that a pH 6.5-7.0 of water is still acidic (contains high hydroxyl ion) and accumulation of such in the body leads to diseases. Ionized water has a pH range within 7.2-7.8 (contains high level of hydroxyl ion) without the addition of any chemical compound. To obtain a pH above 7.8 requires the addition of chemical compound such as sodium hydroxide (NaOH) and excess could push the pH above 8.5. Hard water has a pH from 8.5-14 which should not be consumed or used because it causes skin dryness and itching when use for bathing (Kinetico, 2008).

The results in table 2 showed that the most growth and healthy appearance are the maize watered with ionized water. Thus, the null hypotheses that there is no relationship between different water used (unionized and ionized water) is rejected. An inverse relationship exists showing a lower acid level corresponding to high growth.

CONCLUSION

The test ran on the type of water used and the resulting pH, clearly shows that there were changes (rise) in pH level which indicates ionization (lose or gain of electron) and high level of hydroxyl ion (OH^-), Alkaline nature, Reduce molecule cluster size.

The above fact mentioned are the properties of water which had undergone scientific alteration (Ionized water) which is expedient for human, livestock and plant;

There is a positive change in growth noticed in maize plants planted with ionized water in the plant height, leaves and root length.

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THE EFFECT OF CASSAVA EFFLUENT ON THE GROWTH OF OKRA *(ABELMOSCHUS ESCULENTUS)*

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Abstract

Cassava effluents generated during cassava processing are usually not properly disposed in Nigeria. The continuous accumulation of cyanide a known metabolic inhibitor from these effluents will prevent the utilization of soil nutrients by the plants grown on such polluted soils. The concentration profile of cassava fluid effluent is in the order of sodium > calcium > potassium > magnesium > lead > iron while copper, manganese and Cadmium are low. The occurrence of metals in soils may be beneficial or toxic to the environment depending on the quantity. The soil may require some of these elements in trace quantities but at higher concentrations may constitute toxicity problems. The effect of cassava effluent on vegetables was investigated using okra seeds as grain models. The samples were planted and irrigated/watered using 25, 50, 75 and 100% cassava fluid effluent concentrations by volume with clean watered samples as control. The results revealed that the concentrations of sodium and potassium in the soils pretreated with cassava fluid effluent increased with effluent concentration. There was no significant increase in magnesium concentration with increase in effluent concentration while the concentrations of iron and manganese decreased. At the end of the experiment 80, 60, 40 and 0% germinations were observed at 25, 50, 75 and 100% effluent concentrations respectively with germination days increasing with increase in effluent concentrations. A growth height of 6 and 4.8cm were observed at the control and 25% concentration, while 0.9cm at 50% concentration effluent which then withered with no further growth. The seedlings treated with 75% concentration effluent stops at germination level with no noticeable growth. The accumulation of these metal and cyanide account for the inhibition of growth of the okra plants and its eventual withering. It can therefore be recommended that effluents should not be indiscriminately disposed on agricultural soils since it will not only serve as environmental pollutant but also destroy agricultural farm lands. Further research work should be carried out on the conversion of cassava effluents into more useful materials.

Keywords: Cassava, Effluent, Okra, Cyanide, Growth

INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is a major staple as well as a cash crop in many parts of sub-Saharan Africa. It fits well into smallholder farming systems, thriving across a wide range of ecological zones. It is available all year round, providing household food security and offering an affordable source of calories for small-scale farmers (Rural Agricultural Development Authority, 2004). Cassava is a tropical crop, requiring at least 8 month of warm weather to produce crop. It is traditionally grown in a savanna climate, but can be grown in extremes of rainfall. In most areas it does not tolerate flooding. In droughty areas it looses its leaves to conserve moistures, producing new leaves when rains resume. It takes 18 or more months to produce a crop under adverse conditions such as cool or dry weather (Stephen, 1995).

The cassava tuber consists of about 15% peel and 85% flesh (Olorunfemi *et al.*, 2007) for use as human food, the peel is removed and only the flesh is utilized. Both peel and flesh contain significant amount of hydrocyanic acid that is highly toxic to humans and animals. Cassava has to pass through several detoxification processes, necessary to make it safe for human or animal consumption (Onwueme and Sinha, 1991). Nigeria is one of the world's largest producers of cassava (FAO, 2004) and has consistently generated so much Waste from cassava mills. These Wastes are usually discharged on land or water indiscriminately and this in turn affects the biotic zones especially in the southern part of the country.

Man's industrial and economic activities in his immediate environment have brought about improved living conditions. However, these activities produce Wastes, which inevitably get disposed on land. This has negatively shifted the ecological balance thus threatening his own existence on the planet (Olorunfemi *et al.,* 2007).

There are two important biological Wastes, which may cause damage to environment and are generated during the traditional processing of cassava. These Wastes are; the cassava peels and the liquid squeezed out of the fermented parenchyma mash (Ganiyu, 2006). Cassava effluents are liquid Wastes from cassava mill, which are usually discharged on land or water. The cassava peels derived from its processing are normally discharged as Wastes and allowed to rot in the open with a small portion used as animal feed, thus resulting in health hazards. As a rough estimate about 10 million tones of cassava are processed into gari alone annually in Nigeria. Since these peels could make up to 10% of the wet weight of the roots, they constitute an important potential resource for animal feeds if properly processed by a bio-system. The peels contain toxic levels of cyanogenic glycosides, while the liquid contains a heavy load of microorganisms capable of hydrolyzing the glycosides. The resulting products of fermentation of cassava peels with squeezed out water can be dried and used as animal feeds (Ganiyu, 2006).

Disposal of effluents and Wastes is a source of concern to environmentalists and although there are reports on effect of palm oil mill effluent on soil properties (Lim, 1987), contaminating effect of spent engine oil on plant growth (Anoliefo and Edegai, 2001) and heavy metal accumulation in vegetables grown in mine Wastes (Cobb *et al.*, 2005) literature is scanty on the effects of cassava effluents on plant growth. Cassava effluents are Waste from cassava mills that causes pollution to the environment (soil), there is therefore a need to study the extent at which these Wastes affect agricultural soils and plants. Recommendations of a proper method of disposal of these effluents and possible uses on farm, is therefore very essential.

The main objective of this work is to evaluate the effect of cassava effluent on the growth of vegetables using okra seed as grain models with the aim of proffering solution to the indiscriminate disposal of these effluents and possible benefits on plant growth.

MATERIALS AND METHODOLOGY

Chemical and Elemental Analysis of Cassava Effluents and Soil Samples.

A sample of fresh cassava effluents, pre-treated and untreated soil samples were collected and analyzed at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The properties determined are the amount of biological oxygen demand (BOD), pH, total solids, sodium, calcium, potassium, magnesium, lead, iron, copper, manganese, cadmium, zinc, cyanide and other active ingredients in the effluent as well as the soil samples. The content of each of these elements were determined using standard methods prescribed by AOAC, 2000.

Germination Studies / Viability Test

Three bowls was used for the viability test, with ten (10) seeds planted in each of the bowls i.e. 30 seeds altogether. The percentage viability was calculated using the formula:

$$\text{Percentage viability (\%)} = \frac{\text{No. of germinated seed}}{\text{Total No. of seeds planted}} \times \frac{100}{1}$$

Growth Studies

Two sets of bowls filled with the garden soil were used for the growth studies. A set was irrigated with the effluent – water mixture at concentration of 25, 50, 75 and 100% per volume everyday for ten days. The controlled soil was irrigated with tap water. Three replicate of the soil samples was air-dried at 80^{o}C for elemental analysis.

The same number of seeds was planted in the second set of bowls. These were irrigated with the effluent–water mixture of concentration of 25, 50, 75 and 100% per volume with one irrigated with clean water to serve as control. The percentage viability (%) and vegetable growth parameters of the okra plants in each bowl receiving different treatments were evaluated from the 4th day of planting. The number of surviving seedlings in each treatment was also taken by direct counting.

RESULTS

The Physico-chemical constituent of soil sample

The results showed that the soil sample used for the experiment is neutral sandy-loamy soil with mineral constituents suitable for the propagation of okra plant (Table 1). The soil properties are similar to the soil in southwestern Nigeria as reported by Ogundola and Liasu, 2007.

Table 1. Physical and Chemical constituents of soil sample before treating with cassava effluent

Properties	Content
pH	7.00
Acidity	0.67
Mg (mg/g)	4.86$\pm$0.32
Na (mg/g)	1.54$\pm$0.03
K (mg/g)	1.85$\pm$0.27
Fe (mg/g)	0.34$\pm$0.33
Mn (mg/g)	0.18$\pm$0.02
% sand	71.10
% clay	10.80
% loamy	18.00

Characteristics of the Cassava Effluent

The physico-chemical characteristics of the fresh effluent (Table 2) showed that it is slightly complex with a variety of dissolved cations and suspended particles. The BOD of cassava effluent is within the permissible level of 300 – 100ppm; however the effluent is highly acidic (Table 2). The concentration profile of K, Na, Mg, Ca, Mn, Cd, Cu, Pb and Fe ions was in the order of Na> Ca> K> Mg> Pb>. Fe, Cu, Mn and Cd were low, Zinc was not detected. The properties of the cassava effluent are similar to that reported by Ogundola and Liasu (2006) and Olorunfemi, *et al* (2007).

Table 2: The constituents of the Cassava Effluent

Constituents	Concentration (mgL^{-1})
BOD (ppm)	105.00
pH	4.60
Total solids	14.30
Sodium	120.40
Calcium	62.25
Potassium	50.90
Magnesium	25.25
Lead	9.45
Iron	2.35
Copper	1.91
Manganese	0.71
Cadmium	0.19
Zinc	Nil
Cyanide (μgmL^{-1})	0.65

Characteristics of Soil Pretreated with Cassava Effluent

The concentrations of sodium and potassium in the soils pretreated with cassava effluent increased with effluent concentration (Table 3). There was no significant increase in the concentration of magnesium with effluent concentration. The concentration of iron and manganese in the effluent treated soils did not show a uniform increase, rather a decrease in concentration of these elements were obtained. The cassava effluent at 25% and 100% concentration does not significantly affect the pH of the soil, while it is affected at 50% and 75% concentrations (Table 4) at 95% confidence level.

Table 3: Element analysis of soil treated with cassava effluent at various concentrations ($mg\ g^{-1}$ dry weight)

Concentration (%)	Mg	Na	K	Fe	Mn
0	4.86 ± 0.32	1.54 ± 0.03	1.85 ± 0.27	0.34 ± 0.33	0.18 ± 0.02
25	5.34 ± 0.33	1.71 ± 0.04	2.60 ± 0.34	0.55 ± 0.33	0.13 ± 0.12
50	5.36 ± 0.07	1.86 ± 0.07	3.52 ± 0.12	0.41 ± 0.24	0.10 ± 0.05
75	5.86 ± 0.02	1.98 ± 0.24	3.76 ± 0.23	0.41 ± 0.14	0.09 ± 0.07
100	5.85 ± 0.24	2.31 ± 0.32	4.93 ± 0.04	0.41 ± 0.07	0.13 ± 0.16

Values are means of 3 replicates, 10 days after treatment with cassava effluent

Table 4: pH of soil pretreated with cassava effluent at different concentrations

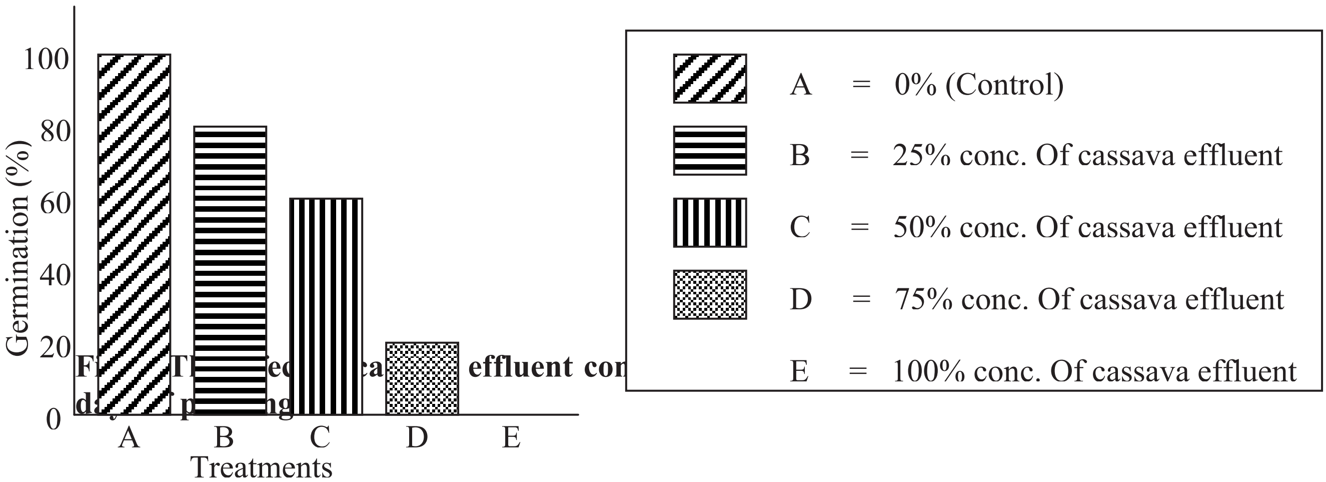
Concentration (%)	pH
0	6.40
25	6.61
50	7.31
75	7.30
100	6.82

Values are means of 3 replicates, 10 days after treatment with cassava effluent

Germination and Growth Studies of Okra in different Effluent Concentration

The viability test showed that the okra seed is 80% viable. The results at the end of the 4^{th} day after planting showed 100% germination of the seeds planted in the control experiment

germinated. Eighty percent (80%) germinated in the soil treated with 25% concentration of the effluent, while only 20% germinated in the 50% cassava effluent treated soil and none (0%) germinated in the soil treated with 75% cassava effluent. At the end of the 5th day after planting; it increased to 60% germination from the soil treated with 50% concentration of cassava effluent and 20% germination in the 75% cassava effluent treated soil. This shows a percentage germination of 100%, 80%, 60%, 20% and 0% for the control, 25%, 50%, 75% and 100% cassava effluent concentrations respectively (Figure 1). This indicates that germination of the okra seeds varies with different concentration of the cassava effluent.
The results at the end of the 6th day of planting showed that the growth of 20% of the plants in the soil treated with 25% cassava effluent was inhibited by the effluent leaving 60% of the healthy seeds to grow. At the end of the 7th day (one week) after planting, the seedlings in the control experiment has grown to an average height of 4.5cm with two leaves each, while the seedlings irrigated with 25% concentration of cassava effluent has grown to an average height of 3.3cm also with two leaves each.



The growth of seedlings irrigated with 50% concentration was inhibited by the effluent after which they started withering having grown to an average height of 0.9cm. The percentage germination in the seedlings planted in the soil treated with 75% effluent concentration increased to 40%. All the seedlings in the control experiment have developed a third leaf by the 10th day of planting, and have grown to an average height of 6cm. Similarly, the seedlings treated with 25% effluent concentration had also developed a third leaf and has grown to an average height of 4.8cm.
The seedlings irrigated with 50% effluent concentration have finally withered with no further growth observed. The seedlings treated with 75% concentration of effluent stops at germination level with no noticeable growth. This showed that okra seed can only grow and survive if 25% effluent concentration is present in the soil.

DISCUSSION
The pH of the soils irrigated with cassava effluent increased towards neutrality. Okra plants grow successfully under a pH range of 6.0 – 7.5, therefore, inhibition of germination / growth of these okra seeds / plants may not have been due to the observed pH increase in the soil in this study.

The occurrence of excess minerals in the soil may be beneficial or toxic to the environment. The soil may require some of these elements in trace quantities but at higher concentrations they may constitute toxicity problems. Its presence in the cassava effluent used for this study may as well partly account for the inhibition of germination and growth of the okra plant. Cyanide, a known metabolic inhibitor (Lehninger, 1984) is present in both the peel and flesh of cassava tuber from which the effluent is obtained during cassava processing with the concentration of the cyanogenic glucosides ranging from 10-500mgkg^{-1} of fresh tuber, depending on the cultivars (Onwueme and Sinha, 1991). The cyanide in the effluent used for irrigating the soil in this study is present in significant amount and its continuous accumulation may have presumably prevented the utilization of soil nutrients by the plants grown in the irrigated soils.

CONCLUSIONS

It is therefore concluded that the presence of some of these minerals and the amount of cyanide accumulated in the plants may have reached higher levels thereby causing inhibition to the growth of the okra plants and its eventual withering. Considering the fact that cassava effluent contains certain elements that pollute agricultural soils and inhibits the growth of plants, it should not therefore be indiscriminately disposed on agricultural soils. It is recommended that environmental scientists should provide a means of extracting the essential elements such as potassium, sodium etc from cassava effluent for other uses before its disposal.

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POTENTIALS OF SAND AS LITTER MATERIAL INSTEAD OF WOOD SHAVINGS IN BROILER ENTERPRISE

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Abstract
This paper critically examines the potentials of sand as broiler litter by putting wood shavings into perspective. It emphasizes their relative characteristics as litters; and the various litter management criteria that can promote broiler performance on them. The paper also puts in focus, how the litters could compromise broiler s' health including how spent litter can be utilized. Recommendations were made on the adoption of sand as litter material in areas where wood shavings are not readily available for raising broilers (e.g. savannah, desert and coastal or riverine areas). However, a further study on the combined benefits of the litters for broiler raising was suggested.

INTRODUCTION
In an effort to reduce problems such as leg weakness, skeletal deformities, stress, bruising and increased mortality; animal welfare associations are constantly rallying for improvements in the methods used for growth, transportation and slaughter of poultry (Bekoff and Meany, 1998).
Therefore, issue of welfare in farm animals needs global attention of every stakeholder in the industry. However, management experts should take a leading role in improving and sustaining poultry welfare towards good performance. It is so expected because housing conditions for poultry dictates the peak of their comfort and well being.
The advent of intensive housing prevented the environment from being vulnerable to disease out break, since birds' movements are restricted to a particular confinement. Under this intensive housing, the deep litter system was traditionally found suitable for broiler production (Oluyemi and Robert, 1988).
The rearing of broilers had become popular with increased meat consumption level of the populace. Hence, disposing their Wastes (droppings) becomes a serious concern. This problem of Waste disposal is a result of intensive management that involves accumulation of droppings with high moisture content. The moisture content of the dropping supports degradative action of bacteria, which releases a pungent smell of ammonia and other suffocating gases into the environment. These gases are both hazardous to the birds and human health. Therefore, strategy to reduce the moisture level of the poultry droppings became an issue of attention under intensive (deep litter system) management of broilers that have direct contact with their droppings.
This led to the discovery of many dropping absorbent materials that can make droppings easily disposable with minimal negative impact on the environment. The absorbents are called bedding materials which are generally referred to as litter. Litter materials generally refer to include peanut hulls, sawdust, straw, corn cobs, chopped newspaper and wood shavings. Many of these have been used but have not replaced wood shavings. Wood shavings and other wood by-products have been litter materials of choice for broiler producers for nearly as long as the commercial broiler industry has existed.

Wood shaving, a by-product from the processing of timbers into wood and wood products is usually handled as Wastes at the sawmills. The Wastes are commonly collected for use as poultry litters by the poultry farmers. Sand, a product from the weathering of rocks could be adequate as alternative or complement to wood shaving. Wood shavings are still highly valued, but cost and availability problems due to rapidly growing poultry industry are provoking thought for alternatives (Bilgili, *et al*., 2000). Therefore, wood shavings will probably continue to be the benchmark for comparison. Litter materials must be readily available in large quantities, inexpensive, free of detrimental compounds and have physical properties that do not compromise birds' health.

Though sand is a readily available natural resource in all parts of the world, significant effort had not been made to exploit its potential as litter material in Nigeria. Sand is available in several forms based on their textures or particle size contents. These forms of sand could be adequate as alternatives or act as complement to wood shaving that is presently threatened with high level of utilization based on the expansion of poultry industry and the government policies against deforestation and desertification in Nigeria.

Litter characteristics

Several factors determine whether or not a material is a good bedding source. In general, bedding materials need to be very absorbent. This is probably a good criterion for organic materials but might not apply to inorganic materials such as sand or clay. In addition to being absorbent, the litter material must have a reasonable drying time. A second criterion is that the material must have a useful purpose following its use as a bedding material. If not, poultry growers would accumulate unmanageable quantities of old litter. This is not acceptable, even on a small scale, and would not be sustainable on an industry wide scale.

Litter as a poultry bedding material, must be readily available. Some products may meet industry goals once under the birds, but if they are difficult to obtain, for whatever reason, they will not find favour as a poultry litter. Finally, if a material is not cost competitive with the current materials being utilized, it will also not be used as a litter material. However, if the new material has increased value once removed from the poultry house in comparison to current litter materials being used, poultry growers may decide to use the alternative litter materials. Bedding materials must not be toxic to poultry or to poultry growers.

Malone *et al.* (1983a) reported that poultry can consume as much as 4% of their diet as litter. Therefore bedding materials must not contain contaminants, such as pesticides or metals, which might be consumed or taken into the bird in any manner (Malone *et al*.,1983b) that might cause the bird to become sick or that might cause the meat or rendered products to become unusable.

The relative amounts of all the constituents present in a soil determine what a soil is called, such as a sandy soil, clay loam etc (NERC, 1978).

The major mineral in sand is called quartz and it is composed of silica and oxygen (SiO2). Sand grains vary in size depending on how long they are exposed to weathering. Quartz is very resistant to weathering, therefore, sand grains are larger in diameter compared to silt and clay particles:

- (i) Very Coarse Sand: 2.00 – 1.00 mm diameter.
- (ii) Coarse Sand: 1.00 – 0.50 mm diameter.
- (iii) Medium Sand: 0.50 – 0.25 mm diameter.
- (iv) Fine Sand: 0.25 – 0.10 mm diameter.
- (v) Very fine Sand: 0.10 – 0.05 mm diameter.

Because sand is larger in diameter than other soil separates, sand grains provide larger spaces in which water and air can more easily move through soil.

Silt contains silicate minerals like sand but the diameter of silt particles is smaller, 0.05 – 0.002 mm and so the pore space between silt particles are smaller. Therefore, silt has the ability to hold water between soil particles.
Silicates, mica, iron and aluminium hydroxide minerals are found in clay. Clay particles are 0.002 mm in diameter or smaller, so the pore spaces between clay particles are very small. Thus water and air movement through clay particles is significantly decreased.
Distribution of soil types in Nigeria revealed seven major soil types in the country (NERC, 1978). These include:

(i) organic-brown to red loose sands
(ii) brown to red-brown compact silty fine sands.
(iii) predominantly red friable porous sands to sandy clays.
(iv) yellow-brown friable porous sand to sandy clays.
(v) freshwater swamp soils grey to white sands, grey clays and sandy clays.
(vi) brown to black saline mangrove soils
(vii) grey to black plastic clays and loose pale grey to brown sands.

However, land type, which is described as being predominantly red, friable and porous sands, changing to sandy clays, constitutes a larger proportion of the soil area of Nigeria than all the other types combined.
Wood is obtained from tree. It is called timber and has wide usage in our day to day activities. The two main types of wood are hardwood and softwood. The terms "Hardwood" and "Softwood" do not mean that all hardwoods are harder than softwoods. Generally hardwoods are harder but there are some softwood that are harder than hardwood. Therefore, the terms are botanical words used to differentiate the woods obtained from deciduous trees (Hardwood) from those got from coniferous trees (softwood). Most Nigeria woods are hardwoods while softwoods are grown mostly in the cooler regions of the world (Fadayomi, 1999). The examples of hardwood include Mahogany (*Khaya ivorensis*), Afara (*Terminalia superba),* Mansonia (*Mansonia altissima*) Iroko, Sapele etc. Softwoods include: Redwood or Pine (*Pinus spp*.), Maple (*Acer spp.)* e tc

Relative performance of broilers on wood shaving and sand litters

Different litter materials like chopped straw, rice husk, sugar cane pulp, oat hulls, corn cobs, ground corn cobs, paper mill by-products, sawdust, wood-shavings, sand and peat moss have been investigated as to their suitability in broiler rearing in different parts of the world (Oliveira *et al*., 1975; Ranade and Rajmane, 1990). The importance of good quality litter for floor reared birds is well recognized, although the bird's performance is unlikely to be severely affected by the type of litters (Brake *et al*., 1993 and Al Homidan *et al*., 1997).
Snyder *et al.* (1958) reported that sand as a litter material was not new; but still receiving renewed interests, especially in the southern part of the USA (Hess *et al.,* 1996). Bilgili *et al.* (1999) reported successful rearing of several broiler flocks on sand in comparison with pine shavings in a research setting. They noted that male broilers were 30 to 40 points heavier on sand with no differences in female weight. There were also no differences in feed conversion or mortality. Carcass grade and paw (Foot) quality was not equally affected. Further studies conducted in the field under commercial conditions revealed equal performance in both broilers reared on sand and pine shavings (Bilgili *et al*., 2000 and Hess *et al*., 2001).
Though sand is a readily available natural resource in all parts of Nigeria, efforts had not been made to exploit its potential as litter material. The work of Asaniyan *et al.* (2006a), where six floor litters of different types of sand and wood shavings were used to evaluate the performance characteristics, haematological indices and serum metabolites of broilers raised for eight weeks showed that broiler performance, haematological indices and serum metabolites favoured raising broilers on sandy loam and wood shaving of Afara (*Terminalia*

superba) wood type. However, sand tends to reflect superior contribution to the broiler performance. Hence, concluded that sand stands as an alternative or complementary litter to wood shavings especially where there is scarcity of wood shavings in Nigeria.

Litter management criteria and broiler performance

Stocking Density

Sand is currently under review in several areas of USA other than South with mixed results (Malone *et al*., 2001a; Malone *et al*., 2001b; Watkins, 2001). While broiler performance was similar or better, in some cases, with sand than for broilers reared on shavings, some issues raised included poorer chick start on sand compared to shavings, dustier air conditions and that sand is not compatible with composting, combustion or pelleting.

Therefore, continued field trials will help determine the best management guidelines for using sand as litter (Grimes *et al*., 2002).

Stocking density of broilers can be either defined by the number or the weight of birds in a given area. The choice of stocking density in broiler production is generally made to maximize economic returns. However, maintaining a high stocking density is a common practice in the poultry industry because it allows for an increased economic return per unit of floor space.

The resulting high stocking density usually leads to reduced growth rate and increased incidence of diseases, especially leg problems (Kestin *et al.,* 1994).

The high stocking rates also result in adverse environmental conditions characterized by wet litter and high ammonia levels, which are significant factors responsible for the adverse density effects (Gordon and Tucker, 1993; Thomsen, 1993). With increasing density, Blokhuis and Van der Haar (1990) found a significant decrease in walking, dust-bathing, pecking and scratching behaviour. In enclosed commercial broiler houses, fixed stocking densities of up to 20 birds per square metre are typical (Elson, 1993).

This should present little discomfort in the early weeks of a bird's life but may reduce welfare in later life by restricting locomotion and preening (Newberry and Hall, 1988; Lewis and Hurnik, 1990). At this density, there will also be increased contact with soiled litter, which can cause contact dermatitis (Greene *et al.,* 1985; Mcllroy *et al*., 1987).Conflicting results have been obtained on the effect of stocking density on locomotion. Bessei (1992) found no effect of stocking density on activity between 10 and 30 birds per square metre, but Bessei and Reiter (1992) reported that activity was greater at 5 than at 15 birds per square metre. Broilers make effective use of their floor space, but in the last weeks of growth, movement may be reduced by the development of aggressive behaviour (Newberry and Hall, 1988).

Other authors, however, have not recorded any agonistic behaviour up to 7 weeks of age (Murphy and Preston, 1988; Preston and Murphy, 1989). Lying bouts can be disrupted by a high stocking density, particularly if it causes heat stress, and results in birds standing periodically to increase heat loss (Murphy and Preston, 1988; Lewis and Hurnik, 1990).

Contrarily, Stamp-Dawkins *et al.* (2004) found that environmental differences provided for the chickens have more of an impact on welfare than as stocking density itself. The authors found that litter moisture and air ammonia were correlated with higher faecal corticosteroid (Stress hormone).The concentration of this hormone was also correlated with mortality, suggesting that stress on birds and their risk of dying depend on the extent to which producers can control the house environment.

The implications of this are that although very high stocking densities do affect chicken welfare, there are other important factors in the birds' environment like the floor litter. Then Asaniyan *et al.* (2008) compared the effect of raising broilers on either sand or wood shavings on performance and organ weights under stocking densities of 5, 10 and 15 birds per m^2. The report of the study showed that weight gain, feed consumption and feed conversion ratio as well as heart and gizzard were significantly different among the different stocking densities on the two litter types. Broilers kept at stocking density of 5 birds per m^2 on both litter types performed best with those on sand comparing favourably with those on wood shavings.

Litter Depth

Michael *et al.* (1992) reported that birds readily dust bathe in wood shavings or other floor litter but if finer materials such as sand is available they use this in preference. In-line with this, Shield *et al.* (2005) reported that broilers increasingly performed many of their behaviours on sand when given a choice, but if only bedding type was provided they performed those behaviours with similar frequency on sand or wood shavings.

Depth of the litter influences the performance of dust bathing behaviour (Estevez, 1994). He further explained that contrary to popular belief, birds are able to scratch; peck and dust bathe more often in a thin layer of litter in which they are able to "dig down" to the underlying floor. Therefore, any litter condition or quality that can hinders dust bathing in broilers will results into welfare problem for them (Vestergaard, 1982).

On the depth of litter in the broiler house, Obeng-Asamoah (1987) suggested that cool sand should be 2cm deep and any other litter should be 8cm deep, while Collins (1996) reported the usual litter depth for wood-shavings to be 5cm and 10cm for chopped straw.

EPA (2002) recommends that fresh bedding should be spread over the entire floor area of poultry house at about 7.5cm-10cm depth for wood shavings and sawdust or any material that is readily available, economical and has good absorbency. Laseinde (1999) was of the view that deep litter system, as cheaper alternative to battery cages should be bedded with a thin layer of dry wood shavings of about 3cm for layers, to eventually build up. Generally, without any specific focus on the litter type, Eurogroup (2005) suggested that litter should be of suitable material and particle size, dry, hygienic and kept to an average minimum depth of 5cm. Asaniyan *et al.* (2007a) in their work to assess the impact of three litter depths of 2, 4 and 6 cm each for both sand and wood shavings litters on broiler performance; reported that broiler on 4 cm litter depth of wood shavings and 6 cm depth of sand litters performed better than those on the remaining litter depths.

Litter Replacement Frequency

Litters need to be very absorbent in having their moisture level maintained between 20-30 percent in a well-ventilated broiler house (Ritz *et al.,* 2005). Poorly managed litter is a suitable environment for bacteria proliferation and ammonia production and is detrimental to both human and chickens health (Ritz *et al*., 2005). Ammonia concentration of 50 to 110 ppm can cause human eye to burn and tear inducing possible health risks among farm workers. Prolonged exposure of chickens to high levels of ammonia can cause kerato conjunctivitis (blindness) (Ritz *et al.,* 2005).

Caked litter can cause breast blisters in broiler-chickens and thus downgrading the carcass (Smith, 2001). In addition, wet litters attract insects (particularly flies) and causes soiled feathers. The two factors that influence litter conditions most are manure and moisture. While manure influence is not readily under the producers' control, litter moisture can easily be controlled and this litter moisture control goes a long way in reducing ammonia concentration and other associated problems. Miles and Butcher (2003) reported that it is common to find localized areas of caking near leaking watering cups, nipples, troughs or roofs. They therefore suggested that such portions of the litter must be continually stirred, raked or replaced to correct the condition. Other causes of wet litters include watery droppings, moldy feed, disease, climate control and bedding type (Miles and Butcher, 2003). Therefore, good litter management practices must ensure the provision of high quality feed, disease organisms' free environment and adequate ventilation with good quality bedding materials.

Miles and Butcher (2003) emphasised that when high humidity accompanies high temperatures, the problem of wet litter can become so severe that it becomes very difficult to properly maintain the litter in a dry and friable condition. In a situation like this, coupled with possible failures to handle predisposing causes of wet litters, it is of necessity to establish a standard litter replacement schedule for broiler rearing. In line with this, Laseinde (1999) suggested that litter should be changed every two weeks or more frequently during rainy season, especially when ventilation is poor. The work of Asaniyan *et al.* (2006b) that assessed the influence of five litter replacement frequencies of every week, every two weeks, every three weeks, every four weeks and zero week (no replacement) within the eight week rearing period on performance of broiler chickens reared on sand and wood shavings litters; recommended that sand litter can be replaced every two weeks while it could be replaced every three weeks for wood shavings.

Relative pathogens harbouring tendencies of wood shavings and sand litters

Livestock welfare and performance necessitate knowledge about the composition of the bacterial microflora present in broiler litter. Martin and McCann (1998) performed a survey of pathogenic microorganisms in poultry litter with selective medium and found *staphylococcus xylosus* to be a predominant species. But sand litter had lower bacterial counts, water activity and moisture level compared with pine shavings litter (Macklin *et al.,* 2005). They then concluded that, bacteriologically, sand can be a viable litter alternative to pine shavings if locally available. However, Asaniyan *et al*. (2007b) reported that though sand litter had lower bacterial load but contained more species of pathogenic organisms below pathogenic threshold than wood shaving litter. Then concluded that proper management of the two litter types could keep the injurious organisms at a tolerable level for the birds reared on them.

Entomological study of the poultry litter by Campbell (1996) revealed that poultry are infested with a variety of insects and mites that live on the skin and feed on skin debris, feathers and blood. Furthermore, he specifically reported the presence of darkling beetles in poultry litter. They feed on poultry carcasses and poultry may feed on them, hence regarded as mechanical vectors of several diseases, including: marek's disease, avian influenza, salmonellosis, fowl pox, coccidiosis, botulism and new castle disease.

In a similar study conducted by Watson (2004), specific report was made that the darkling beetle (*Alphitobius diaperinus*) and the housefly (*Musca domestical*) were common and persistent pests of poultry production. Both insects were definitely implicated in the transmission of Turkey coronaviruses (TCV) in addition to other several poultry diseases. However, Bilgili *et al.* (2000) reported that poultry houses laid with sand as a litter had less dust, lower darkling beetle levels, less caking and more beneficial temperature. Corroborating the report of Bilgili *et al.* (2000), Asaniyan *et al.* (2007b) confirmed that wood shaving litter harboured more darkling beetle (*Alphitobius diaperinus*) than sand litter. They however mentioned it that weekly replacement of the litters for broiler chickens raised on them for eight weeks favoured multiplication of the beetle in wood shavings than sand litter. Therefore integrated litter management procedure is the key to keep litters safe for broilers' survival.

Using spent litters

Poultry litter is a mixture of excreted manure mixed with bedding material. One type of poultry Waste is broiler litter resulting from the production of commercial broiler chickens raised on litters (Williams *et al.,* 1999). Analysis has shown that broiler litter contains potentially valuable plant nutrients including nearly 30% crude protein and high levels of mineral and some heavy metals (Martin and McCann, 1998). Used litter is a good source of manure for crop production; it provides important essential nutrient elements required by the plant (Rao, 1986). However, Stuven and Bock (2001) reported that the use of litter as a fertilizer was being limited by environmental concerns, such as nitrate and phosphate run off to streams, ponds and ground water.

Biswas *et al.* (2001) emphasised that utilization of used poultry litter for increasing the fertility of soil for crop production will be an excellent idea. They added that it would minimize the environmental hazards created by dumping of litters here and there. However, Biswas *et al.* (2001) cautioned that before recommending the wide scale use of the spent litter, it is necessary to examine the possibility of any negative effect on soil fertility.

Adenawoola and Adejoro (2005) and Ayuba *et al.* (2005) reported that poultry litter increased the soil pH, organic matter, nitrogen, available phosphorus, exchangeable potassium, calcium and magnesium higher than those of chemical fertilizer treatments. Sand litter when compared with pine shavings litter had slightly lower or similar nutrient levels on a percentage basis after 9 flocks (Bowers *et al.,* 2003). However, Asaniyan (2006) reported that wood shavings had relatively higher NPK levels than sand litter.

In addition to the use of litter as fertilizer, poultry litter has nutritional value for cattle. Growth performance of cattle on feed supplemented with poultry litter is similar to or higher than a diet with good quality legumes hays (Smith, 1974). The U.S. Food and Drug Administration in 2001, estimated that 20 to 25% of the broiler litter is feed, but there are concerns regarding the safety of feeding large quantities of poultry litter to cattle, which are susceptible to infection by pathogenic microorganisms such as *Listeria monocytogens* and *salmonella* and *campylobacter* species that may be present (Martin *et al.,* 1998). Botulism outbreaks have also been described in cattle herds fed contaminated litter (Ortolani *et al.,* 1997).

SUGGESTION

Asaniyan (2006) observed that the replacement and turning of litters enhanced dust bathing activities in broilers. However, such dust bathing, litter picking and pecking behaviours were more frequent with birds on sand litter. Also non sticking nature of sand on the floor made the cleaning out of sand litter to be easier than that of wood shaving. Though wood shaving have been long time litter of choice by poultry farmers; but sand could still be used as litter where wood shaving is in shortage or not readily available like in savannah, desert and coaster or riverine areas for raising broilers. The use of sand as broiler litter favours government policies against deforestation and desertification. Sand is heavy and this could be disadvantageous, but there is need for its positive qualities to be harnessed e.g. low harbouring of pathogens and dustbathing preference. At the same time, there is a need for further research on the mixing ratio of sand and wood shavings as litters for the benefit of broilers' welfare.

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UTILIZING CASSAVA WASTE PRODUCTS: PEELS AND LEAVES AS FEED RESOURCES FOR WEST AFRICAN DWARF GOATS

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Abstract
Wastes consisting of peels and leaves of cassava (*Manihort esculenta*) were evaluated as complete diet for West African Dwarf goats. In trial 1, effect of methods of preservation (shade and sun dry) of cassava peels and leaves on chemical composition and anti- nutrient contents were evaluated. In trial 2, leaves preserved in either of the methods were fed at 10, 20 and 30% in a completely randomized design. Methods of preservation reduced ($P<0.05$) crude protein content by about 4% in the sun dried leaves. Mineral contents of Ca and P were reduced by about 3 and 4% units respectively in sun dried leaves. The anti- nutrients with the exception of HCN that was reduced by about 6% were not influenced by methods of preservation in the sun dried. Cassava peels was not affected by method of preservation for all chemical, mineral and anti- nutrients content. Feed intake and nutrient digestibility in both the sun and shade dried forms increased with increasing levels of leave supplementation. Optimum levels of supplementation were 10 and 20% respectively for sun and shade dried leaves. Further investigation is required to assess the long term impact of forms and levels of supplementation on weight change, milk production and reproductive performance of WAD goats. While cassava peels is a Waste product of cassava processing factory, its leaves is a Waste material of cassava farms, these materials are of low or no value in the diet of man and can reduce the cost of goat production and reduce environmental pollution.

INTRODUCTION

During the dry period, availability of feed in terms of quality as well as quantity for ruminant consumption is always below the normal requirement (Smith *et al*, 1995). This problem usually leads to high cost of production which also results to high cost of purchasing meat and other ruminant products.
To overcome the shortage of feed during dry period and high cost of production, researchers have been searching for various ways of efficient utilization of locally available agricultural by-products (crop residues) such as cassava peels and leaves for ruminant consumption. One of major advantages of crop residue is that, they serve as bridge between the period of abundance and season of shortage in ruminant feed due to their local availability and cheapness.

Despite the abundance and availability of some essential elements that are available in cassava peels and leaves for animal development. They have not been used extensively due to the presence of anti-nutritive factor known as cyanogenic glucoside that yield toxic acid called hydrogen cyanide (HNC). The effects of this anti-nutritive factor can be reduced in peels and leaves by processing like sun drying, fermentation, and shade drying among others.
This study was therefore aimed at investigating the effects of Shade and Sun drying cassava peels and leaves and their utilization by West African Dwarf goats.
The experiment was carried out at the Small Ruminant unit of Teaching and Research Farm of Ladoke Akintola University of Technology (LAUTECH) Ogbomoso, which is situated in derived Savanna zone of Nigeria.

METHODOLOGY

Fresh cassava peels were collected from the gari processing unit of Teaching and Research farm of Ladoke Akintola University of Technology Ogbomoso. They were divided into two different portions

(1) One part was being processed by sun drying for a period of 4 days when they became brittle.

(2) Second part was shade dried until they became brittle.

Fresh cassava leaves were obtained from Ladoke Akintola University of Technology newly cassava Teaching and Research farm where their roots were harvested. They were also divided into two, one part was sun dried and the other was shade dried. The shade dried cassava peels were turned daily to allow even drying.

Two experiments were conducted sequentially with each divided into 3 different treatments as follow:

Experiment A: - Shade Dried Cassava Peels and Leaves

Treatment 1: 100% cassava peels with 0% cassava leaves

Treatment 2: 90% cassava peels with 10% cassava leaves

Treatment 3: 80% cassava peels with 20% cassava leaves

Experiment B: - Sun Dried Cassava Peels and Leaves

Treatment 1: 100% cassava peels with 0% cassava leaves

Treatment 2: 90% cassava peels with 10% cassava leaves

Treatment 3: 80% cassava peels with 20% cassava leaves

MANAGEMENT OF EXPERIMENTAL ANIMALS AND EXPERIMENTAL DESIGN

Six West African Dwarf goats (Bucks) purchased from reputable local market in Ogbomoso town, were acclimatized for period of 2 weeks. During the period of acclimatization, animals were treated against worms, bacterial infection and parasite in prophylactic measure (using Long acting antibiotics and ivermectin) before they were moved into disinfected metabolic cages that allowed for separate collection of feaces and urine. The weight change of individual animals was determined by weighing the animals before and at the end trial.

Experimental design used was 3 x 3 Latin square and each animal was subjected to 7days of adjustment period followed by 5 days of data collection per period.

FEEDING AND COLLECTION OF DATA

Weighed quantity of feed (Average 3% body weight) was given to individual animal on a daily basis. Intake of each animal was determined by measuring the leftover and subtracted from quantity of feed given. Faeces of individual animals was collected and weighed on daily basis before oven drying. The chemical composition was analyzed according to the procedure of AOAC (1990)

RESULTS AND DISCUSSIONS

Tables 1 and 2 showed that cassava leaves had high crude protein than cassava peels in both methods of preservations (shade dried and sun dried method), and those values falls within the range reported by Ahamefule *et al* (2000).

Table 1: Chemical Composition (%) of Shade dried Experimental diets

Variables	Cassava peels	Cassava leaves
Crude Protein	5.87	23.65
Neutral detergent fibre	66.48	51.62
Acid detergent fibre	43.24	36.84
Acid detergent lignin	16.76	12.26
Gross energy (Kcal/g)	2.84	3.81

Table 2: Chemical Composition (%) of Sun dried Experimental diets

Variables	Cassava Peels	Cassava leaves
Crude Protein	5.24	19.84
Neutral detergent fibre	62.24	54.96
Acid detergent fibre	40.97	39.78
Acid detergent lignin	15.35	13.38
Gross energy (Kcal/g)	2.82	3.99

Cassava leaves are very rich in mineral contents especially in Ca, Mg and Fe (Awoyinka *et al*) when compared with cassava peels in both modes of preservation as shown in Table 3 and 4. Hence, inclusion of cassava leaves or supplementation of cassava leaves in ruminant diets enhances the release of essential elements to body of animal and this will generally improves performance of animal.

Table 3: Mineral Composition (%) of Sun dried Experimental diets

Variables	Cassava Peels	Cassava leaves
Calcium	0.039	0.538
Phosphorus	0.028	0.242
Potassium	0.098	0.134
Magnessium	0.118	0.244
Sodium	0.034	0.789
Copper (mg/kg)	11.2	13.2
Lead (mg/kg)	0.9	2.1
Iron (mg/kg)	18.7	N.D

N.D = Not determined.

Table 4: Mineral Composition (%) of Shade dried Experimental diets

Variables	Cassava Peels	Cassava leaves
Calcium	0.027	0.865
Phosphorus	0.019	0.684
Potassium	0.062	0.186
Magnesium	0.107	0.212
Sodium	0.026	0.946
Copper (mg/kg)	8.3	19.6
Lead (mg/kg)	0.6	3.2
Iron (mg/kg)	14.6	59.6

Table 5 and 6 showed anti-nutritional composition of experimental diets. . Processing has been reported to be a pre-requisite before cassava peels or leaves can be consumed by animals. According to Devendra (1981) drying would substantially reduce the amount of HCN in cassava peels and leaves. This reduction in HCN level (i.e. major anti-nutritional factor of cassava) will probably only take place with slow drying because drying at higher temperature had been proved to be less efficient. Hence, the level of HCN in cassava peels and leaves under sun dried mode of preservation were lower than that of shade dried method of preservation. Likewise, phytase, oxalate and tannin of sun dried cassava leaves were relatively lower than shade dried cassava leaves. Feed intake and nutrient digestibility of experimental diets were shown in tables 7 and 8. Intake and nutrient digestibility level increased with increasing level of leaves inclusion in both sun dried and shade dried methods. 10% inclusion of sun dried cassava leaves seems to be optimal level for inclusion of sun dried leaves to animal diet and this was due to high level of cyanide acid that was present in sun dried cassava leaves when compared with shade dried ones. Therefore, low CP digestibility at 20% inclusion of sun dried cassava leaves under this experiment was caused by aforementioned factor.

Table 5: Anti-nutrients Composition (%) of Sun dried Experimental diets

Variables	Cassava Peels	Cassava leaves
Phytate	0.124	0.218
Oxalate	0.96	1.94
Tannin	0.098	0.126
Cyanide acid	24.43	33.39

Table 6: Anti-nutrients Composition (%) of Shade dried Experimental diets

Variables	Cassava Peels	Cassava leaves
Phytate	0.118	0.246
Oxalate	0.74	2.65
Tannin	0.077	0.149
Cyanide acid	29.48	39.45

Table 7: Feed Intake and Nutrient Digestibility of Shade dried Experimental diets

Dry matter intake (g/d)	**Treatments**			
	0%	**10%**	**20%**	**SEM**
Peels	198.3[c]	189.1[b]	248.9[a]	7.91
Leaves	0.00[c]	37.2[b]	74.5[a]	9.16
Total	198.3	226.3	323.4	
Digestibility %				
Dry matter	45.6[c]	53.3[b]	68.9[a]	2.93
Crude protein	41.8[c]	52.7[b]	66.3[a]	2.94
Neutral detergent fiber	46.8[c]	54.6[b]	69.7[b]	2.89

[abc] means with different super script are significantly different (P<0.05)

Note: 0%, 10% and 20% represents the levels of cassava leaves supplementation.

Table 8: Feed Intake and Nutrient Digestibility of Sun dried Experimental diets

Dry matter intake (g/d)	Treatments			
	0%	**10%**	**20%**	**SEM**
Peels	133.1^{b}	113.5^{c}	164.6^{a}	6.33
Leaves	0.00^{c}	22.1^{b}	32.7^{a}	4.10
Total	133.1	135.6	197.3	
Digestibility %				
Dry matter	49.5^{b}	66.9^{a}	69.5^{a}	3.16
Crude protein	47.5^{b}	56.4^{a}	54.6^{ab}	1.74
Neutral detergent fibre	53.4^{b}	58.1^{ab}	61.5^{a}	1.55

^{ab} means with different super script are significantly different (P<0.05)

Note: 0%, 10% and 20% represents the levels of Cassava leaves supplementation.

CONCLUSION

West African Dwarf goats should not be supplemented above 10% level of sun dried cassava leaves while that of shade dried cassava leaves can be supplemented up to 20%. This is due to the high level of cyanide acid in sun dried when compared to shade dried ones.

RECOMMENDATIONS

Further work should be carried out on long term utilization of shade dried cassava leaves by West African Dwarf goats to determine their weight change and its effect on milk yield when both peels and leaves constitute the entire diets.

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GROWTH PERFORMANCE OF *CLARIAS GARIEPINUS* JUVENILES ON COCOA POD HUSK -SUPPLEMENTED DIETS

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Abstract
An experiment was undertaken to determine the effect of boiling of cocoa pod husk and levels of inclusion that will positively affect the growth rate of *Clarias gariepinus*, a major species of importance cultured in Nigeria. Cocoa Pod husk is a by-product of cocoa industry often discarded as Waste. This study was to assess the effect of incorporation of boiled Cocoa pod husk into the diets of *C .gariepinus* juveniles.

One hundred and thirty juvenile fish (3.35 g initial mean weight) were randomly allocated to five treatments each having two replicates. Two batches of cocoa pod husk were treated differently: the first batch was beaten to smaller pieces, sun dried and ground to fine powder, while the second batch was boiled for 30 minutes in water at 100^0C, sun dried and ground to fine powder. These were done in an attempt to reduce the anti nutritional factor ,theobromine an alkaloid present in the CPH. The experimental diets consisted of 0% cocoa pod husk (control),10% CPH (the best diet in a previous experiment), other treatments consisted of boiled cocoa pod husk at 10,15 and 20% levels of inclusion representing treatments 1 to 5 respectively. The experimental diets were formulated to contain 36% crude protein and fish were fed at 4% of their body weight thrice daily for 8 weeks.

At the end of the trials the experimental diets were analyzed for their proximate composition, growth performance and nutrient utilization. From the result of the experiment, 10% of boiled CPH showed the best results ($p<0.05$) in terms of weight gain, protein efficiency ratio and feed intake of *C. gariepinus* juveniles. Therefore 10% inclusion of CPH was recommended for inclusion in diets of *C.gariepinus* juveniles. However further research should be carried out on other processing conditions of cocoa pod husk that will allow higher inclusion and efficient utilization by fish..

INTRODUCTION

Fish is an important source of animal protein providing 40% of the protein intake of two-thirds of the world's population (FAO, 1993). Lysine, leucine, isoleucine, arginine and valine which are essential amino acid appear to be present in the highest concentrations in fish (Akerelolu, 1991). Fish and fish by- products provide cheap but high quality protein compared to meat from wild animals, poultry, pork or beef. Fish also contains a wide range of vitamins such as vitamin A, B, C, D and E and minerals like potassium, calcium, iron, manganese, zinc, fluorine, copper and iodine (Akerelolu, 1991).

Basic nutrition in fish production is important to produce a healthy and high quality product. Feed is a major limiting factor affecting the growth of aquaculture in Nigeria (Tobor, 1991). For the purpose of nutritional and economic benefits, some research has been undertaken in recent times to increase the use of underutilized plant and animal materials to replace conventional feed ingredients like maize and fishmeal in livestock and fish production (Oyelese, 1995, Olukunle, 1996, Falaye and Oloruntuyi, 1998). This is due to the high cost and competition for the animal protein and energy sources like fishmeal and maize respectively. With the development of the fish feed processing industry it could be possible to put into profitable use some plant and animal by-products which are presently discarded as Wastes.

Cocoa pod husk is a by – product of cocoa processing often discarded as Waste. *Thoebroma cacao* is an important tropical rain forest species, grown for it rich seed cocoa and cocoa butter. Nigeria is the third largest producer and exporter of cocoa in Africa with projected production values of 160,000 metric ton by the year 2005 (FAO, 2000). Several metric tons of cocoa pod husk could be available for use as animal feed although it contains some anti-nutritional factors like theobromine a toxic alkaloid present in low quantities in cocoa pod husk and hinders digestibility. CPH provides high fibre, low protein and moderate energy (2224kcal/kg) when fed to livestock. Other uses of cocoa pod husk include ash use for soap (Arueya, 1991) cocoa pigment used in Japanese food industry (Kimura, 1979). This project looks into the incorporation of boiled cocoa pod husk into the diet of *Clarias gariepinus.*

MATERIALS AND METHODS

Experimental System:

The experiment was carried out using ten plastic bowls for 8 weeks, in the Department of Wildlife and Fisheries Laboratory of the University of Ibadan, Ibadan, Nigeria. The water sourced from the University supply was maintained at a volume of 30litres in each tank and replaced every three days to maintain relatively uniform physiochemical parameters and prevent fouling from feed residues. Each tank was well aerated using air stone and aerator pump (Lawson, 1995). The dissolved oxygen content and pH of the water were measured using a D.O. metre (Jenway 3015pH metre, 0.01 accuracy) and water temperature by mercury-in-glass thermometer.

Each dietary treatment had two replicates, with 13 fish per replicate with mean initial body weight of 3.25±0.01g. Uniform- sized fish were selected from 250 juveniles, weighed and distributed into experimental tanks. The fish were acclimatized for seven days in glass aquaria before the experiment. The fish were fed at 4% body weight with the daily portions divided into two: 2.0% given in the morning by 8.00a.m and 2.0% in the evening by 4.00 pm. Weight changes were recorded weekly and feeding rate adjusted weekly according to the new body weight.

Treatment of Cocoa Pod Husk and Diet Preparation:

CPH obtained from Cocoa Research Institute of Nigeria (CRIN), Ibadan, Oyo State was processed using physical methods: soaking, boiling and drying in attempt to reduce the theobromine content. In the first set, fresh CPH was beaten to increase the surface area, sun dried for a week and ground to fine powder while in the second set, CPH was collected and boiled for 30 minutes in water at 100^0C, beaten to small sizes, sun dried before grinding. Other feed ingredients were mixed together to formulate 36% crude protein diet. Each diet mixture treated separately was extruded through a 1/4mm die mincer of Hobart A-200T pelleting machine to form a noodle like strand, which were mechanically broken into suitable sizes for the *Clarias gariepinus* juveniles**.** The pelleted diets were sun dried, packed in labeled polythene bags and stored in a cool dry place to prevent mycotoxin formation.

Table 1: Gross Composition of Experimental Diets

Ingredients	Control	Check (10%)	10%	15%	20%
Soybean	32.50	32.50	32.50	32.50	32.50
Fishmeal	16.25	16.25	16.25	16.25	16.25
GNC	16.25	16.25	16.25	16.25	16.25
Maize	34.25	30.82	30.82	29.11	27.40
CPH	-	3.43	3.43	5.14	6.85
Premix	0.1	0.1	0.1	0.1	0.1
Methionine	0.1	0.1	0.1	0.1	0.1
Lysine	0.1	0.1	0.1	0.1	0.1
Salt	0.25	0.25	0.25	0.25	0.25
Bone meal	0.1	0.1	0.1	0.1	0.1
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Growth and Feed Utilization Parameters:

WEIGHT GAIN = final body weight - initial body weight

$$\text{WEIGHT GAIN (\%)} = \frac{100\ (\text{final body weight - initial body weight})}{\text{Initial body weight}}$$

SPECIFIC GROWTH RATE (SGR)

$$= \frac{100\ (\log_e \text{final body weight} - \log_e \text{initial body weight})}{\text{Time (days)}}$$

$$\text{FEED CONVERSION RATIO (FCR)} = \frac{\text{Dry weight of feed fed (g)}}{\text{Fish weight gain (g)}}$$

$$\text{PROTEIN EFFICIENCY RATIO (PER)} = \frac{\text{Body weight gain (g)}}{\text{Crude protein fed}}$$

$$\text{SURVIVAL RATE (\%)} = \frac{\text{Initial Number of Fish Stocked – Mortality}}{\text{Initial number of fish stocked}} \times 100$$

TOTAL FEED INTAKE = amount of feed intake per week for the experimental period.

Analytical Methods:

The proximate composition of experimental diets, fish and the fibre contents of boiled and unboiled CPH were determined according to A.O.A.C (1990) methods. The data obtained were subjected to one-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Table 2: Proximate Compsition and Fibre Contents of the Experimental Diets and Cocoa Pod Husk (Boiled)

	CD	CH	TD_1	TD_2	TD_3	CPH
Dry matter	90.83	90.46	91.24	91.48	91.55	90.61
Moisture	9.17	9.54	8.76	8.52	8.45	8.39
Crude protein	35.88	37.84	36.31	36.31	37.73	9.84
Crude fibre	15.00	18.00	12.00	21.00	18.00	26.00
Ether extract	8.50	11.50	10.00	11.50	10.00	8.50
Ash	5.50	3.50	5.00	4.50	5.50	8.00
NFE	35.12	29.16	36.69	26.69	28.77	47.06

Fibre Content of the experimental feeds and the cocoa pod husk (boiled and unboiled)

	CD	CH	TD_1	TD_2	TD_3	CPH (boiled)	CPH (unboiled)
Crude fiber	15.00	18.00	12.00	21.00	18.00	26.00	27.00
ADF	32.00	33.00	26.00	35.00	35.00	45.00	33.00
ADL	23.10	21.20	20.80	25.70	25.70	30.00	22.70
NDF	-	-	-	-	-	-	-

Key

CD – Control (0% inclusion of CPH)
CH – Check (10% inclusion of unboiled CPH)
TD_1 – Treatment 1 (10% inclusion of boiled CPH)
TD_2 – Treatment 2 (15% inclusion of boiled CPH)
TD_3 – Treatment 3 (20% inclusion of boiled CPH)
ADF – Acid – detergent fiber
ADL – Acid – detergent lignin
NDF – Neutral detergent fiber

Water Quality Analysis:

The water quality during the experiment ranged as follows: calcium 76-96, pH 6.7-7.0, Dissolved oxygen 2.5-4 mg/l and temperature26-28^{0}C

Growth Performance aAn Nutrient Utilization of Experimental Fish

Table 3: Growth Performance of Experimental Fish

Parameters	CD	CH	TD_1	TD_2	TD_3
Initial mean weight (g)	2.75	3.15	4.20	2.99	3.19
Final mean weight (g)	8.97	9.61	12.29	10.41	9.17
Mean weight gain (g)	6.22	6.46	8.09	7.42	5.98
Percentage weight gain	62.20	64.60	80.90	74.20	59.80
Total feed fed (g)	150.38	164.78	228.57	173.35	171.61
Specific growth rate	16.90	15.94	15.31	17.84	15.12
Feed/ weight gain ratio	3.02	3.19	3.53	2.92	3.59
Mean feed intake	18.80	20.60	28.57	21.67	21.45
Feed conversion ratio	1.86	1.20	2.19	1.80	2.21
Survival %	100	84.62	100	100	100
Protein efficiency ratio	0.17	0.18	0.23	0.21	0.17
Mortality	-	15.38	-	-	-

Water is important to the survival of fish and the physico-chemical parameters of water must be kept at desirable level for fish to thrive. The water temperature, dissolved oxygen and pH during the study were 26-28^{0}C, 2.5-4 mg/l and pH 6.7- 7.0. The temperature and pH were adequate for fish (Olukunle, 2000) though the dissolved oxygen was lower than recommended (Huet, 1972).

The boiled CPH had relatively the same crude protein content as reported by Opeke (1982). The crude protein content of the 10 % inclusion of the unboiled CPH was the highest .The crude protein contents of the experimental diets fell within the range required for *C.gariepinus* (Faturoti *et al*, 1995). The low crude protein level and the high fiber content of the unboiled and boiled CPH agreed with Sobamiwa, (1996).

Crude fibre content also varied in the experimental diets but the variation was not consistent with the graded levels of inclusion of CPH. The crude fiber content in the boiled CPH was lower than that reported by Opeke, 1982; and Oguntuga, 1975). The crude fibre of the boiled CPH and unboiled CPH were 26.0% and 27% respectively. The crude fibre content in the experimental diet ranged from 12% in TD_1 to 21% in TD_2 this is probably due to different levels of inclusion of CPH. Modern nutritional studies require a more complete knowledge of the fibrous constituents of a feed and so other determinations such as acid detergent fiber (ADF) and neutral detergent fiber (NDF) were made according to the procedures recommended by Van Soest (A.O.A.C,1990).Boiled CPH had a higher value of ADF and ADL than the unboiled CPH.This could be as a result of boiling which caused the heat to expose the coating of the fiber (Babayemi *et al*, 2004). Experimental diets had variations in ADF and ADL which could result from different inclusion levels of CPH. The NDF of all the diets were not determined due to clogging which prevented the filtration of the sample for analysis (Babayemi *et al*, 2004).

Feed Intake:
Feed consumption for the control diet was significantly ($p<0.05$) lower than all other treatments. Intake of diet TD_1 (10% boiled CPH) was the highest and control diet the lowest. However, all the diets with graded level inclusion of boiled CPH were consumed more than the check (10% unboiled) and control diets by the fish. This could be as a result of the boiling of CPH which may have increased the palatability of the diet. Also metabolizable energy level of CPH is lower than that of maize which could have encouraged more consumption of diet with 10% inclusion of boiled CPH and other CPH- based diets. This agreed with the findings of Adeyemo (2005) that CPH could replace maize with no adverse effect in giant land snail. No mortalities were recorded on diets containing boiled CPH indicating that CPH could be included in the diets of *C. gariepinus* juveniles at low to moderate levels of inclusion.

Growth Performance and Nutrient Utilization:
The nutrients required by fish for growth and other physiological functions are similar to those of terrestrial animals. Fish are among the most efficient animals in converting nutrients into flesh because of low energy requirements for maintenance though dietary protein of fish are higher than those of land animals (Smith,1989).
The mean weight gain of the fish was higher on 10% boiled CPH- based diet (TD_1) , significantly different from control ($p < 0.05$) and lowest on 20% boiled inclusion (TD_3) which could be attributed to the higher percentage inclusion of boiled CPH. There was no significant difference ($p> 0.05$) between weight gain in treatment TD_1 and TD_2. These were similar to the findings of Sobamiwa, 1996) who showed successful inclusion of cocoa pod husk in the diet of animal and tilapia fish at 10% level of inclusion .The highest specific growth rate was recorded in treatment TD_2 (15% boiled) while the lowest was recorded in treatment TD_3(20% boiled CPH).
The protein efficiency ratio ranged from 0.23 in the TD_1 to 0.17 in both control diet and treatment TD_3 (20% boiled CPH). The protein efficiency ratio in the treatment containing graded level of inclusion of boiled CPH decreased with increase in boiled CPH. The feed conversion ratio also ranged from 1.20 in treatment CH (10% unboiled CPH) to 2.21 in treatment TD_3 (20% boiled CPH).

CONCLUSION
From the result obtained during this experiment, it can be concluded that boiling of the CPH had an effect on weight gain, specific growth rate and feed conversion ratio of *Clarias gariepinus*. The fish performed well on 10 % inclusion of boiled cocoa pod husk showing the best performance in terms of weight gain, feed intake and feed conversion ratio. 15%

inclusion of boiled CPH was better in terms of specific growth rate and low feed conversion ratio. All the fish from the treatment with inclusion of CPH had higher weight gain than the control with conventional feed except the 20% inclusion of boiled CPH. It can be concluded that further processing of CPH can improve its usefulness as a potential partial substitute for maize in the diet of *Clarias gariepinus*.

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ASSESSMENT OF PERFORMANCE OF *CLARIAS GARIEPINUS* (AFRICAN CATFISH) JUVENILES ON DIETS SUPPLEMENTED WITH KOLA POD HUSK (*COLA NITIDA)*

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Abstract
A twelve -week feeding trial was carried out to assess the nutritive potentials of kola pod husk and to assess the growth performance of *Clarias gariepinus* juveniles on varying levels of kola pod husk- supplementation. The objective of this study was to assess the nutritive potentials of kola pod husk on the performance of *C. gariepinus* and its level of incorporation in such diets.

Eight experimental bowls (60x30x30cm^3) were used for the experiment. There were four treatments with each treatment having two replicates. The fish had initial mean body weight of 10.56g. The experimental diets were formulated at 38% crude protein and the fish fed at 5% of their body weight three times per day with graded levels of 0,10,20, and 30% of kola pod husk. 15 fish were stocked per replicate. Proximate composition of fish before and after the experiment, proximate composition of kola pod husk, the growth performance and nutrient utilization of feed by fish were determined.

Significant differences were observed between the control diet and 10 -20 % inclusion of kola nut pod husk with the control having the best growth indices. However fish on 30 % kola pod husk inclusion performed best among kola nut pod husk -containing diets .There was no significant difference between 30 % inclusion of kolanut pod husk and the control diet on all parameters considered.

The inclusion of 30% sun –dried and kola nut pod husk produced the best growth performance of the experimental fish and could be considered as a potential energy supplier in *C. gariepinus* juveniles' diets subject to further studies

INTRODUCTION
The deficiency of animal protein intake by increasing human population has highlighted the need for greater fish production to meet animal protein requirement (FAO,1997).Fish is a high quality food containing first class protein and nutrients, important for human health and growth. Fish farming offers an opportunity for mass production of fish in Nigeria. With the cultivation of just 20% of about 1.8 million hectares of land suitable for fish farming and at production rate of 3 tons /1 hectare, it was estimated that fish farming could produce 1,313,634 tons of fish annually (Tobor, 1989) but the present production falls short of this estimate.

Nigeria depends largely on the importation of many feed ingredients like fish meal (Ahman, 1991). The cost of fish feed in Nigeria constitutes a disincentive to small scale fish farming. The scarcity and increase in the cost of feed ingredients like maize, guinea-corn, groundnut cake, soybean cake, lead to increased cost of finished feeds and supplementary feeding of fish Alteor (1986) observed that numerous feed formulations and potential feed stuffs are allowed to rot away unused. It is curious to note that most of the tropical world, including Nigeria dispose of large tonnage of agro-industrial by- products and "Wastes" from abattoirs, vegetables oil, milling, sugar industries, rice and flour milling, cassava and cocoa processing. Quite often, filling of ditches is the common means of their disposal. This situation should not be allowed to continue given the potential of some these by- products as partial or total replacement for the expensive and scarce conventional feed ingredients. Falaye (1998) stressed the need to consider the nutrient composition, relative cheapness and availability of the feedstuffs in question.

Kola is grown in Africa and cultivated to a large extent in Nigeria, Ghana, Ivory Coast. It is also grown in Brazil and the West Indian Islands (Oludemokun, 1983). Annual production from these countries alone is in excess of 250,000 tons while the world production is about 300,000 tons (American Horticultural Society, 2002). Nigeria produces 88% of the world's kola production and 90% of this is consumed locally while the remaining 10% is exported. This finding was supported by Oluokun and Oladokun (1999) who claimed that Nigeria produced two million metric tons of kolanut annually representing 70% of the world's kolanut production. Kolanut, has several uses including direct consumption, beverages, drinks and wines, flavouring materials, alkaloids caffeine and theobromine, laxatives, heart stimulants, dyes, sedatives. Several parts of the plant are also used in traditional medicine.

Kola pod husk is a by-product from processing the seed widely used for animal feeding because of its high nutritive quality and has been reported to produce outstanding growth performance in broiler chicken (Babatunde and Hamzat, 2005). The kola pod husk has also been utilized for the production of liquid soap.(Asogwa *et al* ,2006)

This study was undertaken to explore the possibility of incorporating kola pod husk (KPH) into the diet of *Clarias gariepinus* juveniles to determine how much could be incorporated with no adverse effects.

MATERIALS AND METHODS

The experiment was carried out in the Department of Wildlife And Fisheries Management's laboratory for twelve weeks. Fingerlings were purchased from a fish farm in Ibadan and acclimatized for 2 weeks before the experiment. Each 23-litre circular bowl contained eleven fingerlings and fallowed tap water (Boyd, 1979). The water in each bowl was changed every other day, to get rid of excess feed and faeces.

Preparation of Diet

Sun-dried KPH was obtained from Cocoa Research Institute of Nigeria, Ibadan and ground into fine powder. Other feed ingredients were fishmeal, groundnut cake, and soybean meal, premix, salt, bone meal, methionine and lysine.The experimental diets were formulated to contain 38% crude protein as recommended for *C. gariepinus* (Faturoti *et al,* 1986). Four experimental diets were produced containing 0, 10, 20 and 30% KPH. Hot water was added to the ground feed to gelatinize it for effective pellet formation. The pellets were sun dried for two days to reduce the moisture and prevent deterioration then packed in bags and stored ready for use.

Feeding and Management of *C. gariepinus* Fingerlings

The fingerlings were fed at 5% of their total body weight twice daily,weighed every other week and their feeding regime adjusted according to their weights. The water in the bowls was changed every two days using a plastic pipe to siphon the water and the dirt out. Water from each bowl was measured for dissolved oxygen and hydrogen ion concentration (pH).Proximate analyses of the feed and fish were carried during the experiment.

Nutrient Utilization and Performance of Fish

Protein intake was calculated based on the feed intake and percentage protein in the experiment diet.

Protein intake:

$$P.I = \frac{\text{Feed intake x Percentage protein in diet}}{100}$$

The specific growth rate (SGR) **:** $SGR = \frac{\text{Log e W2-Loge X100}}{\text{T2-T1}}$

Where

W2= Final weight of fish at timeT2 by days

W1=Initial weight of fish at time T 1 by days

T2-T1 =Experimental period in days

Log e = natural logarithm

Feed Conversion Ratio (FCR): $\frac{\text{Feed intake}}{\text{Net weight gain}}$

Efficiency of feed conversion: $\frac{1}{\text{Feed conversion ratio}}$

A scoring system with a hedonic scale ranging from 1-9 was used to test for organoleptic properties and acceptability of the fish to consumers. Parameters employed by the panel were: colour ,taste, flavour, mouth feel, tenderness ,and overall acceptability .The scoring pattern was as follows : 9 Like extremely,8 Like Very much,7 Like moderately ,6 Like slightly,5 Neither like nor dislike,4 Dislike slightly,3 Dislike moderately ,2 Dislike very dislike very much and 1 Dislike extremely.

RESULTS AND DISCUSSION

Composition of diets and performance of fish are shown on tables 1 to 4

The water quality parameters during the study were temperature 27 – 28^{0}C, dissolved oxygen 7.36 mg/l and pH 7.2-7.9. These water conditions fell in line with the recommendations of Boyd (1984).The proximate composition of sun-dried KPH was 10.22, 16.4, 1.0 percent and 3190Kcal/Kg for crude protein, crude fibre , ether extract and energy respectively.

Table 1: Gross Composition of Experimental Diets

Ingredients	Treatments			
	0	1(10%KPH)	2(20%KPH)	3(30%KPH)
Maize	36.40	32.76	29.12	25.48
Fish meal	15.51	15.51	15.51	15.51
Soybean meal	31.02	31.02	31.02	31.02
Groundnut cake	15.51	15.51	15.51	15.51
Additives	1.56	1.56	1.56	1.56
KPH(g)	0.0	3.64	7.28	10.92
Total	100	100	100	100

Table2. Proximate Composition of Experimental Diets (%)

Treatment	Crude protein	Crude fibre	Ash	Moisture content	Ether extract	Nitrogen free extract
0%KPH(control)	44.45	5.06	9.72	9.83	6.57	24.37
1(10%KPH)	43.93	6.28	10.56	8.66	7.14	23.43
2(20%KPH)	42.88	7.85	9.86	9.93	7.63	21.85
3(30%KPH)	44.63	6.94	10.92	8.48	6.94	22.09

Table 3: Growth and Nutrient Utilization of *Clarias gariepinus* on KPH-based Diets

	O%KPH	10%KPH	20%KPH	30%KPH
Experimental period (days)	84	84	84	84
No. of fish stocked	11	11	11	11
Mean initial weight (g)/fish	12.00	10.65	10.65	9.60
Final mean weight	32.39	22.36	19.57	29.62
Total weight gain/fish	20.39	11.71	9.57	20.02
Daily weight gain (g)	0.01	0.01	0.01	0.01
Total feed intake (g)	2.55	2.37	2.27	2.41
Specific growth rate	0.24	0.14	0.11	0.23
Total percentage weight	269.9	209.9	195.7	308.5
Protein intake	0.89	0.82	0.79	0.84
Feed conservation ratio	0.13	0.20	0.24	0.12
Gross efficiency food conservation	769.2	500.0	416.7	833.3

Table 4: Proximate Composition of Experimental Fish at the end of the Experiment

Treatment	Crude Protein	Crude Fibre	Ash	Moisture Content	Crude fat	N.F.E
0%KPH	40.60	1.03	14.89	25.20	8.74S	9.54
10%KPH	41.30	1.34	15.76	19.17	9.16	13.27
20%KPH	39.20	1.82	14.96	22.85	11.23	9.92
30%KPH	42.70	1.48	16.67	23.69	8.97	6.49

This study was carried out to determine the performance of *Clarias gariepinus* juveniles on diets supplemented with KPH. Four diets were tested containing 0, 3.64, 7.28 and 10.92 grams of KPH representing 0, 10, 20 and 30 percent KPH inclusions. From the proximate analysis of the diet, crude protein ranged from 42.88 to 44.63, crude fibre 5.06 to 7.85, ash 9.72 to 10.92, moisture content 8.48 to 9.93, crude fat 6.57 to 7.63 and nitrogen free extractive 21.85 to 24.37 percent. Diet 3 contained the highest crude protein and ash. And fish on treatment 3(30% KPH) had the highest crude protein and ash contents which may have been the reason for better growth than treatments containing 10 and 20% KPH.

The Fish on control diet performed best in most parameters. The treatments were significantly different ($p<0.05$) for weight gain and specific growth rate . Among the KPH-based diets, the best performance ($p< 0.05$) of fish was recorded on 30 % KPH inclusion. In all, better performance of fish on control diet could be due to the high fibre content of KPH which may have inhibited proper utilization of the nutrients by fish. This finding was in contrast with those of other workers who suggested that KPH could replace maize in poultry diets by up to 60 percent (Yahaya *et al*., 2001; Hamzat, 2001; Hamzat and Babatunde, 2001; Hamzat and Longe, 2002; Hamzat *et al*., 2000; 2002; Olubamiwa *et al*., 2002). This may be due to the fact that unlike terrestrial animals , fish depend more on protein sources for energy supply

The mean weight and length of fish in all treatments differed significantly ($p<0.05$) over time. The mineral composition of fish on experimental diets were as follows: 0% KPH :0.163,0.757 ,0.0052; 10%KPH 0.83,0.815,0.0061;20%KPH :0.152,0.699,0.0054, and 30% KPH :0.194 ,0.903 and 0.0068 percent for calcium, phosphorus and iron respectively. No mortalities were recorded during the study indicating that the experimental diets were adequate to sustain the fish and support growth. The proximate analysis of fish at the end of the experiment however showed the highest crude protein and ash contents in fish on 30% KPH replacement for maize. These values differed significantly ($p<0.05$) from the control.

The acceptability of the fish was tested by respondents. No significant differences were observed for all treatments. The inclusion of KPH up to 30% was acceptable to the respondents. It was therefore concluded that it is possible to incorporate KPH in diet of *Clarias gariepnus* and up to 30 % substitution of KPH for maize proved the best treatment after the control without significant ($p < 0.05$) decrease in weight, length and quality. However, there is a need for further research on further substitution of kola pod husk for maize in the diet of *Clarias gariepinus* fingerlings.

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ENHANCING THE NUTRITIONAL POTENTIAL OF CASSAVA (*Manihot esculenta* Crantz) PEEL BY BOVINE RUMEN FILTRATE FERMENTATION

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Abstract

Fresh peels from cassava variety TMS 30572 were washed to dislodge adhering soil and processed in four different ways as: Sun Drying + Grinding (SDG); Chopping + Sun Drying (CSD), Chopping only (CHP) and Grinding + Pressing (GPR). The four differently processed peels were then fermented with bovine rumen filtrate (Aliquots of rumen content from freshly slaughter and eviscerated cattle squeezed and liquid portion filtered through the sieve) at the rate of 1kg of peel to 1 litre of rumen filtrate. The treated peels were then divided into three (3) equal parts and fermented in air tight plastic packs for 7, 14 and 21 days, respectively. The proximate composition, cyanide content, mineral as well as methionine and lysine contents were determined.

The results showed that the dry matter (DM) of all the samples were similar ($P > 0.05$). The crude protein (CP), ash and nitrogen free extract values increased with increase in the duration of fermentation. The highest CP value (8.33%) was obtained in the SDG cassava peels fermented for 21 days. Increasing the duration of fermentation from 7 to 21 days reduced the CF and Hydrogen cyanide (HCN) in all the treatment groups. At 7, 14 and 21 days, CSD peels had the least CF values. The HCN value was least in SDG peels with values of 7.32, 6.27 and 5.84 mg/kg at 7, 14 and 21 days, respectively.

The mineral analysis showed that SDG peels had the highest values of Ca, K, P, Zn, Mn and Cu at 7, 14, and 21 days, respectively. Amino Acid (methionine and lysine) profile shows that SDG peels had the highest values at 7, 14 and 21 days of fermentation. The values increased with increase in the duration of fermentation. Untreated cassava peels (UCP) had DM value of 88.69% similar to treated peels but the CP value (5.02%) and nitrogen free extract value (55.20%) were the least when compared with the treated cassava peels.

The result of this study indicate that SDG cassava peels fermented for 21 days can be a possible substitute for maize as energy source in animal feed. The use will also reduce environmental pollution.

INTRODUCTION

The continuous increase in the cost of livestock production, causing a phenomenal rise in the unit cost of livestock products is as a result of the challenges faced by the feed industry. These challenges are not limited to the availability of feed ingredients but the ability to produce high quality products in a cost effective manner (Chauynarong *et al.,* 2009).

For a promising future of livestock industry there is the need to further exploit cheaper energy and protein sources in order to replace expensive conventional ingredients. Recently, Ojebiyi (2009), highlighted conditions for a good non conventional feed ingredient as; must not be a staple item of food that is directly needed by man to avoid scarcity (ii) must be available all year round (iii) must be easy to procure, proceed (if need be and prepared into usable form (iv) must have a comparative cost advantage over the conventional feedstuffs and (v) must not contain toxic factors at levels lethal to animals.

Cassava (*Manihot esculenta Crantz*) is the third largest source of carbohydrate for human food in the world and has been grown extensively as an important economic root crop in South East Asia, Tropical Africa and Central America (Fauquet and Fargette,1990).
Cassava therefore is the staple food for at least 500million people in the tropics (Cock,1985) and the nutritive role of cassava in human and livestock nutrition especially in Africa has ever been on the increase (Aro, 2008). Banjoko *et al.,* (2008) reported that cassava is a supplementary staple food for more than 200million African aside from its use as livestock feed particularly for monogastrics.
At present in Nigeria, the quantity available is not only inadequate for the use of man but equally expensive, therefore its inclusion in livestock feeds will increase cost and ultimately push the prices of animal products up beyond the reach of the common man. Although Hahn (1998), reported that the emerging market for the increased cassava production is as livestock feed, however living in the reality of the movement in Nigeria it will be unwise to use whole cassava root as livestock feed. The stem, leaves and peels could therefore be used in animal feeding. Cassava peels constitute a substantial by-roduct of the cassava processing, being about 10-13% of total tuber weight (Tewe *et al.,* 1976).The peels are normally discarded as Wastes are allowed to rot in the open thus resulting in health hazards and poseses serious threat to the evironment.
The constraints to the use of cassava peels in livestock nutrition are their high level of non-starch polysaccharide (NSP) which include cellulose, hemicellulose, pectin and lignin, low caloric value and anti-nutrients like hydrogen cyanide (HCN), polyphenols (tannins), phytates and low protein (Iyayi *et al.,* 1997), Akpan and Ikenebomeh (1995). These constraints ultimately leads to low digestibility, poor feed intake and reduced performance (Alawa and Amadi 1990; Adegbola and Oduozo, 1992) when fed to mongastric animals.
The use of biotechnological option by way of microbial inoculation of cassava Wastes is a viable and cost effective panacea to these constraints militating against the use of agro-industrial Wastes like cassava peels (Oke 1994, Israelides *et al* 1998 and Olowofeso *et al.,* 2003,). Fermented fodstuffs according to Campell-Platt (1994) are animal and plant tissues subjected to the action of micro-organisms and/enzymes to give desirable biochemical changes and significant modification of food quality. Oboh and Akindahunsi (2003) used micro organism to ferment sun dried cassava peels and observed a significant increase in protein content and digestibility of the microbially treated peels compared to the untreated.
It is therefore expedient to search for at ways of fermenting cassava peels using methods that is not only adaptable to farmers but will also reduced environmental hazards. The use of bovine rumen filtrate obtained from bovine rumen content (BRC) could be a viable option. Bovine rumen content has crude protein ranging between 9-20% (Ekwuoma, 1992, Adeniji 1996; Whyte and Wadak 2002). Dairo *et al*., (2005) reported that the availability of the rumen content in the abattoir could be a good source of protein in livestock feed if properly processed and harnessed. According to Adeniji and Balogun (2002) BRC contain no anti-physiological factors.
This study was designed to evaluate the effect of using bovine rumen filtrate in fermenting cassava peels on the resulting proximate composition, mineral composition and the lysine and methionine contents of such fermented product.

MATERIALS AND METHODS

Site of experiment

The experiment was carried out at the Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. The study area is located between latitudes $8^0,07^0$N and $8^0 12^1$N and longitudes $4^0 04^1$E and $4^0 15^1$E. The mean annual rainfall is

1247mm with relative humidity of between 75 and 95%. The location is situated at about 500mm above sea level with a mean annual temperature of 26.2^{0}C (Oguntoyinbo, 1978)

Collection of test ingredients

Rumen filtrate: Contents of the rumen of freshly slaughtered and eviscerated cattle were collected from the central abattoir in Ogbomoso located within three kilometers from the study centre. The contents were squeezed and the liquid portion filtered through a cheese cloth to obtain the filtrate.

Cassava peels: Fresh cassava peels of the sweet variety, TMS 30572 were collected from the Garri Processing Unit of Teaching and Research farm of Ladoke Akintola University of Technology, Ogbomoso. The peels were rinsed in water to dislodge all adhering sand and dirt.

Processing of test ingredients

The rinsed cassava peels were divided into four parts and treated in four (4) different ways as follows:

Treatment 1 – the fresh peels were chopped into small sizes of about 2cm and spread thinly on concrete floor to sundry for 5 days (CSD).

Treatment 2 – the peels were sun dried whole and then hammer mill using 0.2mm screen guage (SDG).

Treatment 3 – the fresh cassava peels were ground and compressed to remove the water (GRP).

Treatment 4 - the fresh peels were chopped into small sizes of about 2cm (CHP).

Fermention with Rumen Filtrate

Rumen filtrate was added to the differently processed cassava peels at the rate of 1 litre of rumen filtrate to 1 kilogram of processed cassava peels. The addition was done in a plastic container and the mixture was well–stirred. The mixture was then put in polythene bags and made airtight for fermentation for durations of 7, 14 and 21 days. At the end of each period of fermentation, the samples were sun dried on concrete floor for 5 days and stored until required for further analysis.

LABORATORY ANALYSIS

Samples of treated peels were analyzed for proximate composition, using the procedure of AOAC, (1990). The cyanide content was determined by the procedure of Broadbury *et al* (1999) and Esan *et al.,* (1988). The mineral determination was carried out using the AOAC, (1990) method. Bomb Calorimeter was used to determine gross energy determination. Methionine and lysine determination were done using spectrophotometric method described by Lunder (1973) and Jambunathan *et al.,* (1983) respectively.

DATA ANALYSIS

All data collected were subjected to analysis of variance using General Linear model (GLM) of SAS (1990). Treatment means were separated using Duncan Multiple Range Test (Duncan 1955).

RESULTS

The proximate compositions as well as the cyanide content of the treated cassava peels are presented in Table 1. The CP and ash of the cassava peels increases with increasing duration of fermentation irrespective of the processing.

Fermentation had no significant (P>0.05) effect on the DM and NFE contents of the cassava peels. Treatment had significant (P<0.05) effect on the CP of cassava peels. The untreated cassava peels had the lowest (P<0.05) CP content. Treatment 2 at 21 days (8.33%) had the highest CP content and was significantly (P<0.05) higher than treatment 1 at 21 days (7.73%). Treatment 1 at 7 and 14 days were higher (P<0.05) than treatment 3 at 7 days (5.48%), treatment 4 at 7 days (5.33%), treatment 4 at 14 days (5.40%) and treatment 4 at 21 days (5.53%).

There were significant differences (P<0.05) in CF content among the treatments. The trend observed among the treated peels shows that 21 days fermentation had the least CF values. The untreated peels had the highest CF content (P<0.05).

Treatment of cassava peels with rumen filtrate fermentation had significant effect on the ash content (P<0.05). The untreated peels had the highest (P<0.05) ash content. The ash values of Treatments 3 at 7 days (6.72%),14 days (6.73%), 21 days (6.78%) and 4 at 7 days (6.62%), 14 days (6.67%), 21 days (6.67%) are similar. The values were however higher (P<0.05) than treatment 2 at 21 days (6.56%) which was in turn higher (P<0.05) than treatment 2 at 14 days (6.37%) and at 7 days (6.33%).

Treatment of cassava peels with rumen filtrate fermentation had significant (P<0.05) effect on the hydrocyanide content of the peels. The untreated peels had the highest (P<0.05) HCN value of 18.08mg/kg.content. The least (P<0.05) HCN value of 5.34mg/kg was recorded in treatment 2 at 21days. Generally the observed trend shows that duration of fermentation has inverse relationship wth the cyanide level.

The mineral composition, amino acid profile and gross energy values of the tretaed cassava peels are presented in Table 2. All the minerals with exception of Mg, increase with increasing duration of fermentation. At the end of 7 days of fermentation, treatment 2 has the highest (P<0.05) percentage of Na which is 0.038%, followed by treatment 1 (0.037%), treatment 3 (0.024%) and treatment 4 (0.014%). At 14 days treatment 2 had 0.043% treatment 4 (0.016%). At 21 days, treatments 2,1,3 and 4 had 0.046%, 0.037%, (0.030%) and (0.018%) respectively. All values were significantly (P<0.05) different from each other.

At 7,14 and 21 days treatment 2 had the highest (P<0.05) Ca content.

The K content of Treatment 2 remained highest for all fermentation duration while treatment 4 was lowest (P<0.05).

The Mg values for Treatment 2 were highest for all duration. The values are 0.120, 0.140 and 0.180% for 7, 14 and 21 days respectively (P<0.05).

For the P content treatment 2 values was highest for all duration of fermentation. The phosphorus value was constant at 0.050% for 7 and 14 days while it increased to 0.054% at 21 days (P<0.05). Treatment 4 recorded the lowest value for all the durations with 0.036, 0.040 and 0.043% for 7, 14 and 21 days respectively.

All the micro minerais analyses (Fe, Mn, Zn and Cu showed that these minerals increased with increased duration of fermentation irrespective of the treatments. This implies that fermentation with rumen filtrate had effect on the minor mineral composition of the cassava peels.

The lysine content of the treated cassava peels shows that treatment 2 at 21 days of fermentation had the highest (P<0.05) lysine content while the least lysine values were obtained in treatment 1 at 7 days and treatment 2 at 7 days. The observed trend revealed that with the increased duration of fermentation, the Lysine content increases.

Similar trend were obtained in methionine values except that least (P<0.05) methionine values were obtained in treatment 4 and the untreated cassava peels.
The gross energy reduced with increasing duration of fermentation. At 7 days of fermentation treatment 4 reduced from 2.731kcal/g to 2.505kcal/g however the value was not significantly (P>0.05) different from Treatment1 and Treatment 2. At 14 days treatment 4 reduced from 2.505kcal/g to 2.497kcal/g, while treatment 3 reduced from 2.636kcal/g to 2.407kcal/g. At 21 days treatment 4 had 2.493kcal/g which was not significantly (P>0.05) different from Treatment1.

DISCUSSION

The trend of increasing CP and ash observed (Table 1) is in agreement with the reports of Adeyemi and Familadi (2003) that fermentation of corn-cob for 20 days using rumen filtrate resulted in an increase in the CP and ash contents. Adeyemi *et al*. (2007) observed similar increase in CP of cassava when the duration of fermentation was increased using rumen filtrate. EL Hidai, (1978) and Ahmed (1987) reported that fermentation resulted in an increase in protein and his according to Amoa and Muller (1976) was attributed to either microbial synthesis or los of non-protein material.
Decreasing CF, with increasing duration of fermentation is similar to the observation of Adeyemi and Familade, (2003). Adeyemi *et al* (2007) reported the same trend of decreasing CF with increasing duration of fermentation when cassava root meal was fermented with rumen filtrate. Although decline in DM content was associated with increased moisture content with increasing duration of fermentation (Nguyen and Nguyen, 1992). In this study, the DM was not significantly affected by the treatments.
The increase in mineral content of the fermented cassava peels is in agreement with findings of Stuart *et al*., (1987), Kirleis and Monawar (1989). These authors reported that fermentation enhanced mineral contents of agricultural Waste products.
The improvement in the lysine and methione content of the treated cassava peels agrees with the findings of Au and Fields, (1981), Kazanas and Fields (1981) that natural fermentation increased the relative nutritive value and availability of limiting amino acids. The authors also reported that fermentation equally brought about increased availability and digestibility of other nutrients.
The cassava peel treatments though fermented with the same quantity of rumen filtrate and for the same duration has varying content of nutrients and minerals, this is due to the different processing methods the cassava peels were subjected to this made the peels have different surface area and thus fermentation effect is pronounced in some treatments than others. Those with larger surface area (hammer mill) will have pronounced reaction during fermentation.
Decreasing GE observed is also similar to findings by Adeyemi and Familade (2003) when corn-cob was fermented for 20 days with rumen filtrate.
The HCN level of the treated cassava peels reduced considerably and the reduction increases with increasing duration of fermentation. This confirmed the earlier report of Tewe (1991) that the longer the fermentation period the lower the residual cyanide content of cassava.
This significantly low cyanide value recorded in the fermented peels suggests that the micro-organism were capable of partially degrading the cyanogenic glucosides in the peels thus confirming the ealier report of Oboh *et al*., (2002), Balewu and Musa (2003).

CONCLUSION AND RECOMMENDATION

The result of the study shows that although all the treated cassava peels had improved nutritive values compared with the untreated peel, treatment 2 (cassava peels sundried whole and then hammer milled before fermenting with ruminal fluid for 21 days) recorded significant increase in the protein, ash, amino acid profile with subsequent reduction in the cyanide level.

It is thus a good potential feed ingredients to be used as feed for farm animals to replace the expensive conventional feed ingredients like maize.

The adition of artifical microbes to the filtrate before fermentation should also be experimented with.

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THE POTENTIALS OF Agricultural Residues AS LOW COST BUILDING MATERIALS IN NIGERIA

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Abstract
The global demand for decent and affordable housing continues to escalate in the face of increasing population and exorbitant cost of building materials. Typical manifestations of this unmet demand in Nigeria include proliferation of slums in our cities and the menace of sky-rocketing house rents. The situation demands that suitable alternatives be found for the conventional building materials. The global search for alternative building materials has been on for over three decades. It has now been established that Agricultural Residues such as rice husk, coconut husk, bagasse, oil palm shells, maize stalk, tea and coffee Wastes, and tobacco Waste, among others, are potential sources of alternative building materials yet to be fully explored in Nigeria. They could be used in the production of low density, environmentally friendly and fire-resistant cement-based composites. The resulting composite products have a wide variety of exterior and interior, structural and non-structural applications in the building industry such as lightweight concrete blocks, ceiling and floor panels, roofing sheets, insulation and acoustic panels. This paper discusses the potentials for industrial production and utilisation of cement-bonded composites from Agricultural Residues in the building industry in Nigeria.

INTRODUCTION

Chronic shortages of suitable housing exist in many parts of the world, including Nigeria. Reasons for these shortages include rapid population growth, inefficient utilisation of natural resources, shortage in supply and the ever-rising cost of building materials (Ramirez-Coretti *et al.* 1998, Olorunnisola and Adefisan 2002).It is evident that the solution to the global housing problem in the developing world lies largely in the development of low cost building materials. Such materials should, nevertheless, satisfy the many production, construction, economic, cultural, safety, and health requirements, as well as lack of infrastructure. Wood-cement Composite panels, a set of lightweight concrete products in which wood particles, shavings, strands, or chips serve as aggregate in cement-water mixtures, appear to have the potential to satisfy the requirements. The admirable properties of composite wood-cement panel that recommend it for use as building material include relatively high strength to weight ratio, durability; stability i.e., high resistance to moisture uptake; nailability; ease of sawing; excellent insulation against noise and heat; and high resistance against fire, insect and fungus attack. The panels are environmentally friendly since they do not emit gasses or leak harmful chemicals (Badejo 1988, 1989, Ramirez Coretti *et al.* 1998, Olorunnisola 2007, 2008). These products also have a special appeal by virtue of the fact that they can be, and mostly are made, from wood and Agricultural Residues as well as non-commercial or low-value tree species. Because they are produced in panel form, they can be substituted for, or used in combination with other materials commonly used in building construction.

Besides the foregoing admirable qualities, composite wood-cement panels are coatable with paints and plasters, lend themselves to modular construction and they satisfy the cultural preference in many parts of the world, including Nigeria, for cement-based building construction materials (Ramirez-Coretti *et al.* 1998).

Wood particles from agro-forestry materials such as sawdust, coffee Waste, construction Waste, oil palm shells, cork Waste, and rattan furniture Waste have been used with cement to form wood-cement composites (Wolfe and Gjinolli 1999, Karade 2003, Olorunnisola and Adefisan, 2002, Ajayi 2002, 2003, 2004, Olorunnisola 2008, 2009a). Many of these materials are considered as lightweight aggregates containing high volume of air voids which tend to reduce the density of the composites (Karade 2003). The choice of feedstock material is, however, often based on availability, processing cost, and compatibility with Portland cement (due to the inhibitory effect of the starch content of organic materials on cement setting).

This paper discusses the prospects of the local manufacturing and utilisation of wood-cement composites from Agricultural Residues in the building industry in Nigeria.

Wood-Cement Composite Panel Manufacturing Process

The processes involved in the manufacture of composite wood-cement panels include the following:

Wood Material Preparation

The furnish could be obtained from a multiple of sources including wood as round logs, from thinnings, logging and wood processing residues such as sawdust, shavings, and chips. As the competition for solid wood and wood residues increases, it is becoming more necessary to resort to the use of Agricultural Residues such as maize, cotton stalk, bagasse, rice husk etc. and non- timber forest products such as bamboo and rattan.

Size Reduction

At this stage, the furnish is reduced into either flakes (30 - 50 mm long and 0.2 - 0.6 mm thick) or finer sawdust particles. The final particle size to which the material is reduced depends on the ultimate end-use requirement of the board. Longer and thinner flakes are usually stronger, stiffer and more dimensionally stable.

Mixing/Blending

The flakes or particles are thoroughly mixed with water containing additive in a pre-determined mixing ratio. Cement is then slowly added while mixing continues until a homogeneous wood/cement mix of the desired consistency is formed.

Forming

This is the process of laying down a mat of the blended particles. The mats are usually formed onto metal “caul plates”.

Pressing

Pressing involves consolidating the mat. The acceptable mats are stacked up into the required clamping sizes and passed on to the press where it is tamped to the pre-determined thickness.

Maturation

The panels are removed from the press and stored for at least 28 days to allow for further curing of the cement. By the 28th day, the panel would have attained maximum strength.

Trimming

The panels are trimmed to the required sizes and finally stored or shipped as the case may be. Samples manufactures wood-cement composite products are shown in Plate 1.

Plate 1: Samples of wood-cement composite roofing sheets

Potential Sources of Feedstock for Panel Production in Nigeria

There are number of lignocellulosic materials that could be successfully utilized as feedstock for wood-cement composite panel production. The basic selection criteria include:

i. Availability in adequate quantities
ii. Cheapness
iii. Availability in suitable form for board manufacture, and
iv. Relatively low handling and storage costs

Based on the foregoing criteria, the principal Agricultural Residues available for wood-cement panels manufacturing in Nigeria include the following:

(i) Bagasse: Bagasse is the residue fibre remaining when sugar cane is pressed to extract sugar. Bagasse is available wherever sugar is grown. Large quantities of bagasse are available at sugar mills. To improve the quality of bagasse board, only the fibrous portion is utilized. Bagasse has high sugar content. Therefore, special care must be taken during storage to prevent fermentation. The bagasse is usually depithed to reduce the sugar content and increase the storage life. Oyagade (2000) reported that wood-cement composites could be manufactured from the locally generated bagasse.

(ii) Coconut Husk: This is the outer covering of fibre material of coconut fruit, obtained from coconut palm. Coconut trees are available in abundant though un-quantified quantities in many parts of the country. The husks are also available at little or no cost since they are often treated as a Waste material. Previous studies have shown that coconut fibres have relatively high insulation value, high water absorption rate, and can be incorporated in cement for the production of low-cost and low-energy construction materials (Oyagade 2000, Olorunnisola 2004, 2005, 2006, 2009a,b, Olorunnisola *et al*. 2005).

(iii) Cornstalks and Cobs: Corn stalks like many agricultural fiber sources consist of a pithy core with an outer layer of long fibres. Ajayi (2002, 2004) showed that cornstalks and cobs can be converted in to reasonably good wood-cement composite products.

(iv) Rice Husks: Rice husks are Agricultural Residues that are available in fairly large quantities in many parts of Nigeria. Risk husks are quite fibrous and require little energy input to prepare the husks for board manufacture. To make high quality boards, the inner and outer husks are separated and broken at their spine. Preliminary experiments by the author indicate the suitability of rice straw from locally-grown rice varieties for wood-cement composite manufacture.

The foregoing feedstock materials are available in sufficient quantities required for cottage-level industrial production of wood-cement particleboard in different parts of Nigeria.

Wood-Cement Panel Products Currently Manufactured in Nigeria

Wood-cement panel products currently been manufactured and sold locally in Nigeria today include:

i. Basic sawdust-cement products comprising ceiling boards, floor and wall tiles.
ii. Laminated sawdust-cement products that are used for ceiling, flooring, wall cladding, and furniture making (Omiyale 2004).
iii. Pulp-fibre reinforced cement composite products employed as ceiling boards.

These products are available in a wide variety of sizes. Owonubi and Badejo (2000) reported that a number of products already available in the local market compared favourably with ceramic and asbestos-based products of their type as shown in Tables 1 and 2. Laboratory tests also indicate the suitability of wood-cement composite panels produced from maize stalk and coconut husk for utilization as ceiling flooring, wall cladding, and roofing materials (Table 3).

Prospects for Increased Local Production of Wood-Cement Panels in Nigeria

The prospects for increased local manufacturing of wood-cement panels in Nigeria are bright given the following factors:

Availability of Feedstock Materials

All the afore-mentioned potential feed stock materials are generally available in different parts of Nigeria and are currently attracting minimal economic utilization and hence constitute a nuisance in terms of environmental pollution and cost of disposal. Their utilization in wood-cement composite panel production will be ecologically advantageous as previously Wasted materials will now be converted into useful products.

Table 1: Comparison between Selected Locally Manufactured Sawdust-Cement Tiles and Ceramic Tiles

	Thickness (mm)	Weight/unit area (g/cm^2)	Density (g/cm^3)	Water absorption after 144 hrs (%)	Thickness swelling after 144 hrs (%)
Sawdust-Cement Wall Tiles	6	1.02 – 1.23	1.57 – 1.82	6.3 – 13.1	0.36 – 0.46
Ceramic Wall Tiles	6	0.94 – 1.04	1.64 – 1.71	13.25 – 16.20	0.47 – 0.73
Sawdust-Cement Floor Tiles	12	1.92 – 2.18	1.59 – 2.06	11.7 – 14.3	0.16 – 0.25
Ceramic Floor Tiles	9	1.54 – 2.01	1.86 – 2.03	6.20 – 16.88	0.33 – 0.72

Source: Owonubi and Badejo (2000)

Table 2 Comparison between Selected Locally Manufactured Ceiling Boards and Asbestos-cement Ceiling Boards

Board Properties	Sawdust-Cement Ceiling boards	Asbestos-cement Ceiling boards
Thickness (mm)	6	3 – 4
Density(kg/m^3)	1200	1200
MOR (N/mm^2)	2.0 – 4.0 [a]	7.68
	8.7 – 11.2 [b]	
MOE (N/mm^2)	1250 – 3000 [a]	3142
	3000 – 4000 [b]	
Water absorption	18.0 – 27.5 [a]	13.8 – 17.8
after 144 hrs (%)	28.0 49.5 [b]	
Thickness swelling after 144 hrs (%)	0.16 – 0.27 [a]	0.21 – 0.29
	0.43 – 0.52 [b]	

Source: Owonubi and Badejo (2000)

Note: a = 100% sawdust-cement panel, b = 3-layered boards incorporating flakes

Table 3: Properties of Laboratory-Manufactured Cement-Bonded Composites from Maize Stalk and Coconut Husk

Board Properties	Maize Stalk-cement Composite boards[1]	Coconut husk-cement Composite boards[2]
Density(Kg/m^3)	1200	990 - 1200
MOR (N/ mm^2)	3.1- 5.4	4.3 - 7.4
MOE (N/ mm^2)	3060-6409	2835 - 4253
Thickness swelling (%)	25.7-34.1 [a]	0.6 – 0.9 [b]
Sound absorption ratio (%)	35.0[c]	35.0 - 40.3 [c]
Thermal conductivity (W/Km)	0.38 [c]	0.30- 0.38 [c]

Sources: [1]Ajayi, 2004, [2]Olorunnisola (2006),

Note: a = specimens soaked in water for 48 hrs, b = specimens soaked in water for 24 hrs

c = Theoretical value computed from the equation given by Sarja (1988): $\mu = 10(1 + 3000/\rho)$, $\lambda = [(0.4\ \rho \times 10^{-3}) - 0.1]$, where μ = sound absorption ratio (%), λ = thermal conductivity (W/Km),

ρ = Density of oven-dried composite (Kg/m^3). The sound absorption ratio and thermal conductivity values compare favourably with published data for cement- bonded wood composites, i.e.40% and 0.25-0.35 W/Km respectively.

Availability of Supplementary Cementitious Materials

Portland cement is usually used in making wood-cement particleboard. Commercially bagged Type I, i.e., normal, general purpose Portland cement, sold in the standard bag of 50 kg. in the open market, is generally acceptable for use. However, the global production of cement cannot meet up with the demand. Here in Nigeria, the local consumption of cement as at 2009 was estimated at about 19 million tonnes. However, only 9.6 million tonnes was produced locally while nearly 10 million tonnes had to be imported, thus making Nigeria one of the highest importers of cement in the world. Besides, the cost of cement has escalated in the country in recent times, fluctuating between ₦32,000.00 and ₦40,000.00 per tonne in the last two years.

One of the possible ways of enhancing sustainable production of wood-cement composite panels in the country is the use of supplementary cementitious materials derived from industrial and agricultural Waste materials, such as fly ash, rice husk ash, lime, etc., as partial replacement for cement. Interestingly, while accumulation of unmanaged Wastes is major source of environmental hazards in many parts of the country, wood-cement composite panels are noted for their unique capability to utilize large quantities of these supplementary cementitious materials.

Adaptability of the production technology

The production technology for wood-cement panels, in terms of manufacturing equipment and production process, is rather very simple and adaptable to the prevailing climatic and economic conditions in Nigeria. All the necessary equipment – the hydraulic press, the mixer, douser and caul plates- can be manufactured, using available local materials.

Availability of Local Expertise
The processes involved in the production of the panels are well known in the nation's research and development community. There will, therefore, be no need for expatriate services in setting up manufacturing plants.

Favourable Government Policies
The present Federal Government's policy of encouraging small and medium-scale enterprises based on locally sourced raw materials in general and those that are export-oriented, provides a conducive environment for nurturing a viable wood-cement panel industry.

Potentials for Exportation

A global market already exists for wood-cement panel products. They are employed as construction materials for interior/exterior wall cladding, roofing, ceiling and shuttering for bungalows and high-rise buildings. They have become widely acceptable in many countries in Europe, Asia, North and Central America, and the Middle East, including Germany, England, Japan, Indonesia, United State of America, Brazil, Iran, and Saudi Arabia (Ramirez-Coretti *et al* (1998), Alberto *et al* 2000, Owonubi and Badejo, 2000). They have long been in use in these parts of the world, both to satisfy emergency situations (e.g. to provide housing for people affected by natural disasters), and for regular building construction (Ramirez-Coretti *et al.* 1998). Because they are lighter in weight than most other cementitious materials and are produced in panel form, the material can be easily packaged and shipped to different parts of the world.

A primary concern in introducing new construction materials into international markets is compliance with local building codes. Most countries have developed their own building codes and specifications while some follow guidelines from foreign design codes. Most local codes in European, North and Central American countries specify design loads, wind resistance, fire rating, and seismic strength (Ramirez-Coretti *et al.* 1998). However, there are no specific limitations on the use of cement-bonded wood composites. Besides, specific characteristics of these panels can be engineered to meet diverse end-user specifications.

CONCLUSION
Shelter is one of man's primary needs and its satisfaction is essential to the existence of humane life conditions. There is a strong and urgent need for low cost housing in Nigeria today. Wood-cement panels provide a material with many of the traits necessary to satisfy this need. The prospects of production of these panels for local consumption and export are high. Besides, relatively small amounts of energy and petrochemical derivatives are needed for their production, hence their special appeal in a country like Nigeria, where energy costs are increasing at an alarming rate. Their production will go a long way in facilitating (a) the economic utilization of wood and Agricultural Residues, and (b) the development of a local small-to-medium scale manufacturing industry in Nigeria.

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THE POTENTIAL FOR USING AGRICULTURAL PLANT RESIDUES IN CONTROL OF INSECT INFESTATION IN STORED PRODUCTS

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Abstract
Agricultural plant residues are the remnants, excesses or end-products of agricultural plant production and processing that have not been properly or adequately salvaged, recycled or utilized and may be problematic in the environment. They may be converted to ash, pulverized or extracted for insecticidal purposes. Examples and details of utilization of agricultural plant residues as insecticides in stored products protection are given in this paper.

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Introduction
Agricultural plants include crop and forest plant species of economic value to man. Agricultural plant residues are the remnants, excesses or end-products of agricultural plant production and processing that have not been properly or adequately salvaged, recycled or utilized and may be problematic in the environment. What may constitute Agricultural Residues in the production and processing of some plants in Nigeria are given in Table 1. In this paper the potential of using plant ash, fruit peels, and other plant residues in stored products protection against insect depredation is discussed.

Table 1: Main residues from production and processing of some plants in Nigeria

Plant Type	Main Residues
Rice	straw or stalks, husks or hulls, and bran
Maize	stalks, husks, skins, cobs, pressed cake, and bran.
Cassava	woody stems, leaves, soft plant parts, peels and tapioca flour Wastes
Pulses	straw and shells
Alliums	Dry scale leaves
Cocoa	Pod shells and sweatings
Bananas and Plantains	Peels
Cashew	Nut shell liquid; gum exudate
Citrus	Peels
Neem	Seed cake
Coconut	Husks, consisting of coir dust, fibre and outer rind; shells, liquid, and press-cake.
Oil Palm	stalks, fibres, pulp (pericarps), shells, and cake
Sugar Cane	cane tops, molasses, bagasse, and pith
Timber trees	logging Wastes, defective logs, sawdust, edgings, slabs, and trimmings.

Use of plant ash in stored products protection
Plant ash is obtained when plant material is burnt. The use of wood ash for the control of storage beetles, especially *Callosobruchus maculatus* (Fabricius), the cowpea seed beetle, has been investigated (Ofuya, 1986; Wolfson *et al*., 1991; Apuuli *et al*., 1996; Boeke *et al*.,

2001). Grains are mixed with ash that has been sieved and placed in storage containers, tapped-down to compress the mixture and frequently covered with an additional layer of ash (Ofuya, 2001). Ash from different plant materials may offer varied insect pest control capabilities. For instance ash from *Acacia* spp. and *Combretum imberbe* applied at 50-60 g/kg of stored grain was found to be effective against *C. maculatus* (Al-Hemyari, 1994; Javaid and Mpotokwane, 1997) whereas a much lower dosage of 20-25 g/kg of stored grain of *Tamarindus indica* was found effective against *C. maculatus* and many other storage beetles (Ajayi et al., 1987). Buraimoh et al. (2000) reported ash from the neem tree (*Azadirachta indica* A. Juss.) to be effective as seed protectant against infestation of stored cowpea seeds by *C. maculates* at an application rate of 25 g/kg of cowpea seed. Ash storage does not appear practicable in large scale grain storage, but it will be effective for protecting relatively small quantities of seeds which low-resource farmers keep for future planting (Ofuya, 2001). It may not also be attractive for seed storage for household consumption because of extra process of ash removal before cooking. Many workers have given possible modes of action of ash in grain protection against storage insect pests. Ash does not affect development of larvae embedded in seeds (Wolfson *et al*., 1991) such that seeds which have developing larvae prior to treatment will be damaged. It has been reported that storing cowpea seeds by admixture with dry sand or ash reduces insect damage because the sand or ash particles fill the intergranular spaces and prevents free movement of adults for oviposition (Schmutterer *et al*., 1977; Buraimoh *et al*., 2000). Ash may therefore act as a physical barrier preventing adults to locate mates or gain access to the grain (Ofuya, 2001). Ash has been suggested for use as grain desiccant (Apkaetok, 1974) in which case it may desiccate insect eggs, larvae, pupae as well as adults with mortalities resulting from abrasion of the insect cuticle leading to dehydration (De Lima, 1987). Ash particles could also clog insect spiracles and tracheae (Wolfson *et al*., 1991) or block the lateral stigmates (Boeke et al., 2001), causing suffocation of adult insects. Toxicity and/or repellence by components of ashes may also be important in the effects against storage insect pests. Millet ash has been reported to be effective because it contains acidic components that repel storage insects (Boeke et al., 2001). Ash seems to be appropriate for storage periods of intermediate lengths of three to six months (Ofuya, 1986; Baier and Webster, 1992; Songa and Rono, 1998).
Ash may be combined with other methods for more effective stored product protection. For instance, ash from cooking fires have been observed to synergize efficacy of entomopathogenic fungus, *Metarhizium anisopliae* against *Sitophilus zeamais* in stored maize, *Sitotroga cerealella* on stored soghum, *Caryedon serratus* on stored groundnuits and *C. maculatus* on stored cowpea (Ekesi, 2005).

Use of fruit peels in stored products protection
Taylor (1975) in a pioneering work in Nigeria reported the efficacy of fruit peel powders from *Citrus paradisi* and *C. sinensis* in reducing damage by *Callosobruchus maculatus* infestation of cowpea. This has been confirmed by Don Pedro (1985) and Onu and Sulyman (1997). Averagely, 50-100 g/kg of seed was found to be effective. The peels are both toxic and repellent to adult beetles. Inhibition of oviposition and low progeny production are also lethal effects of powder from *Citrus* fruit peels to *C. maculatus* infesting stored cowpea seeds. Don-Pedro (1996a, 1996b, 1996c) reported the effectiveness of employing volatile oils from *Citrus fruit* peels in protecting stored products from insect damage. Application rate of 2 ml/kg of seed has shown some appreciable degree of efficacy (Don-Pedro, 1996b). Topical application of eight lyophilized citrus peel oils showed high contact toxicity to *C. maculatus* (Su et al., 1972).The oils have further been demonstrated to exhibit fumigant toxicity to all developmental stages of *C. maculatus* (Ofuya and Olowo, 2006). Use of sub-lethal doses of citrus fruit peel oils should be avoided since such doses in *C. limon* have been observed to

cause enhanced oviposition in *C. maculatus* (Lale, 1991), a phenonmenon termed hormoligosis (Lale, 2006).

Efficacy of other plant Wastes in storage protection

Ofuya (1986) reported that pulverized dry onion scale leaves significantly reduced oviposition and adult emergence of *C. maculatus* in stored cowpea seeds in comparison with the control. Liquid extracted from cashew nut shell has been reported to be effective in reducing or preventing attack by *C. maculatus* infesting cowpea seeds in storage (Echendu, 1991). Antimicrobial and insecticidal activities of cashew tree gum exudate have also been reported (Marques et al., 1992). Neem seed cake which is the remains after extraction of neem oil from powdered neem seed kernels is useful in protecting stored crops against insect damage (Yar'Adua, 2007). It may be used as ground powder or water extract. Pulverized millet husk has been investigated for stored products protection but it was not as effective as husk ash in preventing adult emergence of *Zabrotes subfasciatus* Boh.and *Acanthoscelides obtectus* Say (Chinwada and Giga, 1997).

Insecticidal Components of Products from Plant Wastes

Fatty acids, phenolics, alkaloids and terpenes especially monoterpenes are often found to be the bioactive constituents of plant products (Lale, 1995). Alkaloids, flavonoids and saponins were also the common bioactive substances extracted from different crop Wastes evaluated for their potential uses as insecticides, medicine or as source of pulp for paper making in investigations carried out in the Philippines (Food and Fertilizer Technology Center, 2003). Dales (1996) provided a compilation of individual bioactive compounds that may be found in insecticidally active plants. Usually more than one active materials or toxicants may be present in a plant Waste. The bioactive components of plant Wastes as potential sources of insecticides must of necessity be carried out in order to determine the principal component on which attention should be focused. For instance, more than 12 to 15 complex constituents (triterpenoids) and some non-terpenoidal bioactive compounds have been found in neem products (Schmutterer, 2002), but the principal constituents are the azadirachtin groups upon which many currently formulated insecticides are based (Yar'Adua, 2007).

CONCLUSION

Plant residues and Wastes may be utilized for beneficial purposes which include source of insecticidal materials. Use of plant ash, and fruit peels especially from *Citrus* species have been clearly investigated in this regard. However, further studies should be geared towards having patented products from these materials for use by farmers, traders, households etc. Other plant Wastes need to be investigated for their insecticidal potential. Inert plant ash may be investigated as carriers of toxicants in insecticide formulations. The combination of insecticidal products from plant Wastes with other methods in integrated stored products protection also needs to be further considered.

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EVALUATION OF THE USE OF COW BONE ASH AS SUPPLEMENTARY CEMENTING MATERIAL

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Abstract
The study investigated the use of cow bone ash (CBA) as a supplementary cementing material. Tests were conducted on cement where Ordinary Portland cement (OPC) was replaced by CBA within the range of 0% to 30%. The physical and chemical properties of CBA were critically examined to evaluate the possible influences on cement properties. The investigation included testing on both fresh and hardened cement mortar. Physical requirements for fineness as specified by ASTM C618 (1994) and NIS 439: (2000) were met by CBA, which indicate a reasonable reaction of cement with CBA. The loss on ignition (LOI) of the CBA was 1.06% which falls within the range of 10% maximum specified for natural pozzolan by ASTM C618. However, the 70% summation of SiO_2, Al_2O_3 and FeO_3 could not be met. The compressive strength of the mortar decreased as the CBA content increased. The minimum Strength Activity Index (SAI) of 75% at 28 days, as specified by the operating standard, was satisfied by CBA replacement of up to 20%. It was concluded that only up to 20% CBA substitution is adequate for use in mass concrete production.
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Keywords: Cow Bone Ash (CBA), Ordinary Portland cement (OPC), Compressive strength.

INTRODUCTION

Portland cement as an ingredient in concrete is one of the main construction materials widely used, especially in developing countries. The current cement production rate of the world is approximately 1.2 billion tons/year. This is expected to grow to about 3.5 billion tons/year by 2015.This increasing demand for cement is expected to be met by partial cement replacement (Coutinho, 2003). The search for alternative binder or cement replacement materials led to the discovery of the potentials of using industrial by-products and agricultural Wastes as cementitious materials. If these fillers have pozzolanic properties, they impart technical advantages to the resulting concrete and also enable larger quantities of cement replacement to be achieved (Hossain, 2003).

The use of agricultural Waste product in cement production is an environmental friendly method of disposal of large quantities of materials that would otherwise pollute land, water and air. The Waste products which possess pozzolanic properties and which had been studied for use in blended cement are **Rice husk ash** [Waswa-Sabuni et al. 2002, Nehdi et al. 2003], **Saw dust ash** [Udoeyo, 2002], **Waste burnt clay** [Syagga et al. 2001, Shihembetsa and Waswa-Sabuni 2002] and **Corn cob ash** [Adesanya, 1996; Adesanya and Raheem, 2009a and 2009b]. The Waste product that is of concern in this study is cow bone ash (CBA).

Cow bone ash (CBA) is obtained from the burning of cow bone, which is a by product obtained from cow, a regular meat supplier to the Nigerian populace. The ready availability of large quantity of cow bone in most parts of the nation indicates a prospect for the local production of CBA. Appropriate utilization of the material brings economical and ecological benefits as well as imparts technological improvement to the final product.

This study examined the physical and chemical properties of CBA so as to evaluate its possible influence on cement properties. The compressive strength of mortar produced by partial replacement of ordinary Portland cement (OPC) with CBA in the range 0 – 30%.was also determined, with a view to ascertaining its suitability as a structural material.

EXPERIMENTAL PROCEDURE

MATERIALS

The cow bone used was obtained from a local abattoir in Attender Market Ogbomoso North Local Government of Oyo State, Nigeria. The cement used was the Elephant brand of ordinary Portland cement (OPC) tagged CEM 1, which was obtained from West African Portland Cement (WAPCO), Ewekoro works, Ogun State. The standard sharp sand used as fine aggregates was obtained from WAPCO.

Preparation of CBA

The CBA used was produced by burning dried cow bones in open air using a local blacksmith furnace that uses charcoal as Fuel. The burning was continuous, with temperature increasing to 750^{o}C in about ten hours, when the cow bones turned to ashes.

The burning of the bone in open air permits as much amount of oxygen as possible, this keeps the Loss on Ignition value (which is a measure of the carbon content), low. A low carbon composition is an important requirement for a good pozzolanic material.The colour changed noticeably when burning from its natural colour to red and then to white on cooling. The burnt cow bone was then ground in a mill to obtain the ash (CBA). The ash was sieved using 90µm sieve size. This step is pivotal as the CBA particles must be fine enough in order to react reasonably with the cement. The ground ash was taken for chemical and physical tests to check its performance as a pozzolanic material.

Testing Procedure

Chemical Analysis

The chemical analysis of CBA involved the determination of the chemical composition, loss on Ignition, (LOI) and moisture content. The chemical composition of CBA was carried out using a cement x-ray spectrometer by running the CBA sample as cement concentrate. The loss on ignition was determined in an oxidizing atmosphere by igniting the CBA in air at 95^{0} C. The moisture content was determined as the amount of water, expressed as a proportion by mass of the dried sample. All the tests were carried out in accordance with the practice at WAPCO Ewekoro Works.

Physical Tests

These tests included the determination of fineness modulus and specific gravity of CBA; as well as the soundness and compressive strength of OPC/CBA mortar. All the tests were carried out at WAPCO Ewekoro Works in accordance with the operating standards.

The fineness determines the rate of reaction of CBA. It was determined using two different methods - Air permeability method and Residue determination method. With Air permeability method (also called Blaine method), the fineness of CBA was measured as specific surface area by observing the time taken for a fixed quantity of air to flow through a compacted CBA sample of specified dimension. The test was performed using Blaine permeability apparatus (see figure 1). For Residue determination method, the fineness of CBA was measured by sieving it on standard sieves of 45µm and 90µm. The proportion of

CBA having the grain size larger than the specified mesh size was determined. Figure 2 showed the Alpine Sieve used for Residue determination.
The specific gravity is the ratio of the density of a material, CBA in this experiment, to the density of a standard material, premium motor spirit (PMS) as used, at a specified temperature. It was determined using a specific gravity bottle.
The soundness test measures the potential expansion of cement. An excessive change in volume on cement paste after setting is as indication of an unsound binder. The soundness test in this experiment measured the volume expansion of OPC/CBA paste. The cement paste was made from the intimate mixture of OPC and CBA in varied percentages of 0, 5, 10, 15, 20 and 30. Table 1 showed the weights of OPC and CBA used for the test. The soundness was determined using the Le chatelier apparatus (see Figure 3), by observing the volume expansion of the OPC/CBA cement paste as indicated by the relative movement of two needles.
The compressive strength of the OPC/CBA mortar was determined using test specimens of 40mm x 40mm x 160mm in size. The binder component was made by replacing 0, 5, 10, 15, 20and 30% by weight of OPC with CBA. The 0% CBA replacement serves as the control. The mortar specimens were cast using one part by mass of OPC/CBA binder and three parts by mass of standard sand, with a water /binder ratio of 0.50. Table 2 showed the mix proportion of the materials used. The mortar specimen was mixed by a mechanical mixer and compacted by means of standard vibration machine. After casting, the specimens were stored in the curing room at 27 ± 5^{o}C with 90% relative humidity for 24hours and then demoulded and placed under water until the testing ages of 7 and 28 days when they are broken in flexure into two halves by a flexural strength equipment and each half tested for compressive strength in a compression equipment shown in Figure 4.

RESULTS AND DISCUSSION

Chemical Analysis

The result of the x-ray analysis which indicated the chemical composition of the CBA is shown in Table 3. The analysis revealed that CBA contained high percentages of phosphorus oxide (54.86%) and calcium oxide (41.52%).This is attributed to its bony nature. The 70% summation of SiO_2, Al_2O_3 and Fe_2O_3 required for a good pozzolanic material could not be met. However, the high calcium oxide content in CBA is similar to that in cement composition. Also, the available alkalies as Na_2O (0.60%) is less than the maximum of 1.5% required by ASTM C618: 1994, which is an indication that CBA would not have any deleterious effect on concrete. Thus, it can be used to replace part of cement at reasonable level.
The LOI had a value of 1.06% which was within the range of 10% maximum as specified by the ASTM C618 for natural pozzolans. According to Uwe (2003), carbon content exceeding the specified requirement will prevent the hardening of the cement paste.
The moisture content recorded for CBA was 0.0005%. The near 0% moisture content obtained, indicate a negligible presence of water, less than the 3% maximum specified by the operating standard. Lower water content reduces the risk of drying shrinkage (Uwe, 2003).

Fineness Modulus and Specific Gravity of CBA

The fineness of CBA as determined by its specific surface area using Blaine permeability method is 603m^2/kg. With the Residue determination method, maximum amount retained on the 45µm and 90µm sieve are 14.22% and 1.59% respectively. Reactivity has been found to be directly related to the quantity passing the 45µm as coarser particles generally do not react in a reasonable time on concrete (Uwe, 2003). ASTM C618 limits the amount retained on the 45µm sieve to 34 % for class N pozzolan. The NIS 439: (2000) also limits the amount

retained on the 45µm sieve to 30% and fineness to a minimum of 250m^2/kg. Since CBA falls into the category of class N pozzolan and with the maximum amount retained on 45µm sieve as 14.22% and specific surface area of 603m^2/kg, there is a reasonable reaction of cement with CBA.
CBA has a specific gravity of about 2.29, which is an acceptable value for the specific gravity for natural pozzolan. (Werner, 1994). Thus, CBA can be used as supplementary cementitious material without any doubt about its reactivity.

Soundness of OPC/CBA Paste
Table 4 showed the effect of addition of CBA to OPC on soundness of the resulting paste. There was a gradual decrease in soundness as the proportion of CBA increased. A range of values from 0.00mm to 1.00mm was recorded. The 15 – 30% CBA replacement was within the 0.8mm limit specified by ASTM C618. The 10mm maximum specified by NIS 439: (2000) was also satisfied. Normally, cement produces free lime as it hardens, this free lime will react with whatever that is available forming expansive gel. CBA therefore reacts with the free lime to form these expansive gels when the mortar is still wet, so that it would not cause too much pressure build –up in the hardened mortar, which may cause cracking and disintegration.

Compressive Strength of OPC/CBA Mortar
The effect of percentage CBA replacement on the compressive strength of mortar at the curing ages of 7 and 28 days are presented in Figures 5. The strength was found to decrease with an increase of CBA content. This is reasonable due to the reduction of cement content in the mix with an increase of CBA content.
With respect to the control (100% CBA), the 28^{th} day compressive strength was reduced by 6.4%, 12.6%, 22.4%, 26.3% and 42.2% with CBA substitution of 5%, 10%, 15%, 20% and 30% respectively. The strength was reduced to a large extent when CBA content exceeds 20%. with over 40% reduction witnessed for the 30% CBA replacement. This is an indication that CBA substitution beyond 20% is not advisable for compressive strength not to be adversely affected. However, since all the specimens meet the minimum strength of 6Nmm^{-2} after 28 days of curing recommended by BS 5224: 1976 for masonry cement, CBA could be used as supplementary cementing material for general concrete works where strength is of less importance such as in mass concrete, floor screed and mortar.
Table 5 showed the Strength Activity Index (SAI) of CBA. Up to 20% of CBA substitution for both 7 and 28 days was within the limit of 75% specified by ASTM C618. This further confirms that up to 20% CBA substitution is adequate from compressive strength viewpoint. From this result, it is evident that the CBA/OPC mortar compares favourably with pure OPC mortar in terms of strength development.

CONCLUSION
From the results of the various tests performed, the following conclusions can be drawn:

1. Physical requirements for fineness as specified by ASTM C618 were met by CBA, which indicate a reasonable reaction of cement with CBA. However, the 70% summation of SiO_2, Al_2O_3 and FeO_3 required for a natural pozzolan could not be met.
2 CBA could be used as supplementary cementing material for general concrete works where strength is of less importance such as in mass concrete, floor screed and mortar.
3 The optimum level of CBA replacement from structural load viewpoint is 20%.

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RETROFITING COMPOSITE CEILING TILES WITH SAWDUST

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Abstract
Properties of compacted sawdust (particleboard) produced from radiata pine are used with previously obtained experimental data of clay-silica tiles to determine the properties of retrofitted ceiling tiles with sawdust addition. The lighter density retrofitted tiles (0.745-1.022 g/cm^3) experienced a 51.8% decrease in bulk density compared with the non retrofitted tiles (1.82-1.98 g/cm^3), while the flexural strength was reduced by 61.26% when 50% of the amount of clay in the non retrofitted tiles was replaced with sawdust. The reduced flexural strength in the range of 21-31 MPa, compared with those of the non retrofitted between 53.29-92.23 MPa still compares favourably well with international standards. The investigation reveals that wood Waste (sawdust) can be recycled as a resource material to produce potentially economically viable ceiling tiles as they produce suitable light weight products capable of guarantee economic incentive and industry empowerment for individuals and corporate groups.

Key words: Ceiling tiles, Sawdust, Properties, Retrofitted

INTRODUCTION

Composite materials as new materials possesses several benefits amongst which are excellent lightweight, heat resistance, mechanical characteristics, and control characteristics, and thus, their uses are increasing broadly as materials of structures in many relevant engineering fields for production purposes (Lee *et al.*, 2008). Most composites have strong, stiff fibres in a matrix which is weaker and less stiff. The objective is usually to make a component which is strong and stiff, often with a low density (Clyne, and Tanovic, 2009). As a means of new product development, composite engineering can also help to address issues of Waste in industrial production processes.

One way of addressing the problem of Waste recycling is to decide on the best ways of making Waste useful and profitable; which was why products such as particleboard, wood panel, sawdust concrete and tiles were developed (Clausen, 2000; Particleboard, 2010; Sawdust Concrete, 2010). Sawdust concrete-based products can be classified as a light weight concrete building material (Sawdust Concrete, 2010) that exploits organic elements being Waste wood like sawdust, chip, and other cuttings with concrete-based material, which are cement and other aggregates. Sawdust concrete has several unique characteristics which make it competitive among other building materials (Sawdust Concrete, 2010): it is made of green, ecologically pure material; it controls interior humidity level; it is frostproof; it has favourable thermal mass and sound-proofing properties; it is fireproof; it is rot resistant; it is not subject to mold and fungi; it is light; it is compatible with cement, different finishes, stains, and varnishes (Sawdust Concrete, 2010).

Shelter is a basic necessity for comfort and sustenance of human existence. Over the years there had been an increasing growth of the world population which has led to a higher demand for more shelter and accompanying structural accessories such as ceiling tiles. The latest United Nations (UN) figures reported by Population Guide (2009) confirm a global population of 6.8 billion in July 2009, rising each year by 78 million, more than the population of the United Kingdom (UK). Modern trends have revealed the indispensability of tiles which are mostly used for walls, floors, roofing and ceiling coverings both for elegance and structural functions (Olusegun *et al*., 2009). For example, the total US demand for ceramic floor and wall tile reached 2.2 billion square feet (0.2 billion m^2) in 2001, which resulted in an average annual growth of 9.4 percent between 1996 and 2001 (Freedonia Focus on Ceramic Tiles, 2002). The above enumerated statistics corroborate the commercial viability and economic potential of retrofitting composite ceiling tiles with sawdust.

In the present investigation sawdust is considered as a composite member for retrofitting of composite ceiling tiles with body mix for clay-silica cement tiles. A mixture of sawdust, sand and cement was successfully used in the past in parts of the USA, UK and Germany for making wall panels as a non-load bearing construction material (Andrews, 2010). The significance of this study is to analyse the properties of tiles which utilises wood Waste (sawdust) as a recycled resource material to produce potentially economically viable ceiling tiles when 50% of the clay is being replaced with sawdust.

MATERIALS AND METHODS

The approach to manufacture retrofitted ceiling tiles is premised on the possible synergetic combinations of clay-silica based tiles (fibre) and sawdust based particleboard (matrix). This is due to the fact that both products have comparable production procedures, differing only in constituents and bonding materials. Also, compacted sawdust properties are rather to be preferred compared with non-compacted sawdust because we are interested in the properties of the retrofitted product in the finished state. Typical values for standard particleboard produced from wood species which are usually pines such as radiata pine, less than or equal to 12 mm thickness are given by AWPA (2008) as: density, 0.66-0.70 g/cm^3; modulus of rupture, 18 MPa accordingly.

Locally sourced materials which include ball clay and silica sand was used to produce experimental tiles investigated. The relative density of ball clay and silica sand used was determined by Ohijeagbon and Adeyemi (2003) as 2.31 and 2.36 respectively. Analysis was carried out to determine the properties of the retrofitted tiles with sawdust addition. The relative densities of cement and sawdust are respectively put at 1.506 and 0.21 (Density of Materials, 2009). Chemical bonding was provided for tile materials mix by cement and water. Respectively produced tiles were by means of a dry press process (ASTM, 1985a) in a 90 degree vertical moulding box under a uniformly applied load of 25 kN. Curing and drying was allowed to take place to achieve full strength before the tiles were tested. Amongst other properties determined for clay-silica tiles are bulk density and modulus of rupture (flexural strength) which are stated in Table 1, and their respective computational steps are enumerated as follows:

1. Bulk density determination

Bulk density is defined as the weight per unit volume of material and can be obtained by the expression given by equation (1) (ASTM, 1985b).

$$B = \frac{M_d}{V} \qquad (1)$$

where,

B = bulk density,
M_d = dry mass and
V = volume.

2. **Modulus of rupture test**

Modulus of rupture also known as flexural strength in bending is the maximum fiber stress at failure and this was obtained by the expression given in equation (2) (ASTM, 1985c).

$$M = \frac{8PL}{\pi T^3} \quad (2)$$

where,

M = the modulus of rupture (MPa),
P = load at rupture (N),
L = distance between supports during test (mm) and
T = the average thickness of the specimen tested (mm).

Table 1: Properties of clay-silica tiles (Tile Thickness = 6.400-7.025 mm, Water absorption of tiles = 7.00-11.11%)

Mixtures		Properties	
Clay (%)	Silica (%)	Bulk Density (g/cm^3)	Modulus of Rupture (MPa)
10	70	1.98	77.71
30	50	1.95	92.23
40	40	1.95	82.99
45	35	1.90	68.37
55	25	1.89	62.14
60	20	1.82	53.29

The following shows the specifications of the material mixtures used to produce the experimental tiles:

% of water by mass to: (silica + clay + cement) = 14%
Dimensions of tiles (Length x Width) = 150 x 150 mm
Base material = Ball clay
% of Cement addition = 20%
Compaction Load = 25 kN
Maximum particle size of sieved clay used = 250 µm
Maximum particle size of silica sand used = 1000 µm

THEORETICAL METHOD

Composite Theory

Clyne, and Tanovic (2009) had stated a basic and important equation of composite theory, sometimes termed the "Rule of Averages" which may be represented by equation (3).

$$f \times M + (1 - f) \times F = A \quad (3)$$

here, f = amount of fibre, F = property of fibre, M = property of matrix, and A = property of composite (i.e, a combination of both M and F).

If the amount of matrix, m is known, then equation (3) may be re-written as:

$$m \times F + (1 - m) \times M = A \quad (4)$$

where, $m + f = 1$ (5)

The average values of density and modulus of rupture of standard particleboard less than or equal to 12 mm thickness are 0.68 g/cm^3 and 18 MPa (AWPA, 2008), and was used for retrofitting computations with those of clay-silica tiles stated in Table 1. Results obtained are shown in the bulk density and modulus of rupture figures of Figures 1 and 2 respectively.

RESULTS AND DISCUSSIONS

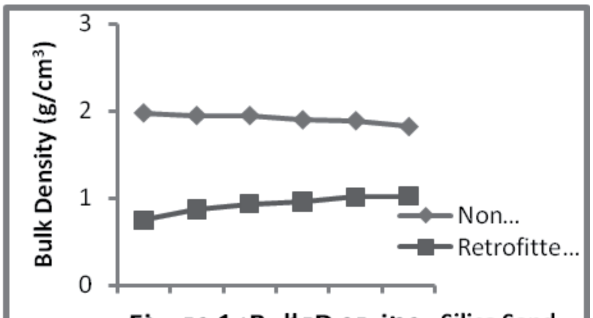

Figure 1: Bulk Density versus Silica Sand

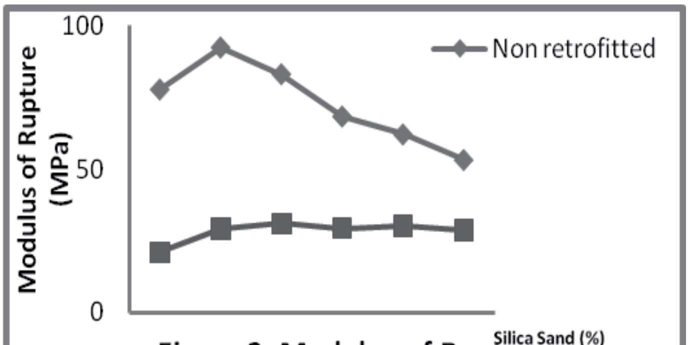

Figure 2: Modulus of Rupture versus Silica Sand

The Figures 1 and 2 showing the bulk density and modulus of rupture for non retrofitted tiles and tiles retrofitted with sawdust respectively indicates that property values of the retrofitted tiles were reduced due to the inclusion of sawdust. It was observed that the bulk density of the non retrofitted tiles experienced slight reduction while that of retrofitted tiles were slightly increased with increasing values of silica sand content as 50% of the clay materials was replaced with sawdust. The lighter density retrofitted tiles (0.745-1.022 g/cm^3) experienced a 51.8% average decrease in bulk density compared with the non retrofitted tiles (1.82-1.98 g/cm^3) when 50% of the amount of clay in the non retrofitted tiles was replaced with sawdust. As a result therefore, the weight reduction achieved during retrofitting with sawdust offers feasible application of the product for ceiling tiles.
Also, a 61.26% average reduction was obtained in the modulus of rupture when 50% of the amount of clay in the non retrofitted tiles was replaced with sawdust. The non retrofitted tiles have a modulus of rupture in the range 53.29-92.23 MPa. Though the reduction in flexural strength is high, however it is still found to be acceptable, being in the range of 21-31 MPa, it still compares favourably well with international standards. The effective modulus of rupture (minimums) (Based on Flexural Strengths per ASTM C 1396) is between 1.5-6.7 MPa which includes gypsum ceiling board (Gypsum Association, 2005).

CONCLUSION

This study have shown that acceptable properties can be obtained when clay-silica based tiles are retrofitted with sawdust, as they are found to produce lighter weight tiles suitable for ceiling applications in building constructions. Hence, wood Waste (sawdust) can be recycled as a resource material to produce potentially economically viable ceiling tiles. Such developments are capable of guarantee economic incentive and industry empowerment for individuals or corporate groups. It will further encourage alternative material for industrial purposes which can lead to wealth creation. Further work is required to experimentally produce retrofitted ceiling tiles with sawdust addition, with due consideration of synergy between the production processes of particle board and clay-silica tiles in order to achieve high sawdust substitution for the clay component.

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EFFECT OF SOME PROCESSING METHODS ON THE PHYSICO- MECHANICAL PROPERTIES OF PARTICLE BOARD MADE FROM MAIZE COB FIBRES.

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Abstract
Preliminary investigations have been undertaken to examine the effects of some processing variables on the physico-mechanical properties of particle board made from maize cob fibres, a by-product from shelled maize crop. Maize cob fibre were used to produce twelve different boards of cement - corn fibre ratio 2:1 and 3:1 at 3 additives level of concentration 1%, 2%, 3% and density of 1000kg/m^3 and 1,200kg/m^3. The treatments were replicated thrice to produce 36 samples of the particle boards. The physical properties (% thickness swelling and water absorption) and mechanical properties (Impact modulus of rupture and modulus of Elasticity) were determined. The result shows that an increase in cement -maize cob fibre ratio, board density, and additives, reduces the rate of water absorption and thickness of swelling. However, an increase in cement-maize cob ratio, additives concentration and board density increases elasticity. It is then concluded that an increase in all the variables result in a more stable Particle boards produced from maize fibre. The results so far obtained are encouraging as they suggest the possibilities of converting agricultural Waste to quality particle boards in Nigeria.

Key word: Physico-mechanical, particle boards, maize cobs, water absorption, thickness swelling, modulus of rupture, modulus of Elasticity.

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INTRODUCTION

Particle board manufacturing is a growing industry. Particle board has been found to be one of the major newly introduced materials in the construction industries. It is used essentially in the construction of architectural designs. Other useful areas include some laboratory or accessories of equipment were particle boards abound. It is composed of fibres bounded by an adhesive and made into a solid board by a pressing operation combined with heat. It is an ideal and appealing alternative to wood based particle boards for economic and environmental reasons. The United Nations industrial Developments organization (NNIDO, 1970) report indicated that much research has been carried out on the use of baggese (fibrous residues from sugar cane) in particle board manufacturing and is now being employed in commercial production in some parts of the World.

Particle boards are broadly classified into three basic types according to density. They are low density board with density of 300-400kg/m^3; medium density boards of between 400 and 800kg/m^3 while the high density is between 800 and 1,200kg/m^3 .Nigeria, a country of about 120million population is greatly in need of avoidable shelter for his people .Currently, the rate of over-exploitation of forest reserve in Nigeria is alarming (Adekunle et al 2002; Adejoba, 2008). With the high cost of building materials, the development of a cheaper product like particle from maize cop fibres is welcome news to building materials market.

Over 200millin tons of corn Cobs are left as a by- product during post harvesting operations of maize in Nigeria. The corn cobs are left to scattered on the street which later constitute environment problems. With the negative environmental effects of agricultural burning on the atmosphere and increasing regulations on burning, using the corn cobs as renewable resources is a positive option

A lot of works have been done on cement bonded particle board using wood particles (Badejo, 1986; Ajayi 1993; Ajayi 2003; Owonubi and Badejo , 2006; Badejo et al 2006; Adejoba et al 2009). The main objective of this work is to convert the corn cobs which are assumed to be an agricultural Waste to a particle board which is wealth, thereby, providing alternative to wood base board and also providing job for people.

MATERIALS AND METHODS

Corn material cobs collected from the shelling centre at Randa, market, Ogbomoso, Oyo state, **Nigeria**, was use for this study. The binder used was the Portland cement. Calcium chloride ($CaCl_2$) was used as the additive. It serves as a neutralizing agent, used to improve the compatibility of the maize cob fibre with the cement binder by quickening the setting of the cement and retard the effect of inhibitory substances.

Experimental design.

The 2x2x3 factorial experiment in a complete randomized design was used to evaluate the effect of variable factors

Factor A = maize cob (grounded maize corb)-Cement ratio by weight– 2 level

Factor B= Additive concentration - 3 levels

Factor C= Board Design - 2 level.

The statistical model is given below:

$Y_{ijkl} = N+A_1+B_j+ (AB)_{ij}+ C_k+ (AC)_{Ik}+ (BC)_{jk}+€_{IJKl}$ -- (1)

Y_{ijkl} = individual observation

N = general means

A_i = Effect due to the maize cob-fibre-cement

B_j = Effect due to the additive concentration

(AB) ij = Effect due to the interaction between maize cob-fibre-cement ratio and additive concentration

C_k = Effect due to board density

$(AC)_{ik}$ = Effect due to the interaction between maize cob-fibre-cement ratio and board density.

$€_{ijk}$ = Experimental error.

The following production variables were used

a. Board density of $100kg/m^3$ and $1200kg/m^3$
b. Mixing ratio of cement-maize cob, 2:1 and 3:1
c. Additive concentration ($cacl_2$)= 1%, 2% and 3%

Constant factors

1. board thickness =6mm
2. moisture content of maize cobs fibre = approximately 12%
3. board size = 350mm x 350 x 6mm
4. pressing pressure = $1.23N/mm^2$

Production Method

The different corn cob fibre cement mixtures were measured, calcium Chloride ($CaCl_2$) use as cement setting accelerator was completely dissolved in water and added to the different mixture of corn cob fibre/ cement. The required quantity of water used in the preparation of experimental specimens was calculated using the relationship below:

Required water (inters) = 0.35c + (0.30-m) W -- (2)
Where C= cement weight (kg)
M= moisture content of the corn cob fibre
W= weight of the corn cob fibre.
The relationship above have been used by Simatupang, (1979)and adopted by Moslem and Pfister ,1987; sudin *et al*. 1995 and Erakurumen *et al*.2008.
The quantity of cement and maize cob fibre were measured out and poured inside an aluminum bowl, a prepared quantity of additive was added and mixed thoroughly manually. The mixture was then poured into a wooden box of dimension 350 x 350 x 6mm and then covered with a polythene sheet. The mixture was then formed into a mat in these boxes covered with the polygene sheet on which a plywood sheet was placed and pre-pressed. The plywood sheet was later removed and replaced with metal call plate. The metal was transferred to the press and cold pressed at a press of 1.23Nmm^{-2} for 24 the bound were cared for 21days this procedure was used in producing all the boards for this study. The specimen's boards were appropriately labeled for easy identification.

Testing of the board properties
Each board was cut into 152mm x 5mm x 6mm to test for some physical properties of the board.

Water Absorption
This is a measurement to test the dimensional stability of board; the test specimens were soaked in cold water at 28^{0}C ± 3^{0}Cfor moisture uptake for 24 hours. The formula below was used in calculating the water uptake

$$W_A = \frac{W_2 - W_1}{W_1} \times 100 \qquad \text{--} \qquad (3)$$

W_A = water absorption in percentage
W_1 = weight of the board
W_2 = final weight of the board.
All the weight were taken using Turbol 005 electronic weighing Machine

Thickness Swelling
The thickness swelling was expressed as the percentage of increase in thickness of the board over the original thickness. The test specimens were squeaked in cold water at 28^{0}C ± 3^{0C} for moisture uptake for 24hours.
Thickness swelling was expressed as

$$T_T = \frac{T_2 - T_1}{T_1} \times \frac{100}{1} \qquad \text{--} \qquad (4)$$

Where
T_T=Increase in thickness
T_1 =initial thickness
T_2= Final thickness

The thickness of the boards was measured using electronic veneer caliper.
Mechanical properties

MODULUS OF RUPTURE (MOR)

The test specimens of 194mm x 50mm x 6mm board thickness were subjected to a force or Load on the tensiometer with the support span. The specimens were supported by two rollers at each ends and loaded at the centers'. The forward movement of the machine leads to gradual increase of lad at the middle span until failure of the test specimens occurred. At the point of failure, the force exerted on the specimen that caused the failure was recorded, the modulus of rupture (MOR) of the test specimens was calculated using.

$$MOR = \frac{3El}{2bh^2} \qquad \text{--} \qquad (5)$$

Where:

MOR = Modulus of Rupture

E= failing Load (kg)

l = Span between centres of support (mm)

b = Width of test specimen (mm)

h = Mean thickness of the specimen (mm)

Modulus of Elasticity (MOE)

The panel's stiffness (MOE) was determined from the bending test performed on each specimen and MOE was calculated using.

$$MOE\left({}^{N}/_{mm^2}\right) = \frac{\varrho L^3}{4bd^3H} \qquad \text{---} \qquad (6)$$

Where:

MOE = Modulus of Elasticity of panel stiffness

P = Falling load (kg)

L = Span between centrs (mm)

b = Mean thickness of the specimen (mm)

H = Increment in deflection (mm)

d = width of the specimen (mm)

RESULTS AND DISCUSSION

The result of experiment on the physical and the mechanical properties of particle board made from maize cob fibre are presented in Table 1. Analysis of variance table to determine the reliability of the result is presented in Table 2.

Table1: The mean of results of experiment on physical and mechanical property of the particle board

Treatments	Water Absorption (%)	Thickness Swelling (%)	Linear Expansion (%)	MOR (N/imn^2	MOE (N/mm^2)
$M_1A_1B_1$	47.28 ± 0.51	1.8 ± 0.03	0.38 ± 0.01	0.16 ± 0.01	572.20 ± 1.34
$M_1A_1B_2$	46.07 ± 0.67	0.98 ± 0.02	0.35 ± 0.00	0.25 ± 0.01	1287.31 ± 7.08
$M_1A_2B_2$	46.20 ± 0.00	0.94 ± 0.01	0.30 ± 0.01	0.33 ± 0.00	1716.41 ± 0.00
$M_1A_2B_2$	45.32 ± 0.96	0.82 ± 0.96	0.28 ± 0.00	0.42 ± 0.05	2002.47 ± 5.23
$M_1A_3B_1$	44.02 ± 0.00	0.74 ± 0.00	0.26 ± 0.01	0.49 ± 0.00	3312.70 ± 1.96
$M_1A_3B_2$	44.07 ± 0.17	0.70 ± 0.03	0.25 ± 0.01	0.57 ± 0.01	4291.02 ± 1.30
$M_1A_1A_1$	42.78 ± 0.82	0.67 ± 0.01	0.24 ± 0.00	0.81 ± 0.00	4391.02 ± 0.00
$M_2A_1A_2$	40.82 ± 0.00	0.63 ± 0.00	0.23 ± 0.01	0.89 ± 0.04	5091.02 ± 9.42
$M_1A_2A_1$	38.53 ± 0.17	0.57 ± 0.00	0.22 ± 0.00	0.98 ± 0.01	5144.02 ± 9.42
$M_2A_2A_2$	37.64 ± 0.03	0.42 ± 0.01	0.19 ± 0.01	1.06 ± -.01	5678.82 ± 9.4
$M_2A_3A_1$	36.14 ± 0.00	0.38 ± 0.01	0.17 ± 0.00	1.22 ± 0.01	6007.47 ± 1.34
$M_2A_3A_2$	33.81 ± 0.41	0.33 ± 0.00	0.14 ± 0.01	1.38 ± 0.00	8436.52 ± 8.61

Foot-note

All readings are average values of four replicate samples of each board ± standard deviation

Mixing ratio M_1 = cement: corn cob fibre ratio 2:1

M_2 = cement: corn cob fibre ratio3:1

Additives concentration A_1 = 1%; A_2 = 2%; A_3 = 3%

Board Density = B_1 = 100kg/m^3; B_2 =1200kg/m^3.

Table 2: **Analysis of Variance for water Absorptions, thickness, swelling, linear Expansion, Modulus OF Rupture and Modulus of Elasticity.**

Source of Variation	DF	WA	F-Ts	VALUE LE	MOR	MOE
Mixing Ratio	1	76.423*	192.308 *	190.500*	763.875*	75.766*
Additive conc.	2	393.240*	844.692 *	640.667*	7107.042*	496.453*
Density	1	2741.090 *	3928.92 3*	32.667*	135.375*	7.762ns
Mixing Ratio x Additive	2	2.208ns	19.923*	11.167*	25.0428	10.078*
MIXING Ratio x Density	1	14.455ns	0.308ns	0.167ns	2.375ns	2.917ns
Additive x density	2	80.293*	1.000ns	0.000ns	2.042ns	0.169ns
Mixing x additive x density	2	6.466ns	5.154ns	1.500ns	3.042ns	2.444ns
Error	12					
Total	24					
Corrected total	23					

*denotes significant ($p<0.005$); ns denotes not significant ($p>0.05$)

Water Absorption and Thickness Swelling

The water absorption properties of the board is shown in figure 1 ,while the effect of processing variables on thickness swelling were shown in figure 2.The boards water absorption and thickness swelling decreased with increase in cement: maize cob fibre ratio, additive concentration and board density. It was observed that the water absorption and thickness swelling are inversly proportional to the increase in additive concentration, board density and binder ratio in the range considered. The water absorption is directly proportional to the thickness swelling. An increase in the water absorbed increases the thickness swelling of the board. A change in the density from $1000Kg/mm^2$ to $1200Kg/mm^2$ result in a decrease of about 2.6 % in water absorption and 48.9 % in thickness swelling . Also ,a change in additives concentration from 1% to 3% result in a decrease in water absorption by about 2.28% and thickness swelling by about 94 % . An increase in cement fibre ratio also decreases the water absorption by about 9.5 % and thickness swelling by about 62.78 %. This showed that at higher level of additive concentration, cement fibre ratio and board density the interaction between materials used for production of particle board stayed together to produce a more stable board. Our findings agrees with the findings of Fuwape,1994 ;Ajayi,2003 ; Ajayi,2005. It is then suggested that more research work should be carried out on the maximum reliable limit of these processing variables for the production of particle board from maize cob fibre .

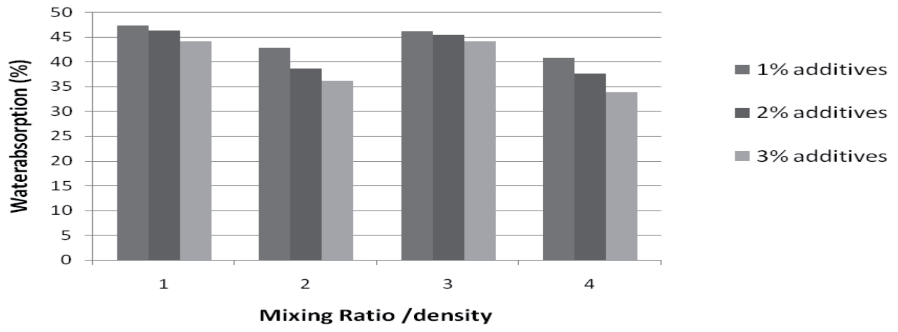

Figure 1: Effect of processing variables on Water absoption of a cement bounded particle board made from corn cob fibres

Foote note:

Mixing Ratio/density:	Cement: corn fibres			Density(Kg/mm^2)
1	2	:	1	1000
2	2	:	1	1000
3	3	:	1	1200
4	3	:	1	1200

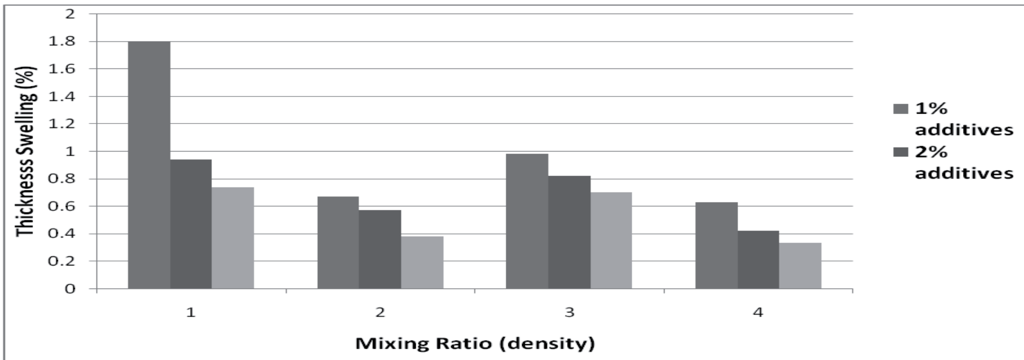

Figure 2: Effect of processing variables on Thickness Swelling of a cement bounded particle board made from corn cob fibres

Foote note:

Mixing Ratio/density	: Cement: corn fibres			Density(Kg/mm^2)
1	2	:	1	1000
2	2	:	1	1000
3	3	:	1	1200
4	3	:	1	1200

Effect of Processing Variables on the Mechanical Properties of the Boards

The effect of processing variables on the modulus of rupture and modulus of elasticity were represented in figure 3 and 4 respectively. Unlike the physical properties considered, the mechanical properties are directly proportional to the variable considered. An increase in cement: corn fibre ratio increases the modulus of Elasticity of the board which is in agreement with the findings of Adejoba *et al*. 2009); also, an increase in the percentage of additive also increases the modulus of elasticity of the board. Our findings also agree with the finding of Oyagade ,1990); Fuwape ,1995 and Ajayi ,(2000) who reported similar findings on particle board produced from other fibres. An increase in density from 1000Kg/mm^2 to 1200Kg/mm^2 results in an increase in modulus of rupture from0.16N/mm^3 to 0.25N/mm^3 and modulus of elasticity increase from572N/mm^2 to 1287N/mm^2. Also, an increase in concentration from 1% to 3% increases the modulus of rupture by 206 % and modulus of elasticity by 479%. It was also observed that a change in mixing ratio from 2:1 to 3:1 increases the modulus of rupture and modulus of elasticity from0.16N/mm^2 to 0.49 and from 572.2N/mm^2 to 4391N/mm^2. The strongest particle board was produced at the highest level of cement: maize cob fibre ratio 3:1, additive concentration (3%) and board density 1,200kg/m^3 and they show greatest improvement and resistance to loading in the range of variable exarmined in this study. It was observed from this result that the strength properties were affected by cement: maize cob fibre ratio, additive concentration and board density.

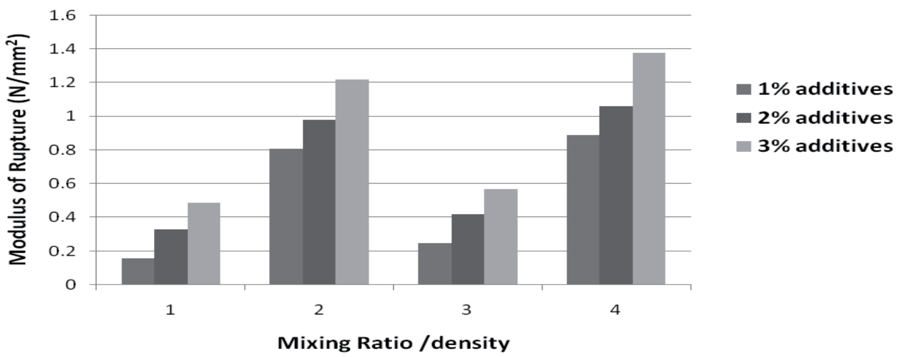

Figure 3: Effect of processing variables on Modulus of Rupture of cement bounded particleboard made from corn cob fibres

Foote note:

Mixing Ratio/density	: Cement: Corn fibres	Density(Kg/mm^2)
1	2 : 1	1000
2	2 : 1	1000
3	3 : 1	1200
4	3 : 1	1200

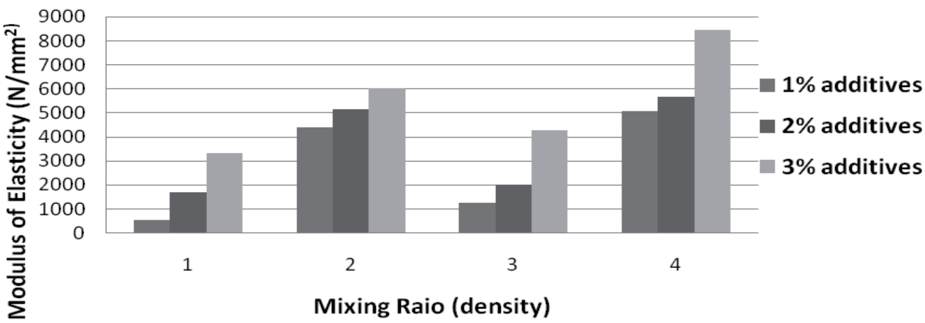

Figure 4 : Effect of processing variables on Modulus of Elasticity of cement bonded particle board made from corn cobs fibre

Foote note:

Mixing Ratio/density	: Cement: corn fibres	Density(Kg/mm^2)
1	2 : 1	1000
2	2 : 1	1000
3	3 : 1	1200
4	3 : 1	1200.

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CONCLUSIONS

The results from this report show that corn cob a great potential as a fibre for making article board. It was also observed that the particle board from highest cements: cob fibre ratio of 3:1; high density (1,200kg/m^2) and additive of 3% is the most stable of the particle board. This will reduce the environmental effect of littering the street with the corn cobs during the harvesting season and provide jobs for people with the establishment of industry using corn cobs for particle board production.

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EXPERIMENTAL INVESTIGATIONS OF THE EFFECTS OF GEOMETRY ON THE PERFORMANCE OF SAVONIUS WIND TURBINE

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Abstract

A study of the effects of geometry on the aerodynamic performance of the Savonius wind turbine was carried out in this work to determine the best configuration for maximum power output. Three different modified forms of Savonius rotor including the semi-circular- and segment of a circle-shaped, and aerofoil with curved tip were thereby investigated. The semi-circular and segment of a circle shaped Savonius rotors were fabricated using the overlap ratios of 0, 20, 30, and 40% while the aerofoil shaped rotor was without overlap ratio. All the models were separately subjected to an air speed of 5.0 m/s in an open wind tunnel. The corresponding power, torque and angular speed for each model were calculated. From the experimental results the highest power developed respectively by a semi-circular shaped rotor with 20% overlap ratio, a segment of a circle shaped rotor with 30% overlap ratio, and an aerofoil shaped rotor with curved tip at 135° blade arc angle was 1.59 W, 1.86 W, and 0.79 W. The results thus indicate that the segment of a circle shaped rotor has the highest power output among the three rotors types investigated. This rotor type has the highest coefficient of power of approximately 0.29 and highest tip speed ratio of 0.88 when the overlap ratio is 30% compared to that of semi-circular shaped rotor with the coefficient of power of 0.28 and highest tip speed ratio of 0.796**.** The respective values of the highest coefficient of power and the tip speed ratio for aerofoil shaped rotor with curved tip at arc angle of 135^{0} are 0.105 and 0.746. The overall results showed that rotor geometry has great significant effects on the aerodynamic performance of the wind turbine model.

Key words: Savonius rotor, power coefficient, tip speed ratio, overlap ratio.

INTRODUCTION

The continuous rise in the price of crude petroleum and the decrease in the crude petroleum deposit suggest the needs to intensify efforts on the study of the conservation of the available energy and the effective utilization of the renewable form of energy. With the consistent and intensified research over the last decades, the renewable sources of energy including solar energy, biogas generation using cow dung, green leaves, or human Waste, and the recent efforts on the utilization of the distillery effluent for the production of biogas, wind energy, etc, are finding greater applications in domestic and commercial uses (Pandey, 1994).
The experience in using wind power is not quite new. Wind power in the earlier days was the dominating source of mechanical energy in the agricultural societies in areas lacking convectional electrical power supply. In the ancient days, wind energy was extracted by windmill, called wind turbine, to generate power needed to mill and irrigate farmland (Baird, 1983; Pandey, 1994). Interest in the wind power as a supplementary source of energy for the production of power such as electricity has recently gained renewed momentum from the widespread concern about the environmental problems involved in the large-scale use of

fossil Fuels and nuclear energy. Moreover, recent events have suddenly drawn the attention of researchers to the importance of having energy resources that are both safe and freely available (Sayigh, 1992).

Different kinds of wind turbines are available with various modifications. The idea of the Savonius rotor was developed by a Finish Engineer, S.J. Savonius in 1920 (Bergeles and Athanassiadis, 1982). The Savonius rotor is a vertical axis wind machine that consists of two scoop-pattern blades with a gap at the central axis that are fitted between two end plates which catch the wind and cause the shaft to turn. The turbine relies solely on drag to produce the force that turns the shaft. Essentially, the device operates at least during parts of its rotation as a two-stage turbine, wherein the wind strikes on the concave side and is circulated through the centre of the rotor to the back of the convex side, thus decreasing what might otherwise be a high negative pressure region. Modi and Fernando (1989) reported that at low angle of attack, lift force also contributes to torque production, which means that Savonius rotor is a compound machine. It is accepted that vertical axis wind machines represent a suitable alternative for wind power extraction in many developing countries because of their simple construction, extreme cost effectiveness and their direction independence.

The aerodynamic performance of a Savonius wind turbine is much influenced by many design parameters such as the overlap ratio, gap size, aspect ratio, blade arc angle, blade shape factor, Reynolds number and the profile of the bucket cross-section (Kamoji et al., 2009a). Hence, there is the need to investigate the effects of some of these parameters. Many wind tunnel experiments or field tests have been done on the conventional and modified form of Savonius wind turbine. Mojola (1985) found out in his field test that conventional Savonius rotor with 25% overlap ratio gives maximum power coefficient. Modi and Fernando (1989) reported that the modified Savonius rotor with shaft has a maximum coefficient of power of 0.32 when tested in closed jet wind tunnel. The results of the experimental investigations carried out by Gupta et al. (2006) show that Savonius wind turbine with 20% overlap ratio has 0.21 coefficient of power at about 0.24 tip speed ratio, which is an improvement of power coefficient with the tip speed ratio.

Although many researchers including Alexander and Holownia (1978), Modi et al. (1984), Alexander and Holownia (1978), Tabassium and Probert (1987) and, Altan and Atilgan (2008) have worked on the performance evaluation of different rotor geometries, but the combined effects of both the geometry and the overlap ratio have not been studied. The main objective of the present study is thus to investigate the effects of the overlap ratio and the geometrical shape on the performance of the Savonius rotor using open wind tunnel. The aim thereby is to evaluate and compare the performance characteristics of the conventional Savonius rotor with the modified ones which are semi-circular- and segment of a circle-shaped rotors, and rectangular aerofoil with curved tip.

THEORETICAL CONSIDERATION

The theoretical power, *P*, in watts available in the air stream (Patel, 1999; Saha et al., 2008) can be determined from the expression

$$P = \frac{1}{2}\rho A v^3 \tag{1}$$

where ρ is the air density (kg/m^3), *v* is the wind speed (m/s), and *A* is the swept area of the turbine. The maximum theoretical efficiency, or Adolph Betz limit, is 0.593 (World Meteorological Organization, 1981). Thus for an optimum system at 100% efficiency, the maximum percentage of wind power which can be extracted from the wind is given as

$$P_{max} = 0.503 \rho A V_o^{3/2} \tag{2}$$

where P_{max} denotes power density, A the swept area of the turbine, v_o the initial wind velocity, ρ the ambient air density, and $\rho v_o^{3/2}$ the ambient power density per unit volume of the wind stream.

The tip-speed ratio, λ, is the ratio of the speed of the windmill rotor at radius R when rotating at angular speed ω (rad/sec) to the speed of the wind, v (m/sec). This is expressed mathematically as:

$$\lambda = \frac{\omega R}{v} \tag{3}$$

where $\omega = 2\pi N/60$ and N is the number of revolutions per minute. The expected power, P_e, for each rotor was calculated using

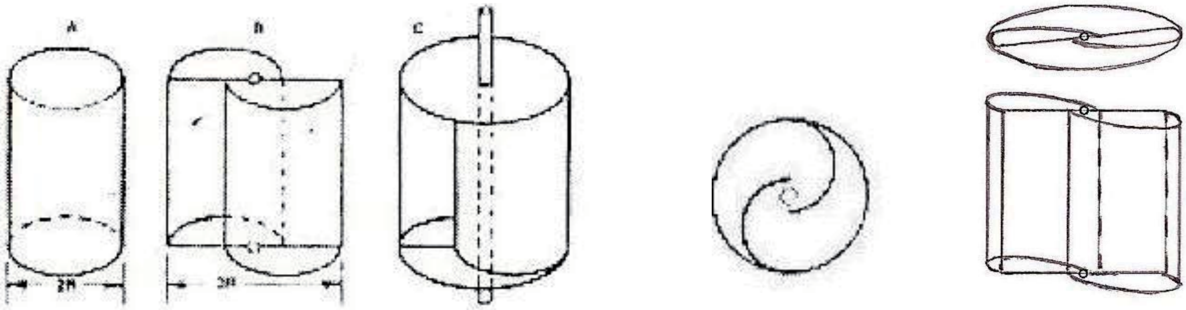
$$P_e = \frac{1}{2} c_p \rho A v^3 \tag{4}$$

where c_P denotes the coefficient of power. The air density was taken to be equal to 1.25 kg/m^3. The efficiency or coefficient of power, c_p, of the wind turbine is the ratio of the shaft power to the theoretical power or power available in the wind. The power, P, generated by the turbine can also be determined as the product of torque, T, and the angular speed from which the torque can be calculated:

$$T = \frac{P}{\omega} \tag{5}$$

RESEARCH METHODOLOGY

The data used for the design of the three Savonius rotor models in this work were based on the results of many researchers including that of Mojola (1985), Alexander and Holownia (1978), Modi and Fernando (1989) and Saha et al. (2008). Four different models each for both the semi-circular- and segment of circle-shaped Savonius rotor with overlap ratios of 0, 20, 30, and 40% and a rectangular aerofoil with curved tip were produced. The schematic diagrams of the models are presented in Fig. 1 and their various dimensional parameters in Table 1. All the models were subjected in a wind tunnel to a wind speed 5.0 m/s, which were



(a) (b) (c)

Fig: 1 Schematic diagrams of Savonius models used in the experiment: (a) semi-circular wind turbine model, (b) segment of a circle-shaped wind turbine model, and (c) rectangular aerofoil with curved tip.

Equipment and Instrumentation

The wind tunnel used in this work is of the closed working section, open-return type. The fan delivers air to a short diffuser of the constant pressure type containing three screens of 1.5 m^2,

and fitted with a smoothing screen. A contraction cone then leads to the working section, which has internal dimension of 457 mm x 457 mm. Static pressure tapings at the entrance to and exit from the contractor permit the air velocity in the working section to be calculated. The working section discharges direct to the atmosphere. This arrangement has the advantage that models are readily accessible and that the pressure in the working section is very nearly atmospheric so that sealing problems are absent. In addition, downstream of the working section a free jet of air is available which may be used, for example, for experiments on cascades.
A variable speed pulley is incorporated in the drive system which allows the fan to run between 470 and 1170 rev/min. The driving motor is mounted on an adjustable base, and by altering the position of the motor, the air speed in the tunnel is controlled. The maximum air speed in the working section is 33 m/s and the tunnel has acceptable level of turbulence, i.e. 0.5% fluctuation of the mean velocity.

Experimentation

Using rectangular thin sheets measuring 16 cm x 20 cm, models of Savonius wind turbine having the same swept area but different geometric configurations were fabricated. The first set of configurations have two semi-circular aerofoils with various overlap ratios ranging between 0% and 40% and the other set of configurations have various types of aerofoil shapes using the same size of the plate. In all nine models of the same surface area but different configurations and overlap ratios were used for experiment. To minimize the friction torque, the output shaft was supported on two ball bearings of low friction and the whole assembly was mounted on a wooden tower.
Experiments were carried out to determine the power, torque and angular speed, in the wind tunnel. The first step taken in the experiment was to determine the position of relative steady velocity from the exit along the axis of the wind tunnel. After this had been done each model was placed at this position and measurements of various parameters were taken.

Table 1: Size characteristics of Savonius rotor used in the experiments

Type of rotor	Characteristics parameter				
	Rotor Diameter, (cm)	Bucket Height, (cm)	Shaft Diameter, (cm)	Shaft Height, (cm)	Bucket Overlap ratio, (%)
Semi-circular shaped	25.40	16.00	0.10	50.00	0
	20.32	16.00	0.10	50.00	20
	17.32	16.00	0.10	50.00	30
	15.24	16.00	0.10	50.00	40
Segment of a circle shaped	30.40	16.00	0.10	50.00	0
	24.32	16.00	0.10	50.00	20
	21.28	16.00	0.10	50.00	30
	18.24	16.00	0.10	50.00	40
Rectangular aerofoil with curved tip	12.40	16.00	0.10	50.00	0

Measurement of wind velocity

The centreline of the wind tunnel facility which was used to generate wind in the laboratory was located. Test stations were established and marked along the centreline to determine the position where relative steady velocity would be obtained. A combination of the pitot-static tube and a manometer was set up on the positions marked and the scale multiplier on the manometer noted. The pitot-static tube was clamped on a tripod stand.

The difference between the total and static pressure was read on the manometer at the marked station (i.e. 210 cm from the exit of the tunnel), and was used to calculate the wind speed at that marked station. This process was also carried out using a digital anemometer. The flow velocities at various pressure difference values were evaluated with the aid of the following expression

$$v = \sqrt{\frac{2\rho_w g h}{\rho_a}} \qquad (6)$$

where g denotes the acceleration due to gravity, h the pressure head, ρ_a air density and ρ_w density of water.

Measurement of torque and speed of wind turbine

The rotor was mounted on a wooden tower and was placed at the marked position were the wind velocity had been measured. The rotational speed of the output shaft of each model was measured with the aid of a tachometer through a hole drilled at the centre of the shaft of the top. The readings were taken after a time sufficient for the rotor to have attained steady rotation. The torque of each model was measured with a specially designed Prony-brake dynamometer which was calibrated with a standard dynamometer of limited-ranged.

RESULTS AND DISCUSSION

Table 2 shows the experimental results for the three models at a wind speed of 5 m/s and overlap ratio ranging between 0 and 40%. It can be see n that the turbine geometric configuration has strong effects on its performance characteristics including the angular speed, tip speed ratio, torque, power and the coefficient of power. The optimum performance of the segment of a circle shaped and semi-circular shaped turbine occurs when the overlap ratio was 30% and 20% respectively. The optimum tip speed ratio, power, coefficients of power and torque measured for the segment of a circle shaped turbine are 0.8804, 1.8602 W, 0.288 and 0.3271 respectively, while the respective values for the semi-circular shaped turbine are 0.7968, 1.5895 W, 0.2781 and 0.349. The power and the coefficient of power obtained for the rectangular aerofoil with curved tip are respectively 0.7862 W and 0.1051. The present result which is an improvement on the power generated by the rotor and on the coefficient of power, also compared favourably well with those from many researchers. For example, Kamoji et al. (2009b) found out that the modified Savonius rotor with an overlap ratio of 0.0, blade arc of 124° and an aspect ratio of 0.7 has a maximum coefficient of power of 0.21 at a Reynolds number of 150,000 as compared with 0.19 for the convectional Savonius rotor.

It can also be seen from Table 2 that the segment of a circle shaped rotor has the best performance characteristics, followed by the semi-circular shaped rotor and the rectangular aerofoil with curved tip in that order. It is striking that the present results show that both segment of a circle shaped and conventional Savonius rotors produced better results than the modified Savonius rotor. Further results reveal that working with the overlap ratio greater than zero against the usual practice (2009a) may produce better result.

Table 2: Experimental results at air speed, v = 5.0 m/s

Type of rotor	Bucket overlap ratio, %	Angular Speed ω (rad/s)	Tip speed ratio, λ	Torque (Nm)	Power (W)	Coefficient of power, c_p
Semi-circular shaped	0	23.9488	0.6083	0.0422	1.0106	0.1591
	20	34.8570	0.7968	0.0456	1.5895	0.2781
	30	22.9640	0.4960	0.0318	0.7303	0.1353
	40	13.1234	0.2667	0.0077	0.1011	0.0199
Segment of a circle shaped	0	21.9309	0.6667	0.0459	1.0066	0.1324
	20	28.7829	0.7875	0.0459	1.3211	0.1931
	30	34.0695	0.8804	0.0546	1.8602	0.2880
	40	34.2654	0.8333	0.0169	0.5791	0.0952
Rectangular aerofoil with curved tip	0	24.8629	0.7459	0.0317	0.7882	0.1051

CONCLUSIONS

The segment of a circle and semi circular shaped rotors with overlap ratios of 0, 20, 30 and 40% the rectangular aerofoil with curved tip were tested in an open jet wind tunnel at a wind speed of 5 m/s. The rotors were fabricated with the optimum geometric parameters given by Modi and Fernando (1989). The angular speed and torque for the experimented models were measured and evaluated to determine other the performance parameters including the tip speed ratio, power and the coefficient of power. The results show that the segment of a circle shaped Savonius rotor at 30% overlap ratio performed better than all the other models with different geometric shape. More useful results may be obtained if further research is carried out on this model to determine, for instance, the effect of the aspect ratio and Reynolds number on the performance characteristics of the rotor.

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A STUDY OF THE EFFECTS OF SOME LOCAL WEATHER PARAMETERS ON THE THERMAL PERFORMANCE OF A SOLAR CONCENTRATING COLLECTOR

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Abstract

The effective and efficient performance of a solar thermal system depends primarily on the geometry and on the optical characteristics of the collector device and on the climatic conditions prevalent in the locality. The effects of some local weather parameters on the thermal performance of a 2.54 m^2 paraboloidal, multifaceted mirror solar thermal collector system which was set up and field tested in Ogbomoso, a town located in southwestern Nigeria on $8^{\circ}7'$ North of the equator and $4^{\circ}16'$ East of the Greenwich meridian, were investigated. The experiments were conducted between April and May, 2009 under varying weather conditions with the measurement of irradiance, windspeed and the ambient temperature taken at every 30 minute time interval between 8.00 and 16.00 hours of the day. The modified form of the Hottel-Whillier-Bliss equation was used with some other governing equations to compute the heat gain, heat loss and the efficiency. The findings show that the system thermal efficiency in the neighbourhood of 59.0% and receiver aperture temperatures of about $600^{\circ}C$ are attainable on a hot and sunny day, while a cool and cloudy day produced respective values of 59.75% and $34^{\circ}C$. The rate of useful thermal energy of about 11.7 kW_{th} was obtained from the system on a windy day. Further results show that there is a reduction in the solar radiation and also the useful heat and thermal efficiency as a result of the increase in the percentage cloud cover. The effects of the changes in the windspeed on the useful thermal energy and efficiency appear irregular. An increase in the ambient temperature leads to a corresponding increase both in the useful heat and the thermal efficiency while these reduce with an increase in precipitation. The efficiency of the parabolic dish receiver system likewise is directly affected by the thermal losses taking place from the open shell receiver.

Keywords: Thermal Performance, paraboloidal dish solar collector, useful thermal energy, climatic factors

INTRODUCTION

Solar energy concentrating collectors have the advantage of higher temperature delivery for better thermodynamic efficiency, reduced losses due to reduced absorber area, reduced cost as well as possibility of attaining higher temperatures. They are useful for medium (100-250^{o}C) and high (250-over1000^{o}C) temperature applications like generation of electricity using Stirling engines, supply of process heat and steam, domestic cooking activities and some metallurgical operations. Up to 3,500^{0}C has been achieved with such systems (Garg and Prakash, 2002). The parabolic dish solar concentrating collector is one of the compound curvature solar systems that focus incident radiant energy to a target point where an absorber, heat exchanger or boiler is placed. It is the most efficient of all solar technologies having efficiency that is approximately 25% compared to other solar thermal technologies with efficiency of about 20% (A.I.E., 2007). Its geometric shape is defined by rotating a parabola about its optical axis. Owing to its circular symmetry, a point image of parallel beam of light is produced, though in practice, a larger focal point is obtained as a result of imperfections in the shape, unevenness of the reflecting surface and the finite angle subtended by the sun (Lovegrove and Dennis, 2006). Parabolic dish concentrators receive beam radiation hence needs to track the movement of the sun. A receiver placed at the focus receives and transfers the thermal energy to a fluid, which becomes a pressurized vapour and can be used to drive a turbine. It could as well be used as an energy source for a furnace, cooker, steam generator and so on.

The application of solar energy conversion systems in a particular locality depends largely on the weather conditions of the area and the intensity of solar radiation (Lovegrove *et al.*, 2003). The insolation reaching the solar collector aperture depends, among other things, on the atmospheric conditions. If the sky is generally cloudy, or the air particles, water vapour, aerosols, dust and other substances flying in the air are of higher percentage, the irradiance that would be reaching the collector would be affected and turn out to be majorly diffuse. Extensive studies have been carried out to investigate the effect of local weather conditions on the performances of solar devices. Guoying et al. (2009) investigated the effect of the local weather condition on the performance of a direct expansion solar-assisted heat pump (DX-SAHP) in Nanjing, China. The results show that the pump was efficient on a sunny day with relatively good insolation but on cloudy or rainy days, it releases little heat from the condenser for water heating. Adsten et al. (2001) investigated the influence of climate and location on solar collector performances. Three different locations in Sweden were thereby investigated: Lund (55.7^{o}N), Stockholm (59.3^{o}N) and Luella (65.6^{o}N). It was discovered, among other things, that the collector output was strongly influenced by the variations of the solar radiation with the longitude and less influenced by the variations of the ambient temperature during operation. Likewise Lund (1985) studied the effect of weather on the thermal performance of solar hot water system in Finland (60^{o}N). He found that the thermal performance varied ±25% from the average based, of course, on changing weather conditions. Anderson and Furbo (2008) also looked into the influence of weather variations over years on the thermal performance of solar heating systems and solar collectors in Danish climatic conditions using measured weather data and weather data from the Design Reference Year (DRY). They also observed that solar collectors are strongly influenced by the weather and collector mean fluid temperature and that the efficiency of the solar collector increases as the heat loss reduces in less sunny years.

The effect of a parabolic dish structure on the wind near a cavity receiver was investigated by Paitoonsurikarn and Lovegrove (2006). Using a 20 m^2 dish in Australian climatic conditions, the incidence angle was varied azimuthally from 90^0 east to 90^0 west corresponding to the wind which is normally incident on the back of the receiver and the back of the dish. It was discovered that the near- aperture velocity of the wind is the greatest when the incident angle is 0^0 i.e. when the wind is parallel to the aperture plane. Hamad (1988) tested a cylindrical solar parabolic concentrator in Basrah, Iraq in winter and summer seasonal weather conditions. He discovered that the performance of the collector depends mainly on the water mass flow rate and that the weather parameters of solar radiation intensity and air temperature have little effect on its efficiency. Salawu and Asere (2003) studied the performance of a compound parabolic solar cooker under varying weather conditions of Bauchi, Nigeria. They were able to observe that contrary to affirmations that the dry and dusty weather prevalent in the locality makes solar energy inapplicable, the solar-thermal system can still be utilized for domestic cooking operations. Likewise Nasir (2004) designed, constructed and tested a cylindrical parabolic trough solar air-heater in Minna, Niger state Nigeria. He also observed, among other things, that the results gotten were affected by the local weather conditions such as the harmattan haze and dusty sky. The contradictory results obtained so far suggest the need for more experimental work on solar energy devices in Nigeria, where available data are still very scanty. It is the intention of this work to study the effect of some local weather parameters including precipitation, the cloud cover, the irradiance, the relative hotness or coolness of the day and the windspeed on the thermal performance of the solar thermal parabolic dish collector in Ogbomoso which is located in the southwestern township Nigeria.

RESEARCH METHODOLOGY

The experimental work was carried out at the campus of the Ladoke Akintola University of Technology (LAUTECH), located at the northern part of Ogbomoso, Nigeria. The area is located on latitude $8^o7'60''$ N and longitude $4^o16'0''$ E and is 341 m above sea level with a relatively high insolation. The test rig comprised a paraboloidal dish solar concentrator with a comparatively high rim angle with its focus located above it (Fig. 1). It comprises the parabolic dish aperture, the receiver, the tracking mechanism and the supporting structures. The dish aperture is based on a network of 3/5 square rigid steel members firmly fitted together using bolts and welds. The entire rig is permanently fixed to the ground. The dish had been constructed to allow for both manual horizontal and the vertical tracking using a system of bolt and nut.

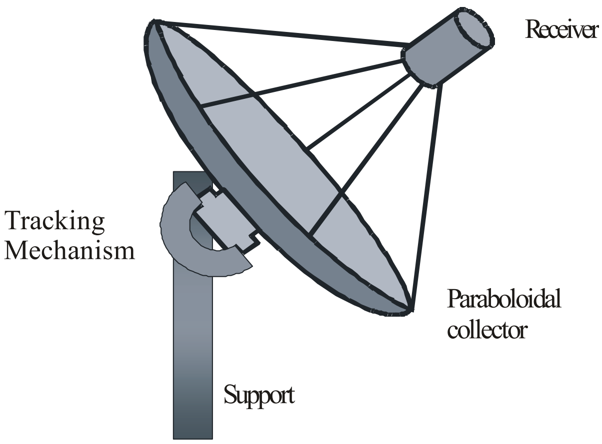

Fig. 1: The experimental rig showing parts of the paraboloid solar concentrator

The parabolic dish has a diameter of 1.80 m and an area of 2.54 m^2 and a depth of 0.215 m deep. The focal length of the dish aperture was determined to be equal to 0.942 m and the rim angle of the dish apparatus is 51.07^0. The aperture was made up of segmented mirror pieces. Around ninety-eight thin, low-iron back silvered mirror pieces of varying quadrilateral dimensions were attached to the dish frame to make its area. The width of the glass mirrors were 3 mm and the reflectance of typical back silvered glass is 0.94± 0.02 (Goswami *et al.*, 1999). The geometry of the dish receiver is more like a short cylinder with hemispherical closed ends. Its diameter is 0.195 m while its height is 0.175 m. The radius of its hemispherical ends is 0.0975 m while the thickness is 0.003 m. The receiver aperture area, which is that part that receives the reflected irradiance, is 0.02986 m^2. The receiver is made of steel and is coated with black paint. The receiver was incorporated with a valve, to allow for the passage of water and a pressure gauge of 15-bar rating for measuring the receiver internal pressure. The geometric concentration ratio of the collector, is approximately equal to 85.

Experimental set-up and procedure

A 1.6 mm nichrome-chromium ground thermocouple together with a digital readout was employed to measure the outer receiver temperature. The digital readout was a XMTA digit display temperature controller with 1.0 precision and having the ability to readout temperature up to 1,600^{o}C. A pressure gauge with calibration in bars was acquired for measuring internal receiver steam pressure. A HERMES thermometer of calibration 0-110 ^{0}C was used to measure the ambient temperature. The paraboloidal reflector aperture was fixed using a network of steel members with bolts and nuts, which helps both to stabilize the face of the dish and to track the sun. The shell receiver was fixed on a rigid stand and set in a way that the reflected energy from the sun impinges upon it. The nichrome-chromium thermocouple was fixed to the lower half of the receiver and it was connected to the digital readout device. A pressure gauge was connected to the top of the receiver shell, which was filled with a litre of water. The paraboloidal dish aperture was aligned to the incident direct solar irradiance. This was done to eliminate any uncertainty due to off-normal incidence angle effects. Data were taken at every ten-minute time step between 10 am and 4 pm daily of the experimental day. Tracking was done manually through azimuth and elevation. The solar thermal system was tested under varying weather conditions towards the end of the long harmattan season of year 2008/2009.

Numerical simulation

The results gotten from the experiment were analysed to obtain useful parameters including heat transfer and efficiency of the solar system for the different local weather conditions.

Useful heat

A modified form of the Hottel–Whillier–Bliss equation was used to determine the useful energy gotten.

$$Q_{useful} = \eta_{opt} I_b A_a - \left[\left(\varepsilon A_{shell} \sigma \left(T_{rec}^4 - T_{amb}^4\right)\right) + UA_{rec}\left(T_{rec} - T_{amb}\right)\right] \quad (1)$$

where A_a is the aperture area, A_r the receiver area, η_{opt} the optical efficiency, σ the Stefan Boltzmann's constant, ε the surface emissivity of the receiver shell, A_{shell} the area of the entire shell, A_{rec} the area of the receiver, T_{rec} the receiver aperture temperature, T_{amb} the ambient temperature and I_b the beam/direct irradiance.

Optical efficiency

The optical efficiency was determined using the expression

$$\eta_o = \tau_r \, \rho_m \alpha_r f_r \delta(\psi_1, \psi_2) \quad (2)$$

The values of the optical parameters obtained from models and estimated from tables (Goswami *et al.*, 1999; Stine and Geyer, 2001) are the reflector aperture transmittance τ_r which is 0.92, mirror reflectance ρ_m which is 0.94, receiver absorptance α_r which is 0.96, fraction of the aperture not shaded by supports, and absorber f_r which is 0.9, intercept factor (product of the mirror slope errors ψ_1 and solar beam spread ψ_2) $\delta(\psi_1, \psi_2)$ which is 0.8. The computed optical efficiency η_{opt} was 0.59775.

Overall heat transfer coefficient

The overall heat transfer coefficient was computed as

$$U = \frac{1}{\left[l/k + 1/h\right]} \quad (3)$$

where *l* is the thickness of the cylindrical shell, which is 3 mm, *k* denotes the thermal conductivity and *h* the convective heat transfer coefficient.

Overall thermal efficiency

The overall thermal efficiency was calculated using the equation

$$\eta = \frac{Q_{useful}}{I_b A_a} \qquad (4)$$

Q_{useful} was determined by using the equ. (1), A_a is the aperture area of the collector which is 2.54 m^2 and I_b is the solar irradiance falling on the collector aperture gotten from measured data.

Heat loss measurements

Heat loss from the receiver was mainly through convection and radiation and also partly through conduction from the receiver insulation (or supports). The expression for the combined heat loss is

$$Q_{loss} = \left[\left(\varepsilon A_{shell} \sigma \left(T_{rec}^4 - T_{amb}^4\right)\right) + UA_{rec}\left(T_{rec} - T_{amb}\right)\right] \qquad (5)$$

RESULTS AND DISCUSSION

The data obtained from the experimental study of the parabolic dish solar collector under different local weather conditions were analysed using equations (1) – (5) to determine the instantaneous useful heat gained and lost, and the instantaneous efficiencies.

Fig. 2 is a plot of the graph of the temperature obtained at the receiver aperture of the concentrating collector against the solar time for different weather conditions considered. From the figure it can be seen that for every weather condition except that for the cool and cloudy day, the temperature increased from morning hour to a maximum value at about midday and then decreased as the day sets. The highest temperature attained on a less windy day was 653°C at 12:00 hours, 612°C on a hot sunny day, 606°C on a day with clear sky, 437°C on a day with evening rain, 354°C on a windy day. The highest temperature attained on a cool, cloudy day was 32°C at around 11:30 hours. This was as a result of the stratus clouds that made the sky totally overcast all through the day. It can be inferred from the figure that the level of clearness of the sky, the precipitation of the locality and the level of hotness or coolness of the environment has significant effect on the receiver aperture temperature.

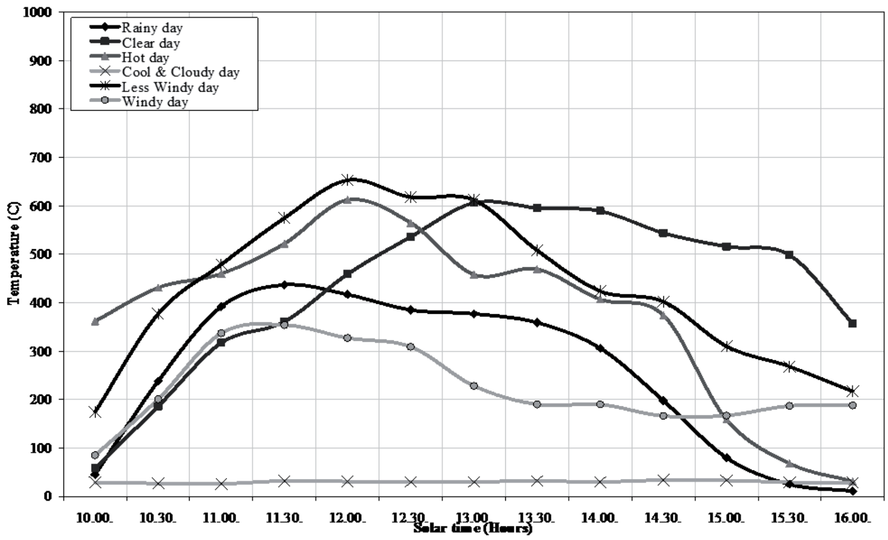

Fig. 2: Temperature of the collector under varying weather conditions

Fig. 3 shows the instantaneous useful heat obtained for the various weather conditions. The useful heat obtained at the receiver decreased from the morning hours to a minimum value at mid-day for all the weather conditions except for the situation on a cool and cloudy day. This was followed by a steady increase in the estimated useful heat till a solar time of between 15.00 and 15.30 hour before it began to reduce as the day set. The curves show that the highest heat lost occurred at about mid-day as can be seen in Fig. 4. The estimated value of the maximum useful heat on the clear day was 1136 W at 11.00 hour, 1125.74 W on the windy day at 10.30 hour, 1032 W on the rainy day at 10.30 hour, 1041 W on the hot day at 15.30 hour, 966.68 W on a less windy day at 15.00 hour, and 536.24 W on a cool, cloudy day at 12.30 hour. The corresponding highest overall heat loss was 780 W at 12.30 hour on the less windy day, 682 W at 13.30 hour on the clear day, 646.17 W at 12.00 hour on the hot day, 560 W at 11.30 hour on the day with evening rain, 219 W at 11.30 hour on the windy day, and 14 W at 11.00 hour on the cool, cloudy day. The total useful heat measured on a windy day was 11.94715 kW, which was the highest of all the values of the useful heat obtained for the different weather conditions considered buttressing the trend results presented in Fig. 2. It was expected that high winds speed have effect on the heat loss, but contrary results were obtained in this work which show that the heat loss by radiation predominate the convective heat loss in the concentrating collector set-up. It can clearly be seen that the level of cloud cover of the sky affects the total heat loss as can be observed from the curve for the cool and cloudy day.

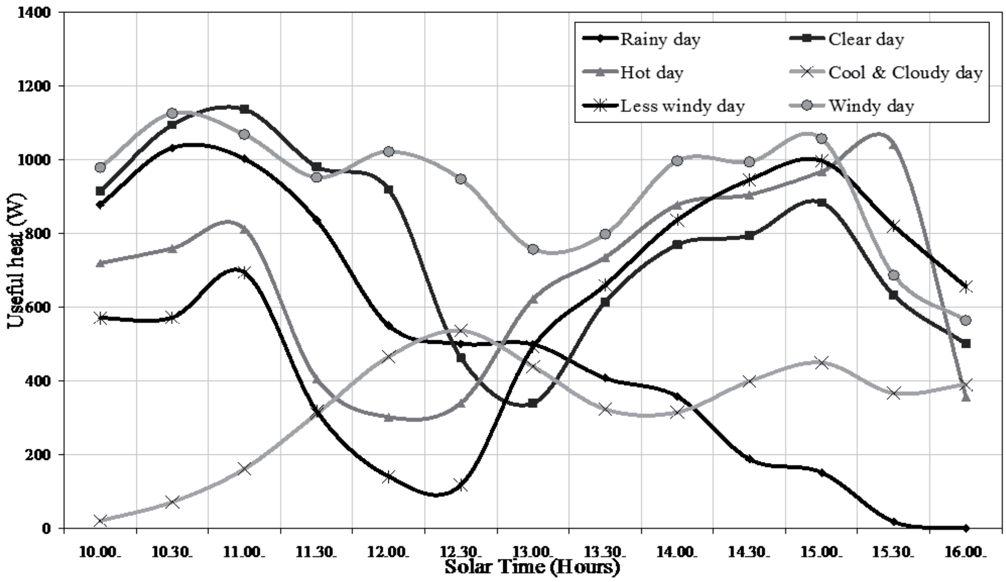

Fig. 3: Useful heat of the collector under varying weather conditions

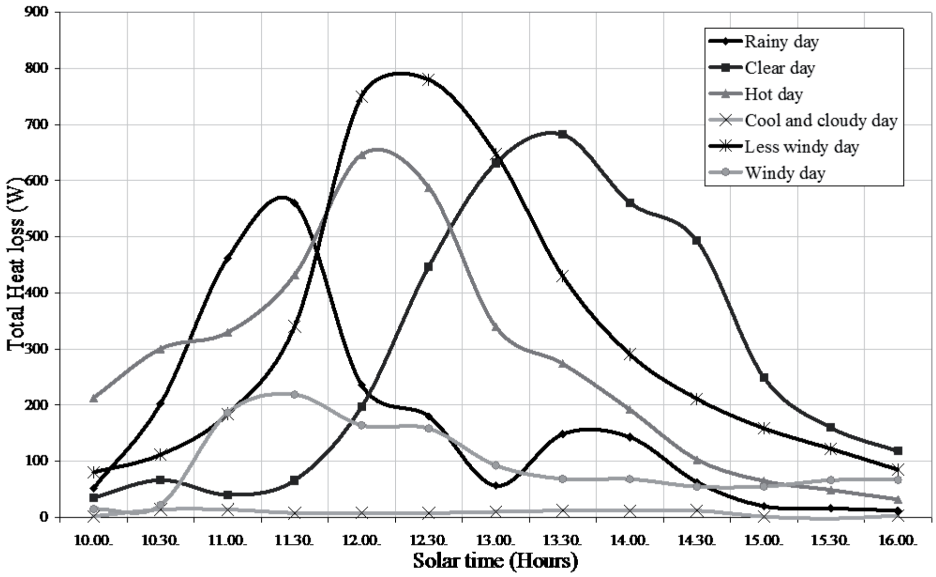

Fig. 4: Total heat loss of the collector under varying weather conditions

The efficiency trends of the system under different weather conditions are depicted in Fig. 5 which have the same pattern with that of the useful heat - declining as it approached mid-day and then ascending again as the day sets. The condition with the highest system efficiency was for the cool, cloudy day with maximum efficiency of 59.75% at 16:00 hour. Minimum efficiency of 0.87% at 12.30 hour was obtained on the less windy day. The graph shows that the efficiency of the concentrating collector depends largely on the useful heat obtained and the level of solar radiation coming upon it.

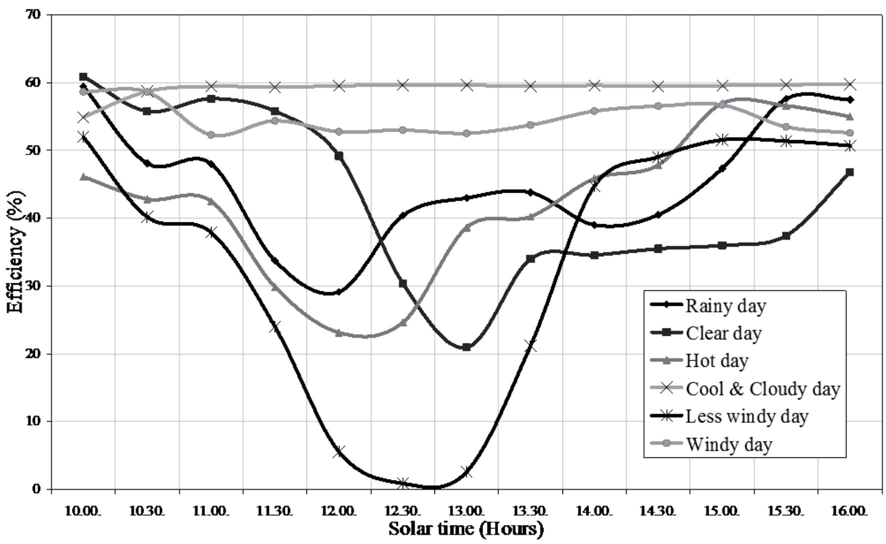

Fig.5: Efficiency of the collector under varying weather conditions

CONCLUSIONS

The experimental investigations on the thermal performance of a parabolic dish solar thermal system of 2.54 m^2 aperture and of concentration ratio of 85 were carried out in outdoor field conditions in Ogbomoso, southwestern Nigeria weather conditions. The experimental results were analysed with the aid of some analytical computations, to determine some useful parameters.

The findings from the study show that the system thermal efficiencies in the neighbourhood of 60% and receiver aperture temperatures reaching over 600 ^{0}C were attainable on a hot, sunny and also on a windy day, while a cool and cloudy day produced lesser values. The rate of useful thermal energy of about 11.9 kW_{th}, which was the highest daily value, was obtained from the system on a windy day. The total heat loss values were highest at mid-day and this made the useful heat values to be at their lowest at that time. The local weather factor of solar radiation directly affects the temperature obtained at the receiver and hence the useful heat, heat loss and efficiency. This is also determined by the cloud cover at the location as well as other factors such as the percentage water vapour, aerosols, dust, smoke and other substances and gases in the atmosphere.

The dominant factor in the total heat loss value for the collector receiver may not be the wind induced convective heat loss factor but the radiation factor which shoots up exponentially with increasing temperature. The increased temperature was directly affected by the solar radiation and the level of sky clearness. The level of hotness/coolness of the day also had considerable effect on the collector performance. Likewise the precipitation of the locality reduces the temperature obtained at the receiver to almost zero. These have all supported the views of other authors (Hamad, 1988; Paitoonsurikarn and Lovegrove, 2006) that thermal performances of solar collector systems are generally influenced by weather variations which are mainly the level of clearness and cloudiness of the sky. Further work can still be done to determine the weather effects on the reflectivity of the collector surface and the prediction of the thermal performance on a yearly basis

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NOMENCLATURE

A_a	Collector aperture area
A_{rec}	Receiver area
A_{shell}	Shell area
f_r	Fraction of aperture not shaded by supports and shade
h	Convective heat transfer coefficient
I_b	Beam/Direct irradiance
k	Thermal conductivity
Q	Quantity of heat
T_{amb}	Ambient temperature
T_{rec}	Receiver Temperature
U	Overall Heat Loss Coefficient

GREEK SYMBOLS

α_r	Absorptance
δ	Intercept factor
ε	Emissivity
η	Efficiency
η_{opt}	Optical efficiency
ρ_m	Mirror reflectance
σ	Stefan Boltmann constant

τ_a Aperature transmittance
ψ_1 Mirror slope error
ψ_2 Solar beam spread

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SIMULATION OF THE HOUSEHOLD ENERGY AND EXERGY CONSUMPTION TREND

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Abstract

The critical energy situation in Nigeria suggests the need to study energy and exergy utilization in the households with the aim to pinpointing areas of wastages and proffer measures for effective and efficient utilization of the scare resource. The household energy and exergy consumption trend is thus simulated in this work by considering 125 homes randomly chosen in Ibadan, a city located in the southwestern part of Nigeria. The energy flow for the period of the first three months in the year 2009 in each of these households was determined using both the primary and secondary data. A quantitative and qualitative breakdown of the energy degradation utilized in the appliances used in the household was estimated by using the appropriate exergy analysis. The results show that the average efficiency of the household energy and exergy utilization is 62.5 and 21% respectively. The large difference between these efficiencies is due to the energy degradation. Further results revealed that about 32% of the total exergy losses are caused by refrigerator and freezer, and 30% by air conditioner. About 16.2% of the losses are due to lighting from bulb, 5% to ironing, 3.67% to florescent light, while all other appliances accounted for less than 2%. The results of the work have demonstrated the effectiveness of the exergy analysis over the energy study for the evaluation and the location of energy degradation in a system. The results of this work can serve as a guide and baseline data for policy makers in the country on sustainable energy policy measures that would reduce energy losses at household level.

Keyword: Energy, Exergy, Efficiencies, Appliance, Household.

INTRODUCTION

The degree of household appliance energy consumption represents the state of the welfare as well as the state of the economic development in any nation. It is therefore important to make sure that our home is as energy efficient as possible. Although, there are wide ranges of energy efficient appliances used nowadays, the poor utilization of energy resource as regards household energy consumption requires proper energy analysis. Energy degradation due to the poor energy utilization is becoming alarming in every sector of the society and for this reason a clear understanding of energy loss is currently an issue of discussion among various researchers from different part of the world (Saidur et al., 2007; Rosen, 1992; Ertesvag and Mielnik, 2000; Ozdogan and Arikol, 1995; and Xi and Chen, 2005). Report has shown that greater proportion of energy utilized in a country or society is apportioned to the household energy consumption (Saidur et al., 2007). It is therefore important to investigate how effectively and efficiently a society manages her energy resources as regard household energy consumption.

Energy is lost in our homes during the process of energy transformation that are taking place. The question on how, when, and where the energy lost occurs is mostly based on the first law of thermodynamics. The first law concept explained that the energy involved in any transfer must be conserved, i.e. energy is neither created nor destroyed but is transferred from one form to another. This would seem to mean that energy usage is endless and energy is never lost irrespective of the process condition. The problem is that this is not the only law that governs energy transfers. While the total amount of energy does not change, the second law of thermodynamics limits the amount of usable energy that can be transferred. One of the consequences of this law is that the total amount of usable energy that comes out of any process will be less than the total amount of energy that went into the process. The difference between the total amount of energy input and the usable energy output is expended as Waste heat. This is an implication that the second law analysis can better and accurately pinpoints the location of the inefficiencies, and therefore can be used to optimize the performance of household appliances (Dincer and Rosen, 2007). In addition, second law analysis which is also referred to as exergy is strongly related to sustainability and environmental impact. Consequently, the application of exergy methods will result in very little energy wastage and reduce environmental impact, with improved sustainability.

The importance of exergy analysis has grown dramatically in recent years due to the global environmental issues, and the widespread recognition of the need for sustainable environment. The usefulness of exergy analysis has demonstrated technological and educational information for individuals or organizations seeking understanding on the techniques, and technologies related to the residential, transport, commercial and industrial energy efficiency. It provides a linkage between the physical and engineering world and the surrounding environment, and expresses the true efficiency of engineering systems and sectoral energy analysis of the countries. Exergy analysis has also recognized the awareness of energy degradation in the residential sector, regions and countries (Dincer et al., 2007; 2004a). It thus encourages the need to take a closer look of how energy is degraded in our society**.** Exergy analysis has remarkably demonstrated its usefulness in the analysis of various energy systems. Waheed et al. (2008), Al –Muslim et al. (2005), Cerci (2002), etc., have demonstrated the application and effectiveness of the use of energy and exergy analysis to various systems. The thermodynamics characteristics of energy systems are usually investigated to assist in improving their performances. The concept of exergy analysis has been accepted as a powerful thermodynamics tools for identifying losses, destructions or inefficiencies of energy systems (Cornelissen, 1997; and Leyla et al., 2005). Mehmet et al. (2007) and Dincer and Rosen (2007) reported that the exergy concept of a system analysis is a useful thermodynamic tool which helps to determine the true magnitude of losses, their causes, locations, and the improvement of the overall energy systems. A number of applications of energy and exergy analysis to homes or residential sectors have shown its effectiveness. Asada and Takeda (2002) worked on the ceiling radiant cooling system and found out that cooling with well water is not exergy efficient because of the relatively large electricity consumption by pumps. Rosen et al. (2001) expressed the opinion that one major weakness in energy account in building is the lack of using the second-law analysis. Saidur et al. (2007) applied the concept to the residential sector of Malaysia and were able to identify the major causes of energy losses in the appliances used in homes. The concept has also been applied to residential sectors of many countries such as Japan, Finland and Sweden (Wall, 1990), Italy (Wall et al., 1994), Norway (Ertesvag and Mielnik, 2000), Turkey (Ozdogan and Arikol, 1995), China (Xi and Chen, 2005), Canada (Rosen, 1992), USA (Reistad, 1975) and Saudi Arabia (Dincer et al., 2004b).

Despite the significance of the concept of exergy analysis to the residential sector of various countries, to the best of the authors' knowledge, exergy method has not been applied to the study of energy degradation in the residential sector of Nigeria. As a means to close this gap, a study has been carried out to simulate the energy and exergy of 125 households in Ibadan, a city located in the southwestern part of Nigeria. The study is expected to give a clear perception of energy consumption pattern and degradation in this part of the Nigerian society. It is also anticipated that the study will provide the policy makers in the country with the knowledge on how efficiently the country utilizes its energy resources which will guide in the formulation of energy policy measures that would reduce energy losses at household level.

ANALYSIS AND METHODOLOGY

Data were sourced with the aid of questionnaires for the survey of the usage of various household Fuels. The questionnaires were administered to different households for a period of three month in order to examine detailed information on energy consumption and factors relating to pattern of energy usage. The information considered includes electricity and fossil Fuel sources available to households, supply and demand characteristics of these sources (the quantities consumed), and the energy services derive from the Fuels and electricity sources that were consumed. Staffs of the district planning office (LGA), the department of energy and other energy stakeholders were interviewed to gain insight into the past and current trend of energy data available. Furthermore, focus group discussions were used to collect data in the study area. The data collection instrument helped unveil emerging issues in the areas of energy consumptions.

The questionnaire comprises two sections, the first section enquires about information of the general kind. Information sought included demographic description of the neighbourhood, the type of the house, family size, number of rooms, income level of the household and commercial venture being run in the household. The second section of the questionnaire was further sectioned into eight sub-sections. The first five sub-sections of the questionnaires were on the use of electricity, liquefied petroleum gas (LPG) and kerosene. Here, attempts were made to get respondents to reveal the quantity and sources of each of these Fuels that the household may be using, the period of its use, the purpose of its use, the methods employed in using it and any problem they encounter in using each of these Fuel types. The last three sub-sections of the questionnaire were on a survey of other energy sources that generally make little contributions to the overall household energy budget. The approach here was to get respondents to reveal the quantity used, the frequency and the purpose of usage.

Applications of exergy analysis

In this section, the methods used to estimate the energy and exergy consumption are described. Data collected are analyzed base on the factor relating to appliance utilization hours, ownership level and power rating. These parameters were extracted from the questionnaire and are outlined below:

Appliance utilization period

It is the duration of usage of each appliance. To evaluate the total energy used by the household appliances, the duration of an appliance operation is determined. Hourly usages of each appliance were collected. The average usage duration was calculated.

Appliance ownership and power rating

The number of each known appliances in every household is a measure of appliance ownership, while the power rating is a measure of the required amount of power that can be used to operate a specific device or appliance. The power rating, in Watts, indicates the rate at which the device converts electrical energy into another form of energy, such as light, heat, or motion. Different types of appliances and brands (i.e. two or more refrigerators of the different model or brand) operate on different power ratings. But appliance of the same type operates in an average range of 120–550 W. This trend can be observed in appliances such as washing machine, air conditioner, and television. Therefore, it is appropriate to find out the power rating of appliances along with the ownership level.

Overall energy used

The main sources of energy in the region can be categorized into fossil Fuel and electricity. The main source of energy for electrical appliance is power from the national grid while non-electrical cooking appliance uses energy from fossil Fuel. The overall energy consumed from each sources of energy is evaluated as follows:

Electrical energy used by appliances.

The electrical energy, A_e, used over a period of time depends on the power rating, number of appliance and length of time in hour the appliance was used. This can be determined using the following formula:

$$A_e = N_a \text{ x } P \text{ x } t \qquad (1)$$

where N_a is the number of appliance, P the Power rating of appliance in Watt, and t the duration of an appliance usage in hours. The sum of energy used by all appliances for a year can be calculated using the following equation

$$A^n = \sum_{i-1} A_{ei}^n \qquad (2)$$

where A^n represents the energy consumed by all appliances for the year n and A_{ei}^n the energy used by an appliance i for the year n.

Fossil Fuel energy used by appliance

The overall energy generated from fossil Fuel was obtained by multiplying the total mass or volume of Fuel consumed per day, m_f and their corresponding heating value, C_f.

$$E_F = C_f m_f \qquad (3)$$

Energy and exergy efficiency analysis

The appliance energy-exergy efficiency are evaluated based on the methodology described by Utlu and Hepbasli (2003), Dincer et al. (2004b) and Saidur et al. (2007). The operating data used for the evaluation of appliance energy and exergy efficiency are presented in Table 1.

Table 1: Energy and exergy efficiency, product and reference temperatures of different types of appliances

Appliance	η_e (%)	T_p (K)	T_o(K)	ψ_e(%)
Florescent Light	20			18.5
TV	80			80
Fan	80			80
Iron	98	432	300	30
Refrigerator-Freezer	60	265	300	7
Electric cooker	80	382	300	17.2
Washing machine	80			80
Bulb	25			25
Hi-fi	70			70
Blender/Mixer	80			80
Vacuum cleaner	70			70
Toaster	98	432	300	30
Electric Kettle	90	341	300	10.8
Hand phone charger	70			70
Hair dryer	70			70
Air conditioner	60	287	300	4.09
Personal computer	70			70
Microwave oven	70			70
Water heater	90	323	300	2.54
Electric stove	98	324	300	7.3
Electric gate	80			80
Electric water filter	70			70
VCD/VCR/DVD player	70			70
Cooking appliances (LPG)	65	393	300	14.88

Source : Saidur at al (2007) and Utlu and Hepbasli (2003)

The energy efficiencies, and the process and reference-environmental temperatures are assumed to be the same as those used by Reistad (1975) and Rosen (1992). However, it has to be noted that the exergy efficiency of cooking appliance are calculated using the following known values: energy efficiency η_f = 65%, reference temperature, T_0 = 300 K, product temperature = 393 K.

The energy efficiency, η, is defined as

$$\eta = \text{energy in products}/\text{total energy input} \quad (4)$$

and the exergy efficiency, ψ, as

$$\eta = \text{exergy in products}/\text{total exergy input} \quad (5)$$

The energy efficiency for electrical heating, $\eta_{h,e}$, is defined in terms of the reference temperature, T_o, product temperature, T_p, product heat, Q_p, and electrical energy, W_e, as:

$$\eta_{h,e} = [1-(T_o/T_p)]Q_p/W_e \quad (6)$$

And the exergy efficiency for electrical heating, $\psi_{h,e}$, as

$$\psi_{h,e} = [1-(T_o/T_p)]\eta_{h,e} \quad (7)$$

The energy efficiency for Fuel heating, $\eta_{h,f}$, is determined from the expression:

$$\eta_{h,f} = Q_p / m_f C_f \qquad (8)$$

and the exergy efficiency for Fuel heating, $\psi_{h,f}$, as:

$$\psi_{h,f} = [1 - (T_o / T_p)]\eta_{h,e} \qquad (9)$$

The weighted mean overall energy and exergy efficiency were determined by following the three steps discussed as follows.

Step 1

The overall weighted mean for electrical energy efficiency is evaluated by using the weighing factor, which is the ratio of electrical energy input to the total electrical energy input to all the appliances (Saidur et al., 2007):

$$M_{\eta e} = \frac{\sum e_{app(i)}\ \eta_{app(i)}}{\sum e_{app(i)}} \qquad (10)$$

where M_{η_e} is the weighted mean electrical energy efficiency, $e_{app(i)}$ the appliance's energy consumption, and $\eta_{app(i)}$ the appliance's energy efficiency. Similarly, the weighted mean for the electrical exergy efficiency is defined as:

$$M_{\psi e} = \frac{\sum e_{app(i)}\ \psi_{app(i)}}{\sum e_{app(i)}} \qquad (11)$$

where $M_{\psi e}$ denotes the weighted mean electrical exergy efficiency and $\psi_{app(i)}$ the appliance's exergy efficiency.

Step 2.

The overall weighted mean for fossil Fuel energy efficiency is evaluated following the definition of the weighted mean for electrical energy efficiency

$$M_{\eta f} = \frac{\sum C_{app(i)}\ \eta_{app(i)}}{\sum C_{app(i)}} \qquad (12)$$

where $M_{\eta f}$ is the weighted mean fossil Fuel energy efficiency, $C_{app(i)}$ the cooking appliance's energy consumption and $\eta_{app(i)}$ the appliance's energy efficiency. The weighted mean for fossil Fuel exergy efficiency is defined similarly as

$$M_{\psi f} = \frac{\sum C_{app(i)}\ \psi_{app(i)}}{\sum C_{app(i)}} \qquad (13)$$

where $M_{\psi f}$ is the weighted mean fossil Fuel exergy efficiency and $\psi_{app(i)}$ the appliance's exergy efficiency.

Step 3

The overall weighted means of energy and exergy efficiencies for electrical and fossil Fuel processes are evaluated. The weighting factor is defined as the ratio of either the total electrical or fossil Fuel energy input to the total energy input. The weighting factor for electrical energy is thus determined using the expression:

$$Wm_e = \frac{\sum E}{\sum E + \sum F} \qquad (14)$$

where Wm_e is the overall weighting factor for electrical energy, $\sum E$ the overall electrical energy consumption, and $\sum F$ the overall fossil Fuel energy consumption. The weighting factor for fossil Fuel is similarly evaluated using the expression:

$$Wm_f = \frac{\sum F}{\sum F + \sum E} \quad (15)$$

where Wm_f is the overall weighting factor for electrical energy. The overall weighted energy efficiency is thus given as:

$$O_{\eta_e} = \left(M_{\eta e} \text{ x } Wm_e\right) + \left(M_{\eta f} \text{ x } Wm_f\right) \quad (16)$$

where O_{η_e} is the overall energy efficiency. The overall weighted exergy efficiency is given similarly by:

$$O_{\psi e} = \left(M_{\psi e} \text{ x } Wm_e\right) + \left(M_{\psi f} \text{ x } Wm_f\right) \quad (17)$$

where O_{ψ_e} is the overall exergy efficiency.

RESULTS AND DISCUSSION

Energy and exergy utilization

The analysis discussed in the previous section was used to evaluate the energy and exergy consumption in 125 households. The sources of energy used are broken down into electrical and fossil Fuel. The electrical energy used over a period of three month (January to March, 2009) is summarized in Table 2. The fossil Fuels used are the Liquefied Petroleum Gas (LPG) and kerosene which have heating value of 57,431 kJ/kg and 46,117 kJ/kg and a utilization efficiency of 65 and 37% respectively. The energy and exergy use by the appliances were evaluated and appliances susceptible to losses were identified. The results show the pattern of energy consumed by the household appliances investigated.

Fig. 1 and 2 illustrate energy and exergy flow pattern as regards energy and exergy inputs, products and losses for the month of January. Electrical energy is mostly depended upon for purposes such as space cooling, recreation, cleaning, grinding, etc., while the use of fossil Fuel is commonly used for cooking purposes. For every month considered (January, February and March), electrical energy consumed accounted for 59, 56.5 and 59% of the total household energy consumption respectively while that of fossil Fuel was estimated to be 41, 43.5, and 41% respectively.

Table 3 shows the weighted mean energy and exergy efficiency calculated for both electric and fossil Fuel energy. The weighted mean for electrical energy and exergy were obtained by using eqns. (10) and (11) respectively. Similarly, eqns. (12) and (13) were used to evaluate the weighted mean for fossil Fuel energy and exergy. On this note, the overall weighted mean were obtained for the energy and exergy efficiencies for the electrical and fossil Fuel processes where the weighing factors is the ratio of energy input to an appliance to the total energy input to all the appliances. The overall weighted mean exergy efficiency for the three months are lower, being 21% for every month than their corresponding energy efficiency of 62%, 63% and 62% for January, February and March is respectively. The disparity between the energy and exergy efficiencies is about 41.5% on the average for the three month studied.

By comparison, exergy efficiencies for the residential sector are reported to be about 23% for Brazil in 2001, 12% for Norway in 1995, 9% for Saudi Arabia in 1990–2001, 22% for Turkey in 2004–2005, 13% for Sweden in 1994, 15% for Canada in 1986, 2% for Italy in 1990, 3% for Japan in 1985, and 14% for the USA in 1970.

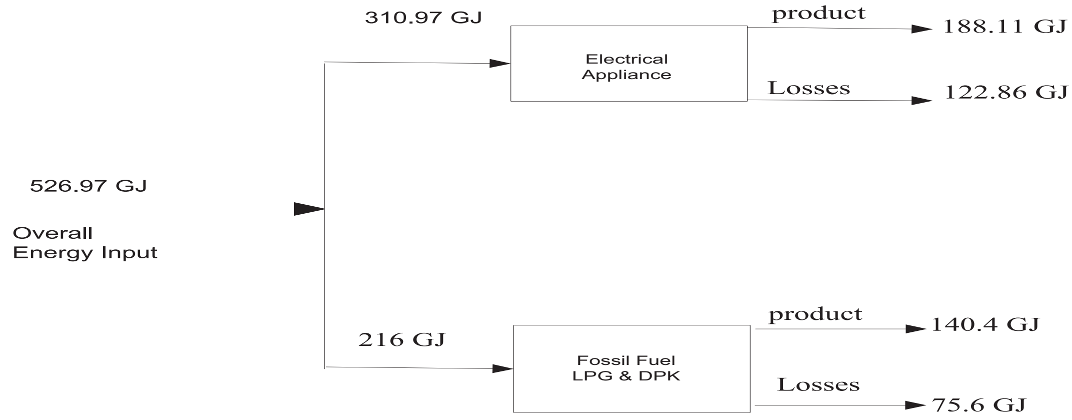

Fig 1 Energy flow diagram for the month of January

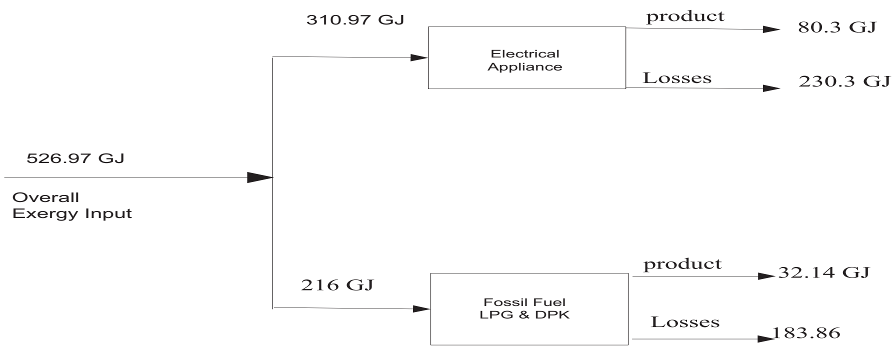

Fig 2 Exergy flow diagram for the month of January

Energy and exergy losses

The energy and exergy losses for each of the appliances for the month of January are reflected on Figs. 1 and 2. The high disparity between the energy and exergy losses underscores the inadequacy of the first law concept for energy analysis. It can also be seen that the evaluation base on the first law concept is inadequate. The electrical and fossil energy losses for the month of January are respectively 122.86 GJ and 75.6 GJ while losses from the exergy point of view are 230 GJ and 183.86 GJ respectively. The refrigerator-freezer is the major exergy consuming household appliance accounting for about 32% of the total exergy loss. Refrigerator-freezer is 24 hours working device and its poor performances can be traced to energy degradation for the transformation of energy from electrical to thermal energy. The air conditioner is the second major exergy consuming device accounting for 30% of the total exergy loss. It should be noted that the compressor of the air conditioner consumes large amount of electrical power which contribute to its large exergy loss. Furthermore, bulb lighting accounts for 16.2% of the total exergy loss, iron 5%, florescent light 3.67%, while all the other appliances account for less than 2%. The results showed that there were large differences between the energy and exergy input, and energy and exergy of product indicating inefficiencies in the appliances. These losses also reveal that there are potential for improvement.

Table 2 Energy pattern consumption for the month of January

Appliance	Ownership level	Duration (h)	Average Power (W)	Energy Consumed (MJ)	Energy products (MJ)	Exergy products (MJ)	Energy loss (MJ)	Exergy loss (MJ)
Florescent Light	300	240.87	40	10.41	2.08	1.93	8.32	8.48
TV	188	188.48	80	10.21	8.16	8.16	2.04	2.04
Fan	189	277.76	130	24.57	19.65	19.65	4.91	4.91
Iron	103	37.2	1200	16.55	16.22	4.97	0.33	11.59
Refrigerator-Freezer	195	558	196	76.78	46.07	5.37	30.71	71.40
Electric cooker	78	31	1000	8.70	6.96	1.50	1.74	7.21
Washing machine	42	49.29	450	3.35	2.68	2.68	0.67	0.67
Bulb	871	264.43	60	49.75	12.44	12.44	37.31	37.31
Hi-fi	89	251.41	25	2.01	1.41	1.41	0.60	0.60
Blender	51	125.24	350	8.05	6.44	6.44	1.61	1.61
Vaccum cleaner	26	77.19	1200	8.67	6.07	6.07	2.60	2.60
Toaster	75	10.23	700	1.93	1.89	0.58	0.04	1.35
Electric Kettle	89	17.05	1750	9.56	8.60	1.03	0.96	8.53
Hand phone charger	331	68.82	45	3.69	2.58	2.58	1.11	1.11
Hair dryer	14	3.41	1100	0.19	0.13	0.13	0.06	0.06
Air conditioner	69	193.13	1500	71.96	43.18	2.94	28.78	69.02
Personal computer	68	72.23	65	1.15	0.80	0.80	0.34	0.34
Microwave oven	12	12.71	700	0.38	0.27	0.27	0.12	0.12
Water heater	33	13.33	1000	1.58	1.43	0.04	0.16	1.54
Electric filter	11	6.82	100	0.03	0.02	0.02	0.01	0.10
VCD/DVD player	95	168.64	25	1.44	1.01	1.01	0.43	5.09

CONCLUSION

The analyses of energy and exergy utilization in the residential sector of 125 households in Ibadan, Nigeria base on actual data collected for a period of three months have been presented. The main conclusions derived from the present study may be summarized as follows:

- The analysis clarified that there were large disparities between the energy and exergy efficiencies of each appliance studied. This was mainly because of low exergy efficient appliances used in each household. It also shows the unreliability of the energy analysis, which is based on the first law of thermodynamics, in identifying the true magnitude and direction of losses. The disparities in energy and exergy utilized indicate the availability of energy losses, which reveal possibility for improvement.
- The overall weighted mean energy efficiencies for each month are 62%, 63% and 62% while overall exergy efficiencies are 21% for every month of January, February and March respectively. The variations in energy and exergy efficiencies clearly indicate that a conscious and planned effort is needed to improve exergy utilization in the household.
- Electrical energy is mostly depended upon for purposes such as space cooling, recreation, cleaning, grinding, etc, where fossil Fuel is commonly used for cooking purposes. Among the appliance studied, refrigerator-freezer and air conditioner has the highest exergy loss of 32% and 30% of the total losses respectively while electric water filter has the lowest exergy loss of 0.004%. The disparities in the energy losses can be traced to inefficiencies of the appliance used.
- The analysis reported here provides a clearer insight and quantitative grasp of the inefficiencies and their relative magnitudes in evaluating the energy utilization performance of the appliances. It may be concluded that the implementation of energy policies has to be reaffirmed. This is because no matter what goals are set for energy use within a region, they must obligatorily be ranked alongside with the technological, economic, social and environmental requirements to attain a sustainable development.

Table 3: Weighted mean electrical and fossil Fuel energy and exergy efficiency

	Electrical energy efficiency	Exergy efficiency	Fossil Fuel energy efficiency	Exergy efficiency
January	60.49	29.74	65	14.88
February	60.49	29.74	65	14.88
March	60.49	29.74	65	14.88

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ASSESSMENT OF SOME AGRICULTURAL RESIDUES AS POTENTIAL ALTERNATIVES TO FOSSIL FUELS AND SOIL AMENDMENTS

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Abstract
Agricultural Residues known as Wastes are potential toxic deposits and reservoir of pollution vectors if not properly handled, controlled, managed and sustainable harnessed for economic purposes. Ironically, the annual average amount of livestock residue in Nigeria was estimated at 83,037Mt without any appreciable economic viable management policy for utilization.
Four livestock source components comprising Cow (Cw), Horse (Hs), Poultry (Po) and Pig (Pg) Wastes were evaluated for their yield potentials of CH_4, CO_2, and $N2_0$ at ambient temperature (28_oc). Both physical and chemical compositions of the residues were determined using standard laboratory procedures after drying until constant moisture at 77_oc. Percent by mass (Pm), molar compositions (Mc); molar ratios (Mr.), air requirements for oxidation (Ar), chemical formulae (Cf), energy content (Ec) and potential volume of methane (Pv) available for harvest were evaluated using empirical models.
Results obtained showed 11.54%CH_4, 5.32%CO_2, 0.06%N_2O and 1.68%N; 11.42% CH_4, 16.42% CO_2, 0.14% N_2O and 1.60%N; 15.51% CH_4, 7.88% CO_2, O.14% N_2O and 1.64%N; 11.12% CH_4, 16.62% CO_2, 0.13% N_2O and 1.68%N. for Cw, Hs, Po and Pg respectively. Similarly, Cw, Hs, Po and Pg uptakes in plants indicated the followings: 2.32%N, 2.5%P, 6.6%K; 2.08N, 2.5%P, and 8.03%k 1.99%N, 2.06%P, 6.211%K and 2.36%N, 3.93%P, 7.3%K, suggesting suitable alternative composting sources for soil amendment. Potential energy values were determined at 35.17 Kj/Kg, 36, 35 Kj/Kg, 45, 852 Kj/Kg g and 41,031 Kj/Kg for Hs, Cw, Po and Pg respectively. Overall result revealed that Po was best in terms of Ec and Hs, the least. Respect to CH4 production or heating values, Cw recorded the highest mean value possibly due to the nature of ionic number in the chemical compounds.

INTRODUCTION
Agricultural activities are generally known to generate Waste materials during crop growth and harvest. Similarly, livestock farming experience a large volume of by products in terms of urines and faeces. Human activities also produce Waste components. These materials are often discarded because of the perception that they are unwanted. However, experience has shown that these Wastes can be transformed into resources for composting or soil amendments in crop production, industrial operations and energy production especially if properly managed and sustainably harnessed.
Notwithstanding, the perceived potentials of the Wastes, certain sensitive and grey areas need for resolution before concerted efforts are put in place for their utilization. These include information on the quantities of Wastes generated per year, crop nutrients requirements annually, the capacity of energy necessary to make up for the short fall on the national level and the expected environmental and human hazards envisaged Chrispeels and Sadara (2003) reported that 25, millions tons of top soils are lost world wide from arable lands annually. Unfortunately, increased use of chemical fertilizers and pesticides have been reported to aggravate ground water contamination, surface water pollution and acute poisoning of farm workers in Nigeria (Odeyemi, 2005) due to their ecotoxicity in terms of oncongenicity, teratogenicity, fetotoxicity, mutagenicity, carcinogenicity and biological refractoriness (Odeyemi, 2003, 2005).

However, in contrary to the menace of mineral fertilizers and chemicals, Agricultural Residues or Wastes have the potential Fuel value of replacing all the 35.3 million tones of lignite and 1.3 million tones of bituminous coal used in electric power generation plants without any appreciable negative environmental hazards (Ergudenler and Isigigun, 1994). In addition, Agricultural Residues are known to play a major role in reduction of net emissions of CO_2, NO_x emissions due to the relatively low sulfur and nitrogen contents compared to materials like lignite (Ergudenler and Isigigun, 1994). Reports from other Scientists (Demirbas, A; Pehlivan, and Altun, T, 2006; Ramsay, 1985; Lewis, 1981; Demirabas and Balat, 2006) Confirmed the superiority and sustainability of agricultural residue based Fuel compared to other forms of residues. They concluded that biomas energy in the form of wood had Fuelled the world's economy for thousands of years before the advent of oil, gas and uranium.

Although literatures are very limited on the use of agriculture residues such as livestock manures for biogas production especially in Nigeria, however few reports from researchers in other countries compared the potentials of other agricultural Wastes with livestock in terms of C/N ratio: vegetable Wastes – 11-13; Fruit Waste- 20-49; Food Wastes – 14-16; Grass clippings – 9-25; leaves – 40-80; Shrub trimmings – 53; Poultry litter (broiler) – 12-15; Cattle manure – 11-30; and Horse manure – 22-50(. George, T; Frank, K. 2002). They concluded the most ideal fraction being between 20 and 25, with horse manure the most proficient. Batzias et al; 2005, Isci and Demirev, 2007 confirmed the grate untapped bio Fuel potentials in livestock residues.Coincidentally, the annual average amount of livestock residue in Nigeria was estimated at 83,037Mt with corresponding values for Sorghum, Leafy vegetable, and Citrus at 10.61, 1.55 and 9.12 Mt without any national economic viable management policy for utilization just like gases that flare freely in the Delta region of Nigeria. This project however aims at assessing the biogas production potentials of four livestock Wastes in terms of CH_4.

MATERIALS AND METHODS

This study was carried out at Ladoke Akintola University of Technology, Ogbomoso. Ogbomoso lies at latitude $8^{O}76^{1}$N and longitude $4^{o}16^{1}$E with altitude 341 m, mean annual rainfall of 1000mm and mean daily temperature of 26.7^{O}C.

Four livestock source components comprising Cow (Cw), Horse (Hs), Poultry (Po), and pig Wastes (Pg) were evaluated for their yield potentials of CH_4, CO_2, and N_20 at ambient temperature. Samples were oven dried at 77^{O}C until constant moisture content. Both physical and chemical compositions of the residues were determined using standard laboratory procedures to ascertain the level of nitrogen concentration for possible composting after digestion for methane production. Percent by mass, molar compositions, molar ratios, and chemical formula were determined with the model developed by Tchnobanoglous et al., (1977).

Energy value of the samples was evaluated from the chemical compositions using modified Dulong formula.

$$KJ/Kg = 337C + 1428 (H-0/8) + 9S \quad (i)$$

Where KJ/kg = energy content

C = Carbon, percent

H = Hydrogen, percent

O = Oxygen, percent

S = Sulfur, percent.

Air requirements for oxidation was obtained using equation developed by Techobanoglous et al., 1977)

$$CaHbOcNd + \frac{4a+b-2c-3d}{4} O_2 \longrightarrow aC02 + \frac{b-3d}{2} H_2O + dNH_3 \quad (ii)$$

Where a, b, c and d are coefficients of C.H.O. and N.

Potential volume of methane available for production was calculated using equation (iii) (Techobanoglous et al., 1977)

$$Ca\ HbOc\ Nd + \frac{4a-b-2c+3d}{4} H_2O \longrightarrow \frac{4a+b-2c-3d}{8} CH4 + \frac{a-b+2c+3d}{8} C02 + dNH3 \ldots \quad (iii)$$

Where a, b, c, d are coefficients.

RESULTS AND DISCUSSIONS

Table 1 shows the chemical composition of the selected livestock samples. The degree of variation in composition is very minimal possibly showing residues of similar soil amendments profile. However, Hs exhibits the lowest carbon concentration but with almost the highest H+ concentration. Table 2 reflects the molar ratios of the livestock residues with chemical formulae for the different residues:

Hs = $C_{38.1}\ H_{49.0}\ O_{1.91}\ N$

Cw = $C_{42.9}\ H_{44.\ 8}\ O_{15.2}\ N$

Po = C_{31} H 44.8 $O_{15.2}$ N

Pg = C_{31} H 38.6 $O_{1.3}$ N

However, the chemical formula for the combination of the livestock Wastes with or without sulfur is expressed as $C_{90}\ H_{2010}\ O_{960}\ S_{1.0}$ and $C_{36}\ H_{804}\ O_{384}\ N_{1.0}$. The energy values generated with the combination of the Wastes was 2,848.72 Kj/Kg compared with the cumulative addition of the values generated separately (158,413Kj/kg) possibly revealing the economic advantage of individual Wastes over mixed residues. However, the mass of air required for the production of methane was highest with Pg and lowest with Hs. Correspondingly, the potential volume of methane production was highest with Cw with the lowest mean volume of air requirement while the highest energy value occurred in Po at 45,852.0Kj/kg. However, it is interesting to note that ionic number of carbon plays a significant role in the potential volume of methane that could be produced. Cw with chemical formula $C_{42.9}\ H_{44.8}\ O_{15.2}$ N exhibiting the highest ionic numbers of carbon and oxygen recorded the highest volume of methane.

Overall results showed that Cw was most preferable for methane production among the four livestock residues investigated, although in terms of energy value, P_O appeared most profitable.

Table1: Percent by mass of the different element in the livestock Waste.

Waste	C		H		O		N		S	
	Mass (kg)	% by mass	Mass (kg)	% by mass	Mass (kg)	% by mass	Mass (kg)	% by Mass	Mass (kg)	% by mass
Hs	0.99	22.8	0.130	23.3	0.062	25.0	0.03	21.4	0.037	28.5
Cw	1.12	25.8	0.098	22.1	0.056	22.6	0.03	21.4	0.019	14.6
Po	1.12	25.8	0.130	29.4	6.070	28.2	0.04	28.6	0.030	23.1
Pg	1.12	25.6	0.112	25.3	0.060	24.2	0.04	28.6	0.044	33.9
Total	4.35	100.0	0.443	100	0.248	100	0.14	100	0.13	100

Table 2: Molar ratios of the elements in livestock residues

	C	MR	H	MR	O	MR	N	MR	S	MR	CHF
Hs	0.08	38.1	0.03	49.05	0.004	1.9	0.0021	1.0	0.012	-	C38.1H49.o^{O}1.91 N
Cw	0.09	42.9	0.098	46.7	0.0035	1.7	0.0021	1.0	0.006	-	C42.9 H46.7^{O}1.7N
Po	0.09	31.0	0.130	44.8	0.044	15.2	0.0029	1.0	0.009	-	C31.oH44.8 ^{O}15.2N
Pg	0.09	31.0	0.112	38.6	0.0038	1.3	0.0029	1.0	0.0014	-	C31H38.6 ^{O}1.3N

MR. = molar ratio, CHf = Chemical formula.

Table 3: Air requirements, to oxidize completely 1 tonne of livestock Wastes, methane production and energy content.

	Mass Of air (kg/t)	Vol. of air reqd M^3/t)	Oxygen reqd (Kg/t)	Mass of Methane (kg/t)	Volume of Methane (m^3/t)	Energy value kJ/kg
Hs	12,713.6	9,834.14	2943.19	706.74	986.10	35,179.2
Cw	12.553.74	9,710.5	290.19	719.9	1,004.65	36,350.7
Po	14,000	10,830	3,240	410.5	572.7	45,852.0
Pg	12,755.5	9,866.6	2,952.9	705.2	983.9	41,031.05

CONCLUSION

Livestock, Poultry and Crop Wastes keep increasing on daily basis which indicates a positive correlation of increasing livestock, poultry and crop farming. Increased agricultural activities in livestock, poultry and crop husbandries encourage aggravated accumulation of leacheates, effluents and solid Wastes with intimidating toxic build-up if not properly managed and harnessed for economic development.

However, climate effect and the attendant issues that seem to defile solution in addition to embarrassingly dwindling natural resources like fossil Fuels, surface and underground water, survival locally, nationally and internationally emanating from exponential trend of population increase becomes and hyper risk. Human nature may drift to become carnivores in an attempt to contend for the ever decreasing resources except efforts are shifted from the conventional natural resources to minimally untapped areas like livestock, poultry and crops Wastes.

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RESEARCH TRENDS IN BIO-ENERGY RESOURCES: THE POTENTIALS OF RESIDUE PYROLYSIS AS MEANS OF PRODUCING ALTERNATIVE FUELS

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Abstract
Energy technology the world over is one of the most important national items in every country. In Nigeria energy is the mainstay of the economic growth and development. It plays a significant role in international diplomacy and also serves as a tradable commodity for the national income, which is used for supporting all developmental programs. Energy serves as an input into the production of goods and services, transport, agriculture, health and education sectors. Agriculture remains the largest sector of the economy, generating employment for about 70% of the population and contributing about 40% to the national GDP, with crude oil contributing about 14% to the GDP. Nigeria is endowed with enormous renewable resources such solar, wind and Biomass resources. The contribution of energy to the GDP is expected to be higher when renewable energy utilization, especially Biomass which contributes about 90% of the energy used by the rural dwellers is considered. Reliance on fossil Fuels as the major power generation is a challenge to achieving sustainable development. Hydro electric power generation is insufficient to cater for the energy needs of the populace. The physical infrastructures to provide Fuel and electricity to the rural poor at low cost are lacking and demand in urban areas is outpacing the ability to generate power. In Nigeria, energy security with the conventional sources is inadequate, hence stressing the need for alternative sources. The availability of low cost energy resources is therefore a challenge to small scale agricultural operations in Nigeria. It has been advocated that future energy resources needs to move towards non-petroleum based resources. Among the renewable, Biomass energy resources has the greatest potentials to help rural farmers in developing countries such as Nigeria. The Agricultural Residues are abundant organic resources which can be available for energy purposes at the rural level. However this natural endowment is inadequately utilized due to in appropriate technology in Nigeria. Among the technologies for conversion of Biomass into gaseous, liquid and solid Fuels, pyrolysis is still at the planning stage in Nigeria. This paper therefore examines the techniques involved in the upgrading of Biomass residues into chemical and energy resources with emphasis on the different pyrolysis methods.
Key words: Biomass, energy, pyrolysis, renewable, residue.

INTRODUCTION

Energy technology has not only become an important weapon for socio-economic development, but in recent times has played a central role in international diplomacy. Therefore concerns for rapid development of all forms of available energy sources and the importance of harnessing renewable sources is increasingly being realized. The renewable sources have the advantage of being non-depleting and are also clean from the environmental point of view (Shaw, 2006). Amongst the natural resources, Biomass energy resources stands out with the highest potential towards sustainable development and in satisfying environmental concerns over fossil Fuel usage (Bridgwater, 2003; Van de Velden *et al.*, 2007). In addition to its uniqueness, it effectively stores solar energy and the only renewable energy source of carbon which can be converted into convenient solid, liquid and gaseous Fuels (Demirbas, 2001).

In Nigeria energy is the mainstay of the economic growth and development. It plays a significant role in Nigeria's international diplomacy and serves as a tradable commodity for the national income, which is used for supporting all developmental programs. Energy serves as an input into the production of goods and services, transport, agriculture, health and education sectors. However agriculture remains the largest sector of the economy, generating employment for about 70% of the population and contributing about 40% to the national GDP. This is followed by crude oil, contributing about 14% to the GDP (Jekayinfa and Scholz, 2007).

Biomass is the oldest Fuel and is still widely used in many developing countries including Nigeria in its traditional form. It accounts for approximately 14% of the world primary energy consumption which is higher than 12% for coal and comparable to those of gas, 15% and electricity, 14%. Biomass importance varies significantly across regions of the world (Senneca, 2007). In Nigeria more than 51 % of the total annual energy consumption is estimated to come from biomas sources like wood and wood Wastes, Agricultural Residues and animal Wastes (Akinbami, 2001). Whereas at the rural areas its contributions is as high as 95 % of the energy needs. This energy sources are inefficiently used and bad from environmental point of view due low technology. Adequate energy is therefore not being made available from these sources in a manner which would enable rapid socio-economic development of the rural areas. Reliance on fossil Fuels as the major power generation remains a challenge to achieving sustainable development. Hydro electric power generation is insufficient to cater for the energy needs of the populace. The physical infrastructures to provide Fuel and electricity to the rural poor at low cost are lacking and demand in urban areas is outpacing the ability to generate power (Olorunnisola, 2007; Jekayinfa and Omisakin, 2005).

The availability of low cost energy resources is therefore a challenge to small scale agricultural operations in Nigeria. It has been advocated that future energy resources needs to move towards non-petroleum based resources (Julia, 2008). Among the renewable, Biomass energy resources has the greatest potentials to help rural farmers in developing countries such as Nigeria. The Agricultural Residues are abundant organic resources with little values and can be available for energy purposes at the rural level. Of the technologies for conversion of Biomass into gaseous, liquid and solid Fuels and electricity only direct combustion (for heat), Biomass briquetting and anaerobic digestion (biogas production) are reported to have received some attention in Nigeria. Modern Biomass conversion technology, pyrolysis is still at planning stage in Nigeria. This paper therefore examines the techniques involved in the upgrading of Biomass residues into chemical and energy resources with emphasis on the different thermochemical methods.

Background Information on Nigeria

Nigeria is the most populous country in Africa with a population estimate of about 140 million and an annual growth rate of about 3.3 % according to 2006 census. The land area is estimated at 98.3 million hectares with about 34 million hectares or 35% under cultivation. A large proportion of the country sits on a plateau, which is divided into several parts by the Niger River and its tributaries and mountains as high as 2,000 m occur in the border area with Cameroon (FAO, 2005). The climate which is humid in the south and hotter and drier towards the north permits the cultivation of a variety of crops such as cassava, yam, cocoyam, sweet potato, maize, millet, rice, sorghum, groundnut, cowpea, and cotton and tree crops including cocoa, oil palm, rubber, and timber. In the south where rain fall is high, the forest and savannah benefits from abundant precipitation and relatively short dry season. The

northern part which lies mostly in the Sudan and Sahel Savannah experiences between 5-7 months of dry season with less than 25mm of rain fall. Between the arid north and moist south lies the guinea savannah region referred to as the middle belt. In Nigeria, agriculture which has remained the largest sector of the economy generates employment for about 70% of Nigeria's population and contributes about 40% to the Gross Domestic Product (GDP). The domestic economy is agricultural based with crops accounting for 80 %, livestock 13 %, forestry 3 % and fishery 4 % and supplies food, raw materials and generates household income for the majority of the people (Jekayinfa and Scholz, 2007).
Apart from agriculture, Nigeria is also rich in both fossil Fuel and renewable energy resources and has large scale hydro power resources. The main exports before the discovery of crude oil were agricultural products. After the discovery of crude oil, there was a reduction in agricultural activities due to the reliance on the oil revenue. However the reliance on fossil Fuels as the major power generation remains a challenge to achieving sustainable development. The hydro electric power generation is insufficient to cater for the energy needs of the populace (Julia *et al.,* 2008). The physical infrastructure to provide Fuel and electricity to the rural poor at low cost is lacking and demand in urban areas is outpacing the ability to generate power. Rural energy supply is therefore an important issue since most agricultural activities are still performed manually.

Agricultural and Energy Resource Base

Nigeria has a tropical climate with sharp regional variances depending on rainfall. The weather condition is diverse and enjoys abundant solar radiation ranging from 3.5 – 7.0 KWhm^2/day and with long hours of sunshine in the far north. The country also enjoys a relatively strong wind power potential, with regimes ranging from 2-4 m/s obtained. There are two major vegetation zones: the forest zone, which occurs in a belt 50 to 250 km wide adjacent to the Atlantic coast; and the savanna zone to the north, which can be divided into the wetter Guinea zone and the drier Sudan zone. Estimates of forest cover range from 9.7 to 13.5 million hectares (FAO 2005). The forests resources contribute up to 0.5% to Nigeria's GDP and provide a major part of domestic energy, food and medical supplies. The Fuel wood and animal Waste resources are estimated at 43.3 x 10^6 and 61 x 10^6 tonnes/yr respectively (FAO, 2005). However the forest and Agricultural Residues have become significant untapped Biomass energy resources in many African countries including Nigeria (NEPAD, 2003).

Nigeria is relatively rich in fossil Fuel resources such as crude oil, natural gas, coal and tar sand and renewable energy resources like solar, wind, Biomass, and has large scale hydropower energy sources. The economy is heavily dependent on the oil sector, accounting for 95 % of the country's export revenues (EIA, 2007). According to oil and gas journal (OGJ), the proven oil and natural gas reserves as at January 2007 were estimated at 36.2 billion barrels and 182 trillion cubic feet (Tcf) respectively. Nigeria also has a large source of liquid natural gas (LNG) with a proven reserve estimated at about 163 trillion standard cubic feet (Rilwanua, 2003). Most of these oil and natural gas reserves are found in the Niger River Delta and offshore in the Bight of Benin, Gulf of Guinea and Bight of Bonny. Nigerian estimates of coal reserves is put at over 2.75 billion tonnes, with approximately 650 million tonnes (Mmt) as proven (Online Nigeria, 2008). The coal resources are located in the Cretaceous Anambra and Makurdi Basins, and Afikpo Syncline and occur in two levels: the lower Mamu Formation and the upper Nsukka Formation. Coal seams occur in three main stratigraphic levels: The brown coals (lignite) of Ogwashi-Asaba Formation of Miocene to Pliocene ages, the upper and lower sub-bituminous coal measures of Maastrichtian age, and the bituminous coals of the Awgu shales of Coniacian age (MOMSD, 2007). The proven reserve of tar sands stands at 31 billion boe. Electrical energy is currently being generated from three main hydro power stations, Kainji, Jebba, and shiroro hydro power stations and from Egbim, Sapele, Ijora, Delta, Afam and Oji thermal stations. The contribution of the gas-fired plants is estimated at about 73 % of the total generation mix EIA, 2007).

Based on these potential reserves, it should be possible to achieve a well-balanced energy generation mix in the country. However, due to series of problems bedeviling the system ranging from political to technical issues, this is not the case. The barriers to sustainable energy generation generally in Africa, including Nigeria include:

- Low refinery capacity
- Low investment by the government on domestic energy production
- Low private sector participation and investment in the energy sector
- Inadequate policy, regulation and institutional frame work
- Transport, transmission, and distribution challenges

Energy supply and consumption

Energy consumption in Nigeria amount to about 26.65×10^6 toe and is largely dominated by combustible renewable resources. Energy from Biomass accounts for more than 51% of the total annual energy consumption and more than 90% in the rural areas (Olorunnisola, 2007; Jekayinfa and Omisakin, 2005). Traditionally, wood in form of Fuel wood, twigs and charcoal has been the major source of renewable energy in Nigeria. The other sources of energy include natural gas (5.2%), hydroelectricity (3.1%), and petroleum products (41.3%), (Akinbami, 2001). Nigeria exports more of its oil than consumed to generate revenue. Coal was the first fossil energy resource to be exploited by Nigeria, a transition to diesel Fuel for rail transport and to gas for electricity generation led to a decrease in coal production. Coal production therefore dropped to an insignificant level from its height of almost 1 Mmt in 1959. At present, coal is not part of Nigeria's energy consumption mix (EIA, 2007). The Nigerian government is seeking to increase the country's level of coal utilization to help stem the loss of its forests to domestic Fuel-wood harvesting and to help reduce its overdependence on oil.

In Nigeria, oil is consumed mainly for transportation, electricity generation and for industries. Although Nigeria is the largest oil producer in Africa, and the 11th largest oil exporter in the world, the refining capacity of the country is very low. It is currently insufficient to meet domestic demand, forcing the country to import petroleum products. According *OGJ*, the refineries (Port Harcourt I and II, Warri, and Kaduna) have a combined installed capacity of about 445, 000 bbl/d, but operate at 214,000 bbl/d due to numerous problems (Lukman, 2003). Additionally, the refineries do not capture the gas that is given off in the refining process and it is instead burned as flares. In most countries this gas is captured and re-inserted into the ground; however, this process requires additional pressurized tanks. It is estimated that significantly more than half of Nigeria's natural gas is given off as flares. Thus, a huge amount of valuable Fuel is simply burned off. This process is also very detrimental to the environment (Julia *et al.,* 2008).

The production capacity of natural gas is estimated at 800 billion cubic feet, out of which about 41 % is consumed. Since the infrastructure to produce natural gas are lacking in Nigeria, 40 % of its annual natural gas production is flared. According the World Bank estimates, Nigeria accounts for 12.5 % of total flared natural gas in the world. A significant portion of Nigeria's natural gas is processed into LNG and has an annual production capacity of about 22 million tons per year of LNG. Nigeria's most ambitious natural gas project is the $3.8 billion Nigeria Liquefied Natural Gas (NLNG) facility on Bonny Island. Partners in the project included NNPC, Shell, Total and Agip.

The Nigeria's installed electricity generating capacity is put at between 5000 and 6000 MW. However the actual output has revolves around 4000 MW. The actual electricity demand including off-grid generators is believed to be closer to 10,000 MW (Ikeme and Obas, 2005). The grid is powered by hydropower and thermal, which itself is composed of fossil Fuels (Table 1). As an attempt to rectify this situation, the government divided the National Electric Power Authority (NEPA) into two sectors in 2005, one in charge of the generation of power and the other in charge of the distribution of power (Julia, 2008). Despite this, the power sector has continued to operate well below its estimated capacity, with power outages being a frequent occurrence.

Table 2.1: Nigeria's Electricity Sources

Source	% Contribution
Gas	39.8
Hydropower	35.6
Oil	24.8
Coal	0.4

Source: World Bank, 2001

Biomass Residue Resources

Biomass residues are known to have high energy potential and therefore their conversion from Waste-to-energy has good economic and market potential, particularly in rural community applications (Sims, 2003). (Agricultural Produciton)s constitute the major source of organic residues, consisting up to 60-75% of every produce. These residues include leaves, stems, and stalks from sources such as agronomic crops, woody crops, cereal straw and forest residues. It also included multiple sources of Waste from industrial and agricultural processes such as citrus peel Waste, sawdust, paper pulp, industrial Waste, municipal solid Waste (MSW) and paper sludge. Rice husks and bagasse are usually accumulated in large volumes at one site. These Wastes tend to be relatively low in moisture content (10-30% wet basis) and therefore are more suited to direct combustion than to anaerobic digestion which better suits wet Wastes such as animal manures, meat cuttings or reject fruit. According to Jekayinfa and Scholz (2007), there is availability of large amounts of non-plantation Biomass resources in Nigeria that can be available for modern energy applications. Estimates of crop production in Nigeria vary for different crops and regions. Production outputs of about 30 to 45 million metric tones have been recorded for cassava and yam which are grown in most regions. Sorghum, millet and maize have an output ranging from 7 to 11million metric tones respectively (NFMS, 2005). Crops like cowpea, groundnut, sweet potato, plantain, cocoyam and rice has an estimated output ranging from 2 to 4 million metric tones. From these crops, a lot of residues in form of husks, bran, cobs, shells, bunch, fibre, bagasse, peels and nuts are generated. Using the process residues to production ratio, the amount of residues generated from these crops varies from 29 million tonnes for cassava to 1.5 million tonnes for cocoyam. It has also been estimated also that total of more than 70 million tonnes of Agricultural Residues were potentially produced in the year 2004 out of which only 58 million tonnes are energetically available (Jekayinfa and Scholz, 2007). Using the total mass of each crop residue produced and their corresponding lower heating values, the potential of available energy of the Agricultural Residues were computed. Cassava and yam residues were found to constitute the largest energy potential from the Agricultural Residues in Nigeria (Quaak et al., 1999).

Biomass Energy Conversion
The technologies for Biomass conversion into useful forms of energy are classified into various types based on the conversion principle in which the energy in the Biomass is converted. The techniques include physical process, direct combustion, bio-chemical processes and Thermo-chemical process. Thermo-chemical conversion technology finds its dominance because of high efficiency conversion under thermal conditions (Munir *et al.,* 2006).

a. Physical Processes
Densification is the processing of wood byproducts into uniform sized particles so they can be compressed into a Fuel wood product. During the process, the ground Biomass is forced through a matrix under high pressure and then cooling immediately for durability and stability. The commonly used densification methods based on shapes and sizes are logs, pellets and briquettes. Logs and pellets are used for residential and industrial applications, wood stove Fuels and as Fuel for boilers. However pellets are used more in commercial applications for industrial boilers where ease of handling and burning characteristics offer a competitive alternative to coal (Agbontalor, 2007). Briquetting is an option to compact the normally light, small pieces or fines of Agricultural Residues into briquettes for ease of handling and direct firing in boilers for steam production. Briquettes are not as popular as pellets especially in developing countries. It is however having an increased intensity of production in recent time.

b. Direct Combustion Process
This is the main process of conversion of Biomass into useful form of energy. It is the most widely employed especially in developing countries for direct heat production for cooking, space heating, and lighting. Modern technology for direct combustion can generate heat, electricity or both (cogeneration or combined heat and power, CHP). The existing technology of direct combustion to generate heat only includes stoves, furnaces, boilers and kilns. Some of these technologies are associated with high energy losses. Efforts at improving the efficiency of use of Biomass energy source is co-combustion or co-firing which refers to the practice of introducing Biomass as a supplementary energy source in high efficiency boiler. The co-utilization of Biomass with other Fuels is advantageous with regard to cost, efficiency, and emission. Some methods of co-utilization of Biomass with coal (Agbontalor, 2007) are:

i. Co-combustion or direct firing where the Biomass is directly fed to the boiler furnace, if needed after physical pre-processing of the Biomass such as in drying, grinding sand so on.
ii. Indirect co-firing is a process whereby Biomass is gasified and the product gas is fed to a boiler furnace.
iii. Parallel combustion is a process whereby the Biomass is burnt in a separate boiler for steam generation. The steam is used in a power plant together with the main Fuel.

c. Biochemical Process
Biochemical is the process between biochemistry of the raw Biomass with the action of microbial organism. This process produces gaseous and liquid Fuels like biogas, Ethanol and mEthanol. The process includes anaerobic digestion and alcohol group production. Anaerobic digestion is the process whereby bacteria digest the Biomass in an oxygen-free environment. It occurs in a sequence of stages involving a few types of bacteria. Controlled anaerobic

digestion is carried out in an air tight chamber or digester. The digester is used to control the temperature and to produce the digester gas or biogas which contains a lot of methane.

d. Thermochemical Process

Thermal process includes pyrolysis, gasification, and charcoal and Biodiesel production. It converts Biomass into more convenient products (gaseous, liquid and solid) of higher energy value content. The advantages associated with this technology include flexibility to Fuel a wide range of power system, easier to distribute and control the gaseous Fuel etc.

i. Gasification process: This process results in the production of gaseous combustible Fuel (H_2, CO, CH_4, etc) termed as producer gas from Biomass in suitably designed reactors or Gasifiers. The gas can be combusted in suitable burners with flame temperature exceeding 10,000^{O}c in the presence of a controlled amount of oxidizing agent (Agbontalor, 2007). It is an endothermic process whereby heat is being absorbed from the Biomass. Wood gasification takes place at approximately 800 – 1,000^{O}C in the presence of a controlled amount of oxidizing agent. The product gas composition and the level of contamination vary with the starting Biomass and its moisture content, type of Gasifier and operating conditions employed. Two types of Gasifier are widely available in the market; fixed bed Gasifiers with varying schemes for both reactor design and reaction media. The fixed bed Gasifier can be classified according to the ways in which the gasifying agent enters the Gasifier i.e. updraft, downdraft, crossdraft and two stage Gasifier. The downdraft Gasifiers are Imbert type (Gasifier with throat) and open core type (throatless). The gasifying media may be air, steam, oxygen or a mixture of these and the producer gas may be used in thermal (heat Gasifiers) or engine (power Gasifiers) applications. The fluidized beds and circulating fluid beds are commonly employ for fast pyrolysis process, due to ease of operation and ready scale-up of the reactor types. Fluidization of the feedstock is created from the suspension of the solid bed particles by the oxidant or gas flowing through the bed at a velocity high enough to overcome the particle weight by means of the drag force (Bridgwater and Peacocke, 2000).

ii. Pyrolysis: This is the process whereby Biomass is exposed to high temperature in the absence of oxygen or air. It is a promising route for the production of solid (charcoal), liquid (tar, acetic acid, acetone etc) and gaseous products (H_2, CO_2, CO) as they are possible alternative sources of energy. It occurs under pressure and at operating temperatures above 430°C (Babu, 2008). Pyrolysis process is a complex chemical reaction involving simultaneous heat and mass transfer processes, which is further complicated by the heterogeneous nature of the feedstock materials. The overall process is broken down into the physical heat transfer and the chemical reaction processes. The basic phenomena that takes place during the pyrolysis process include: Heat transfer from a heat source, leading to an increase in temperature inside the Fuel; Initiation of pyrolysis reactions due to this increased temperature, leading to the release of volatiles and the formation of char; Outflow of volatiles, resulting in heat transfer between the hot volatiles and cooler unpyrolyzed Fuel; Condensation of some of the volatiles in the cooler parts of the Fuel to produce tar; and Autocatalytic secondary pyrolysis reactions due to these interactions (Shaw, 2006).

Depending upon the operating conditions, the pyrolysis process is divided into three subclasses: conventional pyrolysis (carbonization), fast pyrolysis and flash pyrolysis. The ranges of the main operating parameters for each of the pyrolysis processes as given by Bridgwater and Peacorck (2000) are as presented in Table 2.1.

Table 2.2: Range of Main Operating Parameters for Pyrolysis Processes.

Parameters	Conventional pyrolysis	Fast Pyrolysis	Flash Pyrolysis
Pyrolysis temperature (K)	650 – 950	850 – 1250	1050 – 1300
Heating rate (K/s)	0.1 - 1.0	10 – 200	< 1000
Particle size (mm)	5 – 50	< 1	< 0.2
Solid residence time (s)	450 – 550	0.5 – 10	< 0.5

Source: Bridgwater and Peacorck, 2000.

The conventional pyrolysis is defined as the pyrolysis that occurs under a slow heating rate and it permits the production of solid, liquid and gaseous products in significant proportions. If the aim is the production of mainly liquid and or gaseous products, a fast Pyrolysis is recommended (Babu, 2008; Bridgwater and Peacorck, 2000). The achievement of fast heating rates requires high operating temperatures, very short contact times, and very fine particles.

CONCLUSION

1. Low cost forms of energy sources is a major challenge for agricultural operation in rural Nigeria
2. Agricultural and other agro-allied operations are still performed manually in spite of the vast energy resources in Nigeria
3. Large amount of residues from some major crops, maize, groundnut, cassava, millet, sorghum are locally available for energy purpose
4. As a result of 1 to 3 above, it is a welcome development to convert some of the vast energetically available Agricultural Residues into useful chemicals and Fuels.
5. The utilization of any or all the above highlighted processes is expected to enhance the production of energy sources from readily available Biomass Waste materials and provide alternative energy from Agricultural Residues in a decentralized form.

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PERFORMANCE EVALUATION OF AGRO-RESIDUES BRIQUETTING MACHINE

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Abstract
A briquetting machine for compaction of agro-residues into Biomass energy in form of briquettes was designed and fabricated from locally available materials. The design was based on the principle of hydraulic pressure transmission through the application of hydraulic jack. Corncob residue was used as a Biomass feedstock.
The machine produced 4 squared corncob briquettes at a time. The length, breadth and height of the briquette produced on the average are 0.015, 0.015 and 0.005 m respectively. The initial and final bulk densities are 95.33 and 300 kg/m^3 respectively.
Springback (elongation) gave an average value of 16.67 % of the original dimension which is an indication that briquette relaxation in terms of density would be minimal. The implication of this is that, the briquettes produced would be stable and would not easily crumble during storage and transportation.
The capacity of the machine which can be operated by one person is 23 briquettes per hour. Of all the stages involved in briquetting operation with this machine, the extraction consumed the greatest time which resulted in low machine capacity.

Keywords: Briquetting machine, Agro-residues, Briquette, Biomass energy, Performance evaluation

INTRODUCTION

There is a problem of energy shortage throughout the world, Nigeria inclusive. There are incessant increases in prices of petroleum products and at present, prices of cooking gas and kerosene are getting beyond the reach of many urban as well as rural dwellers. There is the need to source energy from other sources apart from the conventional ones. It is therefore, imperative to take stock of energy sources, which are underutilized, conserve them and consider the possibility of harnessing other sources which are not utilized at present (Oladeji, et al. 2009).
Agriculture offers much potential for renewable energy sources in form of Biomass. With advances in biotechnology and bioengineering, some resources, which could have been classified as Waste, now form the basis for energy production (McKendry, 2002). Fortunately, in Nigeria a large quantity of residues and forestry Wastes are generated annually. Unfortunately, these residues are not properly utilized as they are left to rot away or decompose (Jekayinfa and Omisakin, 2005). However, various scientific studies had revealed that most of these residues contain enormous energy which is renewable from time to time (Wilaipon, 2008). However, using these residues in their present form will not bring a desired result. This is because; most of these residues are loose and low density materials (Enweremadu, et al. 2004). Apart from that, their combustion cannot be effectively controlled (Wilaipon, 2007).

There are many conversion routes through which these residues can be converted into Biomass energy. However, one of promising technologies by which they could be converted to renewable energy is briquetting process which has been investigated by several researchers (Wilaipon, 2008; Olorunnisola, 2007; Musa, 2007; Oladeji, et al., 2009, etc). Briquetting is the process of compaction of residues into a product of higher density than the original materials. It is also known as densification (Wilaipon, 2008). If produced at low cost and made conveniently accessible to consumers, briquettes could serve as compliments to firewood and charcoal for domestic cooking and agro-industrial operations (Wilaipon, 2008). The use of briquettes can reduce drastically the demand for wood and therefore decrease deforestation. Besides, briquettes have advantages over Fuel wood in terms of greater heat intensity, cleaningness, convenience in use and relatively smaller space requirement for storage (Yaman, et al., 2000; Olorunnisola, 2004). Among the agro-residues and forestry Wastes that can be subjected to process of briquetting are residues from maize, wood, guinea corn, beans, groundnut, rice, cotton and sugar cane. A lot of residues had been subjected to process of briquetting. Such residues are woods, (Granada et al., 2002), cotton (Singh, 2004), olive refuse (Yaman et al. 2000), rice straw and husk (Pathak et al. 2000) and banana-peel (Wilaipon, 2008). Others are Waste paper + admixture of coconut husks (Olorunnisola 2007), rattan furniture Waste (Olorunnisola, 2004) and maize cob (Wilaipon, 2007).

The device used for the process of briquetting is called briquetting machine. Briquetting machines can be broadly classified into two groups. These are piston press and screw press. In terms of technique of briquetting, briquetting can be classified as low-pressure technique and high-pressure technique, while in terms of binder; briquetting process can be classified as briquetting process with binding agent and briquetting without binder.

Different researchers had fabricated one type of briquetting machine or the other. Adekoya, (1989), developed a simple briquetting machine for the conversion of sawdust into briquettes. However, the briquettes formed could not survive rough handlings encountered while transporting them. Saglam, et al., (1990), reported that a briquette machine was designed and used for the densification of lignite using calcium ammonium sulphite liquor. By 1995, a Seidner Riedlinger compaction machine (Model SW 600) was reported to have been used as briquettes machine to produce solid briquettes from sugarcane Wastes (Akpabio, et al., 1995). Ilechie, et al., (2000) designed a moulding machine to produce briquettes from palm Wastes. Later on, Inegbenebor, (2002), designed and fabricated a low cost agricultural and wood Waste briquetting machine that can produce six briquettes at a time. The design was based on the principle of hydraulic pressure transmission and the slider crank mechanism. Singh, et al. (2007), modified a commercial briquetting machine to produce 35 mm diameter briquettes suitable for gasification and combustion.

The main objectives of this work were:-

1) To design and construct an experimental briquetting machine for conversion of Agricultural Residues into briquettes.
2) To test the machine designed so as to evaluate its performance.

MATERIALS AND METHODS

Materials utilized in this work were selected based on availability, ease of fabrication, cost and mechanical properties (Khurmi and Gupta, 2006). This was done with a view to reducing the overall cost of production. Material used for the construction of the briquetting machine was mild steel in order to make it robust. Mild steel was preferred because, it is common, widely available, cheap and easy to fabricate. The agro-residue selected for briquetting was maize cob. This is because; maize is annually cultivated in about 5.33 million hectares of land yielding about 7.5 million tonnes of the crop (FOS, 2006). Most often, the residues are dumped or flared resulting in wide spread fire hazards and environmental pollution. A small quantity of maize cobs is utilized in corn mills to fire boilers, which means maize cobs will always be available for briquette production.

Description of Briquetting Machine
For the experimental aspect of the work, a briquetting machine was designed and fabricated. The machine consists of four lower rectangular moulds (where Biomass feedstock was placed), which were welded together. These moulds were placed upon a base plate, which moves up and down in vertical guide. This plate is also capable of horizontal movement by sliding on a pair of rails made from angle bars. The vertical motion of the plate along with the moulds is made possible through a manually operated jack, while their horizontal motion is achieved by manual pulling or pushing.

Fig. 1 Briquetting Machine

Design Principle
The design of the machine was based practically on hydraulic principle, although the loading of the Biomass feedstock was purely a manual process.

Design Calculations
Mould design against failure
The most critical part of the machine is the mould; therefore, the mould was designed against failure: From equation δ= P/A (Khurmi and Gupta, 2006), where P=Applied force (5tonnes), A=Area of the mould (30 cmx30 cm) = 49,837/0.3x0.3= 0.55 MPa. This pressure is exerted on the residue as well as on the inside of the mould therefore, for the failure not to occur in the mould, the calculated stress must be less than the yield stress of the material of the mould i.e. $\delta m > \delta$. From Khurmi and Gupta, (2006), δm= 220 MPa. Hence, the applied stress is less than the yield stress of the material. The implication of this is that, the mould designed cannot fail during compaction

Piston Design against Buckling
For a column with one end fixed and one end free, Euler's equation states that:
Buckling load $P_c = \pi^2$ E I/ $4L^2$ (Redford, 2000), where Pc = Buckling load, E = Young's Modulus of elasticity, I = Moment of Inertia, L= Length of the Piston
A rectangular sectioned steel piston of length 30 cm was used, while the piston head was made of rectangular cross section of 130 mm x 150 mm x 4 mm. From Khurmi and Gupta,

(2006), E= 2.02 x 10^{11} N/ m^2**.** Moment of Inertia of rectangular section I= B x H^3 /12 (Redford, 2000; Khurmi and Gupta, 2006) i.e. I = π^2 x 2.02 x 10^{11} x2.746 x 10^{-5}/ 4x 0.3^2 = 151 MN. The load applied by 5 ton jack = 5,080.23 x 9.81 = 49,837.06 N. Hence, the load applied by the hydraulic jack to all the four moulds = 49,837.06 x 4 = 199,348.23 N = 0.20 MN. Since 151 MN is far greater than 0.20 MN, it can thus be seen that the piston will not fail by buckling.

Preparation of Binder

The method adopted by Wilaipon, (2007) and Musa, (2007) was followed and used to prepare the binder for the purpose of this experiment. A little portion of cold water was used to prepare a colloid of the starch. Cassava starch in a powdered form was mixed with boiling water just enough to form a gel, which can facilitate the proper agglomeration of the particles. The weights of the cassava starch, cold and boiling water were determined in such a way to form 5 % by weight of the Biomass feedstock.

Briquette Production

For the production of briquettes, the Biomass feedstock was mixed with already prepared starch gel. The mixture was stirred vigorously to ensure a proper mix. The resulting mix was fed into the moulds of the briquetting machine and compressed. The briquettes were late ejected after the dwell [holding] time of 120 seconds was observed. This was followed by immediate measurement of briquette dimensions and densities. The ejected briquettes were left open in the sun to dry. Time for loading (t_1) and compressing (t_2) the corncob was recorded. Time for pull-back operation (t_3) and for ejecting (t_4) the briquettes from the mould was also computed. Also computed was the total time for briquetting from loading to extraction which was shown as t_T in Table 2.

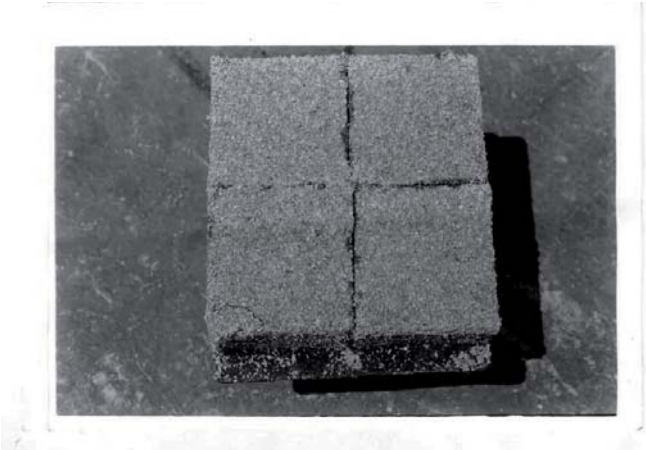

Fig. 2 Briquettes produced

RESULTS AND DISCUSSIONS

The result of determination of bulk density of corncob residue is shown in Table 1, while the results of the briquetting operation carried out are presented in Tables 2 and 3

Table 1: Bulk density of ground particles of corncob residue

No of Experiment	Weight of container (kg)	Weight of container + ground residue (kg)	Weight of the residue (kg)	Volume of container (m^3)	Density (kg/m^3)
1	1.20	6.20	5.00	0.05	100.00
2	1.20	5.70	4.50	0.05	90.00
3	1.20	6.00	4.80	0.05	96.00
Mean	**1.20**	**5.97**	**4.77**	**0.05**	**95.33**

Table 2: Result of Briquetting Operation

Experiment	t_1(sec)	t_2(sec)	t_3(sec)	t_4(sec)	mass (kg)	Height (mm)
R_1	75	120	26	397	0.36	5.7
R_2	87	120	28	395	0.38	6.0
R_3	78	120	27	408	0.34	5.3
Average	**80**	**120**	**27**	**400**	**0.36**	**5.67**

Table 3: Performance Evaluation of Agro-Residue Briquetting Machine

Trials	t_T(sec)	t_1*(%)	t_2*(%)	t_3*(%)	t_4*(%)	Spring-back (%)	Capacity (No/hr)	Bulk Density (kg/m^3)
1	618.00	12.10	19.04	4.20	64.24	14.00	23.30	300.00
2	630.00	13.80	19.05	3.17	62.70	20.00	22.86	316.70
3	633.00	12.32	18.95	4.27	64.45	16.00	22.75	283.30
Mean	**627.00**	**12.75**	**19.01**	**3.88**	**63.80**	**16.67**	**23.00**	**300.00**

Here, t_1= time for loading residue into moulds, sec.
t_2= time for compressing the residue, sec.
t_3= time for pull-back operation, sec.
t_4= time for unloading the briquettes, sec.

$\mathbf{t_T} = t_1 + t_2 + t_3 + t_4$ $\quad$ $t_1^* = (t_1/ t_T) \times 100$, % $\quad$ $t_2^* = (t_2/ t_T) \times 100$, %

$t_3^* = (t_3/ t_T) \times 100$, % $\quad$ $t_4^* = (t_4/ t_T) \times 100$

From Table 3, it can be seen that, the total time (t_T) varies from 613 seconds to 633 seconds with average value of 627 seconds. The pull-back operation recorded the least (with an average 3.88 % of t_T), while the extraction of the briquettes from the moulds consumed a disproportionately high time (with an average of 63.80 % of t_T). However, this is not a welcomed development and this suggests that, there is a need to devise a more efficient means of extracting briquettes from the moulds. Also, because of so much time was spent on extracting the briquettes, the capacity of the machine was low. An average value of 24 briquettes per hour was obtained. The results also revealed that there was spring-back or elongation on ejection from the moulds. The spring-back varies from 14-20 % giving the mean value of 16.67 %. This value is acceptable when compared with the results of Adekoya, 1989) and Oladeji, et al. (2009) where a range of value between 6-22 % and 10-25 % were obtained respectively. Furthermore the low value obtained implies that the briquette would experience minimum relaxation. This is a very good attribute as briquette would not crumble with time. Comparison of bulk density in Table 1 with that of Table 3 shows that, the bulk density had been increased by a factor ranging from 2.95-3.51. This is a welcomed development as considerable increase in density implies that briquettes produced would not crumble with time or when transported from one place to another.

CONCLUSION

A briquetting machine for producing briquettes from agro-residues has been designed and fabricated from locally available materials. The machine produced 4 briquettes at a time. The initial and final bulk densities were 95.33 and 300 kg/m^3 respectively and this implies that the briquettes produced would not disintegrate with time or crumble while on transportation.
Tests carried out on the briquetting machine showed that extraction of the briquettes from the moulds consumed a disproportionately high percentage of the briquetting time. Consequently, the capacity of the machine which was 23 briquettes per hour was low

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AGRICULTURAL AND FORESTRY WASTES AND OPPORTUNITIES FOR THEIR USE AS AN ENERGY SOURCE IN NIGERIA-AN OVERVIEW

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Abstract

This paper examines energy conversion and utilization systems based on agricultural and forestry residues. Various agricultural and forestry Biomass convertible to energy products are identified. Various conversion routes and utilization are discussed. The paper suggests that all the techniques of conversion discussed could form an agricultural complex utilizing briquettes as a renewable energy source; using anaerobic digestion (biogas) to produce energy and fertilizer; composting for soil conditioner; pyrolysis to produce medium grade Fuels and chemical preservatives and production of animal fodder through the process of pelletizing. The paper also highlights the benefits to be derived from the use of agricultural and forestry residues as energy source in Nigeria. Finally, the paper concludes that, finding practical and economic uses for the agricultural and forestry residues will create an opportunity to build a bioeconomy which will deliver sustainable economic growth with job creation and social cohesion as key outcomes

Keywords: - Agricultural Residues, Biomass, Energy, Forestry Wastes.

INTRODUCTION

Agricultural and forestry residues offer much potential for renewable energy sources in form of Biomass. With advances in biotechnology and bioengineering, some resources, which could have been classified as Waste, now form the basis for energy production (McKendry, 2002). It is estimated that, Nigeria has about 71.2 million hectares of available agricultural land, out of which about 36 million hectares of land are being currently utilized for (Agricultural Produciton) (FOS, 2006). The large quantities of Agricultural Residues produced in Nigeria can play a significant role in meeting her energy demand. Most of these residues are Biomass which contains enormous amount of energy (Fapetu, 2000a). However, it is unfortunate that these Wastes are neither utilized efficiently nor properly managed effectively in all developing countries, including Nigeria (Jekayinfa and Omisakin, 2005). The current farming practice is usually to burn these Wastes or leave them to decompose. This burning or decomposition apart from amounting to a colossal Waste of resources, contributes to environmental degradation and pollution. It also constitutes a public nuisance and an eyesore as these Wastes are left to litter almost everywhere. The type and quantity of agricultural Wastes in Nigeria change from one village to another and from one year to another because farmers always cultivate the most profitable crops.

Substantial amount of agricultural Wastes being generated in the country is used as Fuels in rural areas by direct combustion in low efficiency traditional furnaces. The traditional furnaces are primitive mud stoves and ovens that produce large quantities of air pollution and are extremely energy inefficient.

The main aim of this paper is to identify various sources of agricultural and forestry Wastes available in the country and suggest ways of utilizing them for economic advancement of the country.

Forestry and Energy Plantation
Wood is a major source of energy in Nigeria, and the potential exists for it to become a significant renewable source. The productivity in the forest areas of Nigeria ranges between 12 to 36 MT/ha/yr as opposed to a productivity of 3-9 MT/ha/yr in the grasslands (Fapetu, 2000a). Energy and forestry crops can be grown on a large scale and it has the potential to improve agricultural productivity, conserve land and diversify economy. Forestry residues are generated by operations such as thinning, extracting stem wood for pulp and timber, and natural attrition. In sawmills, wood processing generates significant volumes of residues in the form of sawdust, off cuts, bark and wood-chip rejects.

Agricultural crops and Residues
These include residues obtained during harvesting, crop processing and food processing Wastes. In Nigeria, agricultural crops are not grown specifically as energy sources because at present it is uneconomical to do so and more so this could lead to food shortage. The agricultural crops which can be grown specifically for energy purposes include sugar-cane, maize, sorghum, eucalyptus and vegetable oil-bearing crops such as sunflower and soya. These agro-Wastes abound in the country, though, not much use is made of them as energy resources. A number of agricultural and Biomass studies however, had concluded that it may be appropriate to remove and utilize at least a portion of these residues for energy production, providing large volume of low cost materials (Fapetu 2000b).

Manure Resources
Manure resources from animals account for over 92 % of such Wastes (Bamigboye and Oniya, 2003). Considerable yields are obtainable from cattle and poultry farming. The rest are produced by human beings. The quality of the manure is a function of the environment from which they are recovered. In the arid regions of Nigeria, cattle Wastes in form of dung are used for energy resources for domestic heating and cooking.

Advantages of Agricultural Residues for Biomass Production
There are a lot of benefits to be derived for using Agricultural Residues for Biomass energy production. Among these benefits are: -

(a) They are readily available in the rural areas where petroleum products are not always available and affordable

(b) They serve as a useful way of Waste disposal.

(c) Their use will help to reduce rate of deforestation as the rate of felling trees in the forest will be greatly reduced (Adekoya, 1989).

(d) Their use will promote clean environment as less pollutants are deposited into the atmosphere, thereby reducing the green house effect (Wilaipon, 2008).

(e) Their use will serve as additional way of generating income to farmers in rural areas, because once a market has been established, the residues may well acquire a monetary value (Wilaipon, 2008).

Limitations of Agricultural and Forestry Residues as Biomass Fuel
It is observed that several kinds of Agricultural Residues are available and ready to be utilized as Fuels. Utilization of agricultural and forestry residues is often difficult due to their uneven characteristics. This is because, it is widely accepted that the majority of the residues are not appropriate to be used as Fuels directly. As compared to other kinds of Fuels, Agricultural Residues have lower density, higher moisture content and lower energy density.

Besides, the low bulk density and dusty characteristics of the Biomass also cause problems in transportation, handling and storage (Husan, et al. 2002). Therefore there is the need to transform these residues into forms that will make their combustion easy and more efficient. There are many conversion routes and these are discussed below.

Conversion Routes of Agricultural and Forestry Residues to Energy and Products

Agricultural and forestry residues lend themselves to either thermo-chemical or biological conversion to energy or energy products. The process could lead to the production of solid, liquid or gaseous Fuels, and in some instances Agricultural Residues can be converted into heat energy. Some of the conversion process include: - direct combustion, gasification, pyrolysis, and briquetting, composting and pelletizing e.t.c (Fapetu, 2000a).

Combustion

This is a direct conversion of Biomass to heat energy. It is initially accompanied by drying of the Biomass followed by dissociation at about 250^0C and above to solid residue (char), tar oil mixed with water and gases such as methane and carbon monoxide (Fapetu, 2000a). All the products of dissociation except water vapour and pyroligneous acid are combustible.

Briquetting System

The briquetting process is the conversion of agricultural Wastes into uniformly shaped briquettes that are easy to use, transport and store (Wilaipon, 2008). The idea of briquetting is to use materials that are otherwise not stable due to lack of density, compressing them into a solid Fuel of a convenient shape that can be burned like wood or charcoal, (Olorunnisola, 2007). Briquetting process has been investigated by several researchers (Olorunnisola, 2007; Wilaipon, 2008; Peter, 2002; Singh, 2007; Yadong and Henry, 2000; Matti, 2004; Oladeji, et al., 2009 and so on). Process of briquetting usually transforms Biomass feedstock into high quality Fuel for domestic or industrial use. The briquettes will not only help to meet the energy needs, but also solve the disposal and pollution problems often created by Biomass residues. The briquettes have better physical and combustion characteristics than the initial Waste (Olorunnisola, 2007). Raw materials suitable for briquettes are rice straws, maize cobs, sugar-cane Waste (bagasse), sawdust, cowpea chaffs, melon and groundnut shells among others (Oladeji, et al. 2009).

Pyrolysis of Agricultural Wastes

This is an incomplete thermal degradation of Biomass (Agricultural Residues inclusive) into solid Fuel (char), condensable liquids (tar oils and acids) and non-condensable gaseous products (Bridgewater, 2002; Fapetu, 2000a). All known Biomass feed stocks could be subjected to pyrolysis, to obtain Fuel and chemical products. Few researchers on renewable energy had worked on pyrolysis of agro-residues. Examples of such residues studies are oil palm Waste (Guo and Lua, 2001), maize cob (Bamigboye and Oniya, 2003; Ogunsola and Oladeji, 2009), wood residues (Fapetu, 1994 and 2000b) and so on. Fapetu, (1994) has evaluated the potential yields of some agricultural and forestry Biomass (i.e. the ekki, wood coconut and palm kernel shells) during pyrolysis at temperature ranging between 960^0C and 1200^0C. The study established that coconut shells with an average yield of 29.64 % tar oil, and 30.92 % pyroligneous acid have the best overall potential for these products. However, the study concluded that ekki wood products retained the highest energy content of the parent Biomass on analysis.

Bio-gasification

This is the process of anaerobic fermentation of organic materials by micro-organisms under controlled conditions. Biogas is a mixture of gasses mainly methane and carbon dioxide that results from anaerobic fermentation of organic matter by bacteria. Animal manure is the major Biomass feedstock while other plant Wastes could be added occasionally. Water hyacinth has been successfully used to produce biogas in Nigeria.

Composting

Composting is the anaerobic decomposition of organic materials by micro-organisms under controlled conditions. Agricultural Waste is rich in organic matter. This matter is derived from the soil and the soil needs it back in order to continue producing healthy crops. Compositing is one of the best known recycling processes for organic Waste to close the natural loop. The major factors affecting the decomposition of organic matter by micro-organism are oxygen and moisture. Temperature, which is a result of microbial activity, is also an important factor. The other variables affecting the process of compositing are nutrients (carbon and nitrogen), pH, time and the physical characteristics of the raw material (porosity, structure, texture and particle size) (El-Haggar, et.al. 1998).

Liquid Fuel Production

Liquid **Fuel**s are principally Ethanol and mEthanol. MEthanol could be produced from wood and crops residues. Ethanol could also be produced from grass and starch contents. However, the technology of production of Ethanol is different from the technology of mEthanol (Fapetu, 2000a). Four distinct steps have been recognized in the production of Ethanol. These include: production of a simple sugar solution, fermentation of the sugar produced, fractional distillation of the liquor to produce 95 % Ethanol solution and further chemical distillation of 95 % Ethanol solution to remove the remaining water content. MEthanol could be obtained via three routes. It could be distilled from the raw pyroligneous acid obtained in the pyrolysis of Biomass. MEthanol is also produced from natural gas. The other method is to use the hydrogen and carbon monoxide from the gasification of Biomass.

Pelletizing

This process is similar to briquetting. The only difference here is that the product of pelletizing is much smaller than briquettes produced through briquetting. Furthermore, process of pelletizing is exclusively reserved for production of animal fodder. Agricultural Wastes could be transformed into animal foodstuffs through pelletizing. Agricultural Wastes have a high content of fibre that makes them not easily digestible. The size of the Waste in its natural form might be too big or tough for the animals to eat. To overcome these two problems, several methods were used to transform the agricultural Wastes into a more edible form with a higher nutritional value and better digestibility. The further addition of supplements can enrich the foodstuffs nutritional contents. Mechanical and chemical treatment method could be used to transform the shape of the roughage (Waste) into an edible form.

Oil Extraction from Agricultural Biomass

Oil can be extracted from a variety of Biomass including sunflowers, soya-beans, oil palm and rape. The oils can be used neat or blended with diesel oil for running compression ignition engines

Possible Areas of Agricultural Residues Application in Nigeria

Biofuels

The production of Biofuels such as Ethanol and Biodiesel has the potential to replace significant quantities of fossil Fuels. Ethanol can be mixed with petrol to produce gasohol for driving compression ignition engines such as tractors and harvesters in farms (Bamigboye & Oniya, 2003). Briquettes which are an improved form of charcoal and high grade solid Fuel would also be useful for domestic and industrial application (Olorunnisola, 2007).

Other Areas of Application

Electricity can be generated in small-scale from a number of Agricultural Residues. The combustion of Agricultural Residues and biogas produced can be used to generate heat and steam. The heat can be used in domestic cooking while the steam can be used to drive steam turbines and in boilers for industrial application. The biogas produced from anaerobic digestion, pyrolysis or gasification has a number of uses. It can be used in internal combustion engines and it can produce heat for industrial needs such as grass drying, running of absorption refrigeration. The ash by-product of combustion has potential for utilization as a fertilizer. The product of composting is very rich in organic matter and the soil needs it back to continue producing healthy crops. Agricultural Residues provide foodstuffs for animals and this helps in overcoming deficiency in animal foodstuffs. The chemicals produced are useful as adhesive tar that can be used to bind wood particles. Some of these chemicals could be used for embalmment of dead bodies.

Benefits of Agricultural Residues use in Nigeria

Agricultural Waste is a Biomass that is renewable source of energy and its use does not contribute to global warming. In fact, it has been found to reduce the atmospheric level of carbon dioxide as it acts as a sink (Wilaipon. 2009).

Biomass Fuels have negligible sulphur content and therefore do not contribute to sulphur dioxide emissions that cause acid rain. The ash produced by combustion of agricultural residue is less than coal combustion and this ash can be used as soil additive on farmland to recycle materials such as phosphorous and potassium (Musa, 2007).

Furthermore, finding practical and economic uses for the residues will create an opportunity to build a bioeconomy which will deliver sustainable economic growth with job creation and social cohesion as key outcomes. Creating such a bioeconomy involves the substitution of fossil materials with renewable carbon. As a consequence of increasing the use of renewable resources for industrial feed stocks and for energy, the bioeconomy will bring benefits in a number of areas. This will save a considerable amount of money and avoid negative environmental impacts and health hazards as a result of field burning process or decomposition of the agricultural Wastes.

CONCLUSION

Agricultural Wastes can be utilized using all the techniques mentioned above to form a cosmplex in which valuable products such as briquettes, biogas, liquid Fuels, animal fodder, fertilizer and chemical preservatives could be produced. All these do not contribute to global warming. Furthermore, finding practical and economic uses for the residues will create an opportunity to build a bioeconomy which will deliver sustainable economic growth with job creation and social cohesion as key outcomes.

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ANNUAL QUANTITIES OF AGRICULTURAL RESIDUES AND FOOD SCRAPS GENERATED AND USED IN URBAN AREARS OF NIGERIA

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Abstract
National development efforts in Nigeria have recognized two distinct areas – urban and rural. The rural area was characterized by high level of agricultural activities carried out mostly by the youths with full support by government. Only civil and public servants were found in urban areas with few traders. The only agricultural practices in the urban areas then were in Government Reserved Areas where residents grew vegetables and ornamentals and keep animals for pets. But with the oil boom, government gradually withdrew the supports and focused on the huge resources that were coming from oil. At the same time, the youths withdrew from the sector and started to migrate to the urban area in search of white collar jobs. The economic measures introduced by the government to check the situation did not achieve the objective as more people continued to migrate to the urban area. Instead, the measures threw many people out of job while many others remained unemployed. Worst still, those who retired are not returning to the rural areas. The only viable alternative in the urban area is for the people to take to farming and other agricultural ventures. Emanating from these agricultural activities are residues and food scraps. The objective of this study is to quantify Agricultural Residues and food scraps generated and used in urban areas of Nigeria. Three urban areas, Enugu Abakaliki and Umuahia were selected for the study. Methods of study were a combination of rapid urban approach and use of questionnaire to obtain information and data. Results show that in the area studied, there are up to ten types of Agricultural Residues and food scraps being generated from cropped farms, animal husbandry, meat, crop and timber processing, and they include livestock and poultry droppings, saw dust and wood shavings, livestock sludge, paper scraps, plant leaves etc. Also, a total of 694,323.53 Mettric tonnes are generated per annum in Enugu urban, 270,234.33 Metric tonnes are generated in Abakaliki and 110,654.16 Metric tonnes in Umuahia. The quantity used stood at 4,478, 1,959.33 and 115416 Metric tonnes per annum for Enugu, Abakaliki and Umuahia respectively.

INTRODUCTION
Attempts at national development have divided Nigeria into two distinct dichotomies – urban and rural sectors (FMARD, 2004). The rural area is characterized by abundant and fertile land and water resources. Before and shortly after independence the government put up institutions to harness these resources for food and raw materials production, processing and distribution. The major agricultural activities then were carried out in the rural area and mostly by the youths. Only civil and public servants were found in urban areas with few traders. The only agricultural practices in the urban areas then were in Government Reserved Areas where residents grew vegetables and ornamentals and keep animals for pets (Gibird and Girbird, 1977). The results of these efforts were abundant food and raw materials which satisfied effective demand without resort to importation (Liman, 1979), improved standard of

living for the rural dwellers, reduced rural to urban migration, increased employment opportunity, huge foreign exchange earnings etc. But as time went on, and with the oil boom, government withdrew her supports from agriculture and focused on the huge resources that were coming from oil. At the same time, the youths withdrew from the sector and started to migrate from the rural to the urban area in search of white collar jobs. Unable to cope with this trend, the government adopted measures to control the situation. Some of the measures include; embargo on employment, job cut, down sizing, aggressive rural development programme, etc all aimed at reducing rural to urban migration. These harsh policies threw many people out of job while many others remained unemployed. But these measures did not achieve the expected result as more people continued to troop to the cities. Worst still, those who retired are not returning to the rural cities due to social unrest in some cases, natural disasters lack of educational opportunities and medical facilities (UNDP, 1977). The only viable alternative in the urban area was for the people to take to farming. Hence one finds farms in open spaces, river banks, road sides, abandoned buildings, points of burst water pipes and at sewage points etc. Untreated Waste water has also been a valuable source of water for farming to millions of farms in urban areas of developing countries [SIWI,.2003] Also, some embark on livestock production, crop meat, timber and food processing, crop storage, etc. A field survey conducted in Enugu and Nsukka urban areas (Adama and Onwualu, 2005) showed that there are about 24 spots where agricultural and/ or agricultural related activities take place.

Emanating from these farm activities are residues and food scraps of various quantities and types. In the past, these products were regarded as Wastes (Eshenaur, 1984). Indeed, they were Wasted as the vast majority of them were discarded. But people have since recognized that these residues and food scraps are not Wastes as they could be used to create wealth by recycling them and using for many purposes including as source of energy for cooking, powering irrigation, generation of electricity, bedding for poultry and as natural fertilizer in the face of high cost and scarcity of inorganic fertilizers.

Urban area is an area comprising all territory population and housing units of 2,500 or more persons. It is an area in which majority of the people are not directly dependent on national resource based occupation and includes; the entire built up, non-rural area and its population. It is more broadly defined as a town or city having a free standing built up area with a service core with a sufficient number and variety of shops and services including per- haps a market to make it recognizably urban in character (Bureau of the Census, 1990; de B life and Muller, 1996; DOE, 1996).On the other hand rural area is a place where agriculture is the chief source of income (Ibrahim, 1991) By 1960s and 1970s few cities attained urban status in Nigeria judging from the population, availability of infrastructure, source of income, etc. However due to some policies of the government which were geared towards rural development, a number of rural areas attained urban status. Some of these policies include: creation of local government areas, rural electrification scheme, the community bank approach, creation of ministry and departments of rural development, the Directorate of Foods and Rural Infrastructure programme, the Agricultural Cooperative and Rural Development bank policy etc. Agricultural practice in urban areas is associated with a number of disadvantages which include: defacing of the urban land, distortion of the urban plans, pollution, blocking of water ways exposing the soil to erosion, etc (Ofomata, 1981). However, there are many advantages derived from the practice which include: provision of employment opportunity for urban residence, utilization of open spaces and abandoned buildings, source of income for the urban dwellers, supply of nutritionally adequate and safe food to city dwellers, reduction in post harvest losses as production is located close to the consumers, source of manure for the crops and food for livestock, etc (UNDP, 1977: Olarewaju, 1999; Adama and Onwualu, 2005)

The objective of this study is to quantify Agricultural Residues and food scraps generated and used in urban areas of Nigeria. Three urban areas in the South East Nigeria were used for the field study. They are Enugu, Abakaliki and Umuahia.

MATERIALS AND METHODS

THE PROJECT AREA

Enugu is the capital of Enugu state. Abakaliki is the capital of Ebonyi state and Umuahia is the capital of Abia state, all being states in Nigeria, and Nigeria has 36 states.

Enugu is chosen for the study because of its status as the capital of the former Eastern Region. Abakaliki is important because of its potential for food (especially rice) production. On the other hand Umuahia is strategic because of its location in the transition zone between the Niger Delta region and the Derived Savannah zone of the country. Enugu urban consists of three local government areas. One local government each make up Abakaliki and Umuahia urban areas. The populations of the areas are: Enugu 722,662; Abakaliki, 151,723 and Umuahia, 220,662 (FRN, 2007). Enugu situates on Lat 6.27N and Long 7.29E. It is a scarp footed town lying on the plains close to the east facing escarpment of the Enugu - Awgu cuesta with a rich formation known as the lower coal measures with crops at the foot of the escarpment (Ofomata,1975).The mean annual temperature is 21^{O}C while the rainfall ranges between 1520mm and 2030mm. The dominant crops are cassava, maize, vegetable and oil palm (Aneke, 1991).

Abakaliki is on a fairly level to moderately rolling plains under 200m above sea level. The vegetation is the tropical rain forest. The soils are of high fertility potential very suitable for rice production. Hence small and medium scale rice production farms and processing mills are found in different parts of the city. The average temperature is 21^{0} C.

Umuahia on the other hand lies on the transition zone between the Niger- Delta and Derived Savannah Zones of Nigeria. It situates between Longitude 04^{0} 45' and 06^{0} 17' North and Latitude 07^{0} 00' and 08^{0} 10' East. The annual temperature ranges between 20^{o} C and 36^{o} C (ABSEEDS 2006). The soils are manly sandy loam with high erodability potential. The average annual rainfall is 1677.3mm. The major crops grown in the city are vegetables, maize and cassava.

THE RESEARCH INSTRUMENT

The instrument for this research is the questionnaire. In addition to the questionnaire, the author visited farms, workshops, abattoirs, markets, dump sites of the states agencies responsible for environmental protection/ management etc The objective of the visit is to undertake personal assessment of residues and food scraps generated and how they are used or disposed of.

THE FIELD SURVEY

THE RESEARCH POPULATION AND POPULATION SAMPLE

The population for this research is the entire residence of the study area who generate and /or use Agricultural Residues and food scraps Due to cost, time and labour constraints, a sample of the population was taken for the study in each of the areas.

DESIGN OF QUESTIONNAIRE

A questionnaire was developed and used to obtain information and data from people who generate and/ or use Agricultural Residues and food scraps in the area of study. There are ten questions grouped A, B and C.

RESEARCH QUESTIONS

The first group of the questions was on the background of the respondent such as the sex, occupation, marital status, etc. The questions in group B were meant to obtain information on sources and quantities of residues and food scraps generated in the study area.

Group C questions were seeking to find out the quantities of residues and food scraps used and the quantity handled by the states agency responsible for Waste collection and disposal.

ADMINISTRATION OF QUESTIONNAIRE

The enumerators for this study were drawn from Federal Department of Agriculture, Enugu, Ebonyi State Environmental Protection Agency Abakaliki and the Department of Agricultural Engineering, Michael Okpara University of Agriculture, Umudike. The following constitute our respondents: timber processors and carpenters, crop processors, poultry farmers, livestock rearers, butchers, crop farmers printers and publishers, food vendors, canteen/ restaurant operators and hoteliers. Effort was made to obtain information from at least 3 respondents in each of the group above. Also interviewed are some field staff of the agency responsible for environmental management/ protection in the study area. 160 questionnaires were produced and used as follows: Enugu, 90; Abakaliki, 30 and Umuahia, 40.

DATA ANALYSIS

Data from the field are calculated from the equation

$Q = 0.365\ q \times n \quad MT$

Where: Q = quantity of Agricultural Residues and food scraps generated in a year, MT
q = quantity of Agricultural Residues and food scraps generated per a day by an individual / household / group or in a location Kg/ day
n = population or the number of groups or household or location depending on the type of product.

RESULTS AND DISCUSSION

AGRICULTURAL RESIDUES AND FOOD SCRAPS GENERATION TYPES AND THE SOURCES (PARENT MATERIAL)

Table 1 presents types of Agricultural Residues and food scraps and their sources (parent materials) being generated in Enugu Abakalilki and Umuahia urban areas. Ten types were identified and these include: wood shavings and saw dusts from timber processors, carpenters, upholstery workers, etc; plant leaves, stems, stalk, straw and grasses from crop farms (Fig 1); droppings from poultry houses; sludge, bones, shoe and horns from abattoirs (Fig 2); chaffs from food processing industries; papers from printing houses and schools; cooked foods from food vendors, canteens,/restaurants, hotels etc; domestic residues (general) from homes; dung; from livestock houses and general which includes the residues and food scraps handled by state agencies responsible for environmental management.

Fig. 1: A Vegetable Farm Near Central Police Station Barracks in Umuahia Urban

In Enugu and Umuahia urban areas, the major crops grown and which constitute the sources of the residues are vegetables, maize and cassava while in Abakiliki urban, the major source of plant residues is rice. In the three urban areas, animal residues (bones, sludge, shoe, horn, droppings and dung) are from cattle, goat, pig and poultry. The major sources of food scraps in the study area are from cassava fufu, garri, tapioca, rice, beans, soup, yams maize, and barbara groundnut. The parent materials of residues from processing industries include; tomato, maize, barbata groundnut, flour, palm kernel cake. Saw dusts and wood shavings come from timber and wood products. Other residues generated in the study area are peels from cassava, yams, fruits such as orange, pine apple, cashew, mangoes, etc. There are also paper scraps from schools and printing houses.

Fig. 2: Livestock Sludge in the Abattoir at 82 Division Nigeria Army Barracks, Enugu

Table 1: Agricultural Residues and Food Scraps Generated in Enugu Abakaliki and Umuahia Urban Areas if Nigeria by Type and Sources

S/N	Type of Residue and Food Scraps	Sources (Parent Materials)	Remarks
1	Sawdust and wood shavings	Wood and wood products	Produced by carpenters upholstery makers and timber dealers.
2	Grasses, crop leaves, stems, stalk, etc	Weeds, farm crops mainly vegetables, maize, cassava, rice.	Generated by field crop farmers
3	Livestock bones, hoofs and horns	Cattle, sheep goat and pig	Generated by butchers in abattoirs
4	Livestock sludge (rumen, blood, water, etc)	Cattle, goat and pig	Generated by butchers in abattoirs
5	Poultry droppings	Birds mainly broiler, layer, cockerel etc.	Generated by poultry farmers
6	Livestock droppings (urine, faeces, grasses, food scraps, etc)	Cattle, sheep, goat and pig	Generated in livestock markets and houses
7	Paper scraps	Pulp	Generated in printing houses, schools, hospital,
8	Cooked food scraps	Garri, cassava fufu, tapioca, yam, rice, beans, meat, fish, fruits, etc	Generated from canteens, restaurants, food ,vendors hotels, etc
9	Domestic residues	Fruits, garri, cassava fufu, tapioca, yam, rice, beans, meat, fish,	Generated from homes
10	Chaffs from processed products (kernel cake, tomato sludge, melon, barbara, groundnut, etc),	Farm crops mainly tomato, oil palm, barbara groundnut, melon, etc.	Generated from food and crop processing industries

UTILIZATION OF AGRICULTURAL RESIDUES AND FOOD SCRAPS GENERATED IN ENUGU. ABAKALIKI AND UMUAHIA URBAN AREAS

Agricultural Residues and food scraps generated in Enugu, Abakaliki and Umuahia are utilized in different ways either by the people who generate them or other people. Some species of grass and plant leaves including vegetables and other field crops as well as the peels from fruits, yams, cassava, etc are used in feeding livestock. Parts of these residues are recycled into the soil as soil organic nutrient by compost and decomposition. Palm kernel cakes, food scraps and abattoir sludge are used in feeding pigs. Hence in the study area, people are easily seen scarveging on the dump sites of the states agency responsible for Waste collection and disposal. Livestock bones and the hoofs and kernel cakes are used in poultry feed formulation. Livestock horns are used as cups for dinking palm wine. Wood shavings and saw dusts are important products for forming bedding for the poultry. Poultry and livestock droppings are recycled into the soil as soil manure. Industries manufacturing toilet tissues cart away paper scraps and recycle them into pulp.

QUANTITIES OF AGRICULTURAL RESIDUES AND FOOD SCRAPS GENERATED AND USED IN THE STUDY AREA

The annual quantities of Agricultural Residues and food scraps generated and used in Enugu Abakaliki and Umuahiia areas are presented on table 2. In the three, areas the largest residues and food scraps are enerated from domestic homes which is 5275.27 Metric tones for Enugu, 1107.57Metric tonnes for Abakaliki and 1610.83 Metric tonnes for Umuahia. This is followed by livestock droppings in Enugu and Umuahia cities which are 2015.76 Metric tonnes and 600.72 Metric tonnes respectively, and then chaffs from processed products for Abakalki (894.25MT). The least quantities in the three cities are from crop farms where 1.10, 0.42 and 0.38 Metric tonnes are generated for Enugu, Abakaliki and Umuahiia respectively. All the residues generated from crop farms, poultry droppings, paper scraps, cooked foods,livestock bones, hoofs and horns are fully used. The total quantity of Agricultural Residues and food scraps generated in the three urban areas are also shown on the table. Based on our survey, the figures are: 11,417.81Metric toones for Enugu Urban; 4,360.45 Metric tonnes for Abakaliki and 3,357.14 Metric tonnes for Umuahia. The quantity used are 4,478.53 Metric tonnes for Enugu; 1,959.33 Metric tonnes for Abakaliki and 1154.16 Metric tonnes for Umuahia.

Table 2: Annual Quantities of Agricultural Residues and Food Scraps Generated and Used in Enugu, Abakaliki and Umuahia Urban Areas of Nigeria.

S/N	Type of Residue and Food Scraps	Quantity Generated and Quantity Used, MT					
		Enugu Urban		Abakiliki		Umuahia	
		Generated	Used	Generated	Used	Generated	Used
1	Sawdust and wood shavings	1562.50	512.50	837.50	347.50.	590.00	238.00
2	Grasses, crop leaves, stems, stalk, etc	1.10	1.10	0.42	0.42	0.38	0.38
3	Livestock bones, shoe and horns	730.00	730.00	19.00	219.00	146.00	146.00
4	Livestock sludge	109.50	32.85	308.85	9.86	21.90	6.57
5	Poultry droppings	1029.30	1029.30	39.42	39.42	32.85	32.85
6	Livestock droppings	2,015.76	1007.88	806.30	322.52	600.72	241.89
7	Paper scraps	156.00	156.00	23.4	23.4	22.31	22.31
8	Cooked food scraps	173.38	173.38	82.13	82.13	58.40	58.40
9	Domestic residues	5,275.27	527.52	1107.57	110.75	1610.83	161.08
10	Chaffs from processed products (kernel cake, tomato, sludge, melon, Barbara, groundnut, etc),	365.00	328.50	894.25*	804.83	273.75	246.38
	Total	11417.81	478.53	4360.45	1959.33	3357.14	1154.16

*** mainly rice husks and bran**

ANNUAL QUANTITIES OF AGRICULTURAL RESIDUES AND FOOD SCRAPS HANDLED BY GOVERNMENT AGENCIES IN THE STUDY AREA

Our investigation reveals that there exist agencies that undertake Waste collection and disposal in each of the area studied. In Enugu state, the agency is known as Enugu State Waste Management Authority. That of Abakakliki is the Ebonyi State Environmental Protection Authority and for Abia state, it is called Abia State Environmental Protection Authority. Information from our survey shows that in Enugu the agency handles 689,850 Metric tones of Agricultural Residues and food scraps in a year. In Abakaliki the agency handles 268,275 Metric tonnes and for Abia the figure is 109,500 Metric tonnes

TOTAL ANNUAL QUANTITIES OF AGRICULTURAL RESIDUES AND FOOD SCRAPS GENERATED IN ENUGU, ABAKALIKI AND UMUAHIA URBAN AREAS OF NIGERIA

The total annual quantities of Agricultural Residues and food scraps generated in the study area are therefore obtained by adding the quantity handled by the agencies and the quantity used. Based on this, for Enugu urban the annual quantity is 694,323.53. For Abakaliki, the annual quantity is 270,234.33 and for Abia, the figure is 110,654.16 Metric tonnes.
Further analysis shows that in Enugu urban, 0.64% of Agricultural Residues and food scraps generated are utilized while in Abakaliki 0.73% is utilized. For Abia State, 1.05% is utilized.

CONCLUSION

The following conclusions are drawn from the study:

1. Large quantities of Agricultural Residues and food scraps are generated in Enugu, Abakalili and Umuahia urban areas of Nigeria.
2. The quantities of Agricultural Residues and food scraps generated in Enugu, Abakaliki and Umuahia urban areas are: 694,323.53, 270,234.33 and 110,654.16 Metric tonnes respectively.
3. The percentage quantity of residues and food scraps utilized in the areas are 0.64% for Enugu urban, 0.73 for Abakalik and 1.059% for Umuahia
4. There are no Agricultural Residues and food scrap recycling systems in the area of study.

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ASSESSMENT OF BIOMASS UTILIZATION TECHNOLOGIES IN SOUTH EASTERN NIGERIA

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Abstract

A survey of existing technologies at utilization of major Biomass resources such as rice straw, oil palm Wastes, cassava Wastes , forest product/sawmill residues in the south eastern, Nigeria was done. Primary data for this study was collected from 300 respondents randomly selected from Abia, Enugu and Imo states through structured questionnaires and interview schedule. The data collected include Biomass utilization methods, level of awareness and availability of Biomass technologies, and constraints/challenges encountered in the utilization of Biomass technologies (cooking stoves, biogas digester, briquetting machine and dryer) in the zone. Descriptive statistics were used to analyze the data obtained. Result showed that Biomass utilization is still in its infancy. Most of the respondents were not aware of the technologies while 75.0 %, 84.0 % and 65.6 % of the respondents claimed that biogas, briquetting machine and dryer respectively were not readily available in the study area. The development of appropriate indigenous technologies through adaptive research and enactment of government policies to support adoption among others is recommended.

Keywords: Biomass, utilization, indigenous, technology, diversification, Wastes, residues

INTRODUCTION

Biomass resources and availability in south eastern Nigeria

Green plants capture solar energy, convert it to chemical energy and then store that energy in their tissues. This mass of biological tissues or Biomass can be utilized for the chemical energy contained in it (Boor, 2008). According to ASABE (2006), Biomass is organic materials that are plant or animal based, including but not limited to dedicated energy crops, agricultural crops and trees, food, feed and fiber crop residues, aquatic plants, forestry and wood residues, agricultural Wastes, bio based segments of industrial and municipal Wastes, processing by-products and other non fossil organic materials. ASABE(2006)further categorized Biomass into primary, secondary and tertiary forms:

i. Primary Biomass which are produced directly by photosynthesis and harvested or collected from the field or forest where it is grown;
ii. Secondary Biomass are residues and byproducts streams from food, feed, fiber, wood and materials processing plants such as sawdust, black liquor and manures from concentrated animal feeding operations and
iii. Tertiary Biomass which are post consumer residues and Wastes such as fat, greases, oil, construction and demolition wood debris, other Waste wood from urban environment as well as packaging Wastes, municipal solid Wastes and land fill.

Biomass, constituting a large fraction of (Agricultural Produciton) process needs to be recognized for its economic value. Currently it has evolved into serious problem because of the abundance of Biomass Waste. The present disposal through incineration and landfill leads to health hazards as well as severe concentration of particulate emissions. Little attention has been focused on the utilization, which may be due to its being perceived as a Waste instead of a resource in need of development. As a Waste, there are costs and environmental problems associated with its disposal while as a resource, it can be controlled to provide energy and develop a source of revenue for the people. With no action, it will continue to be seen and treated as only Waste product with problems.

Biomass if tapped is an important renewable energy source which can provide energy requirement for cooking and heating in rural households and processing industries. Energy from Biomass is renewable, carbon neutral and is produced domestically
and would reduce energy costs, reduce global carbon emissions, reduce the dependence on depleting conventional fossil products, increase economic activities and jobs in rural areas, not impact the environment negatively and provide alternative income streams for farmers. It would also create practical and viable economic uses for the residues. As an energy resource, Biomass may be used as solid Fuel, or converted via a variety of technologies to liquid or gaseous forms for the generation of electric power, heat or Fuel for motive power (Sambo, 2009).

In the south eastern zone of Nigeria, major Biomass resources in the zone are rice husk/straw; oil palm Wastes; cassava Wastes; forest products; animal Wastes and urban Wastes. Rice Biomass consists of rice husk and rice straw. Rice straw can be used for feed, paper, mushroom cultivation, soil conditioner while rice husk can be used as Fuel, packing and building materials, litter materials, soil conditioner. The oil palm Biomass consist of the stem/leaves; palm empty bunches, palm nut shell, palm oil residues. Palm frond and leaves- the frond can be used as stakes for climbing and creeping plants. The core of the frond provides cordage material while the bark when split to strands provides raw materials for weaving baskets, cages and trays/sieves. The frond with leaves can be used as thatching material for roof and fencing while the leaves midribs are used for broom making. Palm kernel shell is an agricultural residue obtained during the cracking process of the palm nut in the oil processing. It can be used in the foundry work for melting metals by the blacksmith, soap making, reinforcement material in construction , source of Fuel and erosion control. Oil palm trunk- in log form is used in bridges while if converted can be used in roof trusses. Empty fruit bunches burnt to provide ash for black soap making. Mill effluent can be compressed to sludge cake and used for Fuel (Mijinyawa and Ogunbanjo, 2003). Cassava Biomass consists of the cassava stem/leaves, cassava peel, and liquid Waste. Cassava stem/leaves are used for organic matter for improve soil fertility and team for planting. Cassava peel is used for animal feed, fertilizer and mushroom cultivation. Cassava pulps are used for animal feed and improve soil fertility. Cassava liquid Waste is discharged and also used for biogas. Saw dust and wood Wastes are Biomass resources associated with the lumber industry. There is also poultry and pig Waste.

Biomass resources are available in processing mills in significant quantities in the south eastern ecological zone, Nigeria which could be utilized. However in their present loose form they make poor Fuel, burning with a lot of smoke, difficulty in handling and sometimes not present in the site they could be best utilized. The low bulk density of the Agricultural Residues also means high storage, handling and transport costs thereby reducing the economic values. Effective utilization of agricultural Waste products may reduce excessive pressure on the use of Fuel wood which usually leads to the attendant effects of deforestation and erosion. Agricultural Waste or forestry residue cannot be used efficiently directly as a source of energy except they are first converted to a more suitable and stable form (Olaoye, 2001). Olaoye (2001) further observed the reality and myth associated with availability and utilization of Biomass resources and concluded that availability of the resource is a reality but the required technologies to harness the resources or its variant is a missing link in its conversion and utilization in Nigeria.

Therefore the aim of this study is to assess the availability and level of awareness of Biomass utilization technologies (cooking stoves, biogas digester, briquetting machine and dryer) for conversion of the abundant Biomass resources to utilizable products in the south eastern ecological zone of Nigeria.

LITERATURE REVIEW

Modern Biomass utilization technologies

Several studies (Shaw et al., 1985; Ndirika, 1994, Krushna et al., 2004; Yi et al., 2007) in the past have shown the feasibility of various modern Biomass conversion and utilization technologies such as:

Direct combustion- combustion is the most simple and direct conversion process for Biomass which is used in many applications. The combustion process start with ignition of Biomass materials and proceed if sufficient air supply is guaranteed. Combustion process though apparently simple is a complex process characterized by high reaction rates and high heat release with many reactant and reaction schemes involved. Cooking by direct combustion is practiced by over 2 billion people worldwide primarily in the rural areas of developing countries (Larson and Jin, 1999).

Gasification- Gasification is the reaction of carbonaceous materials with steam and oxygen to produce a mixture of carbon monoxide (CO) , hydrogen (H_2), carbon dioxide (CO_2), methane (CH_4), some tar and char (Olorunnisola, 2002). This is the production of a combustible gas from carbon containing materials, which is thermo chemical conversion, typically occurring at 750 to 850^{0}C in an oxygen- deficient environment. The production of gaseous Fuel from solid Fuel have attractive properties like easy handling, combustion with low excess air, low levels of contaminants and possible application in internal combustion engines. Gasification generates Fuel gas that can be integrated with combined cycle turbines, reciprocating engines and potentially, with Fuel cell that converts Fuel energy to electricity more than twice as efficiently as conventional steam boilers (Okoroigwe et al., 2007).

Anaerobic digestion- Anaerobic digestion process consists of a series of decomposition reactions of organic material carried out by a well integrated community of several microbial populations in a moist environment in the absence of oxygen. The end products are a combustible gas (known as biogas) plus liquid slurry containing a number of inorganic salts which can be used as a fertilizer. Biogas is a mixture of methane (55-70 %) carbon dioxide (30- 40%) and traces of other gases including nitrogen, hydrogen, carbon monoxide, ammonia and hydrogen sulfide (Abubakar, 1990). Anaerobic digestion is a naturally occurring process which, if the end products are to be utilized needs to take place in a holding tank or digester. The design of the digester depends on the volume and type of Waste to be treated as well as environmental and social conditions in which the digester is to be used. The production of biogas during anaerobic digestion depends on a number of physical and biological factors such as pH (optimum range 6.6 to 7.6), temperature (optimum range is 30 to 40^{0}C) and carbon: nitrogen ratio (about 30:1 is optimum) (Olorunisola, 2002).

Carbonation-charcoal is the solid product of the breakdown of Biomass in the absence of oxygen (air) at temperatures above 250^{0}C. The process is similar in nature to pyrolysis, but occurs at lower temperature and longer residence time in the reactor. The decomposition takes place in four stages:

i. Between 100^0C and 170^0C all loosely bound water is evaporated from the raw material
ii. Between 170^0C and 270^0C the thermal decomposition of the wood starts with the production of gases containing carbon monoxide and carbon dioxide, and condensable vapours which forms pyroligneous acid or oil
iii. Between 270^0C and 280^0C an exothermic reaction starts, which can be detected by an increase in temperature. At the same time the production of carbon monoxide and carbon dioxide ceases but the production of the condensable vapours increases. No further external heating is required.
iv. The temperature slowly rises to between 400^0C and 450^0C. The air inlet should be closed to prevent further combustion of the Biomass and increase the charcoal formation.
These phases occur simultaneously, although one specific phase will predominate at a particular point in the combustion process.

Alcohol production- Ethanol or ethyl alcohol which is commonly known as alcohol is a colourless transparent liquid with a pleasant odour and burning taste. The molecular formula for Ethanol is C2H5OH and the molecular weight is 46.07. It has some important physiological characteristics; for example, it is intoxicating and can be used as a sterilizing and disinfecting agent. By nature, Ethanol is volatile and combustible. It mixes well with water and many other organic solvents and dissolves a number of organic chemical compounds. Because of these properties, Ethanol is extensively used in drinks and foods, medicines, cosmetics and in chemical industries. Moreover, in recent years, its use as a clean substitute for petroleum Fuel has been popular because it does not cause any environmental pollution and destruction (CIGR, 1999).

Pyrolysis- is the thermo chemical conversion of Biomass in the absence of oxygen at temperature conducted at 400 to 600^0C which gives three groups of products: a solid (char or charcoal), a liquid (pyroligneous acid or oil) and a mixture of gases (carbon monoxide, hydrogen, and nitrogen). Pyrolysis is a slow, irreversible process of thermal degradation of organic components in Biomass in the presence of limited amount of air. The ratio of the products varies with the chemical composition of the Biomass and operating conditions (EMSI, 2000).

Densification or briquetting is the process of using mechanical pressure to reduce the volume of Biomass material thereby converting Biomass residues into more acceptable Fuel by improving the physical properties of the Biomass in terms of higher density, better handling and combustion characteristics than the loose materials. Densification provides a descent , convenient and efficient way of using agricultural Wastes (Faborode,1998) and thus improves the economies of material handling, transportation and storage thereby enhancing more versatile application(Olaoye, 2001). Residues vary in their physical and chemical properties which require different densification processes. Parameters influencing the briquette quality are moisture content, particle size and morphology (shape).

METHODOLOGY

The method used in gathering information involves a field survey from three out of the five states in the south eastern ecological zones of Nigeria. The areas visited were the state capitals and sub- urban, strategically selected because of the prevalent of Biomass resources in such places. Primary data for this study was collected from three hundred respondents randomly selected from Abia, Enugu and Imo states through structured questionnaires and personal interview schedule. The data collected include Biomass utilization methods, level of awareness and availability of Biomass technologies, and constraint/challenges encountered in the utilization of Biomass technologies in the zone. Descriptive statistics were used to analyze the data obtained.

RESULTS AND DISCUSSION

The demographic data in terms age, sex, marital status and education of respondents are given in table 1. Most (37.7 %) of the respondents are within the age bracket of 41- 50, most of the respondents are youths. The implication of the result is that Biomass utilization is tilted towards those who are in their most productive years of age.

The gender distribution of the respondents indicated that 44.3 % were male while 55.7 % were female. Women are the ones that carry out the domestic work of cooking mostly in the family and also the crop processing activities of (Agricultural Produciton) processes.

Table 1 also revealed that majority 77.7 % of the respondents are married while 22.3 % are single. Married people may tend to use more of these technologies because they are cost responsive than single people.

Education qualification of the respondents showed that 44.4 % of the respondents have tertiary education while 40 % had secondary education. For efficient utilization of Biomass technologies education may be necessary condition. The adoption of new technology will depend on the level of education of the users.

Table 1: Demographic data of respondents

Respondents	Frequency	Percent
Age		
0-30	80	26.7
31-40	87	29.0
41-50	113	37.7
51-60	13	4.3
Above 61	7	2.3
Total	300	100
Sex		
Male	133	44.3
Female	167	55.7
Total	300	100
Marital status		
Single	67	22.3
Married	233	77.6
Total	300	100
Education		
Primary	34	11.3
Secondary	120	40.0
Tertiary	133	44.3
Others	13	4.3
Total	300	100

Level of awareness of Biomass utilization technologies

The technologies for transformation and utilization of Biomass cover a wide range from local, to well developed technologies or research level technologies. Biomass conversion technologies varies, it may be technologies for producing heat, electricity and Fuel (solid, liquid and gas). Effort was made to ascertain the level of awareness of bio Fuel, gasification, carbonization, biogas and briquette technologies by the respondents. Majority (51-89 %) of the respondents are not aware of these technologies as shown in table 2. However, 49 % and 26.3 % of the respondents are aware briquette and biogas technologies respectively.

Table 2: Level of awareness Biomass utilization technologies in the south eastern, Nigeria

	Yes		No	
Technologies	Frequency	Percent	Frequency	Percent
Biofuel	93	31.0	207	69.0
Gasification	60	20.0	240	80.0
Carbonization	60	20.0	240	80.0
Biogas	80	26.7	220	73.3
Briquette	147	49.0	153	51.0

Availability of Biomass utilization technologies in South east Nigeria

The respondents were asked of the availability of various modern application/utilization technologies, with local capacity for producing economically viable units, for them to purchase. Table 3 gave the responses of the respondents. The cooking stove is the most available technology as indicated by 89.0 % of the respondents followed by the dryer (22.3%). The high availability of cooking stoves could be as a result of the development and adoption of the improved versions of cooking stoves locally popularized by the Energy Commission of Nigeria through its Energy Centres at the University of Nigeria, Nsukka and Othman Dan Fodio University, Sokoto, which has been noted to reduce Fuel wood consumption by 50 % (Sambo, 2009). The biogas digester, briquetting machine and dryer are the most unavailable technologies with 86.3 %, 79.0% and 62.0 % respectively attesting to that fact. It can be seen from the result that Biomass utilization is presently dominantly limited to thermal application as Fuel for cooking and crop drying.

Table 3: Biomass utilization technologies availability in the south eastern Nigeria

	Readily Available		Available		Not Available	
Technologies	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Cooking stoves	176	58.7	91	30.3	33	11.0
Biogas digester	14	4.7	27	9.0	259	86.3
Briquetting machine	35	11.7	28	9.3	237	79.0
Dryer	67	22.3	47	15.7	186	62.0

Constraints and challenges of Biomass utilization

The respondents from the survey gave multiple responses on the constraints and challenges they encountered in the adoption of the Biomass utilization technologies in the south eastern ecological zone Nigeria, as indicated in table 4. The table revealed that high cost of cooking stoves constituted the most prominent constraint of using cooking stove technology in the study area. On the other hand, majority of respondents 75.0 %, 84.0 % and 65.6 %, respectively claimed that biogas, briquetting machine and dryer were not readily available for use in the study area. 20.3 % of the respondents reported that cooking stoves available are not efficient while 5 % claimed that biogas is difficult to use.

Table 4. Constraints/challenges of utilization of Biomass technologies

	High cost		Difficult to use		Not efficient		Not readily available	
Technologies	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Cooking stoves	205	68.3	0	0	61	20.3	34	11.3
Biogas	61	20.3	14	4.7	0	0	225	75.0
Briquetting machine	48	16.0	0	0	0	0	252	84.0
Dryer	82	27.3	7	2.3	14	4.7	197	65.6

Biomass utilization in the south eastern Nigeria

Result of the survey showed that Biomass utilization is still in its infancy in the south eastern zone of the country and its value chain has not been fully explored. Presently Biomass resources are seriously underutilized in the south east. The responses are summarized as follows:

i. Rice husk/straw is used mainly as livestock feed, manure and making fire
ii. Animal Waste is used as manure
iii. Oil palm Waste is presently used predominantly for making fire, soap making and animal feed
iv. Cassava Waste is used as animal feed and manure
v. Forest product is used as manure, making fire and litter for livestock housing.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The potential of abundant Biomass resources is yet to be tapped due to the infancy and high cost of accessing the conversion and utilization technologies in the south eastern states of Nigeria. Many of the technologies are still at the developmental stages with the attendant improper choice of materials for construction and low performance efficiency. These challenges can be overcomed though, since there are enormous opportunities for the promotion and adoption of the utilization technologies.

Recommendations

The following recommendations were made based on the major findings of the study:

i. The technologies should be readily available for the populace to purchase with the view of adopting them.
ii. Credit facilities should be available for the developer and the adopter to mass produce the technologies and purchase respectively.
iii. The public should be aware of the potentials and benefits of the technologies through various sources of information.
iv. Research and development efforts should be directed at fine tuning the technologies available to make them more efficient.
v. There should training of the end users and capacity building of technology developers to enable proper usage of the technologies.
vi. The technologies should be simple and affordable for it to be easily adopted.
vii. Spare parts should be available to ensure ease of maintenance of the technologies
viii. Use good materials for construction
ix. Good road networks to open up the rural areas where the end users of the technologies resides and to move the raw materials.
x. Government should facilitate adoption of Biomass technologies through enactment user friendly policies.

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JATROPHA CURCAS: A POTENTIAL ENERGY CROP AND AN ALTERNATIVE BIOFUEL

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Abstract
The diversion of food crops for the production of bioenergy generated global concerns which have led to research in the use of alternative crops for bioenergy. In recent years, interest in the use of *Jatropha curcas*, a drought resistant shrub, as an alternative bioenergy is greatly increasing. This shrub which usually thrives on marginal lands belongs to the family Euphorbiales. About 31-37% of oil extracted from *J. curcas* can be used as Biodiesel in any diesel engine without modification. The oil from the *Jatropha* tree is considered one of the top sources of Biodiesel, which could be used as a renewable liquid Fuel. Several investigations have looked at the properties of this formerly unpopular shrub and concluded that it is the possible solution for a Fuel source that is clean and does not trade off with crop lands. It is known as the world's fastest growing alternative to crude oil. Unfortunately, this species is still a wild plant with various ongoing researches on its cultivation and properties. This paper gives an overview of available information on the cultivation and agronomic properties of *J. curcas* as an alternative energy. The review concludes with a call for increased cultivation of the shrub so as to increase production of Biodiesel, enlarged natural green sink for carbon sequestration and climate change mitigation.

Keywords: Biodiesel, Cultivation,, Environmental Impact, Physic nut

INTRODUCTION
Biodiesel is a Fuel made from natural sources, such as vegetable oils and animal fats, for use in diesel engines. It is safe, biodegradable and contains fewer pollutants than gasoline. Since it is extracted from vegetable oil, it is an alternative renewable Fuel source reducing the dependence on fossil Fuels. According to Knothe (2006), Biodiesel is monoalkyl esters of fatty acids derived from vegetable oils or animal fats, usually produced by the transesterification of vegetable oils or animal fats with mEthanol or Ethanol. The advantages include its being renewable, safe for use in all conventional diesel engines, offer the same performance and engine durability as petroleum diesel Fuel, non-flammable and nontoxic, reduces tailpipe emissions, visible smoke and noxious fumes and odors. The use of Biodiesel has grown dramatically during the last few years. Feedstock costs account for a large percent of the direct Biodiesel production costs, including capital cost and return (Bozbas, 2005). One way of reducing the Biodiesel production costs is to use the less expensive feedstock containing fatty acids such as inedible oils, animal fats, Waste food oil and by products of the refining vegetables oils. bio-diesel derived from plant species has been a major renewable source of energy. *Jatropha curcas* is considered most potential both to the growers, the processors and the end users. To the rural society, the crop can create regular employment opportunities, as it provides never ending marketing potential. The fact that *Jatropha* oil cannot be used for nutritional purposes without detoxification makes its use as energy/Fuel source very attractive (Emil *et al* 2009). Although it is known that Jatropha can be established

from seed and cuttings, still very little information is available/ documented in Africa about the silviculture and management of Jatropha.

Description of *Jatropha curcas*

Jatropha curcas is known by over 200 common or local names, indicating its occurrence in various countries (Jones and Miller, 1992). Such names include Poughere (French), purgeer noot (Dutch): meaning cleaning of the intestine (Chen *et al*. 2008). It is also known as physic nut, purging nut, pinoncillo, Habb-El-Meluk, black vomit nut, wild castor or diesel beans, depending on the region of the world where it is grown (Makkar *et al*., 1997). It was brought from the Mexican and Central American region by traders and sailors to all other colonies due to its medicinal applications in 1600AD. Distribution of *J. curcas* beyond tropical America was facilitated by the Portuguese and Arab traders who transported the plant to Africa and Asia where it has since become naturalized and widely utilized on a local basis. In Nigeria, it is known as "lapalapa". The bark is used to produce blue dye and wax while the root is used to produce yellow dye. The leaves are used to dress wounds while the juice and the flowers are used for medicinal purposes. It can be found almost everywhere in the warm tropics i.e. semi arid to humid (Figure 1). It is a tall bush or small tree (up to 6 m height). The lifespan of this perennial bush is more than 50 years, and it can grow on marginal soils with low nutrient content. *Jatropha curcas*, or "physic nut" has a straight trunk with thick branchlets. It has green leaves with a length and width of 6 to 15 cm. The fruits have an "American Football" type of shape, of about 40 mm length and each contains 3 seeds (on average), which look like black beans. with similar dimensions, of about 18 mm long (11-30) and 10 mm wide (7 – 11) The seed weight per 1000 seeds is about 750 grams, which is equivalent of 1333 seeds per kg on average (Joker and Jepsen 2003). It is used traditionally for soap making and live fence in Africa while it is used for candles in Madagascar. It was tested for Fuel production by the French in Mali and also by the Portuguese on Cabo Verde in 1955. Projects in Mali and Madagascar used the plants for erosion control and soil improvement (Heller, 1996). The seeds contain more than 30% of oil by weight. The branches contain whitish latex, which causes brown stains that are difficult to remove. Normally five roots are formed from seeds: one tap root and 4 lateral roots.

Cultivation and growth of *Jatropha curcas*

Jatropha grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content (Heller, 1996). *Jatropha curcas* has the advantage that not only is it capable of growing on marginal land, but it can also help to reclaim problematic lands and restore eroded areas. Openshaw (2000) also reported that the plant can be established in gravelly, sandy, degraded or acidic soil and the plants deep roots will recycle nutrients and reduce the possibility of erosion. The trees can grow to 6.1meter tall, can live up to 50 years. According to Eijck and Romijn (2008), the shrubs will live approximately 40-50 years and produce seeds three times per annum. The bush can be expected to start bearing fruit within one year of planting (Jones and Miller, 1992).and can be harvested as quickly as 18 months after planting, under ideal conditions. It does well in both good and poor soil and doesn't require heavy cultivation, fertilization or irrigation. According to Chen *et al* (2008), seeds are encased with green capsules in the plant's fruit. They become mature when capsules change from green to yellow. As it is not a food or forage crop, it plays an important role in deterring cattle, and thereby protects other valuable food or cash crops when used for fencing. Planting widths are 2 x 2 m, 2.5 x 2.5 m, and 3 x 3 m. This is equivalent to crop densities of 2500, 1600 and 1111 plants/ha, respectively. Under good rainfall conditions, nursery plants bear fruit after the first rainy season, while direct seeded plants start fruiting for the first time after the second rainy season. Jatropha is a soft tree. It does not break or get uprooted in case of

cyclones and floods. The species is easily propagated by direct seeding, transplanting of spontaneous wild plants and direct planting of cuttings. Plants from seeds develop a typical taproot and four lateral roots, and cuttings do not develop a taproot (Heller, 1996). Jatropha is a fast growing plant that can achieve a height of three meters within three years under a variety of growing conditions. Seed production from plants propagated from seeds can be expected within 3-4 years. The use of branch cutting for propagation is easy and results in rapid growth; Jatropha is not browsed by cattle and goats, hence is used as a live fence around homesteads and gardens. Since the plant is a perennial, ploughing and planting are not needed regularly. The growth and management of Jatropha in Nigeria has not been well documented. There has not been any plantation or intentional planting for commercial use in existence. Currently growers are unable to substantially benefit from the plant, especially from its potential uses as the major use of Jatropha in Nigeria is for hedgerow.
Jatropha is a Biodiesel crop that does not compete with food crops. Mycorrhizal associations have been observed with Jatropha and are known to aid the plant's growth under conditions where phosphate is limiting (Jones and Miller, 1992). Whilst Jatropha grows well in low rainfall conditions (requiring only about 200 mm of rain to survive) it can also respond to higher rainfall (up to 1200 mm) particularly in hot climatic conditions. In Nicaragua for example, Jatropha grows very well in the country's hot climate with rainfall of 1000mm or more. Experience in Zimbabwe has shown that high rainfall in the relatively cooler parts of the country does not encourage the same vigorous growth. However, in the low-veld areas, such as in the mid-Save region, Jatropha grows well, although comparative yields have not been established. Jatropha does not thrive in wetland conditions. The plant is undemanding in soil type and does not require tillage. As early experiences from the cultivation of Jatropha as a managed agricultural crop are beginning to accumulate, it is becoming increasingly clear that although Jatropha is indeed able to survive under hostile environmental conditions, oil yields can be much higher in conditions where the plant has adequate access to soil nutrients and water (FAO, 2008; Achten *et al.*, 2008).

Advantages of Jatropha Plantations
A perceived advantage of Jatropha is its capability to grow on marginal land and its ability to reclaim problematic lands and restore eroded areas. In Guatemala, the Ministry of Agriculture identified more than 600,000 hectares of unproductive land – mostly deforested or depleted soil from repeated corn crops – that is suitable for the Biofuel crop, Jatropha (FAO 2009) so as to improve the livelihoods for the poor. As it is not a forage crop, it plays an important role in keeping out the cattle and protects other valuable food crops or cash crops when used as live fencing. Jatropha products from the fruit - the flesh, seed coat and seed cake - are rich in nitrogen, phosphorous and potassium (NPK) and serve as fertilizers soil improvement. The use of Jatropha hedges and shelterbelts to improve the microclimate and provide humus and fertilizers to the soil can further enhance the productivity of other agricultural crops. It has been observed that one acre of Jatropha plantation absorbs and reduces 500 kg of CO_2 every year, from the atmosphere. Jatropha plantation reduces the amount of dust/ sand that is carried by high winds. Jatropha grows much faster than any other bush and fixes CO_2 into its stem and branches, thus reducing CO_2 from Atmosphere. This is a good way to reduce Green House Gas Emissions. Jatropha, being a soft tree does not break or get uprooted in case of Cyclones and Floods, like other Oil Bearing Seed Trees. Plantation of Jatropha reduces the amount of dust/ sand that is carried by high winds (especially in deserts) and reduces spread of respiratory deceases. It cools the entire area and also provides rural employment and Fuel for lighting in local areas.

Jatropha curcas oil

According to Swanson (2008), oil from Jatropha is considered one of the top sources of Biodiesel, the world's fastest growing alternative to crude oil. Barbados nut or physic nut also contains glycerine that must be extracted from the Fuel. Early Central American settlers lit the long-burning seeds in a bowl, as makeshift candles. Jatropha seeds can be pressed into bio-oil that can be used to run diesel engines, which in turn can drive pumps, food processing machinery, or electricity generators. The bio-oil can also be the basis for soap making. In most cases this requires little or no chemical processing of the oil. The pressed residue of the seeds is a good fertilizer and can also be used for biogas production. The most promising and currently exploited uses of Jatropha are in rural agro-industrial development where oil pressed from the seed is used in making soap, candles, and lubricants while the seed cake can be used as organic manure. The seed oil is 80 percent unsaturated, made up mainly of oleic and linoleic acid. Most vegetable oils that are liquid at room temperature have a comparable fatty acid composition. Many investigations have been done on the content of the Jatropha seeds. Table 1 shows the chemical properties of the seed. About one-third of the energy in the fruit of Jatropha can be extracted as an oil that has a similar energy value to diesel Fuel. Jatropha oil can be used directly in diesel engines added to diesel Fuel as an extender or trans-esterised to a bio-diesel Fuel. In theory, a diesel substitute can be produced from locally grown Jatropha plants, thus providing these areas with the possibility of becoming self sufficient in Fuel for power generation. Pramanik (2003) obtained acceptable thermal efficiency for a compression ignition engine by using oil blends containing up to 50% volume of Jatropha oil. From the properties and engine test results, he established that 40-50% Jatropha oil can be substituted for diesel without any engine modification and preheating of the blends. Sotolongo *et al* (2005) used the Sundhara oil expeller to obtain oil extractions of around 29%. 3.3 kg of seed was used to produce 1 kg oil (1.086 litres oil) with the physical - chemical properties in Table 2.

Pests and diseases of *Jatropha curcas*

The above uses and advantages of *Jatropha curcas* can be jeopardized by the prevalence of pests and diseases that attack the plant. Existing literature indicates that contrary to popular belief that toxicity and insecticidal properties of *J. curcas* are a sufficient deterrent for insects that cause economic damage in plantations, several groups of insects have overcome this barrier. Insects in the order Heteroptera has at least 15 species in Nicaragua that can extract nutrients from the fruit of the physic nut. The stem borer from the coleopterous family of Cerambycidae that is known as a minor pest in cassava can kill mature physic nut trees. The relatively few leaf-eating insects present are not capable of doing much damage once the trees have passed the seedling stage. Biological control can make use of beneficial arthropods – polyphagous predators and specialized parasitoids – either by conservation or augmentative releases; the first alternative being the more cost efficient (Grimm and Maes, 1997). In some areas of Zimbabwe, the golden flea beetle (Podagrica spp.) can cause harm – eat young leaves and shoots, particularly on young plants. Jatropha is also host to the fungus "frogeye" (Cercospera spp.) common in tobacco.

Plate 1: *Jatropha curcas* trees

Table 1: Chemical properties of *Jatropha curcas*

Material	Kernel (60% of weight)	Shell (40% of weight)	Meal
Crude protein	25.6	4.5	61.2
Lipid (crude fat)	56.8	1.4	1.2
Ash	3.6	6.1	10.4
Neutral detergent fiber	3.5	85.8	8.1
Acid detergent fiber	3.0	75.6	6.8
Acid detergent lignin	0.1	47.5	0.3
Gross energy (MJ/kg)	30.5	19.5	18.0

(Pramanik, 2003)

Table 2: Properties of extracted oil of *J. curcas*

Properties	
Calorific value, MJ/kg	39,08
Relative density a 150 C g/cm^3	0,9207
Kinematic viscosity a 20 0 C cst	44,31
Relation C/H, %wt	13.11
Sulphur content, % wt	0.04
Water content, % wt	0.21

Sotolongo *et al* (2005)

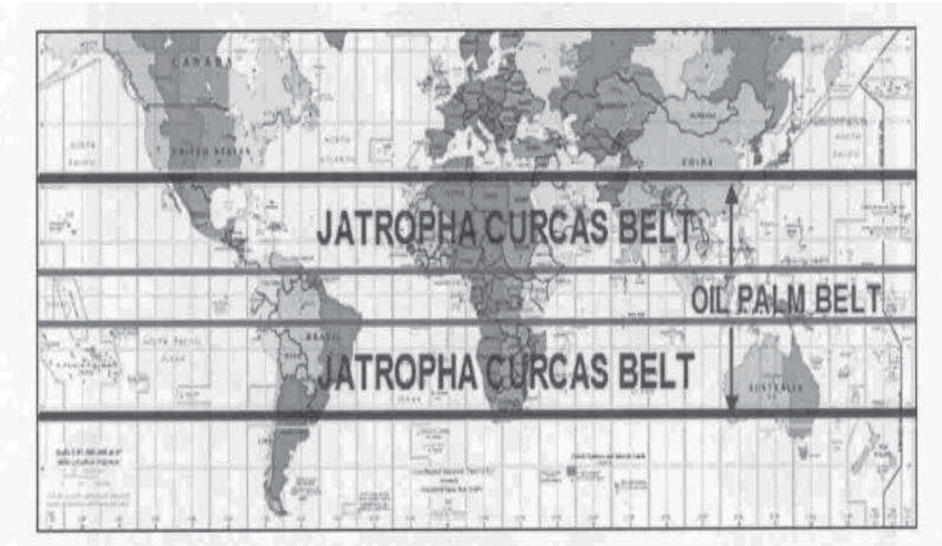

Fig. 1: *Jatropha curcas* belt
Source: Chen *et al* 2008

CONCLUSION AND RECOMMENDATION

Jatropha is still a wild plant of which basic agronomic properties are not thoroughly understood and the environmental effects have not been investigated yet (Achten *et al*, 2008). There is need to examine issues relating to silvicultural production systems and nutrient requirements of *Jatropha curcas*. This will include the best management techniques that will be required to promote the optimum growth of Jatropha to optimize for instance nut production, the types of edaphic factors, climatic conditions that will provide the best growth environment for *Jatropha curcas*, both from the perspective of fruit and Biomass, the ideal rotation age for nuts and the plant and the varieties, including non-toxic varieties which will perform best in Nigeria. Also, there will be need to look into establishment of *Jatropha curcas* plantations by themselves or in agro-forestry combinations and how this can be used to alleviate problems of deforestation and soil erosion to improve the environment. There is also a need to research into available biological control/ techniques for pests and diseases of Jatropha. Researchers should also be encouraged to look into increased cultivation of the shrub so as to increase production of Biodiesel using plant materials that do not compete with food crops. This will lead to enlarged natural green sink for carbon sequestration and climate change mitigation. Further research should also be carried out on the effects of Jatropha on the environment.

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CASSAVA UTILIZATION WITHOUT WASTE: PERFORMANCE EVALUATION OF A CONTINUOUS-FLOW ROTARY CASSAVA PEELER

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Abstract
The machine peeling efficiency, throughput capacity, flesh loss, labour cost, Fuel consumption rate and Fuel cost of a continuous-flow rotary cassava peeler when powered by a 3.73 kW(5.0 Hp) petrol engine were determined and compared with the similar data determined for the machine when powered by a 2.24 kW (3.0 Hp) single phase electric motor. The machine peeling efficiencies, throughput capacities, flesh loss and costs determined for the two modes of powering the machine were compared with the peeling rate, peeling efficiency, flesh loss and cost obtained for manual peeling of fresh cassava root tubers.
The average machine peeling efficiency, throughput capacity, flesh loss, Fuel consumption rate and cost as well as the total cost of the using machine to peel when powered by petrol engine were determined as 88.79%, 751.97kg/hr, 17.21%, 1103kg/L, N58.86/tonne and ₦457.19/tonne respectively.
The average machine peeling efficiency, throughput capacity, flesh loss, electric energy consumption rate and cost as well as the total cost of for using the machine to peel when powered by electric motor were determined as 88.79%, 1041.03kg/hr, 16.01%, 1250 kg/kWhr, ₦5.20/tonne and N300.50/tonne respectively.
The average peeling rate, peeling efficiency, flesh loss and total cost were determined for manual peeling of fresh cassava root tubers as 18.06 kg/hr, 83.42%, 9.9% and ₦27, 660.00/tonne respectively for manual peeling of fresh cassava tubers.
Peeling fresh cassava root tubers with the machine when powered by either electric motor or petrol engine was most efficient while peeling manually was least efficient and most expensive. Peeling fresh cassava root tubers with the machine when powered by electric motor was the least expensive.
The incorporation of the machine in the unit operations for cassava processing into animal feeds and industrial raw materials will reduce costs to a level that will make the use of cassava much more competitive.

INTRODUCTION
Cassava (Manihot Esculenta Crantz) is a crop with multiple end-uses, such as for human consumption, animal feeding as well as for processing into many different products, including starch and Fuel Ethanol.
In Africa, albeit Nigeria, cassava is gradually becoming transformed from a famine-reserve commodity and rural staple food to a cash crop for urban consumption. For the cassava transformation process to advance to the next stage of livestock feed and industrial raw material, labour-saving production, harvesting and processing technologies must be put in place to reduce costs, improve productivity and make cassava more competitive. Yet it should be borne in mind that the transformation process will cease to continue unless new uses and markets are identified to absorb the increase in production.

The first unit operation, apart from washing, in the processing of cassava for human consumption, is peeling-an operation which remains a bottleneck both at the peasant and industrial levels of operation. It is an operation which involves tedious and time-consuming manual labour inputs (Taiwo, 2009).

Whenever cassava tubers are harvested in large quantities and peeling is manual, deteriorations often set in fast because the freshly-harvested roots usually contain high level of moisture which is left intact for a relatively long period of time while waiting to be peeled. During this period of waiting (or storage), the high concentration of some enzymes, such as linamarine, in it initiates some complex biochemical enzymatic activities which make the tubers deteriorate fast (Oke, 2005). There is, therefore, the need for the introduction of faster peeling devices to prevent the consequent economic losses that have been the problem of peasant farmers and processors who constitute the bulk of cassava tuber and product producers (Itodo, 1999).

Peeling is, by definition, the removal of the outermost layer of fruits, stems or root tubers. Cassava peels constitute 10-20% of the root by weight with the coniferous layer constituting 0.5-2.0% of the root weight (Odigbo, 1986). The effective mechanization of this vital unit operation in cassava processing chain will go a long way in ameliorating the high level of drudgery and its attendant high cost currently constraining timely and economically-feasible large scale production of cassava chips and other ancillary products.

The aim of this study was to prepare ground for the development of an economically viable technique for participatory mass production of cassava chips for both export and domestic markets in Nigeria.

The objective of the study was to determine the throughput capacity, peeling efficiency and cost of using a developed continuous flow rotary cassava peeler when powered by a petrol engine compared with the results obtained from manual peeling and when powered by an electric motor.

LITERATURE REVIEW

Cassava production seems to be more promising in Nigeria due to its enormous potentialities which have been estimated to be worth over 100 billion US dollars per annum (Agbetoye, 2003). Cassava production and processing have taken a central stage in Nigeria since the year 2004 when the Food and Agriculture Organization of the United Nations, (FAO) announced that it is currently the largest producer in the world. As a follow-up to this declaration, the leadership of the country at that time immediately set up a presidential initiative on cassava processing and Exportation. Further to this initiative, the President, Olusegun Obasanjo set up a National Committee on Cassava Production and Export Promotion under the chairmanship of the then Honourable Minister of Commerce, Ambassador Idris Waziri and several meetings and actions have been held since then, with a lot of work done in sensitizing the public about this "*wonder crop*" called cassava (Oke, 2005).

Taiwo (2009) reported that one way of making cassava production, processing and exportation a reality is to identify a functional and economically appropriate cassava harvesting and peeling machine designed for the use of small holder cassava growers and processors in the world. Such machines, when identified, should urgently be put to test on-farm with a view to adapt, fabricate and diffuse immediately among farmers.

At the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, three models of self-loading cassava peelers were developed by the Integrated Cassava Research Project in a bid to find a lasting solution to the problem of mechanizing cassava peeling operation (Olakunle et. al, 2005). Although these models represented remarkable improvement over

the manually loaded models earlier developed, their throughput capacities were much less than the requirement of a medium-to large-scale processor.
In other to improve upon these models, several other types of machines such as continuous-process mechanical peelers, steam peelers, chemical batch process peelers, rotating blade peelers, belt conveyor peelers, etc have been developed by so many other researchers and research organizations.
In order to solve the problem of preceding mechanical peeling of cassava roots with manual cutting into pieces, Odigbo (1976a) developed a batch abrasive peeler. Some of the features which created some advantages for this improved model over the previous models were that manual peeling was completely and effectively eliminated because high pressure spray water was introduced for use in simultaneous washing and supplementary peeling of the cassava roots with a view to produce absolutely clean product. Unfortunately, however, this improved design still had a low throughput capacity (about 180kg/hr) even when the time spent on intermittent loading and unloading of the roots were not taken into account.
Ezekwe (1976) developed a cassava peeler which had a built-in abrasive device that served the dual purpose of conveying and peeling sliced cassava roots. The conveyor belt, on which blades were incorporated, moved the sliced cassava roots over another horizontal belt which moved in the opposite direction and at different speed. As the conveyor belts moved, the sliced cassava roots rotated in a fashion that enabled a continuous slip to occur between their surfaces and the conveyor blades and pads, leading to their subsequent peeling (Itodo, 1999).
Igbeka, (1985) developed a cassava peeling machine which was originally developed for potato tubers. The machine, which basically consists of a vertical cylinder with a rotating disc at the bottom and a hinged cover at the top, is operated by loading the cylinder with cut cassava tuber pieces of known weight and covered up with a lid. The rotation of the disc makes the cassava tubers contained in it to spring and stumble as they moved along; peeling was achieved as a result of the rubbing of the peels against the abrasive surfaces.
Itodo, (1999) designed and constructed a manually-operated cassava peeling machine which basically, consists of a peeling unit and a handle which served the purpose of transmitting power from the operator to the peeling unit. The peeling unit consists of two sets of brushes-the first set were arranged along the periphery of the rotating drum while the second set-were arranged on springs located inside the concave to facilitate the peeling of irregular-shaped roots. The cassava root peeling were effected by the scribing action of the brushes located on the concave and rotating drum whenever roots were introduced into the space between them. The peeling rate of Itodo's machine was only 97kg/hr; apart from the relatively low peeling rate of the machine, no provision was made for separating the peels from the peeled roots. Another disadvantage of this machine is that the roots must be cut into very short and small pieces before feeding them into the machine. This is an addition to the labour requirement of the machine.

MATERIALS AND METHODS

The manual peeling technique was appraised and the results obtained were compared with those obtained from the evaluations carried out on a previously-developed continuous flow rotary cassava peeler when powered by a prime mover in form of a petrol engine and when powered by a secondary mover in form of an electric motor.

Description of the Continuous Flow Rotary Cassava Peeler

The continuous flow rotary cassava peeler basically consists of three cylinders arranged 120 degrees apart as shown in Figure 1. The drive shaft (1) is mounted on the left cylinder on which several helical knives are wound in clockwise direction. The idle roller (13) constitutes the third cylinder which is mounted on a rigid bearing (14). Mechanical power

transmitted from either a prime-or secondary mover to the driveshaft is transmitted to cylinders via a double strand roller chain and sprocket drive mechanism (3) and (2).
Whenever cassava root is loaded into the hopper of the machine for peeling, it is directed onto the top of the wide pitch clockwise-rotating cylinder (11). A pressure plate (12) which is a 50mm x 100mm (2" x 4") sawn lumber placed in the space between cylinder (11) and (13) is used to control the pressure between the rotating cutting knives and the cassava root tubers being peeled. The fact that lateral motion is allowed between cylinder (11) and the other knife carrying cylinder via a spring-loaded arrangement (8) makes it possible for the machine to accommodate any size and shape of cassava root tubers without the need for any re-peeling, dressing or cutting.

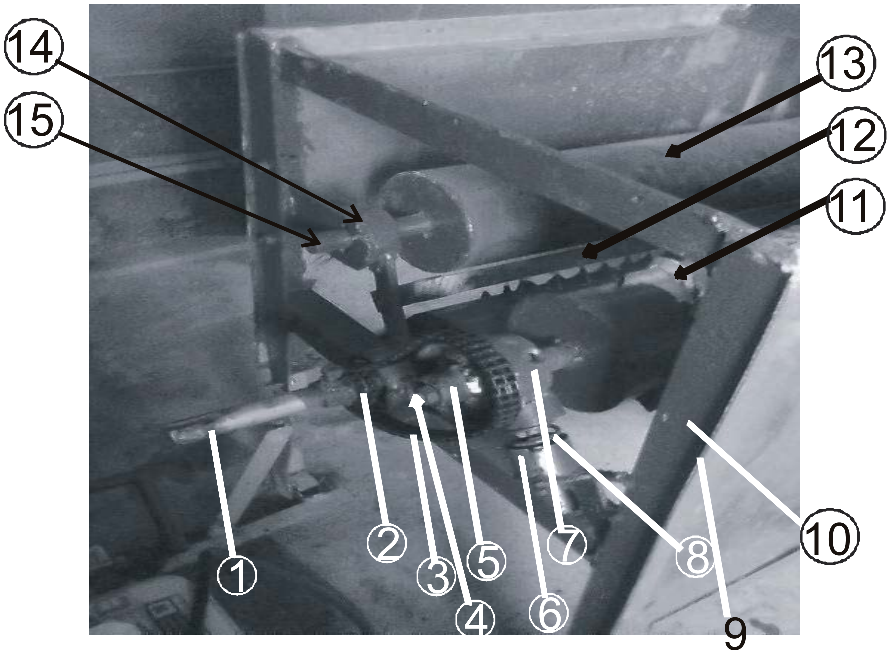

Figure 1: 120-Degree Arrangement of the three Cylinders of the Continuous Flow Rotary Cassava Peeler

1. Drive Shaft; 2. Driving Sprocket; 3. Double Strand Roller chain; 4. Driven Shaft; 5. Driven sprocket; 6. Driven Shaft mounting; 7. Bearing Housing for drive shaft; 8. Suspension for driven shaft mounting; 9. Sheet metal enclosure for the machine; 10. Machine frame; 11. Cylinder for counter-closwise helical knifes; 12. Pressure plate; 13. Idle roller; 14. Bearing housing for idle roller shaft; 15. Idle roller shaft.

Evaluation of Manual Peeling Technique

One thousand kilograms (1000kg) of freshly-harvested cassava tubers were procured and divided into 5 batches of 200kg each with the use of the weighing scale. Four people (women) were assigned to peel each 200kg batch making a total of 20 people assigned for the one metric tonne (or 1000Kg) fresh cassava tubers.
The time taken to complete the peeling of each batch was observed and recorded. Thereafter, the weight of the cassava peels removed from the tubers were weighed and recorded. The peels were carefully sorted with a view to separate those which consists of cortex material

and cassava flesh from those which consists of only the cortex. Those which consists of cortex and cassava flesh were made to go through a secondary manual peeling operation during which the flesh were removed .Again, the peels removed from the secondary peeling exercise were weighed and recorded.

The flow chart for the material flow during the manual peeling operation is as shown in Figure 2. The peels were also inspected with a view to see whether any flesh got removed with the peels by the peeling knife. The flesh in the peels were removed and weighed separately.

CASSAVA CHIPS

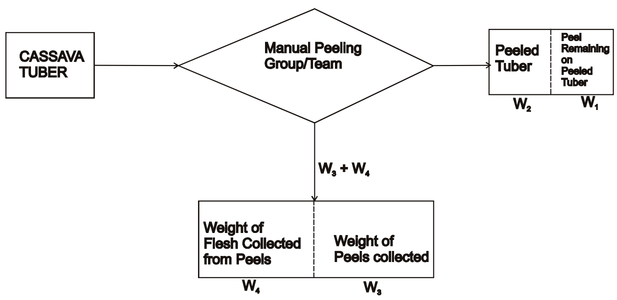

Figure 2: Material Balance Flow chart for Manual Cassava Peeling

where :

W_1 =Weight of peels remaining on the peeled tubers;

W_2 = Weight of completely-peeled tubers;

W_3 = Weight of peels without flesh collected;

W_4 = Weight of flesh removed from peels.

The percentage of cassava tubers remaining as peels on the peeled cassava tubers (PRP) was determined by Itodo (1999) as:

$$PRP = \frac{\text{Weight of peels remoed form peeled tubers}}{\text{weight of tubers peeled by hand}} \times 100 \qquad \ldots\ldots\ldots(1)$$

$$\text{Peeling Efficiency} = \frac{\text{Total Weight of Tubers - Weight of Completely Peeled Tubers}}{\text{Total weight of Tubers - weight of Peeled Roots Obtianable if Only theCortex were removed}} \quad ..(2)$$

The flesh loss was calculated in terms of percent flesh loss (PFL) as:

$$PFL = \frac{W_4}{W_2 + W_4} \times 100 \qquad \ldots\ldots\ldots(3)$$

The labour cost was calculated on the basis of ₦ 1000 ($6.58) per man-day (or N125/man-hr) ($0.82/member) which is the amount currently being paid for unskilled labour in Oyo State, **Nigeria** .

Evaluation of Mechanical Peeling Technique
The performance evaluation of the continuous-flow rotary peeler used for the mechanical peeling of fresh cassava tubers was carried out in two stages-viz: (a) With the use of a prime mover in form of petrol engine and (b) With the use of a secondary mover in form of electric motor.

(a) Use of Petrol Engine to Power the Rotary Cassava Peeler
Six metric tonnes (6000 kilograms) of fresh cassava tubers were purchased and divided into two batches of three metric tonnes (3000kilograms) each.
With a 3.73 kW(5.0 Hp) petrol engine installed on the rotary peeler as its prime mover, 1meric tonne(1000 kilograms) of the fresh cassava tubers were fed into the machine as fast as the engine would permit while the time taken to complete the peeling operation as well as the Fuel consumed were noted and recorded. Thereafter, the peeled tubers as well as the peels removed were collected and weighed with the use of the weighing scale. The flow chart for the material balance during the peeling operation is as shown in Figure 3.

The peeling percentage (PP) is a measure the mass of fresh cassava root tubers that constitute what was removed as peels by the machine from the fresh tubers expressed in percent.

Mathematically, it is expressed as follows in equation (4):

$$\text{Peeling Percentage (PP)} = \frac{\text{Mass of peels remaining on the Peeled tuber} + \text{Mass of peels collected from the peel outlet of the Machine}}{\text{Mass of Unpeeled fresh tubers fed into the Mahine}} \times 100$$

…(4)

CASSAVA CHIPS

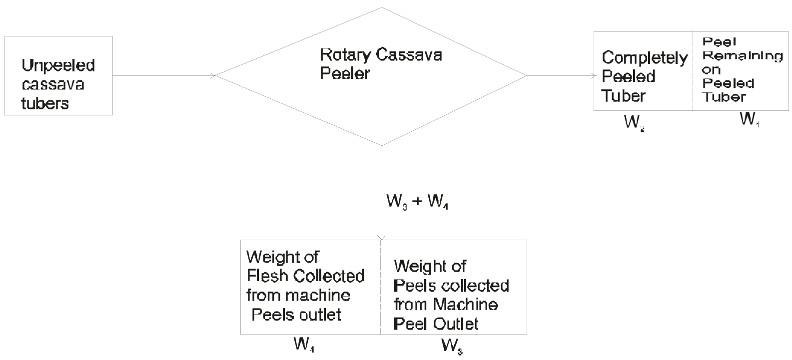

Fig. 3: Material Balance Flowchart for Continuous-Flow Rotary Cassava Peeler

Both the peeling efficiency and the peeling flesh loss were determined exactly as in equations (2) and (3).

(b) **Use of Electric Motor to Power the Rotary Cassava Peeler**
With the use of a 2.24 kW (3.0 Hp) electric motor connected to the rotary cassava peeler as its secondary mover, and with all other electric energy consuming appliances switched off,

another one metric tonne (1000 kilograms) batch of fresh cassava tubers were loaded into the machine while the motor was switched on and the time taken to peel the entire batch as fast as the motor would permit taken. Prior to the time the cassava tubers were loaded into the machine, the kilowatt-hour metre reading of the circuit to which the motor was connected was taken. The reading was also taken when the peeling operation was completed. The difference between the two hour metre readings was taken as the electrical energy consumed in kilowatt-hours. The processes in (a) and (b) were repeated three times. The (PRP) and the (PFL) for this case were calculated exactly as in the case of the prime mover using equation (3) and (4).

RESULTS AND DISCUSSION

Results

The results obtained for the manual peeling of fresh cassava tubers are shown in Tables 1 and 2.The results of mechanical peeling are as shown in Tables 3, 4, 5,6 and 7.
Tables 3 and 4 show the results of mechanical peeling when the machine was powered by a prime mover (in form of petrol engine) and when powered by a secondary mover (in form of electric motor). The flesh loss data for mechanical peeling powered by prime and secondary movers are shown in Figures 5 and 6.

Table 1: Results for Manual Peeling of Fresh Cassava Tubers

Batch	Mass of Unpeeled Tubers(kg)	Time Taken Taken to peel (min)	Labour Input (man-hour)	Mass of Completely Peeled Tubers (kg)	Percentage of Completely Peeled Tubers	Peeling Rate	
						Kg/hr	Kg/man-hr
1	200	520	34.7	155	77.50	17.90	4.50
2	200	500	33.3	160	80.00	19.20	4.80
3	200	500	33.3	163	81.50	19.56	4.90
4	200	550	36.7	152.5	76.25	16.64	4.16
5	200	550	36.7	156	78.00	17.01	4.25
Avg.	200	524	34.94	157.3	78.65	18.06	4.52

Table 2: Results of Flesh Loss Analysis for Manually- Peeled Fresh Cassava Tubers

Batch No.	Mass of Unpeeled Tubers, W (kg)	W_1 (kg)	W_2 (kg)	W_3 (kg)	W_4 (kg)	Mass of Optimally-Peeled Roots, W_e (kg)	Peeling Efficiency $E = \frac{W - W_2}{W - W_e}$	Flesh Loss PFL= $W_4 / (W_2+W_4)$ (%)
1	200	10	165	15	10	156	79.6	5.7
2	200	10	160	12	17	156	90.9	9.6
3	200	8	163	12.5	16.5	156	84.1	9.2
4	200	2.5	162.5	10	25	156	85.2	13.3
5	200	4	166	18	22	156	77.3	11.7
Average	200	6.9	163.3	13.5	18.1	156	83.42	9.9

*W_e= Mass of peeled roots that would be obtained if only the cortex were removed.

Table 3: Results of Peeling with the Continuous-Flow Peeler Powered by Prime mover

Batch No.	Mass of unpeeled Fresh tubers fed The machine hopper, W (kg)	Time taken To peel, (min.)	Mass of Optimally-peeled roots, W_e (kg)	Mass of Machine-peeled Roots, W_a (kg)	Machine Peeling Efficiency, $E = \frac{W-W_a}{W-W_e} x100$ %	Throughput Capacity, Kg/hr	Rate of **Fuel** Consumption	
							L/min	kg/L
1	1000	75	780	800	90.90	800	0.01	1,333.3
2	1000	80	780	800	90.90	750	0.01	1250.0
3	1000	85	780	810	86.36	705.9	0.011	1069.50
Average	1000	80		803.33	88.79	751.97	0.01	1217.60

Table 4: Results of Peeling with the Continuous-Flow Peeler Powered by Secondary mover

Batch No.	Mass of unpeeled Fresh tubers fed The machine hopper, W (kg)	Time taken To peel, (kg)	Mass of Optimally-peeled roots, W_e (kg)	Mass of Machine-peeled Roots, W_a (kg)	Machine Peeling Efficiency, $E = \frac{W-W_a}{W-W_e} x100$ %	Throughput Capacity, Kg/hr	Electric Energy Consumed (kWh)
1	1000	50	780	800	90.90	1200.00	0.8
2	1000	60	780	800	90.90	1000.00	0.8
3	1000	65	780	810	86.36	923.08	0.8
Average	1000	58.33		803.33	88.79	1041.03	0.8

Table 5: Results of Flesh Loss Analysis for Peeling with the Continuous-Flow Rotary Cassava Peeler Powered by Prime mover

Batch No.	Mass of unpeeled Fresh tubers, W (kg)	Time Taken to Peel (min)	Mass of Peels On Peeled Tubers, W_1 (kg)	Mass of completely-peeled roots, W_2 (kg)	Mass of Flesh-free peels, W_3 (kg)	Mass of Flesh Removed From Peels, W_4 (kg)	PFL= $\frac{W_4 x100}{W_2 + W_4}$	Peeling Percentage= $\frac{W_1 + W_3}{W}$ %
1	1000	75	300	485	50	100	17.09	35.00
2	1000	80	350	450	100	100	18.18	45.00
3	1000	85	350	460	100	90	16.36	45.00
Average	1000	80.00	333.33	465.00	83.33	96.67	17.21	41.67

Table 6: Results of Flesh Loss Analysis for Peeling with the Continuous-Flow Rotary Cassava Peeler Powered by Secondary mover

Batch No.	Mass of unpeeled Fresh tubers, W (kg)	Time Taken to Peel (min)	Mass of Peels On Peeled Tubers, W_1 (kg)	Mass of completely-peeled roots, W_2 (kg)	Mass of Flesh-free peels, W_3 (kg)	Mass of Flesh Removed From Peels, W_4 (kg)	PFL= $\frac{W_4 x100}{W_2 + W_4}$	Peeling Percentage= $\frac{W_1 + W_3}{W}$ %
1	1000	50	325	475	50	100	17.39	37.50
2	1000	60	350	450	125	75	14.29	47.50
3	1000	65	350	460	100	90	16.36	45.00
Average	1000	58.33	341.67	461.67	91.67	88.33	16.01	43.33

Table 7: Cost Outlay for Manual Technique and Use of Continuous-Flow Peeler for Peeling Fresh Cassava Tubers

	Cost of Machine, ₦	Annual FixedCosts, ₦/yr					Variable Cost,₦/yr				Total cost			
		***Dep. @ 10%**	**Est. Machn. life,yr.**	**Int. @ 9%**	**Housing & Ins. @3%**	**Total**	**Labr.**	**Fuel**	**Elec. Energy**	**Total**	**₦/yr**	**₦/hr**	**₦/kg**	**₦/t**
Powered by Petrol engine	250,000	45,000	5.0	12,375	7,500	64,875	624,000	107,078.40	-	731,078.40	795,953.40	318.89	0.4572	457.19
Powered by Electric Motor	250,000	45,000	5.0	12,375	7,500	64,875	624,000	-	12,130.62	636,130.62	701,005.62	280.85	0.3005	300.50
Manual Peeling							312,000			312,000	312,000	125	27.66	27,660

* Assume 10% salvage value and straight line depreciation.

Discussion

Manual peeling of fresh cassava root tubers

From the results obtained from manual peeling of fresh cassava root tubers in Table 1, the average percentage of completely-peeled tubers is 78.65% while the average peeling rate is 18.06 kg/hr which translates to man-hr utilization rate of 4.52kg/man-hr. In terms of the prevailing wage rate of ₦125/man-hr for casual labour as at the time the studies were carried out, the labour cost for peeling fresh cassava roots manually was ₦27.66 per kg or ₦27, 660.00 per tonne.

Since the mass of optimally-peeled roots was found to be 156kg, the average peeling efficiency and the average percentage flesh loss were determined as 83.42% and 9.90% respectively from the data in Table 2.

Mechanical peeling of fresh cassava root tubers with the continuous-flow rotary cassava peeler

The data in Table 3 shows the results obtained when the continuous-flow rotary cassava peeler was used to peel fresh cassava tubers when powered by a prime mover in form of a petrol engine with a 4.1kW(5.5hp) rated power. Table 4 shows the results obtained when the same machine was powered by a secondary mover in form of a 2.24kW (3hp) single phase electric motor.

When the machine was powered by the petrol engine, the machine peeling efficiency was 88.79%, the throughput capacity was 751.97kg/hr and the rate of Fuel consumption was 0.01L/min. The machine peeled 1217.68kilograms of fresh cassava tubers with every litre of Fuel consumed. The Fuel cost was ₦0.0534 per kg of fresh cassava tuber peeled or ₦53.40 per tonne of fresh cassava tubers peeled. Since the machine required the services of two people to keep it working continuously, with the labour cost pegged at ₦125 per man-hr, (same as the rate for manual peeling), the labour cost for the machine is ₦250/hr which implies that the labour cost for every kilogram of fresh cassava tuber peeled with the machine was only ₦0.3584 or ₦358 per tonne. When added to the Fuel cost, the cost of peeling fresh cassava root tubers using the continuous-flow rotary cassava peeler when powered by the petrol engine is ₦411.40 per tonne (Table 7).

When the machine was powered by a 2.24kW (3hp) single phase electric motor, the average throughput capacity was 1041.03 kg/hr. The average machine peeling efficiency was 88.79% (Table 4). The average electric energy consumption rate was 8.0×10^{-4} kWhr/kg or 1250kg/kW-hr.

According to the current Power Holding Company of Nigeria (PHCN) rate of ₦6.50per kWhr for commercial consumers of electric energy in Nigeria, the average cost of electric energy consumed by the machine per kilogram of cassava peeled is ₦5.2×10^{-3} or N5.20/tonne. When the labour cost at the rate of ₦358/tonne is added to this, the average cost of using the continuous-flow rotary fresh cassava root peeler when mounted with the electric motor as the secondary mover is ₦363.20/tonne. This is only 1.3% what it costs to peel a tonne of fresh cassava tubers manually if peeling is to be completed before the time required for the destructive enzymatic actions to take place in the cassava roots being peeled. Similarly, the cost of carrying out peeling operation with the rotary cassava peeler when powered by the electric motor is 88.28% of the cost of peeling with the machine when powered by the petrol engine.

Flesh loss analysis

The flesh loss analysis was carried out for the three cases of manual peeling, peeling with the rotary cassava peeler when powered by a petrol engine and when powered by an electric motor.

(a) Manual peeling

In this peeling method only three parameters related to flesh loss were studied-viz: mass of optimally-peeled roots, average peeling efficiency and average percentage flesh loss. In optimally-peeled roots (i.e. roots peeled with 100% efficiency) only the cortex will be removed. The context of the peeling efficiency studied in this peeling method merely compared the peeled roots with the optimal. With 780kg as the average mass of the optimally-peeled roots, the average peeling efficiency for manual peeling as shown in Table 2 is 83.42% and the average percentage flesh loss is 9.9% from the same table.

(b) Peeling with the rotary cassava peeler when powered by petrol engine

The results of the flesh loss analysis when fresh cassava roots were peeled with the continuous-flow rotary cassava peeler when powered by petrol engine are shown in Table 5. The percentage flesh loss was 17.21% and the average peeling percentage was 41.67%. The percentage flesh loss was higher than that obtained when peeling was carried out manually.

(c) Peeling with the rotary cassava peeler when powered by petrol engine

The results for flesh loss analysis for the machine when powered by an electric motor are as shown in Table 6.

The average percentage flesh loss was 16.01% while the average peeling percentage was 43.33%. Although the average percentage flesh loss was higher when the machine was powered by petrol engine, the average peeling percentage was higher when the machine was powered by electric motor. This implies that the machine removed slightly more peels from the fresh cassava roots when powered by electric motor than it did when powered by petrol engine. The fact that it also resulted in slightly lower flesh loss implies that it is also a better option than powering with petrol engine from the standpoint of flesh loss in addition to the results obtained from the standpoint of cost. This observation will even be more obvious if the flesh loss is expressed in terms of monetary value and added to the costs of fresh root peeling under each of the three methods. The only snag to this proposition in this project is that the peels are not considered as Waste.

CONCLUSIONS

The study has corroborated the much talked-about need for mechanization in cassava processing.

The results obtained in this work have successfully prepared ground for the development of a participatory economically viable cassava chips production for export and domestic markets in Nigeria.

With the use of 20 people working continuously to peel one tonne of fresh cassava tubers, their production output was only 18.06kg/hr while the throughput capacity of the machine when powered by electricity and petrol engine were 934.62 and 697.5kg/hr; in other words while it took the 20 man gang 55hrs to peel one tonne of fresh cassava tubers manually, it took only 1hr and 1hr 26min. for the continuous-flow rotary cassava peeler to peel the same mass of cassava when powered by electric motor and petrol engine respectively.

The percentage flesh loss was 17.21, 16.01 and 9.9% when peeling was carried out with the use of the CFRCP powered by petrol engine, electric motor and by manual peeling respectively.

Although, the 318.89 and ₦280.85/hr hourly cost of peeling with the machine when powered by petrol engine and electric motor respectively were higher than the ₦125.00/hr hourly cost of manual peeling, the ₦27,660.00 per tonne cost of manual peeling fresh cassava tuber was 60 and 92 times higher than the ₦457.19 and ₦300.50 per tonne cost of peeling with the CFRCP when powered by petrol engine and electric motor respectively; this pattern was even maintained when the cost of peeling was expressed in ₦/kg.
The study has successfully proved that an economically technique for achieving participatory and sustainable mass production of cassava chips for both export and domestic markets in Nigeria will continue to be a mirage unless the problem of irregular supply of electricity is solved nationwide.

RECOMMENDATIONS

The continuous-flow rotary cassava peeler used in this study should be popularized among all the peasant cassava producers and processors in this country as a matter of urgency. It will encourage processing of fresh cassava roots at the exact point of production instead of transporting bulky roots to the processing centres in neighbouring, and sometimes distant, towns and villages. When transported as roots, the moisture content which is usually very high and not needed in the long run is transported and paid for together with the needed dry matter content of the roots. The money paid for transporting the moisture amount to a colossal loss in revenue.
It is also recommended that urgent steps be taken by the Federal Government to ensure steady supply of electricity to all the nooks and crannies of this country as this will contribute to substantial reduction in the cost of processing cassava for both the export and domestic markets.

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CASSAVA PROCESSING WASTES EVALUATION IN DELTA STATE, NIGERIA

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Abstract
An evaluation of Waste disposal practices in some cassava processing sites in Ughelli North and Sapele Local Government Areas of Delta State, Nigeria was carried out. A total of one hundred and six respondents were selected from six villages in the area, the respondents were interviewed with prepared questionnaires.The results showed that cassava processing sites generates a very high level of both solid and liquid Waste; out of every 1000kg of cassava tuber processed 120-200kg of peels is generated as solid Wastes, and with about 15% of this constituting the peels. Cassava peels therefore constitute about 9.8 million tonnes from the 39 million tones presently being produced in Nigeria annually. 130 – 160 liters is also generated as liquid Waste and 20 – 60kg as fiber Waste from 1 tonne of cassava tuber. This Wastes are not properly managed, though some of them use the peels for feeding fish, feeding pigs, the liquid for washing snails, to coagulate rubber, majority of respondents littered their Wastes indiscriminately. This degradation affects the soil, groundwater and other aquatic system. It is recommended that there should be location of livestock feed mill beside cassava processing site, provision of centrally located treatment plant into which all liquid Waste in the site are drained and treated before being released into the drainage, and regardless of what type of treatment that is used, the Waste should be treated with chlorine gas before been discharged into the environment because it destroys disease causing bacteria.

INTRODUCTION

Cassava (*Manihot esculenta crantz*) is the staple food of more than 500 million people in the tropics many of whom are very poor (Cock 1985). It is a root crop grown in Nigeria farming system. It ranks second to cereal grains as major source of calories in the diets of Nigerians. It also provides about 40% of all the calories consumption in Africa. Cassava is grown in all Nigeria states, due to the fact that the country's tropical climate supports the growth of the crop.

By zone, the North Central zone produced over 7 million tonnes of cassava (1999 to 2002). The South-South region produces over 6 million tonnes a year, while the South West and South East produce just less than 6 million tonnes a year. The North West and North East produced 2 and 0.14 million tonnes respectively (Table 1).

Table 1: Cassava Production by Zone Year 2000 – 2002 (Tonnes)

Region	2000	2001	2002
South West	4993380	5663614	5883805
South-South	6268114	6533944	6321674
South East	5384180	5542412	5846310
North West	2435211	2395543	2340000
North Central	7116920	7243970	7405640
North East	165344	141533	140620
Total	26363099	27521016	27938049

Source: (IITA 2004).

As at the end of year 2008, cassava production level in the country has increased to 49 million tonnes making Nigeria to retain her position as the world largest cassava producer. However over 90% of the production is consumed locally. Even the exported cassava-based products are usually in processed form. Therefore, Nigeria can also be said to be the largest producer of cassava Wastes in the world. But can we really refer to the cassava peels and the juice expressed from the tubers as Wastes? According to Ubalua (2007), Wastes are materials with no apparent economic or social values but only constitute an environmental nuisance and a source of pollution. They often result from processing operations. To him the word residue is preferred. According to him residues are substances produced alongside the end products of every processing operation. When such residues are put into profitable use they become a co-product or by-product, otherwise they become a Waste. In essence, we make cassava processing residues to become Wastes, they are actually resources.
If cassava processing residues are considered as resources in their own unique ways, then, their values in quantitative terms need to be estimated for exploratory and exploitative reasons. Hence, the objectives of this study included an on-site assessment of the magnitude and significance of residues generated from cassava processing sites, the Wastes management practices employed and the adequacy of such practices.

MATERIALS AND METHODS

This study was carried out in Delta State of Nigeria. The State is bounded by Anambra State in the North – East, Edo State in the North – West, Rivers State in the East and Bayelsa in the South – East and also bounded by the Atlantic Ocean in the South–West. The climatic condition of the study areas is hot and humid with an average air temperature of 29^0C and rainfall ranging between 100m – 200m annually.

Site Selection

The areas selected for the study are Ugehlli North and Sapele Local Government Areas. These areas were purposely selected because they are among the major cassava producing areas in the state. Three villages were selected from each of the two local government areas, these included, Oteri, Ogor and Uduere from Ughelli North while those of Sapele Local Government included, Amukpe, Okirigwre and Gana. Fifty three cassava processors were selected at random from each of the two selected local governments areas, bringing the total number of processors interviewed to hundred (106).

Data Collection Method

Data for the study were collected through a participatory on-site data collection. 100kg of fresh cassava tubers were weighed and processed into *gari* by peeling, grating and pressing-out the cassava juice. Afterwards the peels obtained were weighed and pressed out water from the pulp were measured using measuring cylinders. Personal interviews were conducted, personal observations were made and structured questionnaires were administered.

RESULTS AND DISCUSSION

Wastes Generation

Results of the study revealed that cassava processing generates high level of both solid and liquid Wastes. Table 2 presents the level of solid Wastes (peels) generated per tonne from each of the studied locations. The peels generated ranged between 120-200kg per tonne, (12-20%) with the highest solid Waste production level obtained from okirigwe, where a solid Wastes of 20% of the fresh tubers was obtained. On average the solid Waste generated was 148.4Kg (14.84%). This result is in close agreement with the result published by Adetan *et* *al.,* (2003) which ranged between 10.6 and 21.5% with an average of 15.1%. It however, varies slightly with the values obtained by Ezekwe (1979) which ranged between 8.5 and 17%. The slight difference may be due to the varieties of cassava used for each of the experiments and probably the season the experiments were conducted. The results published by Ekundayo, (1980), however, reported a peel percentage that ranged between 20 and 35%. Seasonal and varietal reasons could also be responsible for this. Also, 20-60kg of fibre Waste was generated from sifting of the cassava cake after pressing.

Table 2: Peels Generated Per Tonne of Cassava Tubers

LOCATION	*PEELS GENERATED (kg)*	*PEEL PERCENTAGE OF TUBER*
OTERI	125.50	12.50%
OGOR	120.00	12.00%
UDUERE	144.90	14.49%
AMUKPE	125.00	12.5%
OKIRIGWE	200.00	20.00%
GANA	175.00	17.5%

Table 3 shows the volume of liquid Waste pressed out of the fresh cassava tubers during dewatering operations. The highest and the lowest volume of water pressed out of a tonne of cassava were 160cm^3 and 130cm^3 respectively.

TABLE 3: VOLUME OF LIQUID WASTE GENERATED PER TONNE

LOCATION	AVERAVGE VOLUME (L)
OTERI	**135.50**
OGOR	**159.60**
UDUERE	**134.50**
AMUKPE	**130.00**
OKIGIGWRE	**130.50**
GANA	**160.00**

On average, about 147.68 cm3 of pressed-out water was obtained from a tonne of fresh cassava tubers. Cooke and Arguedas*,* (1982), however, reported that the pressed-out water produced from one tonne of cassava was between 250 – 300 litres. Differences in cassava varieties used and the seasonal reasons sited above could also be responsible for the variation in the values reported by these researchers.

Wastes Disposal Practices

Table 4 present the different methods of disposing solid cassava Wastes employed by the processors.

Table 4: Methods of Disposing Solid Cassava Wastes

Method	*Number*	*Percentage*
Burning	9	8.6
Burying	19	18.1
Littering	49	43.8
Fed to livestock	30	27.4
Dump into stream	2	1.9
Total	106	100

Majority of them, (about 46%) litterred their solid Waste carelessly on the processing sites only to return the following day to sweep them off before the commencement of the day's work. The peels are then heaped and left to decay just a few metres away from the processing sites (Plate1). This becomes a problem during the raining season when it starts giving off foul odour due to decomposition. 27.4% of the processors sell their solid Waste to livestock farmers, who used it to feed their animals. 19% of them burned the peels.

Plate 1: A Heap of Cassava Peels **Plate 2: A Pressed-out Water Channel**

The burning was, however, not effective because of the high moisture content of the peels. This indicates that only less than 30% of the peel-Waste generated from cassava processing operations are reused for livestock feed production, (including fish) while the remaining over 70% are left to decay and pollute the environment, including streams and underground water bodies. This is, however, a pointer to the fact that only 30% of the cassava processors in the studied areas made meaningful use of their peel Wastes while others just make them to mountains of Wastes.

The pressed-out water, on the other hand, was generally channeled into nearby streams without undergoing any form of treatments. The water, however, settled in ditches and depressions found all over the processing sites (Plate 2). This made the whole place into an eyesore which gave off poignant smell. The over-flown water from the ditches and depressions eventually ended up in the streams. Rainfall occasionally washed them into the streams.

But, generally, more than 50% of the processors were involved in this unwholesome practice (Table 5). One interesting way of utilizing the pressed-out water is its addition to rubber latex in order to coagulate it before further processing of the rubber takes place. 16.9% of the processors were involved in this. This could be of benefit in the rubber producing areas of the country. The water is also used occasionally to wash snails before cooking.

Table 5: Methods of Disposing Liquid Cassava Waste.

Methods	Number	Percentage (%)
Sewage pit	9	8.8
Burying	23	21.9
Littering	53	50.5
Sold to rubber tapers	19	16.9
Dumping into stream	2	1.9
Total	**106**	**100.0**

Some of the processors (about 21.9%) dug shallow pits into which the pressed-out water was channeled. Carbide was later added to it to control the bad odour. This practice was however, not effective because it only put the odour under check for about three days.

CONCLUSIONS

i) Cassava residues are still considered as Wastes in Nigeria and they are so treated.

ii) Cassava processing sites generates a high level of solid and liquid Wastes which are not disposed appropriately. Improper disposal of these Wastes gives off foul odour and contaminates ground water.

iii) 120-200kg of solid cassava Wastes were generated from one tonne of fresh cassava tubers.

iv) 130-160 litres of pressed-out water was obtained from one tonne of fresh cassava tubers.

v) At the present cassava production level of 49 million tonnes per year, solid cassava Wastes available in Nigeria for value addition is estimated at 9.8 million tonnes per year, while the pressed-out generated annually could estimated at 7.8 million litres per annum.

vi) These resources are presently being under-utilized as negligible percentage of them are utilized especially the peels, the pressed out water is far less utilized in the country.

RECOMMENDATIONS

Based on the findings of this study the following recommendations are made;

(i) Recycling of cassava Waste water for biogas production as it is practiced in many cassava producing countries across the world could be given a serious consideration.

(ii) Siting of cassava-based livestock feed-mills close to cassava processing sites could be a right step towards value addition to cassava peels. Earlier studies have shown impressive results with 100% cassava peel-based feed for poultry and other livestock.

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DETERMINANT OF LAND MANAGEMENT PRACTICES AMONG CROP FARMERS IN SOUTH-WESTERN NIGERIA

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Abstract

The study examined the determinants of land management practices among crop farmers in South-Western Nigeria. A total of 360 respondents were selected from the three agro-ecological zones of the State typical of some Nigeria South-Western States. Well-structured questionnaires with few open-ended questions were administered out of which 301 were found to be very useful for the study. Analysis of data was done using descriptive statistics and probit models were employed as the inferential statistics.

The result showed that 90 percent of the farmers are male and married while 85.5 percent of their household members are literate. About 40 percent of the farmers are in their active age. The male education at secondary and tertiary level has significant impact on land management practices contrary to female education. Also the livelihood strategy of the household head has limited impact on most land management practices. Investment on land encourages fallowing and incorporation of crop residues while assess to credit favors non-farm rather than farm activities.

INTRODUCTION

Land is the major resource for the livelihood of the poor. In Nigeria, a typical villager recognizes land in its entirety. According to Fabiyi, (1990) land, to the farmer, is home and work place and shares it with the entire biotic complex. As important as land is to farmers' livelihood, Adekoya (1997) observed that subsistent farmers are with a lot of in integrating many of the land management practices. Dixon (1995) arranged these constraint under three headings; economic obstacles such as capital need and financial incentives; social conditions which include land tenure, availability of infrastructures and educational level of farmers; and ecological consideration such as limited knowledge of inputs and sustainability of some systems.

Land use in many African nations have been characterized by a significant amount of land degradation. Moreover, these two processes are clearly related (Brabier, 1999). Many poor African pastorialists and farming households respond to declining land productivity by abandoning existing degraded pasture and cropland, and moving to new land for grazing and crop cultivation. Due to the fact that the pattern of land use will often result into depletion of soil nutrients, appropriate management practices have to be adopted.

Couper (1995) noted that the need for appropriate soil management in tropical soils becomes imperative because of inability of the soil to sustain increased crop yields as cultivation continues on an annual basis. This was traced to the fact that the clay in most tropical soil, referred to as low activity clay (LAC) does not expand and contract readily with moisture changes and the soil becomes susceptible to soil compaction. Also, LAC soils have a low cation exchange capacity, which means that nutrients are not held by the soil, but quickly leached below the crop roots. This is due to high temperatures, which makes organic matters in tropical soil to be susceptible to rapid mineralization.

Furthermore, in an imperfect market setting, the nature of poverty is also important in determining its impact on natural resources management and degradation. Households that are not poor by welfare criteria such as minimum levels of consumption may still face “investment poverty” that prevents them from making profitable investments in resource conservation and improvement. (Reardon and Vosti 1995) claimed that households that lack access to road and markets, or that own little land may deplete soil nutrients less rapidly since they are subsistence – oriented and thus export less soil nutrients in the farm of crop harvest and sales. On the other hand, households that are livestock poor may deplete soil nutrients more rapidly because they lack access to manure.

As a result of this, the study centered on land management since land is the major resource for the livelihoods of the poor. A large body of past research shows that the major determinants of land management include households’ endowments of different types of capital, land tenure and the biophysical and socio-economic environment in which rural households live (Reardon and Vosti, 1995; Barrett, et al, 2002; Nkonya, et al, 2004).

Land use and management practices affect human health directly and indirectly. It affects fauna and flora, contributes to local, regional, and global climate changes and is the primary source of soil, water and land degradation (Sala et al., 2000; Pielke, 2005). Altering ecosystem services— i.e., the provisions people obtain from ecosystems (e.g., food, water), regulating services (e.g., predator-prey relationships, flood and disease control), cultural services (e.g., spiritual and recreational benefits), and support services (e.g., pollination, nutrient cycling, productivity)—that maintain the conditions for life on Earth affect the ability of biological systems to support human needs (Vitousek et al., 1997). Alterations lead to large scale land degradation, changing the ecology of diseases that influence human health and making it more vulnerable to infections (Collins, 2001).

In addition, the identification of constraints to farmers’ use of sustainable management practices would provide a direction of action for government in trying to boost farmers involvement in land management practices, reveal areas of inadequacy and where the farmers need improvement. There is likewise the need to focus on the sustainability of the environment through emphasizing the desirable ways by which farmers can utilize the land that would prevent consequential depletion of the soil fertility.

Finally, there is the need to develop a benchmark of wider dimension that would identify land-use indices and threshold in a typified smallholder farming system. This is even more important now that the Federal Government of Nigeria is exploring ways of sourcing revenue from non-oil sector. The consequence of enhanced production is also most likely to result in enhanced welfare for crop farming communities.

The achievements of all these would not only improve (Agricultural Produciton) but would further ensure the sustainability of the environment. The results of this study is likewise expected to provide policy makers with good understanding of the situation in the south-western part of the country such that they would be adequately equipped with the right policy intervention tools that will promote the welfare of crop farming households.

OBJECTIVE OF THE STUDY

The main objective of the study is to identify the determinants of land management practices among crop farmers in South-western Nigeria. The specific objectives are to:

(i) identify the socio-economic characteristics of the farmers,
(ii) examine the pattern of land use as regards crops diversification, and
(iii) highlight the determinants of land management practices in the study area.

Hypothesis

The working hypothesis stated in null form is ;

There is no significant relationship between access to credit and land management practices.

Methodology

The study was conducted in Osun State of South-Western Nigeria that is made up of three agro-ecological zones, characteristics of some of the South-Western States of the federation. The State has six administrative zones and thirty local government areas. The predominant farming system in the area is shifting cultivation with mixed cropping and crop rotation. Crops cultivated include maize, yam, cassava, cocoyam, cocoa, kolanut, citrus and vegetables. Livestock like sheep, cattle, goat, pig rabbit and poultry are also reared for sales and consumption. A three-stage sampling procedure was adopted in proportionately selecting 71 respondents from Iwo (Ssavannah zone), 109 respondents from Osogbo (Derived savannah zone) and 180 respondents from Ife/Ijesha (Rainforest zone) zones of the State. Out of the 360 questionnaires administered, 301 were found to be very useful for the study. The primary data collected were coded and subjected to both descriptive and inferential statistics.

The descriptive statistics used are frequency and percentage distribution, mean and standard deviation to describe the socio-economic characteristics of the respondents while the probit models were employed as the inferential statistics since the dependent variables are dichotomous (e.g whether or not farmer use inorganic fertilizer, organic fertilizer, purchased seeds and agrochemicals) as shown below;

$$LM = f\,(NC, PC, HC, FC, AS, XN,) \qquad \text{----- (1)}$$

Where;

LM = Land management practices

NC = Natural capital (including land size and investments on land)

PC = Physical capital (including fixed inputs such as farm buildings, equipments)

HC = Human Capital (including education and primary source of income of household head).

FC = Financial Capital (including access to financial capital or participation in rural credit and savings).

XN = Village and higher level factors influencing comparative advantage (agro-climatic potential and access to roads)

AS = Access to agricultural technical assistance (including contact with extension agents).

e^I = random factors

Land Use Pattern Analysis

Analysis of land use pattern was done by measuring the index of crop diversification. Crop Diversification Index (CDI) consists of Entropy and Herfindal Index. Entropy Index is given as;

$$CDIe = \sum_{i=1}^{n} P_i \log P_i^{-1} \qquad \text{----- (2)}$$

Where CDI_e = Crop Diversification Index

P_i = Proportion of net income from the crop.

The Diversification Index is optimal when $0 < CDI_e/n \leq 1$

The Herfindal Index is given as;

$$CDI_h = \sum^{n} P_i^{\,2} \qquad \text{----- (3)}$$

i=1

P_i is as described above.

Probit model

The probit model represents another type of widely used statistical model for studying data with binomial distributions. Probit models are generalized linear models with a probit link;

$$\eta = \varphi^{-1} (\mu) \qquad \text{----- (4)}$$

Where η is a linear predictor produced by $x_1, x_2, x_3, \ldots\ldots\ldots\ldots, x_k$

φ^{-1} is the inverse of the standard normal cumulative distribution function (CDF) and

μ is the expected value of the x_s.

The inverse of the normal CDF is in effect a standardized variable, or a Z score. As with the logit model, the probit model is used for studying a binary outcome variable. The probit model can be expressed in probability thus;

$$\Pr ob(y=1) = 1 - F\left[-\sum_{K=1}^{K} \beta_K\, b_K\right] = F\left[\sum_{K=1}^{K} \beta_K\, b_K\right] = \phi\left[\sum_{K=1}^{K} \beta_K\, b_K\right] \qquad \text{---- (5)}$$

Where the more general form of CDF, F, is replaced by the standard normal cumulative distribution function, φ. Unlike the logit model, which may take on two major forms-one expressing the model in logit (and a transformed version expressed in odds) and the other expressing the model in event probability-the probit model expressed in η is a linear regression of the Z score of the event probability. The equation for probability of nonevent is then;

$$\Pr ob(y=0) = 1 - \phi\left[\sum_{K-1}^{K} \beta_K b_K\right] \qquad \text{---- - (6)}$$

The farmer's decision on use of a particular input depends on the criterion function,

$$Y_i^* = \gamma Z_i + \mu_i \qquad \text{----- (7)}$$

Where Y_i^* is an underlying index reflecting the difference between the use of an input and ts non-use, γ is a vector of parameters to be estimated, Z_i is a vector of exogenous variables which explain use of an input, and μ_i is the standard normally distributed error term. Given the farmer's assessment, when Y_i^* crosses the threshold value, 0, we observe the farmer using the input in question. In practice, $Y_i^*$is unobservable. Its observable counterpart is Y_i, which is defined by

$Y_i = 1$ if $Y_i^* > 0$ (Household i use the input in question), and

$Y_i = 0$ if otherwise.

In the case of normal distribution function, the model to estimate the probability of observing a farmer using a input can be stated as

$$P\left(Y_i = 1/X\right) = \Phi\left(X^1\beta\right) = \int_{-\alpha}^{X^1\beta} \frac{1}{\sqrt{2\pi}} \exp\left(-z^2/2\right) dz \qquad \text{---- (8)}$$

Where,

P is the probability that the ith household use the input and 0 otherwise;

x is the K by 1 vector of the explanatory variables;

z is the standard normal variable, i.e., $Z \sim N(0,\sigma^2)$; and

β is the K by 1 vector of the coefficients estimated.

LIMDEP 8.0 software was used to derive estimates for the probit model used.

RESULTS AND DISCUSSION

Table 1.0 reveals that about 69.8 percent of the farmers are between 16-45 years of age, showing that they are in active age brackets. The mean age is 46.81 and this has implication on the available family labor and productivity of the labor because age has a direct bearing on the availability of farm labor and the ease with which improved agricultural practices are adopted. The gender distribution of the farmers depicts more male (94.01%) than female owning farms. This result conforms with the cultural setting in the study area where male have more access to land than female.

Also the main occupation of most of the sampled farmers is farming and larger proportion (84.%) of them depends on crop production for daily existence. This result has effect on the level of cropping pattern and intensity in which the agricultural land is used. Majority (95.10%) of the respondents are married, 4.3 percent are single and just 0.3 percent each are widowed and divorced.

Most of the farmer's households (85.8%), male and female, have at least a primary education. Those households with tertiary education probably constitute the civil servants who engaged in part-time farming in the area. This is expected in line with a priori expectation, to have significant impact on productivities, income earning opportunities and ability of farmers to effectively adopt better management practices.

Table 2.0 shows that 52.5 percent of the farmers had two-crop mixture on their farm with combination mean of diversification index being 0.714. For the four-crop combination and five-crop combination, the average H-index is 0.433 and 0.218 respectively. The result however, shows that as the number of crops in combination decreases, the H-index increases and would become one for sole cropping implying specialization. But on the average, the H-index for all the sampled farms is 0.578. The H-indices show that the sampled farmers undertook one form of cropping diversity or the other, but the majority of them practiced one to two crop combinations.

Table 3.0 implies that secondary and tertiary education of males is associated with higher likelihood of practicing crop rotation and greater likelihood of encouraging fallow respectively. Encouraging crop rotation may be less labor intensive means of addressing concerns about soil fertility, pest and weeds while education at the tertiary level is a signal of higher opportunity cost of labor in more educated households directly encouraging fallow of agricultural land. But female education at all levels has no significant impact on land management practices.

The livelihood strategy of the household measured by the primary source of income of the household head, has limited impact on most land management practices. Non-farm activity as a primary source of income increases the probability to fallow relative to household for whom crop production is the primary activity. Likewise non-farm activities enable and encourage less intensive crop production, by providing households with alternative sources of income and increasing the opportunity cost of family labor. There is no statistical significant difference in land management practices between households whose primary income source is livestock as against crop production.

Natural capital, particularly in terms of investment on land encourages fallowing and incorporation of crop residues. Fallowing, for example, is common on farms where agro forestry (non-crop) trees have been planted. Other land investment such as fishponds, fences and paddocks increase the probability to incorporate crop residues. Furthermore, as expected, larger farms are more likely to fallow since they have enough land for crop production while resting part of their land. They are likewise less likely to incorporate crop residue on a given plot.

Access to credit has statistically insignificant impacts on most land management practices, except a negative impact on crop rotation. The negative association of credit with crop rotation may be because credit is used to facilitate non-farm activities, rather than efforts to increase soil fertility and crop production. This findings suggest that credit constraint are not major impediment to adoption of improved land management practices, and that access to credit may promote less intensive land management practices by facilitating more remunerative non-farm activities. This finding goes in contrary to observation of Sharma and Buchernrieder (2002) that limited credit is a constraint to improved land management practices.

The results of the agro-ecological zone shows that fallowing and crop rotation practices are more common in the rainforest zone of the State than the other zones perhaps because of the adoption of non-crop trees in their farming systems.

Table 1: Distribution of Respondents by their Socio-economic Characteristics

Characteristics		Frequency	Percentage
Age group (years)			
16-25		14	4.7
26-35		77	25.6
36-45		119	39.5
46-55		36	11.9
56-65		44	14.6
>66		11	3.7
Gender			
Male		283	94.01
Female		18	5.99
Occupation			
Crop production		253	84.1
Livestock production		7	2.3
Non-farm activities		41	13.6
Marital status			
Single		13	4.3
Married		286	95.1
Widowed		1	0.3
Separate		1	0.3
Household Educ. Level			
No schooling	M	79	6.6
	F	91	7.6
Primary level	M	222	18.6
	F	210	17.6
Secondary level	M	235	19.7
	F	166	13.9
Tertiary level	M	145	12.2
	F	39	3.5

Source; Field Survey, 2005/2006

Table 2: Herfindal Index of Crop Diversification

Description	Frequency	Combination	S.D	Min. value	Max. value
Sole cropping	63	1	1	1	1
Two-crop combination	158	0.714	0.051	0.323	0.875
Three-crop combination	50	0.526	0.118	0.427	0.662
Four-crop combination	27	0.433	0.101	0.152	0.609
>Five-crop combination	3	0.218	0.073	0.198	0.414
Sample mean	60.2	0.578	0.269	0.420	0.712

Source; Field Survey, 2005/2006

Table 3: Determinant of Land Management Practices

Variable	Fallow	Crop Rotation	Crop Residue
Human Capital			
Male Household Members			
Primary education	-1.40	-0.137	0.354
Secondary education	0.066	0.062*	0.168
Tertiary education	0.572***	0.175	0.430
Female Household Members			
Primary education	0.240	0.341	0.564
Secondary education	0.150	-0.044	0.334
Tertiary education	0.034	-0.461	-0.063
Primary Source of Income of the Household Head			
Livestock	-0.286	-0.154	0.711
Non-farm	0.301***	-0.158	-0.098
Natural Capital			
Investment on Land	1.114**	-1.096	0.086**
Farm size (ha)	0.485**	-0.017	-0.115*
Physical Capital			
Fixed Capital	0.036	-0.708	1.123
Access to Farm and Services			
Access to credit	-0.244	-0.104**	-0.591
Number of extension visits	0.058	-0.246	-0.575
Distance of farm to residence (km)	0.066	0.037	0.067
Village Level Factor			
Agroecological Zone			
Savannah	0.164	-0.173	-0.128
Derived Savannah	-0.121	0.038	0.040
Rainforest	0.305*	0.226**	0.106

Source; Field Survey, 2005/2006

SUMMARY

The study revealed that about 40 percent of the farmers are between 36 to 45 years of age, majority (94.01%) are male and 84.1 percent of the farmers takes farming as main occupation. 95.10 percent of the farmers' are married and 85.8 percent of the farmers' households have at least primary education. Education of male at secondary and tertiary education level has significant impact on land management practices contrary to female education. Also the livelihood strategy of the household has limited impact on most land management practices. Investment on land encourages fallowing and incorporation of crop residues while assess to credit encourages non-farm rather than the expected farm activities.

RECOMMENDATION

Government should encourage researches that would be farmers specific for awareness to be created on how to improve the quality of farm management practices currently in practice. More farmer groups should be formed for collection, distributions and utilization of agricultural loans. There is need for the government to augment the present subsidy style (credit support) of providing subsidized planting materials, inorganic fertilizers and agro-chemicals as well as provision of soft loan in with a price support policy where farmers' outputs at peak period are bought at fairly reasonable prices above the current market prices. This will encourage farmers who are unable to benefit directly from the credit subsidies to remain in agriculture.

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THE NEED FOR THE UTILIZATION OF AGRICULTURAL WASTE: LESSONS FROM MAIZE (*ZEA MAYS*)

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Abstract
(Agricultural Produciton) generally leads to generation of Wastes. These Wastes could become nuisance except if they are made use of.
Average kernel production of maize was 45.3%. Thus straw, husk and cob constitute the remaining 54.7%. Energy and money had been invested into producing this quantity of Waste.
Maize cob has been used in particle board production, as a source of Fuel while husk and straw had been employed as mulching materials and animal bedding. Researches should be encouraged into the utilization of Waste from (Agricultural Produciton)s.

INTRODUCTION
Agriculture, as a business, involves activities that lead to generation of Waste of different categories. All aspects of agriculture, ranging from crop production, food processing, packaging, and animal production generate Waste of one kind or the other. The said Wastes constitute environmental nuisance and sometimes adversely affect the environment and the natural habitats of plants and animals. The irony of it all is that money and energy (in different forms) are used to produce these Wastes. If Waste production involves the use of money and energy, it is reasonable, I suppose, to find a means of converting these Wastes to wealth.
For instance, in many towns and cities in developing countries, agricultural Wastes, such as banana (and plantain) peels, maize husks and cobs, mango peels and seeds, cassava peels among others, litter the places. These Wastes block water ways and drainages which often result in flooding. The Wastes sometimes full reservoirs and this reduce the storage capacities.
Maize (*Zea mays*), otherwise known as corn is an herbaceous plant domesticated in Mesoamerica and subsequently spread throughout America continents. Maize spread to the rest of the world after the European contact with the Americans in the late 15th Century and early 16th Century (Sturtevant, 1894). Maize is the most widely grown crop in the American, with a production of about 332 million metric tons per annum, (Wikipedia, 2000). du Plessis (2003) also reported that maize is the most important grain crop in South Africa, with an annual production of about 8million tons. This condition is not peculiar to South Africa only but also to the rest of Africa, particularly West Africa. For instance in Nigeria and Ghana, the average annual yield is about 1.5 metric ton/ha (IITA, 20009). Maize is a source of major staple food in this region. Maize is the number one feed grain of the World, including the developing countries. It is used extensively as the main source of calories is animal feeding and feed formulation (Okoruwa, 1995). Maize gives the highest conversion of dry substance to meat, milk and eggs compared to other cereal grain because it is among the highest in not energy content and lowest in protein and fibre content (Okoruwa, 1995).

PHYSIOLOGY OF MAIZE

Maize stems superficially resemble bamboo canes and the internodes can reach 20-30cm. Maize, according to Wikipedia (2009) has a very distinct growth form with the lower leaves being like broad flags (50-100cm long and 5-10cm wide). The stems are erect, conventionally 2-3m in height with many nodes, casting off flag-leaves of every node. The ears grow under these leaves close to the stem. The … grow about 3mm per day (Wikipedia, 2009). A mature maize plant has between 8 to 20 leaves. du Plessis (2003) reported that a mature maize plant has a height varying between 0.6m and 5.0m, depending on the genotype. He further reported that the plant may have between 8 and 21 internodes with each internodes ranging from 2.5cm to 9.0cm.

The maize ears (the female inflorescence) terminate one or more lateral branches, usually half way up the stem. The ears are tightly covered by several layers of leaves, and so closed in by them to the stem that they do not show themselves easily until the emergence of the pale yellow silks from the leaf whore at the end of the ear (Wikipedia, 2009).

Maize Production in the World

Maize is the most widely cultivated crop among the grains in the USA. It ranked 2nd to wheat among the worlds cereal crops in terms of totalproduction (Okoruwa, 1995). The United State produced almost half (~42.5%) of the world total production of about 800million tones in 2007 (Wikipedia, 2009). Other top producing countires are China, Brazil, Mexico, Argentina, India and France. In 2007, over 150million hectares of maize were planted worldwide, with average yield of 4970.9kg/ha (FAO, 2008). Production can however be significantly higher in certain regions of the world, for instance, the 2009 forecasts for production in Iowa State of the United State were 1161kg/ha (Cedar Rapids Cazette, 2009). Table 1 shows the top ten maize producing countries in 2007.

Table 1: Top Ten Maize Producing Countries in 2007

Country	Production (Tones)
United States	332,092,180
P R China	151,970,000
Brazil	51,589,721
Mexico	22,500,000
Argentina	21,755,364
India	16,780,000
France	13,107,000
Indonesia	12,381,561
Canada	10,554,500
Italy	9,891,362
World	784,786,580

Source: FAO: Economic and Social department: The Statistic Division (http://faostat.org/site/567/DesktopDefault.aspx?pageID=567ancor)

In the developing countries, the yield is lower when compare to the developed world, however, the potentials to increase the yield are right there (IITA, 20009) www.itta.org/cms/details/

Energy and Water Requirements for Maize Production

According to du Plessis (2003) maize needs 350mm to 450mm of water per season. He submitted that about 10-16kg of grain is produced for each millimeter of water consumed. At maturity each maize plant would have consumed about 250l of water in the absence of water stress. The total leaf area at maturity is put at above one square metre (du Plessis, 2009) per plant. This gives an impression of sun (light energy) that may be consumed.

Maize has been regarded as an effective user of sunlight. At maturity, the total sun energy used by one plant is equivalent to that of eight thousand, two hundred and ninety three 15W electric bulb (globes) in an hour.

Maize also uses chemical energy in form of fertilizer. According to FAO/IFA (2001), hybrid varieties of maize, for instance in Indonesia will require 120 to 130kg/ha N, 45 to 0kg/ha P_2O_5 and 30 to 60kg/ha K_2O while local varieties will require 45 to 90kg/ha N, 30 to 45kg/ha P_2O_5 and up to 30kg/ha K_2O. Table 2.0 shows nutrients removal by maize for two specific yields.

Table 2: Nutrient Removal by Maize in Kg/ha

Yield	**Nitrogen**	**Phosphorus**		**Potassium**		**Calcium**	**Magnesium**	**Sulphur**
(Kg/ha)	**N**	**P_2O_5**	**P**	**K_2O**	**K**	**Ca**	**Ma**	**S**
3,000	72	36	16	54	45	na	na	5
6,000	120	50	22	120	100	24	25	15

Source: Adapted from FAO/IFA, 2001

The energy requirement for maize production is enormous when compare to the grain yield. Abegunrin and Idowu (2009) found that at harvesting of dry maize, the average kernel yield was 45.3%. This implies that the remaining 54.7% of the maize plant at harvest constitute Waste in the forms of cob, husk and straw. Table 3.0 presents the percentage composition of maize plants at harvest.

Table 3.0: Percentages of Kernel, Cob, Husk and Straw in a Maize Plant at Harvest

	Kernel	**Cob**	**Husk**	**Straw**
Mean	45.3	13.04	8.24	33.42
SD	3.3	3.02	1.6	3.9

Source: Adapted from Abegunrin and Idowu, 2009

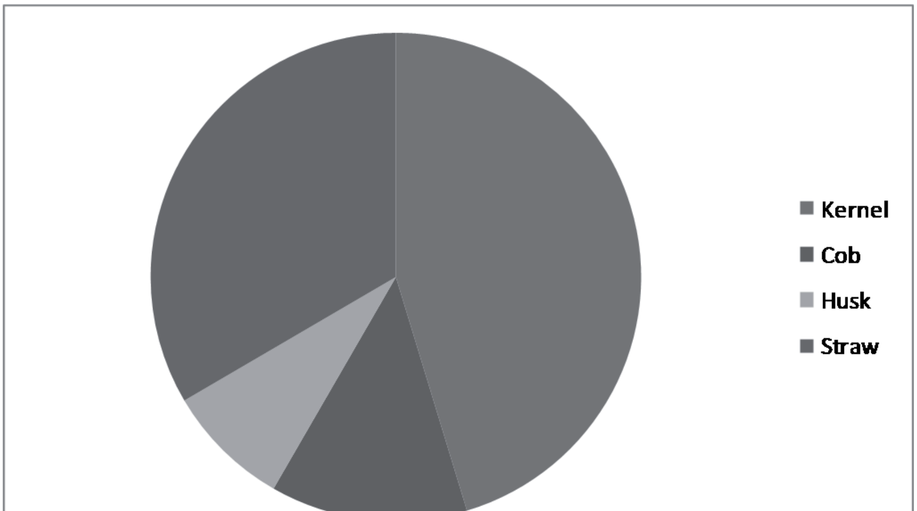

Figure 1: Composition of Maize Plant at Harvest

It is observable from table 3.0 that the kernel yield of maize per plant is (45.3 $\pm$ 3.3)% while that of cob is (13.04 $\pm$ 3.02)%, of Husk is (8.24 $\pm$ 1.6)% and of straw is (33.42 $\pm$ 39)%. Ordinary, only the kernel constitute the useful products, and hence if the other, which are Wastes, are not use, it will amount to the fact that money and energy was use to produce Waste.
However, several works had been carried out and many in progress, on the utilization of Wastes from maize plant. For instance, Idowu, *et al.,* (2009) has produced particle boards from maize cob. This particle board could be used for furniture making, packaging materials etc.
Maize straw is used as animal bedding roofing materials animal feed, mulching material and as a Biomass for cooking at homes. Thus energy 'investment' into the production of maize straw could be withdrawn. Maize husk is used for packaging a local dish in Ghana known as *donkunu.*
When Wastes form maize plant decay, they release some of the chemical energy absorbed from the soil back to the soil. Presently, maize is used for the provision of Biodiesel. This may, on the long run causes food shortage. However, researching into the utilization of Waste may being another good source of Biodiesel from Waste and this will leave maize kernel for its other uses.

CONCLUSIONS AND RECOMMENDATION

Conclusion

One can conclude that without the proper utilization of Wastes from maize plant, the investments into its production is not profitable as only 45.3% of the entire plants is kernel. This will mean that energy, money and time were invested in producing 54.7% Waste. However, with the utilization of the Waste, most of the investments into the production could be withdrawn and hence, maize production becomes profitable. This is the case for most agricultural products.

Recommendation

Because of the potential usefulness derivable from Waste from maize paint, it is recommended that thorough research should be carried out on these Wastes. Such research should be extended to Wastes form other agricultural products, as this will have the effect of conserving nature, increasing the return from such plants. It could also be a way towards the development of crawling economies.

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