## Investigation of Combustion Efficiency of Coconut shell (*Cocos nucifera*) in an Improved stove in Comparison with Neem wood

**ABSTRACT**

The demand for fossil fuel in the world market is increasing by the day and high cost of it. The problem of environmental degradation as a result of emission of dangerous gasses that has adverse effect on the ozone layer and the need to make good use of our large biomass resources which are thrown away, is becoming too much. Biomass, mainly coconut shell, about 90% of coconut, empty fruit bunches, fibers, fronds, trunks, shell was discarded as waste and either burned in the open air or left to settle in waste ponds. Based on economic as well as environmental related issues, efforts were made in this research towards utilization of the biomass. This study compares the efficiency of coconut shell biomass and fuel wood (neem wood) using an improved metal stove. The findings reveal that coconut shell have less ash, less charcoal, uses less fuel but fuel wood uses less time*.*

**Keywords:** Coconut Shell, Improved Stove, Water, Charcoal, Ash, Biomass

**INTRODUCTION**

There is worldwide interest in biofuel as a renewable energy source for long-term fuel sustainability because of the predictable depletion of fossil fuel. The world is increasingly accepting the fact that conventional source of fuel and energy are rapidly depleting and cannot be renewed unlike other renewable energy sources, biomass is a fully renewable resource that can and be used for biofuels, power, chemicals, materials and other products and generate virtually no greenhouse gas. What is needed is a safe reliable and efficient method of generating renewable biofuels that can potentially replace or mitigate fossil fuel dependence.

Researchers all over the world today are focusing on ways of utilizing, either industrial or agricultural waste as a source of raw materials for the industry. This waste utilization would not only be economical, but may also result to foreign exchange earnings and environmental pollution control. (Biennia *et al*., 2003) (Algbodion *et al.,* 2003) Coconut shell is an agricultural waste and is available in very large quantities and one noteworthy byproduct of the coconut shell is liquid smoke, derived through pyrolysis. (D’Almeida and De Albuquerque, 2024) Throughout the tropical countries of the world. Moreover, coconut is becoming an important agricultural product for tropical countries around the world as a new source of energy. (Bamgboye and Jekayinfa, 2006).

Previously, coconut shell was burnt as a means of sound waste disposal which contributed significantly to CO; and methane emissions. (Bamgboye and Jekayinfa, 2006). However, as the cost of fuel oil, natural gas and electricity supply has increased besides becoming erratic; coconut shell has come to be regarded as a source of fuel rather than refuse. Presently, in Nigeria, coconut shell is used as a source of fuel for the boiler, and residual coconut shell off and traditional fuel is fire wood, which is obtained either from wood or fallen trees, and responsible for deforestation, desertification, hunger, poverty and biodiversity loss. In this experiment the type of stove involved is an enclosed stove with only one slot for the biofuel. The biofuel in this experiment is coconut in the form of shell and husk biomass. Coconut shell is an important product obtained from coconut tree, scientifically as *cocos nucifera*. Coconut shell is one of the raw materials for coconut shell charcoal production, it is produced by burning shells of fully matured nuts in limited supply of air, sufficiently only for carbonation. During the process of carbonation activated carbon is processed as charcoal in the presence of oxidizing agent such as steam and carbon dioxide. An enclosure like a stove, improved coking stove (CS) is a device that is designed to consume less fuel and save cooking time. Convenient in cooking process and great smokeless environment in the kitchen or reduction in the volume of smoke produced during cooking against the traditional stove United mission to Napel.

**MATERIALS AND METHODS**

**MATERIALS**

Measuring cylinder (500ml)

Beaker 100Oml

Improved force draft stove (locally called Mukubar)

Weighing balance (electronic precision balance).

Matches.

Stop watch.

Filter paper

Coconut shell.

Fuel wood (Neem wood),

Thermometer

**METHODOLOGY**

The coconut biomasses were collected from local disposal sites in Maiduguri Metropolis. The biomass (shell and husk) was spread and allowed to dry in the sun. The fuel woods of neem tree were purchased from local fuel sellers in Maiduguri town, Borno State. The fuels were allowed to dry in the sun to reduce its moisture content. The two fuel types (Coconut biomass and fuel wood) were used in an improved metal stove with only one opening as slot and for aeration. This particular stove was chosen because it was an improvement over the open three stones and partially closed one which have been the traditional domestic stove in circulation and use in Maiduguri. Weight of each fuel type were taking using an electronic precision balance (made), a digital scale which repot more accurate values than other classic measuring scales. One liter of water was measured using a measuring cylinder for the water boiling trails, A mercury thermometer was attached to indicate boiling point (100°c) per unit time after boiling, weight of each fuel type residues, charcoal and ash contents were collected. weighed and recorded. The boiling procedure was replicated three times for each fuel type.

**DATA ANALYSIS**

Average values of replicated data were collected from the trial observation, were subjected to a two way analysis of variance (RCBD) at 5% and 1% probability level and the least significance difference (LSD) were used to compare the significant difference between means (Akindele, 1996).

**RESULT AND DISCUSSION**

**RESULTS**

**Table 1: showing means attributes of Coconut Shell Biomass, Trails for Boiling Using an Improved Stove**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Wt. of Biomass before use (g) | Wt. of Biomass after use (g) | Vol of H2O (Liter) | Time taken to reach 1000c (min) | Ash content (g) | Wt. of Charcoal (g) | % different of initial Wt. and residue | % different of initial Wt. and Ash content C | % different of initial Wt. and Charcoal weight  |
| Mean trials | 500 | 181.93 | 1 | 5.3.33 | 1.8 | 18.57 | 63.61 | 99.64 | 96.29 |

|  |  |  |
| --- | --- | --- |
| % Ash Content | % of Residue | % of Charcoal |
| 0.36 | 36.61 | 3.71 |

In this result, the average weight of the coconut biomass after use (residue) was 8193g which represents 36.61% of the initial biomass (500g). About 318.07g of the biomass was utilized to boil 1 liter of water in 5.33minutes, representing about 63.61% of the biomass. This quantity seems to be more significant. The large percentage of the residue was due to the nature of the fuel: it is very hard, which made it to take time to burn completely. The ash content was1.8g which is equivalent to 0.36% 0f the whole biomass. It has a very low percentage of ash which is one of the characteristics of a good fuel. The average weight of charcoal was found to be 18.57g which is 3.71%.

The result is in corroboration with the findings of Sotannde *et al.*(2017) reported Coconut shell briquettes had higher compressed density though lower in relaxed form (0.80 g·cm-3 vs 0.78 g·cm-3) when compared to Bambara nut shell briquettes (0.77 g.cm-3 vs0.75 g.cm-3).

According to (Weier, 1998; Mendoza *et al.,* 2002), the use of biomass for energy reduces dependency on imported petroleum and minimizes greenhouse gas emissions by closing the carbon loop. According to (Samson, 2002), It also creates economic development for rural and communities, and reduces the widespread deforestation that is a result of wood tree use for household purposes.

**Table 2: Showing means attributes of Fuel wood, Trails for Boiling Using an Improved Stove**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Wt. of Biomass before use (g) | Wt. of Biomass after use (g) | Vol of H2O (Liter) | Time taken to reach 1000c (min) | Ash content (g) | Wt. of Charcoal (g) | % different of initial Wt. and residue | % different of initial Wt. and Ash content C | % different of initial Wt. and Charcoal weight  |
| Mean trials | 500 | 181.93 | 1 | 5.3.33 | 1.8 | 18.57 | 63.61 | 99.64 | 96.29 |

|  |  |  |
| --- | --- | --- |
| % Ash Content | % of Residue | % of Charcoal |
| 0.36 | 36.61 | 3.71 |

In this result, the average weight of fuel wood after use (residue) was 29.53g which represents 5.91% of the initial biofuel (500g). About 470.47g of the whole biofuel was utilized to boil 1 liter of water in 3.7 minutes, representing about 94.04% of the biofuel. This small percentage of residue was about 94.04% of the biofuel. This small percentage of residue was due to the nature of the fuel, it is not hard and this made it to burn easily. The ash content was 11.13g which is equivalent to 2.23% of the whole biofuel this percentage of ash is higher than that of coconut shell biomass. The average weight of charcoal was found to be 15.27g which is 3.05% of the whole biofuel. In contrast Kumar and Saha, (2022) reported that the inclusion of coconut particles improved the overall mechanical performance of the biocomposites and observed CRC-5.0 biocomposites have superior tensile strength (32.58%), and fexural strength (35.45%), and surface hardness (23.61%) compared to CRC-0.0 biocomposites. The impact strength, fracture toughness, and fracture energy are higher for CRC-2.5 biocomposites.

Kamal *et al.,* (2021) also reported that the use of an agricultural by-product i.e. coconut shell can be a promising material for manufacturing the concrete in the partial replacement of coarse aggregates. Their result indicates that coconut shell can be used as lightweight concrete which can be used in non-load bearing structures, strip footings and non-structural elements. Environmental concerns can also be minimizing by making such sustainable efficient practices by the use of these waste coconut shell materials.

**Table 3. Showing Analysis of Variance for Values of Residue for the two Biofuels**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Source of variation  | Degree of Freedom (df) | Sum of square (SS)  | Mean Sum of Squares (mss) | F. Calculated (Fcal) |
| Replicate  | 2 | 9788.03 | 3399.02 | 9.36 |
| Treatment  | 1 | 33480.57 | 33480.57 | 92.22 |
| Error | 2 | 726.1 | 363.05 |  |
| Total  | 5 |  |  |  |

The calculated ANOVA for coconut shell biomass and fuel wood residue were, replicate means were observed to be non-significant at both 5% and 1% probability level. Whereas treatment means were found to be significant at 5% and non-significant at 1% probability level.

In a similar study by Kongninea *et al.* (2020)*,* reported the average yields obtained ranged from 37.81 % for palmyra shells to 27.57 % for the doum palm shells. The highest yield achieved was 42.32 % obtained at 280 °C for palmyra shells, the lowest yield (24.42 %) was recorded at the highest maximum temperature of 590 ° C for doum palm shells. The results of energy parameters of the studied biochar showed that coconut shells charcoal presented the highest lower calorific value (28.059 MJ.kg-1), followed by doum palm shells (26.929 MJ.kg-1) when, with 25.864 MJ.kg-1, whole fruit of doum palm charcoal showed the lowest lower calorific value. Similarly, with the highest bulk density of 0.625 g/cm3 coconut shells charcoal presented the highest energy per unit volume (17536.88 J/cm3), whereas with the lowest bulk density of 0.415 g/cm3, whole fruit of doum palm charcoal presented the lowest energy per unit volume. The ash content analysis showed that whole fruit of doum palm had the highest ash content (18.75 %) and palmyra nut shells charcoal (8.42 %). Teak wood charcoal, took as control, has the highest lower calorific value (32.163 MJ.kg-1), less dense as coconut shell (0.43 g/cm3), his energy per unit of volume is 13830.09 j/cm3 but the lowest value of as content (2.90 %). Among these biomasses’ charcoals, only whole fruit of doum palm charcoal ash showed a high chloride and sulfide content respectively 9.73 % and 1.75 % in weight. From these results, the produced charcoals could be used as alternative fuels except for whole fruits of doum palm charcoal which chloride and sulfide content were found high.

**Table 4. Showing Analysis of Variance for Values of Content for the two Biofuels**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Source of variation  | Degree of Freedom (df) | Sum of square (SS)  | Mean Sum of Squares (mss) | F. Calculated (Fcal) |
| Replicate  | 2 | 10.58 | 5.29 | 1.35 |
| Treatment  | 1 | 130.66 | 130.66 | 33.37 |
| Error | 2 | 7.83 | 3.915 |  |
| Total  | 5 |  |  |  |

The calculated ANOVA for coconut shell biomass and fuel wood ash contents for replicate means were observed to be non-significant at 5% probability level. Whereas treatment means were found to be significant at 5% probability level

Archana *et al.,* (2020) reported Coconut shell is being used by farmers as organic fertilizer as it has the capacity to conserve the moisture in the farm land and also it helps in the reduction in the nutrient loss during farming. In the course of time, the coconut shell is modified into compost by which it exhibits the property of fertilizer. So, if the coconut shell is being taken up as a source to produce biofuel, with low cost, it reduces the pollution due to carbon dioxide emission and it’s by product can be used as fertilizer

T**able 5. Showing Analysis of Variance for Values of Charcoal Weight for the two Biofuels**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Source of variation  | Degree of Freedom (df) | Sum of square (SS)  | Mean Sum of Squares (mss) | F. Calculated (Fcal) |
| Replicate  | 2 | 83.21 | 41.61 | 3.78 |
| Treatment  | 1 | 16.34 | 16.34 | 1.48 |
| Error | 2 | 22.02 | 11.01 |  |
| Total  | 5 |  |  |  |

The Calculated ANOVA for coconut shell biomass and fuel wood charcoal were both were found to be non-significant at 5%nprobabiliy level.

**SUMMARY, CONCLUSION AND RECOMENDATION**

**SUMMARY**

The study looked into the efficiency of coconut shell as a biofuel compared to that of fuel wood (neem wood). The research was conducted to look into some efficiency parameters such as boiling time, ash content, weight of residue and charcoal weight. The study was divided into five chapters to be handled specially in each phase of the study: this was to give room for easy organization and flow of ideas as the researcher work through the project as well as giving the reader the opportunity of going through the research work very easily.

The introductory part of the project highlighted the important aspect of the study which stated the aim and objectives of the study. Related literatures such as text books, written documents, Google and journals were consulted and reviewed on the research topic to back up the study. The research breaks into various sub-

Headings The method and procedures the researcher used in carrying out the research was through practical using an improved stove and comparing the efficiency of coconut shell biomass with that of fuel wood (neem wood). Major findings of the research work were highlighted and discussion of each was made.

**CONCLUSION**

We know that, nowadays the use of fuel wood as an alternative fuel for energy generation is increasing day by day which leads to high deforestation and global warming. Therefore, we can introduce some fuel as alternative like coconut shell. After analyzing the cost, heat value and availability of coconut shell by this project, it is expected to make good use of coconut shell biomass as an alternative fuel because of its environmentally friendly, environmental degradation as a result of emission of dangerous gases that has adverse effects on the ozone layer will be managed, and the need to make good use of our large biomass which are regarded as waste rather than fuel which will save our forest from deforestation. The shell biomasses contain less ash, about 0.36% of 500g compared to that of wood which was 2.23%, furthermore only 318.07g of shell biomass was utilized to boil 1 liter of water in 5.33mins while that off fuel wood was 470.47g was used in 3.7mins. From the above observations of the two biofuels, it clearly shows those coconut shell biomasses are more efficient, healthy and safe for use as an alternative biofuel.

**RECOMMENDATION**

After examining the efficiency of coconut shell biomass as an alternative biofuel compared to fuel wood, the researcher has therefore recommended the following which will assist in the encouragement of using an alternative fuel rather than relaying only on the fuel wood.

1. The use of coconut shell biomass as an alternative fuel.

2. There should be a public enlightenment on the importance of using alternative fuels and the effects behind using fuel wood which lead to global warming, deforestation and others.

3. Further research should be carried out on other different biofuels such as rice husk (hull) and saw dust using a suitable improved stove for the research so as to compare their efficiency.

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1.

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