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Original Research Article

Evaluation of the Calorific Value of Biomass

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Abstract

This study aims at identifying the potentially viable renewable fuel resources, characterizing the combustion properties of each and to determine those that have potential for use as commercial fuels for domestic and industrial uses. Twenty-three (23) fuels were identified and studied by characterizing their combustion properties viz; calorific value. Also their availability and ease of preparation were studied. As a result of the tests, ten (10) of the twenty-three (23) fuels have been recommended as suitable for exploitation for domestic or industrial uses. Also, it has been recommended that project titles be initiated on the development of systems (equipment) to utilize these recommended fuels.

Keywords: Biomass or Biofuels, Renewable energy, calorific value. e.t.c.

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1. INTRODUCTION

Increase in national population, rise in industrial activities and global climatic changes among other factors have given rise to high energy demand in homes and industries. Fossil fuel can no longer meet the energy requirements due to their scarcity and rising cost. Consequently, the need to have an alternative energy source is a priority issue. To achieve this laudable goal, some identified challenges must be properly addressed to pave way for the enormous benefits of using renewable energy sources (Chilakpu K.O 2015). Renewable energy can be defined initially as any energy source that is derived directly or indirectly from solar energy. In the broadest sense, however, almost all of the energy we use today, including fossil fuels, can be considered a form of solar energy. The most familiar forms of energy, such as wood, oil, gas, and coal, are embodied forms of solar energy gathered, stored, and transformed by natural processes. (Shahrouz A. *et al*. 2014). Woody biomass from forest management is a renewable, low-carbon feedstock that can substitute for fossil fuels in the production of energy and other products a potentially important tool in the national strategy to reduce greenhouse gas emissions and resist global climate change. Markets for logging residues, small diameter trees, and other low-value forest products can add value to working forests, help provide financial alternatives to land clearing and development, and create incentives for investing in sustainable forest management. Forest thinning and removal of small-diameter, low value trees are integral parts of forest management for a number of values and objectives biodiversity conservation, ecological restoration, wildfire prevention, and timber stand improvement (Jesse 2009). Some argue that biomass is a renewable resource that is widely available, may be obtained at minimal cost, and may produce less greenhouse gas than fossil fuels under certain situations. Others contend that biomass has seen limited use as an energy source thus far because it is not readily available as a year-round feedstock, is often located at dispersed sites, can be expensive to transport, lacks long-term performance data, requires costly technology to convert to useful energy, and might not meet quality specifications to reliably fuel electric generators (Kelsi 2019).

The biomass considered to be most significantly in terms of energy sources are wood and wood wastes. The world annual forest wood increment is estimated to be $12,900 \times 10^6$ tons of which only 13% is harvested (Mcg raw hill 1987).

The use of renewable energy sources is becoming increasingly necessary, if we are to achieve the changes required to address the impacts of global warming. Biomass is the most common form of renewable energy, widely used in the third world but until recently, less so in the Western world (Peter McKendry 2002).

Biomass is currently the most widespread form of renewable energy and its exploitation is further increasing due to the concerns over the devastative impacts of fossil fuel consumption, i.e., climate change, global warming and their negative impacts on human health. In line with that, studies review the different sources of biomass available, along with their chemical composition and properties. Subsequently, different conversion technologies (i.e., thermo-chemical, biochemical, and physico-chemical conversions) and their corresponding products are reviewed and discussed. In the continuation, the global status of biomass *vs.* the other renewable energies is scrutinized. Moreover, biomass-derived energy production was analyzed from economic and environmental perspectives. It is organic material made from plants and animals. It contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis. The chemical energy in plants gets passed on to animals and people that eat them. Biomass is a renewable energy source because we can always grow more trees and crops, and waste will always exist. Some examples of biomass fuels are wood, crops, manure, and some garbage (E.I.A 2007).

(Andrzej G. 2019) Biomass can be used for the production of energy from renewable sources. Because of social resistance to burning crop plants, mixtures and pellets made from or including waste materials are a good alternative. The mixtures analyzed, prepared from wood and municipal waste, were characterized for their calorific values, 7.4–18.2 MJ·kg^{-1} . A result, over 15 MJ·kg^{-1} was obtained for 47% of the quantities of mixtures being composed. It has been demonstrated that wood shavings and sewage sludge have a stabilizing effect on the durability of pellets. The emissions of acidic anhydrides into the atmosphere from the combustion of pellets from waste biomass were lower for NO, NO2, NOx and H_2S than emissions from the combustion of willow pellets. Obtained emission results suggest the need to further optimize the combustion process parameters. Biomass technology must be encouraged, promoted, invested, implemented, and demonstrated, but especially in remote rural areas.

2. METHODOLOGY/EXPERIMENTATIONS

There are several limitations associated with finite mineral resources; therefore, interest is gradually shifting to biomass. A total of twenty-three (23) potentially viable renewable fuel resources were identified in the cause of this study. These were:

(1) Wood bark
(2) Saw dust
(3) Wood cutoffs/shavings
(4) Palm kernel shells (Elaeis guineewsis)
(5) Palm branch (Elaeisa guineensis)
(6) Corn Cobs (Zea-mays)
(7) Corn leaves
(8) Elephant grass (Pennisetum purpureum)
(9) Coconut shells (cocos nucifera)
(10) Cashew leaves (Anacardium occidentale)
(11) Coconut fibres (exocarp cocos nucifera)
(12) Sugar cane fibres (bigasse Saceharium officinalis)
(13) Orange leaves (citrus sinensis)
(14) Pear leaves (Persea americana)
(15) Palm fronds (Elaeis guineensis)
(16) Pawpaw leaves (carica ipapaya)
(17) Ebelebo leaves (Terminalia catapa)
(18) Mango leaves (Mangifera indica)
(19) Rubber leaves (Havea brassiliensis)
(20) Awolowo grass (chromolaena odorata)
(21) Sugarcane leaves (Saceharium offieinalis)
(22) Banana leaves (musa)
(23) Plantain leaves (Musa paradisiaea).

Experiments were carried out in order to be able to analyze the characteristics of the different identified fuels-successfully. These are the determination of the calorific value using Bomb-calorimeter and that of the physical properties e.g flame color, flame speed and rate of smoke emission.

3.1 Experiments to Determine the Calorific Value.

This experiment was carried out in order to be able to know the energy content of the twenty-three different identified fuels.

The experiment was started with a thread of about 5cm, the oxygen valve was opened and the bomb fired. There was a deflection on the galvanometer via the thermo-couple connected to the bomb and this deflection indicated was noted. The experiment was repeated for three more threads and while for each time, recording the maximum deflection indicated on the galvanometer. This is done in order to be able to estimate the amount of heat that can be transferred to the bomb by the thread.

This was followed by placing the weighed disc of benzoic acid inside the bomb. A thread was used to transfer the firing to the weighed disc containing benzoic acid, by connecting it to a solenoid wire. When the oxygen valve was opened, the pressure was increased until the gauge read 25 bar. The bomb was then fired and the galvanometer-deflection for that specific mass of benzoic acid used was recorded. This was repeated for five more different masses of benzoic acid, and each time the bomb is fired, the galvo-deflection was recorded. Note that before each successive firing, the bomb is cooled to room temperature using distilled water.

The above procedure was repeated using the weighed disc containing different samples. Two different readings of the galvanometer-deflection was recorded for each of the different fuel materials used.

3. RESULTS/DISCUSSION

The object of this discussion is to draw inferences from the recorded results of the experiments carried out as tabulated in the preceding chapter.

These inferences would help in the recommendation of those fuels with potential for use as commercial fuels for domestic and industrial use.

The results shown in Table 4.1-4.4 vary greatly for each fuel material. One common trend is that most of the leaves have the same range of calorific value, which are (between 17 and 18 MJ/kg). However fuel materials for recommendation will have to satisfy the following requirements:

(a) High or moderate calorific value
(b) Low or moderate flame speed
(c) Availability
(d) Moderate rate of smoke emission
(e) Greater ease of preparation i.e drying up, collection and shredding to smaller sizes for densification.

Table-4.1: Fuel materials with high calorific value

Fuel materials	Botanical Name	Calorific value MJ/kg
Wood Bark	-	21. 58±0.21
Coconut shells	Cocos nucifera	20. 64±0.07
Palm kernel shells	Elaeis guineensis	20. 60±0.05
Sawdust	-	20. 56±0. 11
Sugar-cane fibre	Saceharum off icinalis	19. 20±0.02

Table-4.2: Fuel materials with moderate calorific values

Fuel materials	Botanical Name	Calorific value MJ/kg
Coconut fibre	Cocos nucifera	18.81±0.19
Palm bunch	Elaeis guineensis	18. 59±0. 13
Corn shank	Zea-mays	18.32±0.07
Cashew leaves	Anacarcliurn Occidentale	18.31±0. 11
Wood carvings/ cut-off	-	18.24±0.03
Plantain leaves	Musa paradisiacal	17.89±0.08
Sugar-cane leaves	Saceherum officinalis	17.83±0.01
Pear leaves	Persea americana	17.79± 0.06
Corn leaves	Zea-mays	18.08±0.14
Ebelebow leaves	Term inalia catapa	17. 77±0.03
Awolowo leaves	Chromolaena odorata	17.71±0.07
Rubber leaves	Havea brassiliensis	17.71±0.03
Mango leaves	Mangefera indica	17. 63±0.07
Pawpaw leaves	Carica papaya	17.55±0.2
Banana leaves	Musa	17.43±0.2
Palm fronds	Elaeis guineensis	17.38±0.0
Orange leaves	Citrus sinensis	17.21±0.07

Table-4.3: Fuel material with low calorific va1ue

Fuel material	Botanical name	Calorific value
Elephant grass	Pennisetum purpureum	15.12±0.01

Table-4.4: Fuel materials with high Flame Speed

Fuel materials	Botanical name	Flame speed cm/min
Elephant grass	Pennisetuni purpureum	57.14
Corn leaves	Zea-mays	35.29
Sugar-cane leaves	Saceharuni officinalis	34.28
Awolowo grass	Chromolaena odorata	33.89
Banana leaves	Musa	33.89
Sugar-cane fibre	Saceharum officinalis	33.34

4. CONCLUSION

The main objective of this project which was to determine the combustion Characteristics of Renewable Fuels was achieved. The focus has been on how to harness the abundant renewable fuel resources in this country by first determining the various combustion properties of fuel materials identified. The fuel materials identified have been mainly biomass materials. In this case we have worked on the direct combustion of dried forest and agricultural wastes which abounds within our locality. The success of this work has been due to the systematic approach in the identification of the fuel materials, the method of analysis of the materials by experimentation and the very simple and easy method used in analyzing the results and hence selecting the final fuel materials. This work has again created an awareness of the importance of exploiting/harnessing the renewable energy resources for national development. This also will help to conserve our crude petroleum in no small measure. The relevant ministries and government agencies should initiate projects geared towards the development of systems (equipment) to utilize the above recommended fuels for domestic and industrial applications. Examples are sawdust powered stoves or burners.

REFERENCES

- Abolhosseini, S., Heshmati, A., & Altmann, J. (2014). A review of renewable energy supply and energy efficiency technologies.
- Caputo, J. (2009). *Sustainable forest biomass: promoting renewable energy and forest stewardship*. Environmental and Energy Study Institute.
- Chilakpu, K. O. (2015). Renewable energy sources. Its benefits, potentials and challenges in Nigeria. *Renewable Energy*, *5*(9).
- Energy Information Administration, Annual Energy Review 2006, June 2007.
- Goodger, E.M. (1980). Alternative fuels, Chemical energy resources Macmillian, London and Basingstoke.
- Greinert, A., Mrówczyńska, M., & Szefner, W. (2019). The use of waste biomass from the wood industry and municipal sources for energy production. *Sustainability*, *11*(11), 3083.
- Kelsi, B. (2019). Biomass: Comparison of Definitions in Legislation Updated June 27, 2019.
- Macrae, J. C. (1966). Study of Fuels, Elsefum Publication Co.
- Mc Graw Hill. (1987). Encyclopedia of Science and Technology Volume 6,6th edition.
- McKendry, P. (2002). Energy production from biomass (part 1): overview of biomass. *Bioresource technology*, *83*(1), 37-46.
- Norman, L. Brown. (1978). Renewable Energy Resources and Rural Applications in the Developing World. *Western Press Colorado*.
- Tursi, A. (2019). A review on biomass: importance, chemistry, classification, and conversion. *Biofuel Research Journal*, *6*(2), 962-979.