An Alternative Fuel by Blending of Non Woody Biomass and Coal for Use in Power Generation

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Abstract - *With the development in technology the power consumption is rising gradually. This necessitates that in addition to the obtainable source of power such as coal, water, petroleum etc. Power generation from biomass becomes attractive way for energy generation due to their high energy potential and less pollution. Out of these renewable energy sources, biomass may be a ton of economically viable for nearly all the continents inside the planet. Woody biomass usually used for the generation of heat, electricity, and biofuels. In many cases, the technology for dynamic woody biomass into energy has been established for several years, but as a result of the value of woody biomass energy has not been competitive with ancient fossil fuels, bioenergy production from woody biomass has not been widely adopted. The present project work might be a positive step towards energy and environmental problems facing the world. Presently, co-firing (coal + biomass) has been tested to be lots of partaking and economically viable technique for power generation. inside the work, briquettes were prepared by combining non-coking coal mines and thus the connected biomass species in varied relation. The objectives seem at their energy values and power generation potential. The project aim is to the determination of proximate analysis, energy worth of assorted parts of biomass, coal & there mixture. The experiment analysis their result and discussion as shown throughout this project.*

***Key Words*: Proximate Analysis, Electricity Generation, Energy Content, Non-woody Biomass Species.**

1.INTRODUCTION

India being a developing nation, Energy could be a basic demand for economic development. Each sector of Indian economy – agriculture, industry, transport, business and domestic – wants inputs of energy. Energy is a very important issue for any developing country. Ever increasing consumption of fossil fuels and speedy depletion of acknowledged reserves are matters of significant concern within the country. This growing consumption of energy has additionally resulted in the country changing into progressively addicted to fossil fuels like coal, oil and gas. Economic process of oil and gas and potential shortages in the future result in issues regarding the safety of energy offer required to sustain our economic process.

Conventional sources are non- renewable and certain to end in the future. As a result of these reasons, it's become necessary to explore and develop non-conventional energy resources to scale back an excessive amount of dependence on standard sources and development of different sources of energy that are renewable and atmosphere friendly.

Power generation from biomass becomes enticing means for energy generation as a result of their high energy potential and fewer pollutants. Property production and utilization of biomass in power generation will solve the very important problems with part pollution, energy crisis, waste development, rural employment generation and power transmission losses. Thus, the event of biomass-based power generation system is assumed to be favorable for a majority of the developing nations as well as Asian country. Biomass is also capable of providing firm energy. Besides electricity offer to the national power grids, biomass offers large opportunities for redistributed power generation in rural areas at or close to the points of use and therefore will build villagers/ tiny industries self-dependent in respect of their power necessities. To use biomass species in electricity generation, characterization of their numerous properties like energy values, chemical compositions, reactivity towards chemical element, bulk densities etc. is crucial. This work deals to work out the proximate analysis of three biomass species and mixed-biomass briquette and to seek out the most effective appropriate quantitative relation for power generation and land needed for plantation.

1.1 DIFFERENT RENEWABLE ENERGY SOURCES

The varies types of renewable energy sources are as follows:

- Wind Energy
- Solar Energy
- Hydropower
- Geothermal Energy
- Nuclear Energy
- Biomass and Bio-energy

1.2 BIOMASS ENERGY

Biomass is renewable organic matter derived from trees, plants, crops or from human, animal, municipal and industrial wastes. Biomass may be classified into 2 varieties, woody, and non-woody. Woody biomass comes from forests, plantations, and biological science residues. Non-woody biomass contains agricultural and agro-industrial residues and animal, municipal and industrial wastes.

Biomass doesn't add greenhouse emission to the atmosphere because it absorbs an equivalent quantity of carbon in growing because it releases once consumed as a fuel. Its advantage is that it may be want to generate electricity with an equivalent instrumentation that's currently getting used for burning fossil fuels. Biomass is a vital supply of energy and also the most significant fuel worldwide. Bio-energy, within the kind of biogas that comes from biomass, is anticipated to become one among the key energy resources for the development of the nation. Biomass offers higher energy potency through kind of Biogas than by direct burning.

Biomass contains keep energy from the sun. Plants absorb the sun's energy in an exceeding method known as a chemical process. Biomass could be a renewable energy supply as a result of we are able to forever grow additional trees and crops. Some samples of biomass fuels wood, crops, manure and a few garbage once burned, the energy in biomass is discharged as heat. In an exceedingly hearth, the wood that's burnt could be a biomass fuel. Wood waste or ash-bin is burnt to provide steam for creating electricity, or to produce heat to industries and homes. Burning biomass isn't the sole thanks to unleashing its energy. Biomass may be regenerate to different usable varieties of energy like alkenes series gas or transportation fuels like grain alcohol and biodiesel. Alkenes series gas is the main ingredient of fossil fuel. Footed stuff, like rot garbage and agricultural and excretory product, unleash alkenes series gas additionally known as "landfill gas" or "biogas." Crops like corn and sugar cane may be soured to provide the transportation fuel, ethanol. Biodiesel, another transportation fuel, may be made from leftover food merchandise like vegetable oils and animal fats.

1.3 WHY BIO-MASS ENERGY?

- Biomass is a renewable energy source generated through natural processes and as a by-product of human activity.
- It is also more evenly distributed over the earth surface than fossil fuel energy source, and may be harnessed using more cost-effective technologies.
- It provides us the opportunity to be more energy self-sufficient and helps to reduce climate change.
- It helps farmers, ranchers, and foresters better manage waste material, providing rural job opportunities and stimulating new economic opportunities.

1.4 AIMS AND OBJECTIVES OF THE PRESENT PROJECT WORK

1. Selection of non-woody biomass species and estimation of their yield by field trial.

2. Determination of proximate analysis (% moisture, %volatile matter, % ash and % fixed carbon contents) of their different components, such as wood, leaf and nascent branch.

3. Mixed these biomass components separately with coal sample in different-different ratio.

4. Characterization of these biomass components for their energy values (calorific values).

5. Characterization of coal mixed biomass components for their energy values (calorific values)

6. Estimation of power generation potentials of these biomass species for a small thermal power plant on a decentralized basis.

7. Comparative study of coal and mixed coal-biomass in a different ratio of 95:05, 90:10, 85:15 and 80:20 with respect to selected biomass species.

2. LITERATURE REVIEW

T.T. Al-Shemmeri et al. [2015] [1] In this paper, the authors attempted to investigate the performance of a small-scale biomass combustor for heating, and the impact of burning different biomass fuels on useful output energy from the combustor. The test results of moisture content, calorific value and combustion products of various biomass samples were presented. Results from this study were in general agreement with published data as far as the calorific values and moisture contents are concerned. Six commonly available biomass fuels were tested in a small-scale combustion system, and the factors that affect the performance of the system were analyzed. It was concluded that some crucial factors have to be carefully considered before selecting biomass fuels for any particular heating application.

A.Raju et al. [2014] [2] This work have proximated analyzed different components, such as wood, leaf and nascent branch and energy content of different components of paddy husk hypogeal. Medical wastes from hospitals and items that can be recycled are generally excluded from MSW used to generate electricity. These biomass components were separately mixed with coal dust and MSW in different-different ratio and also their proximate analysis was done and their energy values were determined to find out the best suitable mixture for power generation.

3. EXPERIMENTAL WORK

3.1 SELECTION OF MATERIALS

In the present project work, three different types of non-woody biomass, MORINGA OLEIFERA (common name Drumstick), CAJANUS CAJAN (common name Arhar) and HIBISCUS (common name GUDHAL) were procured from the local area. These biomass species were cut into different pieces and their different component like leaf, nascent branch, and main wood were separated from each other. These biomass materials were air-dried in cross ventilator room for around 30 days. When the moisture contains of these air-dried biomass sample came in equilibrium with that of the air, they were crushed in mortar and pestle into powder of -72 mesh size. These materials were than processed for the determination their proximate analysis and Energy values.

Fig-3.1: Sample of biomass component, component powder, and coal powder

3.2 PROXIMATE ANALYSIS

Proximate Analysis consist of moisture, ash, volatile matter, and fixed carbon contents determination were carried out on samples ground to -72 mesh size by a standard method. The details of this analysis are as follows:

3.2.1 Determination of Moisture

One gm. (1 gm.) of air-dried -72 mesh size powder of the above said materials was taken in borosil glass disc and heated at a temperature of 110°C for one hour in air oven. The discs were then taken out the oven and the materials were weight. The percentage loss in weight was calculated which gives the percentage (%) moisture contains in the sample.

3.2.2 Determination of Ash Content

One gm. (1 gm.) of -72 mesh size (air dried) was taken in a shallow silica disc and kept in a muffle furnace maintained at the temperature of 775°C. The materials were heated at this temperature for one hour or till complete burning. The weight of the residue was taken in an electronic balance. The percentage weight of residue obtained gives the ash contained in the sample.

% Ash = Wt. of residue obtained × 100 / Initial wt. of sample.

3.2.3 Determination of Volatile Matter

One gm. (1 gm.) of -72 mesh size (air dried) powder of the above said materials were taken in a volatile matter crucible (cylindrical in shape and made of silica). The crucible is covered from the top with the help of silica lid. The crucible was placed in a muffle furnace, maintained at the temperature of 925°C and kept there for 7 minute. The volatile matter crucibles were then taken out from the furnace and cooled in air. The de-volatized samples were weighted in an electronic balance and the percentage loss in weight in each of the sample was calculated. The percentage volatile matter in the sample was determined by using the following formula:

% volatile matter (VM) = % loss in weight - % moisture

3.2.4 Determination of Fixed Carbon

The fixed carbons in the sample were determined by using the following formula.

% FC = 100 − (% M + % VM + % Ash)

Where, FC: Fixed carbon, M: Moisture, VM: Volatile Matter

3.3 CALORIFIC VALUE DETERMINATION

The calorific values of these species (-72 mesh size) were measured by using an Oxygen Bomb calorimeter 1 gm. of briquettes sample was taken in a nichrome crucible. A 15 cm long cotton thread was placed over the sample in the crucible to facilitate in the ignition. Both the electrodes of the calorimeter were connected by a nichrome fuse wire. Oxygen gas was filled in the bomb at a pressure of around 25 to 30 atm. The water (2 litre) taken in the bucket was continually stirred to homogeneous temperature. The sample was ignited by switching on the current through the fused wire and the rise in temperature of the water was automatically recorded. The following formula was used to determine the energy value of the sample.

Gross calorific value (GCV) = {(2500 × ΔT) / (Initial wt. of sample) − (heat released by cotton thread + Heat released by fused wire)}

Where 2500 is the water equivalent value for the apparatus and ΔT is the maximum temperature rise.

4. CALCULATION AND RESULTS

The studies of the proximate analysis of fuels energy sources are important because they give an approximate idea about the energy values and extent of pollutants emissions during combustion. The proximate analysis of different components of Drumstick, Arhar and Gudhal plant and these biomass species component briquettes with coal are presented in Tables 4.1 – 4.7. The data for proximate analysis of the components of these species are very close to each other and hence it is very difficult to draw a concrete conclusion.

The results obtained from proximate analysis and calorific value of non-woody biomass species, coal, coal-biomass mixed briquettes of selected biomass species and coal-biomass mixed (in ratio) during the course of this project work have been summarized in Tables 4.1– 4.7.

Table 4.1: Proximate Analysis of Drumstick

Component	Proximate Analysis(Wt. %, air-dried basis)				Gross Calorific Value(Kcal /Kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Wood	10.1	3.9	72.1	13.9	4103
Leaf	8	7.2	68.2	16.6	3781
Nascent Branch	10.3	4.6	72	13.1	3801

Table 4.2: Proximate Analysis of Arhar

Component	Proximate Analysis(Wt. %, air-dried basis)				Gross Calorific Value(Kcal /Kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Wood	8.1	3	69.1	19.8	4605
Leaf	9.1	6.9	63.2	20.8	4180
Nascent Branch	9.5	4.1	67	19.4	4218

Table 4.3: Proximate Analysis of Gudhal

Component	Proximate Analysis(Wt. %, air-dried basis)				Gross Calorific Value(Kcal /Kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Wood	10.2	6.9	62	20.9	4234
Leaf	11	6.3	60.12	23.58	4111
Nascent Branch	9.3	4.9	62.1	23.7	3513

Table 4.4: Proximate Analysis of Non-coking Coal

Component	Proximate Analysis(Wt. %, air-dried basis)				Gross Calorific Value(Kcal/Kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Coal	9	39.6	22	27.34	4382

Table 4.5: Coal: Drumstick Biomass Different Component

Ratio(Coal:Biomass)	Proximate Analysis(Wt. %, air-dried basis)				Gross Calorific Value(Kcal /Kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Main Wood					
95:05	3	34	33	30	3301
90:10	6	35	31	28	3519
85:15	4	38	40	18	3811
80:20	7	34	43	16	4111
Leaf					
95:05	3	39	26	32	3412
90:10	7	37	27	29	3501
85:15	5	26	42	27	3017
80:20	6	35	31	28	3911
Nascent Branch					
95:05	2	37	35	26	3511
90:10	8	33	31	28	3498
85:15	3	27	42	28	3501
80:20	5	32	41	22	3905

Table 4.6: Coal: Arhar Biomass Different Component

Ratio(Coal:Biomass)	Proximate Analysis(Wt. %, air-dried basis)				Gross Calorific Value(Kcal /Kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Main Wood					
95:05	7	37	27	29	3211
90:10	5	34	31	30	3317
85:15	4	36	34	26	3714
80:20	6	35	33	26	4191
Leaf					
95:05	5	35	29	31	3410
90:10	6	38	31	25	3511
85:15	3	30	37	30	3012
80:20	6	31	33	30	3910
Nascent Branch					
95:05	5	40	33	22	3546
90:10	3	32	37	28	3489
85:15	9	31	41	19	3510
80:20	8	32	45	15	3911

Table 4.7: Coal:Gudhal Biomass Different Component

Ratio(Coal:Biomass)	Proximate Analysis(Wt. %, air-dried basis)				Gross Calorific Value(Kcal/Kg , Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Main Wood					
95:05	2	36	34	28	3111
90:10	5	35	33	27	2812
85:15	6	40	41	13	3510
80:20	7	36	43	14	3491
Leaf					
95:05	3	40	31	26	3280
90:10	4	38	32	26	3712
85:15	5	32	42	21	3010
80:20	4	33	35	28	4211
Nascent Branch					
95:05	2	40	32	26	3413
90:10	9	37	29	25	3101
85:15	4	32	42	22	3710
80:20	3	36	41	20	3701

Table 4.8: Total Energy Contents and Power Generation Structure from 11 Months old (approx.), Drumstick Plants

Component	Calorific Value(Kcal/t, Dry Basis)	Biomass Production (t/ha, Dry basis)	Energy Value(Kcal/ha)
Main Wood	$4103{\times}10^3$	22.10	$90676.3{\times}10^3$

Leaf	3781×10^3	6.91	26126.7×10^3
Nascent Branch	3801×10^3	11.10	42191.1×10^3

Energy Calculation:

On even dried basis, total energy from one hectare of land= $(90676.3+26126.7+42191.1) \times 10^3$

$= 158994.11 \times 10^3$ Kcal/ha

It is assumed that conversion efficiency of wood fueled thermal generators = 30 % and mechanical efficiency of the power plant = 85 %

Energy value of the total functional biomass obtained from one hectare of land at 30 % Conversion efficiency of thermal power plant = $158994.11 \times 10^3 \times 0.30$

$= 47698.23 \times 10^3$ kcal/ha

$= 47698.23 \times 10^3 \times 4.186$ kJ/ha

$= 199664.8 \times 10^3$ kJ/ha

$= (199664.8 \times 10^3)/3600$ kW-hr/ha

= 55462.44 kW-hr/ha

Power generation at 85 % mechanical efficiency

$= 55462.44 \times 0.85$

= 47143.1 kW-hr/ha

Land required to supply electricity for entire year

$= 73 \times 10^5 / 47143.1$

= 154.848 hectares

Table 4.9: Total Energy Contents and Power Generation Structure from 11 Months old (approx.), Arhar Plants

Component	Calorific Value(Kcal/t, Dry Basis)	Biomass Production (t/ha, Dry basis)	Energy Value(Kcal/ha)
Main Wood	4605×10^3	25	115125×10^3
Leaf	4180×10^3	8.12	33941.6×10^3
Nascent Branch	4218×10^3	12.13	51164.34×10^3

Energy Calculation:

On even dried basis, total energy from one hectare of land= $(115125+33941.6+51164.34) \times 10^3$

$= 200230.94 \times 10^3$ Kcal/ha

It is assumed that conversion efficiency of wood fueled thermal generators = 30 % and mechanical efficiency of the power plant = 85 %

Energy value of the total functional biomass obtained from one hectare of land at 30 % Conversion efficiency of thermal power plant = $200230.94 \times 10^3 \times 0.30$

$= 60069.28 \times 10^3$ kcal/ha

$= 60069.28 \times 10^3 \times 4.186$ kJ/ha

$= 251450.01 \times 10^3$ kJ/ha

$= (251450.01 \times 10^3)/3600$ kW-hr/ha

= 69847.22 kW-hr/ha

Power generation at 85 % mechanical efficiency

$= 69847.22 \times 0.85$

= 59370.14 kW-hr/ha

Land required to supply electricity for entire year

$= 73 \times 10^5 / 59370.14$

= 122.95 hectares

Table 4.10: Total Energy Contents and Power Generation Structure from 11 Months old (approx.), Gudhal Plants

Component	Calorific Value(Kcal/t, Dry Basis)	Biomass Production (t/ha, Dry basis)	Energy Value(Kcal/ha)
Main Wood	4234×10^3	19.12	80954.08×10^3
Leaf	4111×10^3	5.03	20678.33×10^3
Nascent Branch	3513×10^3	9.91	34813.83×10^3

Energy Calculation:

On even dried basis, total energy from one hectare of land= $(80954.08+20678.33+34813.83) \times 10^3$

$= 136446.24 \times 10^3$ Kcal/ha

It is assumed that conversion efficiency of wood fueled thermal generators = 30 % and mechanical efficiency of the power plant = 85 %

Energy value of the total functional biomass obtained from one hectare of land at 30 % Conversion efficiency of thermal power plant = $136446.24 \times 10^3 \times 0.30$

$= 40933.87 \times 10^3$ kcal/ha

$= 40933.87 \times 10^3 \times 4.186$ kJ/ha

$= 171349.19 \times 10^3$ kJ/ha

$= (171349.19 \times 10^3)/3600$ kW-hr/ha

= 47596.99 kW-hr/ha

Power generation at 85 % mechanical efficiency

$= 47596.99 \times 0.85$

= 40457.44 kW-hr/ha

Land required to supply electricity for entire year

$= 73 \times 10^5 / 40457.44$

= 180.436 hectares

5. CONCLUSION AND DISCUSSION

In the present work three non-woody biomass species MORINGA OLEIFERA (common name Drumstick), CAJANUS CAJAN (common name Arhar) and HIBISCUS (common name Gudhal) were selected. Experiments to determine the proximate analysis and calorific values were done on each of the components of the selected species such as leaf, main wood, and nascent branch were performed. The following are the different conclusions drawn from the present work:

1. All three plant species (Drumstick, Arhar, and Gudhal) showed almost the similar proximate analysis results for their components, the ash contents being more in their leaves and volatile matter content less in wood and leaf.

2. Mixed ratio of both biomass with coal (in four different ratios) also showed the same proximate analysis results, the ash contents being more when 95% coal mixing with 5% biomass and volatile matter is more when 80% coal mixing with 20% biomass.

3. Amongst the three biomass species, Arhar has the highest energy value compared to Drumstick and Gudhal.

4. Amongst the four different ratios, ratio 80:20 gives the highest energy value compared to 95:05, 90:10, 85:15.

5. Energy values of coal mixed Arhar biomass component was found to be a little bit higher than that of coal mixed Drumstick and Gudhal biomass component.

6. Calculation results have established that nearly 154.84, 122.95 and 180.436 hectares of land would be required for continuous generation of 47143.1 kWh per hectares from Drumstick, 59370.14 kWh per hectares from Arhar and 40457.44 kWh per hectares from Gudhal biomass species.

7. This study could be positive step in the exploitation of non-woody biomass species for power generation.

6. SCOPE FOR FUTURE WORK

1. The Similar type of study can be extended for another non-woody biomass species available in the local area.

2. Pilot plant study on laboratory scale may be carried out to generate electricity from biomass species.

3. The powdered samples of these biomass species may be mixed with cow dunk and the electricity generated potential of the resultant mixed briquettes may be studied.

4. New techniques of electricity generation from biomass species may be developed.

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