Comparative Study of Products of Pyrolysis of Cow Dung and Poultry Litter

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Abstract

In this work, comparative study of products of pyrolysis of cow dung and poultry waste was carried out and determined with a view to establishing their energy potentials.

A pyrolysis assembly that consists of brick furnace, condensate receiver, retort and gas collection unit was used. The moisture content of the residues and the weight of wood used for pyrolysis were determined. Sample of each residue was loaded into the retort and placed inside the furnace chamber for firing one at a time. The process of pyrolysis took 30 minutes. The products collected were each weighed and recorded. The pyrolytic gases collected were taken to laboratory for further analysis in order to establish the constituents of the gases.

The yields obtained for cow dung are 42.00 % for char, 35.66 % for the mixture of tar oil/pyroligneous acid and 17.34 % for pyrogas. The corresponding values for the poultry litter in the order listed above are 47.33 %, 28.33 % and 24.34 % respectively. For the cow dung, the pyrogas consists of 56.67 % methane (CH_4) and 54.33 % propane (C_3H_8), while for the poultry litter the pyrogas consists of 22.89 % by volume of methane (CH_4), 17.35 % of propane (C_3H_8), 35.22 % of ethyne (C_2H_2) and 24.54% by volume of ethane (C_2H_8).The higher heating values obtained for the chars of cow dung and poultry litter were 32.42 and 39.30 MJ/kg respectively.

The results of this work showed that the two animal residues examined would make a good biomass fuel and they lent them easily to process of pyrolysis. However, findings show that the poultry litter indicates more positive attributes of biomass fuel than its cow dung counterpart. The poultry litter produced four different pyrogases as against the two produced by cow dung. Also, the higher heating value of poultry litter seems higher than the cow dung.

Keywords: Char, cow dung, poultry waste, pyrogas, pyrolysis, tar oil

1. Introduction

Energy plays an important role in the development of any nation. Its demand, supply and pricing have a great impact on the social and economic development as well as the living standard and the overall quality of life of the entire populace (Livingstone, 2004). Nigeria's quest to be among the 20 richest nations by 2020 will be a mirage, if the issue of energy is not seriously addressed. Indiscriminate and inefficient burning of fuel wood being presently practised in the country had resulted in environmental pollution, desertification and health hazards to populace (Oladeji, 2012). The use of petroleum based products does not help matter due to disruption in their supply, incessant hike in prices and pollution of environment as a result of green house gas emission (Oladeji, 2010; Oladeji, 2011a). Therefore, there is the need to generate alternative form of energy in order to shift attention from fossil fuels and firewood, which are environmentally unfriendly.

One of the most important energy sources for mankind is biomass, which accounts for approximately 14% of energy consumption in the world (Kaygusaz and Turker, 2002). Animal and poultry wastes often discarded occur in large amounts and have the potential to be an important source of fuel for many people in rural areas (Oladeji, 2011b).

Although, it is possible to use these animals and poultry litter directly for domestic cooking, many of these wastes are loose and low-density materials, which make them difficult to burn in a controlled and effective manner (Musa, 2007).

In Nigeria, a large quantity of animal and poultry wastes is generated annually, but it is unfortunate that these wastes are badly managed. In most cases, these wastes are burnt or they are left to rot away (Jekayinfa and Scholz, 2009).

Most of these residues contain enormous amount of energy (Oladeji, 2011b). In Nigeria, especially in the northern part, large amount of cow dung is produced annually, while in the southern part of the country, poultry wastes are produced in large quantity. Unfortunately, as earlier mentioned, they are left to rot away or they are burnt like other agricultural wastes. This is a poor way of waste disposal, which in itself contributes to environmental pollution and constitutes a public nuisance; eye-sore and health hazards both to human and ecology (Oladeji, 2011a). However, these residues, if properly harnessed and managed will go a long way to alleviate some of the energy crises being experienced in the country.

The two residues examined in this work may be converted to products of higher-grade fuels and chemical preservatives through the process known as pyrolysis. Pyrolysis can be defined as the thermal breakdown of biomass in the absence of oxygen to produce solid fuel, condensable organic liquid and non-condensable gases

(Boateng, et al., 2007). Pyrolysis normally occurs under pressure and operating temperature above 450 degree Celsius (Bridgewater, 2002).

Some researchers on renewable energy had worked on pyrolysis of agro-residues. Examples of such residues studied are oil palm waste (Guo and Lua, 2001), maize cob (Bamigboye and Oniya, 2003; Ogunsola and Oladeji, 2009), cow dung (Oladeji, 2011b) among others. Process of pyrolysis is being made use of in the United States of America in handling municipal solid wastes with moisture content of between 30-70 % (Bamigboye and Oniya, 2003; Poultry Tech, 2008).

The aim of this work was to investigate the energy potentials of cow dung and poultry wastes commonly found in Nigeria and to characterize pyrolytic conversion of these wastes with a view to determining which of them give reasonable or better yields.

2. Materials and Methods

The cow dung and poultry litter utilized in this experiment were obtained at Fasola farms settlement, Oyo and Folawiyo farms, Ilora respectively. The two residues were sun-dried until they have stable moisture content and their weights were determined. The two residues were oven-dried at a temperature of 103 ± 2^0C and their moisture contents were determined one after the other in line with the procedure as highlighted in accordance with ASAES269.4 (2003).

A simple pyrolysis assembly was set up and developed to facilitate the process of pyrolytic conversion of these residues into biomass fuels (Plate 1 and Figure 1). The pyrolysis assembly is made of retort, which is made of steel, where the biomass residue was put. The retort was placed in the furnace for indirect firing of the biomass feedstock. The liquid products of pyrolysis were collected inside the condensate receiver. Another important unit of the pyrolysis chain is the gas collection unit, where the pyrogases were collected. Three (3 kg) of each sample was put inside the retort and placed in the brick furnace for direct burning using firewood of 1.5 kg closely packed around the retort. A little amount of kerosene was sprinkled over the firewood to initiate combustion.

A stop watch was employed to record the duration of the experiment. The retort became gradually red hot and the residue began to pyrolyze. The pyrolyzed products slowly went into the condensate receiver, which was surrounded by ice bath to cool the products entering the receiver. The pyrolytic gases were collected in the cylinder, which was attached to the condensate receiver. The whole process took 30 minutes. The products collected were each weighed and recorded. The pyrolytic gases collected were taken to laboratory for further chemical analysis in order to establish the constituents of the gases as well as percentage by volume of gases.

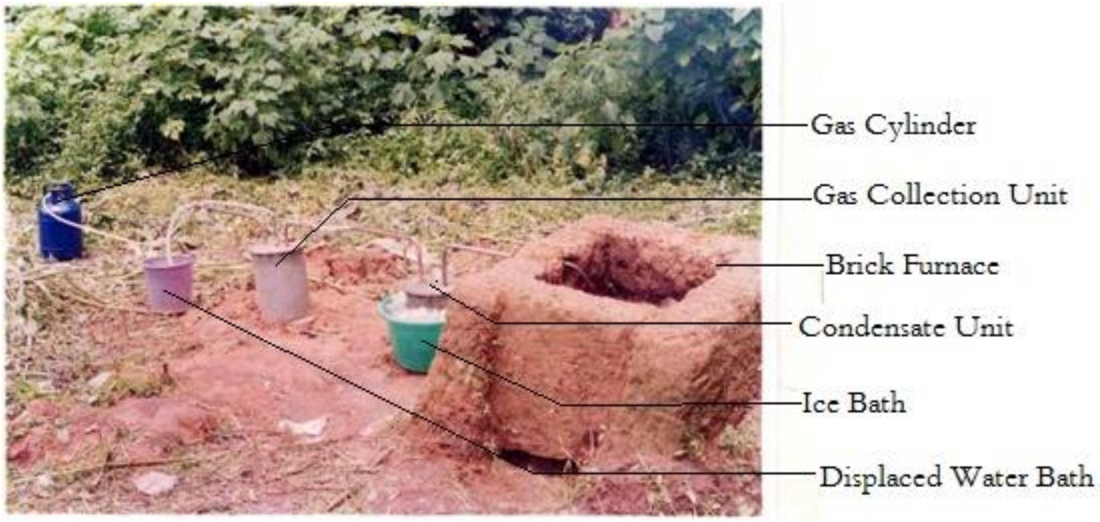

Plate 1. Pyrolysis Chain Assembly

Part No	Part Name	Materials	Quantity
11	Flange	Galvanised Steel	2
10	Retort	Mild Steel	1
9	Gas Cylinder	Galvanised Steel	1
8	Water Bath	Plastic	1
7	Valve	Brass	1
6	Pipe	Galvanised Steel	16
5	Bolt and Nut	Steel	60
4	Gas Collection Unit	Galvanised Steel	1
3	Ice Bath	Plastic	1
2	Condensate Receiver	Galvanised Steel	1
1	Furnace	Brick	1

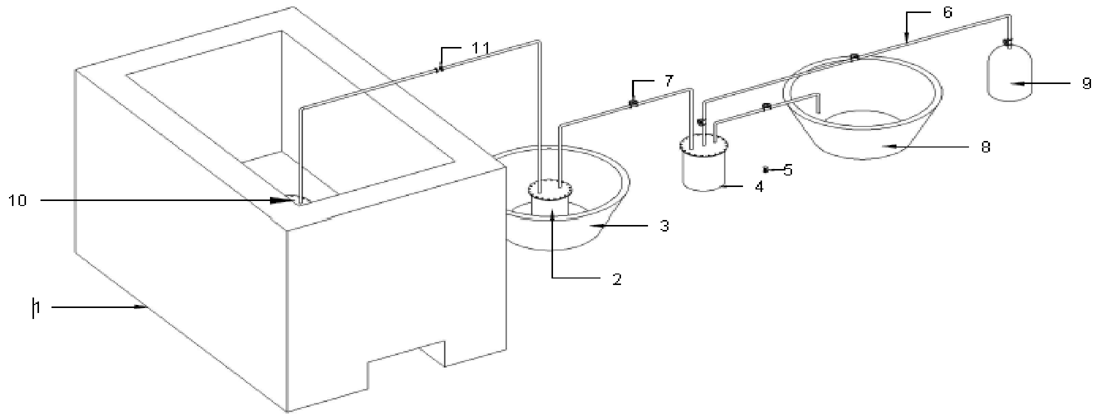

Figure 1. Isometric View of Pyrolysis Assembly

3. Results and Discussion

The results obtained for the pyrolysis trials are presented in Tables 1-4

Table 1. Compositions of products of pyrolysis of cow dung and Poultry waste

Parameter	Residue/Value	
	Cow dung	Poultry litter
Weight of oven dried of residue (kg)	3.0	3.00
Weight of firewood used (kg)	8.50	8.50
Weight of char obtained (kg)	1.26	1.42
Weight of mixture of oil and pyrolytic acid (kg)	1.07	0.85
Weight of gas (kg)	0.52	0.69
Conversion efficiency %	95.00	98.60
Higher heating Value (MJ/kg)	32.42	39.30

Table 2. Products of pyrolysis expressed as % of input feedstock

Product	Percentage Composition	
	Cow dung	Poultry litter
Char yield	44.21	47.33
Mixture of tar oil and pyrolytic acid	37.54	28.33
Pyrogas	18.25	24.34

Table 3. Constituents of pyrogas

Product	Percentage Composition (%)	
	Cow dung	Poultry litter
Carbon	74.78	65.24
Hydrogen	25.22	34.76

Table 4. Percentage composition by volume of gases

Gas	Chemical formula	Percentage Composition (%)	
		Cow dung	Poultry litter
Methane	CH_4	56.67	22.89
Propane	C_3H_8	54.33	17.35
Ethyne	C_2H_2	Nil	35.22
Ethane	C_2H_8	Nil	24.54

The pyrolysis of cow dung and poultry wastes yielded the following products: char, mixture of pyrolytic oil/pyroligneous acid and pyrolytic gas. The percentage char yield for cow dung and poultry litter were 44.21 and 47.3 respectively, while the corresponding values for the mixture of tar oil and pyroligneous acid are 37.54 and 28.33%. For pyrogas, cow dung yielded 18.25%, while the poultry litter yielded 24.34%. The constituents of pyrogas for cow dung are 74.78% carbon and 25.22% hydrogen, while for poultry waste; it was 65.24 % for carbon and 34.76% for hydrogen. Further chemical analysis revealed that the pyrogas of cow dung contained two different gases i.e 56.67 by volume of methane (CH_4) and 54.33% by volume of propane (C_3H_8), while for poultry litter the pyrogas is made of four gases, which are 22.89% by volume of methane (CH_4), 17.35% by volume of propane (C_3H_8), 35.22% by volume of ethyne (C_2H_2) and 24.54% by volume of ethane (C_2H_8). These results differ from the ones obtained by Oladeji (2011c) during pyrolysis of corn cob, rice husk and sawdust, where the char yields were 35.8, 30.56 and 17% of the total volume respectively. The results also deviate from the work of Fapetu (2000), where the char yields from pyrolysis of palm kernel, ekki wood and coconut shell gave values of 28.7%, 25.07% and 29.62% respectively. However, the results of composition by volume of gases obtained in this study show the similar pattern as the one obtained by Oladeji (2009) during the pyrolysis of sawdust, where the percentage of carbon and hydrogen were 74.69% and 25.31% respectively. The implication of this is that the products of pyrolysis and the percentage yields depend on the type of biomass residue used, its chemical constituents, quality and operating conditions.

The higher heating values of chars from cow dung and poultry waste are 32.42 and 39.30 MJ/kg respectively and these appears higher and better than the ones obtained by Oladeji (2011c), where values of 20.89, 15.3 and 17.1 MJ/kg were recorded for corncob, rice husk and sawdust respectively. The values are also higher than the ones obtained by Bamigboye and Oniya (2003) and Ogunsola and Oladeji (2009).

The char products obtained could be used for traditional and industrial cottage applications as in domestic cooking and as fuel in open earth furnace for blacksmithing and goldsmithing operations (Fapetu, 2000). The pyrolytic gas could be used as household cooking gas and as fuel for gas lamps (Bamigboye and Oniya, 2003); while the pyrolytic oil can be used as fuel in the internal combustion engines (Bridgewater 2002).

Conclusion

From the study, the following conclusions were drawn:-

- The two residues examined in this study lent themselves easily to process of pyrolysis.
- The products of pyrolysis and its percentage yields depend on the type of the biomass feedstock used, its quality, quantity and chemical constituents as well as operating conditions.
- The heating values obtained are sufficient enough for domestic and small industrial cottage applications.
- The conversion efficiencies for the two biomass residues examined in this study were higher.
- Of the two residues examined, the poultry waste has more positive attributes of pyrolysis than that of cow dung judging from the fact that four different types of gases can be obtained from the same quantity of residue as against the two for the cow dung. The higher heating value of the chars produced from poultry waste is also higher than that of cow dung. Furthermore, conversion efficiency of poultry waste is also higher than that of cow dung.

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