FAECAL SLUDGE BRIQUETTES: TURNING HUMAN WASTE INTO ENERGY

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INTRODUCTION

➢ Biomass is the main source of energy for many households in Kenya, and a major energy source for the country as a whole.

➢ In 2013, 72% of the country's total primary energy supply came from bioenergy and waste.

➢ A large share of the biomass used is in the form of charcoal, which provides 82% of household energy in urban areas, and 34% in rural areas.

➢ According to McKendry (2002), biomass fuels continue representing the primary source of energy for more than 50% of the world population and amount to about 14% of the total energy global consumption.

Introduction Continued

➢ In developing countries demand for energy continuously increases due to the increasing population growth rate.

➢ Additionally, atmospheric pollution rate has increased due to the emission of greenhouse gases by larger consumption of fossil fuel by the industrial, commercial and agricultural sectors.

➢ The direct combustion of fossil fuels releases a great amount of CO_2, SO_x, and NO_x into the atmosphere

➢ With increasing wood heat demand, alternative sustainable sources are being explored to meet energy needs.

➢ For instance, faecal sludge is being converted to charcoal for use at household level.

How is the product performing?

Insight

To gain insights into the variability of the **physical quality** among faecal sludge fuel products, **the chemical composition of samples prepared from faecal sludge** from **Naivasha-Kenya** were **analyzed for energy and chemical properties**

proximate

separated bio-briquette into four important properties (**moisture**, volatile matter, **fixed carbon** and **ash content**).

The bio briquettes were compared to conventional charcoal bought from the local market.

Production system

- biomass comes as a natural source due to its ecofriendly nature and higher hydrocarbon contents meaning that biomass can be used to produce eco-friendly and energy efficient fuels.

- biomass decomposition is a function of firing temperature.

PATHWAYS FOR INCREASING PERFORMANCE

SUPPORT SYSTEM

- biomass decompositions starts at temperature range of 250-300° C and

- volatile release at a temperature range of between 300-350° C while

- complete combustion of biomass is carried out at a temperature range of 500-600° C.

- thermal pre-treatment or torrefaction of biomass under anoxic condition can produce an energy dense and consistent quality solid biomass fuel for combustion and co-firing applications.

ENERGY SYSTEM

- There was need to look at characteristics of emerging and innovative alternative sustainable energy sources since complete study on the characterization of biomass (**faecal sludge made briquettes) for the kinetic analysis is less reported.**

- **However, these fuels can be used when converted under controlled thermal treatment**.

Table 1 presents the energy density for a variety of common fuels as modified from Malla and Timilsina (2014) and includes findings for briquettes from this study.
Table 1: The energy density (MJ/kg) of a variety of different fuels

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Serial no	Fuel Type	Reaction Type	Energy Density (MJ/kg)	Typical uses
1	Briquettes	Chemical	19	Cooking
2	Wood	Chemical	16	Space heating, Cooking
3	Coal	Chemical	24	Power plants, Electricity generation
4	Ethanol	Chemical	26.8	Gasoline mixture, Alcohol, Chemical products
5	Biodiesel	Chemical	38 [8]	automotive engine
6	Crude oil	Chemical	44	Refinery, Petroleum products
7	Diesel	Chemical	45	Diesel engines
8	Gasoline	Chemical	46	Gasoline engines

Proximate and ultimate analyses of fuels are necessary for their efficient and clean utilization while the HHV of fuels determine the quantitative energy content of fuels.

Determination of calorific value of briquette samples
The low heating value (LHV) and high heating value (HHV) were calculated using the modified Dulongs Equation 1 (Bank, 2009).
HHV (KJ/Kg) = 337 C + 1419 $(H_2-O_2/8)$ + 9S   (1)

The calorific values were again calculated by using the Dulong Equation, considering Nitrogen in the formula as shown in Equation 2.
HHV (KJ/Kg) = 337 C +1419 $(H_2 - O.125O_2)$ + 93 S + 23 N   (2)

In these equations, C, H, O, S and N are percentages (%) of carbon, hydrogen, oxygen Sulphur, and nitrogen obtained from ultimate analysis of the biomass, respectively. LHV (KJ/Kg) is the net energy released on combustion.
          LHV = HHV – (2,766 x W)   (3)

Where, W = moisture content, 2.766Kg/g = coefficient of heat requirement for evaporation (Enthalpy of vaporization) (Bank, 2009).

Results and Discussion

Physicochemical parameters of briquettes

The characteristics of briquette sample from the analysis is summarized in Table 2. The briquette made from faecal sludge contained C, H, N, S, and O as 45.00%, 7.09%, 2.50%, 0.29%, and 45.12%, respectively. The sample was shown to contain 70% volatile matter, 20.4% fixed carbon and 8.9% alkali.

| Properties		Briquettes	Charcoal
Net calorific value (MJ/Kg)		19.00	18.2-21.4
Ultimate analysis (wt %)	Carbon	45.00	45-50
	Hydrogen	7.09	6-6.5
	Nitrogen	2.50	0.1-0.5
	Sulphur	0.29	Max 0.05
	Oxygen (by difference)	45.12	30.6
Proximate analysis (%) (Dry mass basis)	Moisture (%)	0.70	17.1
	Volatile matter (%)	70.00	80.9
	Fixed carbon (%)	20.40	26.00
	Ash (%)	8.90	2.0

Discussion con't

➢ Faecal sludge characteristics are site specific and need to be determined on case-by-case basis. Same observation was reported by Niwagaba et al. (2014)

➢ The lower nitrogen (< 2.50%) and sulfur content (< 0.29%) in the sample indicated that there is a lower risk of emission of toxic gases (NO_x, SO_x) from its pyrolysis.

➢ Also observed was the low nitrogen fraction in the briquettes.

➢ **Ash content was high at 8.9% (Briquettes) compared to 2.0% (wood).**

➢ **Ashes are usually formed of SiO_2, Fe_2O_3, P_2O_5, CaO, K_2O, Na_2O, MgO, SO_3 and Cl.**

➢ **Therefore, the ash content of any faecal sludge affects its slagging behavior together with the operating temperature and mineral composition.**

Calorific value

➢ The HHV indicates the amount of energy available from the biomass upon combustion.

➢ Range was between 18.79 and 19.43 MJ kg−1 (average 19.00 KJ/Kg) which is reasonably higher than the HHVs of several well-known energy sources.

➢ The estimated HHV indicate the remarkable energy potential of the briquettes when compared to recognized energy of other bio-wastes.

FTIR spectra analysis

➢ FTIR analysis of briquette and charcoal's, chemical compounds and functional groups identified from the FTIR analyzer and summarized in Table.

➢ The major identification of the chemical compounds is summarized in Table 3. These chemical groups were commonly found in all the samples of briquettes and charcoal.

➢ But intensities of chemical groups were found to be varied from each sample.

➢ The presence of chemical groups influences the calorific value, binding properties and ash content of various biomass materials

normal charcoal
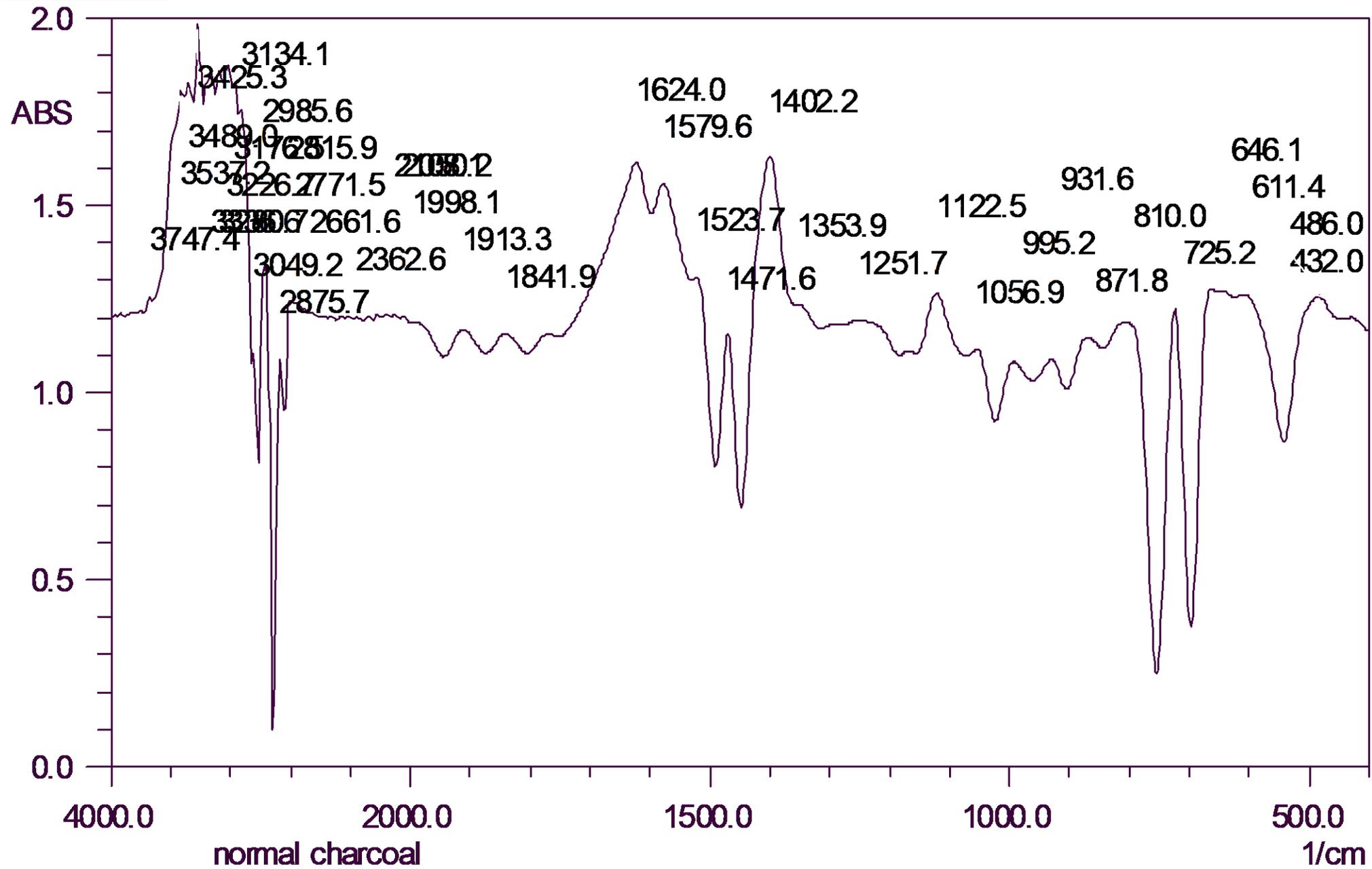
Table 3: Summary of identified major compounds

Species	Identified band	Wavelength range	Functional groups	vibrations
C=C	3049.2	3010-3100	alkene	stretch
C-H	2977.9	2850-3000	alkane	stretch
C=C	1471.6 & 1519.8	1400-1600	alkene	stretch
C-N	1251.7	1080-1360	nitrile	stretch
Fingerprint region				
=C-H	815.8 & 725.2	675-1000	alkene	bending
C-O	1122.5-1056.9	1050-1150	monoxide	stretch

OBSERVATION

➢Briquettes is produced with faeces sludge pyrolized at a HHT of 300°C and therefore, meets the minimum HHV defined by the Food and Agriculture Organization (FAO). In the long run, these briquettes could substitute wood-based charcoal as a cooking fuel.

➢The briquettes had a HHV similar to commercially available charcoal since its volatile matter was 70%; calorific value 19.00 KJ/Kg and ash content of 8.9%, they can be used just like charcoal.

Adequate, Affordable, Reliable, farm input

Affordable, Reliable, Raw materials

By products and waste used to make briquettes

Increased yields of staple food for livelihoods

Enhanced household, region and national energy, and income securities

THANK YOU

TOGETHER WE CAN REDUCE ON THE USE OF WOOD FUEL