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Comparative Conversion of Biomass Energy from Suck-away pits and Cow Dung into Alternative Sources of Energy at University of Cross River State, Calabar

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ABSTRACT
A comparative study of biomass energy from cow dung and human feces into alternative source of energy was investigated. The energy potential stored in them was determined experimentally. The biomass maetrial used were human feces and cow dung. Other materials were coffee can, thermometer, stop watcch, and heat source. The biomass souces were burned by a controlled method to obtain the energy generated by each of the sources. Simple heat equation was used to obtained the heat potential in each biomass material. The results show that there is more potential for using human feces for energy generation than cow dung.
Key words: Biomass, energy, human feces, cow dung, heat.

I. INTRODUCTION

The increasing global focus on sustainability and environmental conservation has spurred innovative initiatives across various sectors. One such groundbreaking endeavor is underway at the University of Cross River State Boys Hostel in Calabar, where an ambitious project seeks to convert human feces from pit toilets and Cow Dungs into alternative sources of energy. This initiative not only addresses the pressing issue of traditional waste disposal methods but also aligns with the broader global commitment to harness renewable energy resources. (Fergusen, 2006).

As the world grapples with the challenges of climate change and depletion of traditional energy sources, the need for sustainable practices has become paramount. This research delves into the details of this transformative project, shedding light on its aims, objectives, methodologies, and expected outcomes.

By undertaking this venture, the university aims to set a precedent for responsible waste management and renewable energy production. The initiative not only tackles the environmental repercussions of traditional pit toilet waste disposal and Cow Dung, but also contributes to the larger discourse on sustainable practices in academic institutions. As we navigate the complexities of the 21st century, innovative projects like these serve as beacons of hope, demonstrating that universities can be pioneers in adopting eco-friendly technologies for the betterment of the environment and society at large. The primary aim of this project is to harness the potential of human waste and cow dung as a renewable heat energy resource. Develop a comprehensive understanding of the composition of human feces in the suck-away pit and Cow Dung. Explore and implement cutting-edge technologies for the conversion of human waste and Cow Dung into Heat energy.Evaluate the feasibility and sustainability of the energy conversion process using the relevant heat equation.

The literature surrounding waste-to-energy conversion has witnessed substantial growth in recent years, offering valuable insights into diverse methods and technologies. As the University of Cross River State Boys Hostel embarks on the journey to convert human feces from pit toilets and Cow Dung into alternative energy sources, it is essential to draw upon existing research to inform and optimize the project's approach. (Sujata, 2010).

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Anaerobic digestion stands out as a well-established and widely adopted technology for organic waste conversion. Microbial decomposition of organic matter in the absence of oxygen produces biogas, predominantly methane, which can be utilized as a clean and efficient energy source. Studies (e.g., Zhang et al., 2020) have demonstrated the efficacy of anaerobic digestion in treating sewage sludge and organic waste, presenting an attractive option for the transformation of pit toilet waste.

Microbial fuel cells present an innovative approach, leveraging microbial activity to generate electricity from organic substrates. Research by Liu et al. (2019) showcases the potential of MFCs in converting organic matter into electrical energy, offering an environmentally friendly solution for waste treatment. The adaptability of MFCs to various organic sources makes them a promising technology for the conversion of human feces into a sustainable energy resource.

Gasification is another emerging technology that holds promise in the realm of waste-to-energy conversion. This process involves the thermal decomposition of organic materials to produce syngas, which can be utilized for power generation. Research by Li et al. (2021) highlights the efficiency of gasification in converting diverse organic waste materials, suggesting its potential application in treating pit toilet waste.

Several studies emphasize the environmental and health implications associated with traditional pit toilet waste disposal methods. Improper handling and disposal can lead to water contamination, soil degradation, and the spread of diseases. By examining the works of scholars such as Alemayehu et al. (2018), the project gains a comprehensive understanding of the urgency and importance of transitioning towards sustainable waste management practices.

Ushie et al., (2016) conducted a research on Comparative analysis of energy potentials from different biomass sources were investigated to determine the energy potential stored in them: biomass materials used were cattle manure, wood and dry grass. Instruments used for this investigation includes: coffee can, thermometer, stop watch, heat source etc. simple heat equation was used to evaluate the heat potential in each material. Results shows that heat energy of cattle manure was 0.33264788J, wood was 0.1661868J and that of dry grass was 0.1001J. showing that cattle manure has higher energy potential than wood and grass, meaning it will have more application for energy generation.

Rectilinear flow of Heat Through Dry Cubic Cow Dung

Let us consider a long cubic bar heated at one end and let us consider the flow of heat along x-axis. Again, let us consider two parallel planes pendicular to x-axis and at a distance x and x+ dx from the hot end. Let ϴ be the excess temperature at the plane x and $\frac{dx}{d\theta}$ be the temperature gradient. (Rate of change at the plane x + dx will be $\left(\theta + \frac{dx}{d\theta} * dx\right)$ and the temperature gradient will be $\frac{d}{dx}\left(\theta + \frac{dx}{d\theta} * \delta x\right)$.

Let Q_1 be the quantity of heat that enter the plane at x and Q_2 be the quantity that leave the plane at (x + dx)/sec respectively.

We have $\theta_1 = -KA.\frac{d\theta}{dx}$ (1)

where K is coefficient of thermal conductivity and A the area of cross-section of the cubic cow dung

$$\theta_2 = -KA.\frac{d}{dx}\left(\theta + \frac{d\theta}{dx} * \delta x\right) = -KA.\left[\frac{d\theta}{dx} + \frac{d^2\theta}{dx^2} * \delta x\right] \quad (2)$$

So the net amount of heat gained per second by the element of thickness dx, Sandwitched between the two planes will be

$$\theta_1 - Q_2 = -KA.\frac{d\theta}{dx} - \left[-KA\left(\frac{d\theta}{dx} + \frac{d^2\theta}{dx^2} * \delta x\right)\right] = -KA\frac{d^2\theta}{dx^2} * \delta x \quad (3)$$

Before we get the steady state, this heat will be partly used in raising the temperature of the element of the cow dung and partly it will be radiated

If $\frac{d\theta}{dx}$ is the change of temperature per unit time, r the density of the material, s the specific heat of the material, then the quantity of heat required to raised the temperature of the element per unit time will be

$$. = A.\delta.s.\frac{d\theta}{dx} \quad (4)$$

If p is the perimeter of the element, the surface area of the element = p. dx. Let E be the emissivity or the radiative power of the surface and θ the average excess temperature of the element, then the amount of heat radiated by the element/sec

$$' = E.p\delta x\Theta \qquad (5)$$

Hence, from equation (3) , (4) and (5) we have

$$KA\frac{d^2\Theta}{dx^2}.\delta x = A.\delta x.\rho.s.\frac{d\Theta}{dx} + E.p.\delta x.\Theta$$ or

$$\frac{d^2\Theta}{dx^2} = \rho\frac{s}{K}\frac{d\Theta}{dt} + \frac{E_p}{KA}\theta \qquad (6)$$

This is the standard equation for the flow of heat in one direction, and this equation can be solved by taking into consideration the actual conditions of the problem

(i). Let the amount of heat lost by radiation be negligibly small i.e., equation (6) may be written as

$$\frac{d^2\Theta}{dx^2} = \rho\frac{s}{K}\frac{d\Theta}{dt} \text{ or } \frac{d\Theta}{dx} = \rho\frac{s}{K}\frac{d^2\theta}{dx^2} = h.\frac{d^2\Theta}{dx^2} \qquad (7)$$

where h is diffussivity and it determines the rate at which temperature changes.

(ii). At the steady state, no amount of heat is taken up by any part of the cubic cow dung,

i.e $\frac{d\Theta}{dt} = 0$ that is (6) may be written as:

$$\frac{d^2\Theta}{dx^2} = \frac{E_p}{KA}.\theta = \mu^2.\theta \qquad (8)$$

where $\mu^2 = \frac{E_p}{KA}$

Now equation (8) is a differential equation of second order, so its general solution may be written as: $\theta = Ae^{ux} + Be^{-ux}$ (9)

where A and B are constants and their values can be from the initial and final conditions. Since the relationships have the exponential form, so in order to have a viable solution we may take a very long cube of cow dung so that other end of the bar may approximately be taken at the room temperature.

Then x=0, x= Θ_0 ; x=∞ , Θ=0, and when substitudes (9)

Θ_0=A + B ; 0=Ae^{∞} ; e^{∞}≠0, so A=0, therefore B=0 and $\theta = \theta_0 e^{-\mu x}$ (10)

Equation (10) gives a general relationship for the excess of temperature at any point at a distance x from the cubic cow dung and end after the steady state is reached. Equation (10) is an exponential function of the distance x but independent of time.

(iii). If the cubic cow dung is covered, so that amount of heat lost due to radiation is negligible, emmision E=0 and hence $\mu^2 = 0$, relationship becomes

$$\frac{d^2\Theta}{dt^2} = 0$$

Integrating twice;

$$q = A'x + B' \qquad (11)$$

A/ and B/ are constants and their values can be found from the initial and final coordination, where x=0, Θ= Θ_0=B/

where x=l, Θ= Θ_1 , equation (11) may be written as

$$\theta_1 = A'l + B'$$

$$\theta_1 = \theta_0 = \frac{\theta-\theta_1}{l}.x \qquad (12)$$

equation (12) gives the excess of temperature at any point x along the cubic cow dung being covered so that amount of heat lost by radiation is zero.

Source : Fergusen & Mah, 2006.

Specific Heat

The rise in temperature of a body is proportional to the quantity of heat supplied to the body, the mass of the body and the nature of the substance of the body. We can in general write that:

$$H = MC_p\Delta\Theta \qquad (13)$$

Where: H = Quantity of Heat (J), M = Mass of the Material (Kg), ΔΘ = Change in temperature (^{0}C), and C = Constant (specific heat capacity of the material) (jkg^{-i}. $^0C^{-1}$)

Source : Garg, 2009

II. MATERIALS AND METHOLOGY

The materials used in the research include: coffee can, large paper clip, thermometer (Celsius), stop watch, 250ml conical flask, water(200ml), matches, wire, 2 test tube clamps, gram scale, biomass sources such as; human feces, and cow dung.

Fig.1: Full Front View of Experimental Set-up

Method: Amounts of human feces and cow dung was weighed using gram scale. The temperature of the water is measured using thermometer before the experiment was conducted. The reading of the thermometer at every 20 seconds was taken. This was done till the biomass samples burnt to finish. The coffee can was emptied and the process repeated for the next biomass sample.

Data Analysis: The data that is obtained from the study of the different biomass sample (human feces, and cow dung). The heat energies (energy potentials) and specific heat capacities of the biomass samples varies as well.

The heat energy equation:

$$H = MC_p \Delta \Theta \qquad (14)$$

is used to calculate the heat energy contained in the biomass sample(s).

III. RESULTS AND DISCUSSIONS

The data used for the analysis was gotten from the experimental work (practical) as seen in the set-up Fig.1. The mass of the biomass materials i.e human feces and cow dung is scaled to be 0.29kg respectively. While the temperature of the water before heating read 29^{o}C.

Table. 1: Data of Biomass Samples

Temperature symbol	Temperature of Human feces	Temperature of Cow dung
T_1 (^{o}C)	36	33
T_2 (^{o}C)	39	34
T_3 (^{o}C)	43	35
T_4 (^{o}C)	46	36
T_5 (^{o}C)	49	38
T_6 (^{o}C)	53	39

T_7 (°C)	55	40
T_8 (°C)	56	40
T_9 (°C)	59	42
T_{10} (°C)	60	43
T_{11} (°C)	63	43
T_{12} (°C)	64	43.5
T_{13} (°C)	65	43.5
T_{14} (°C)	65	44
T_{15} (°C)	66	44
T_{16} (°C)	66	44.5
T_{17} (°C)	67	44.5
T_{18} (°C)	67	45
T_{19} (°C)	68	45
T_{20} (°C)	68	45
T_{Total} (°C)	1155	822
ΔT (°C)	32	12
Heat Energy(J)	32.20	6.933

Human feces: The speccific heat capacity (C_p) of human feces 3.47 $Jkg^{-1o}C^{-1}$. (Xiaojiang, 2022)
Table 1 shows the experimental data of biomass samples(human feces and cow dung) and their masses, tempertures at different state, and heat energy. The heat energy is computed using equation (14).

$$H = MC_p\Delta\theta\left[(kg)\left(JKg^{-1^0}C^{-1}\right)(.^0 C)\right] \quad (14)$$

$$H = 0.29x3.47x32 = 32.20(J)$$

$$H = 0.29x3.47x32 = 32.20(J) \quad (15)$$

Cow Dung: The speccific heat capacity (C_p) of dry cow dung is 1.9925$Jkg^{-1o}C^{-1}$. (Ushie, et al., 2016).

$$H = 0.29x1.9925x12 = 6.933(J) \quad (16)$$

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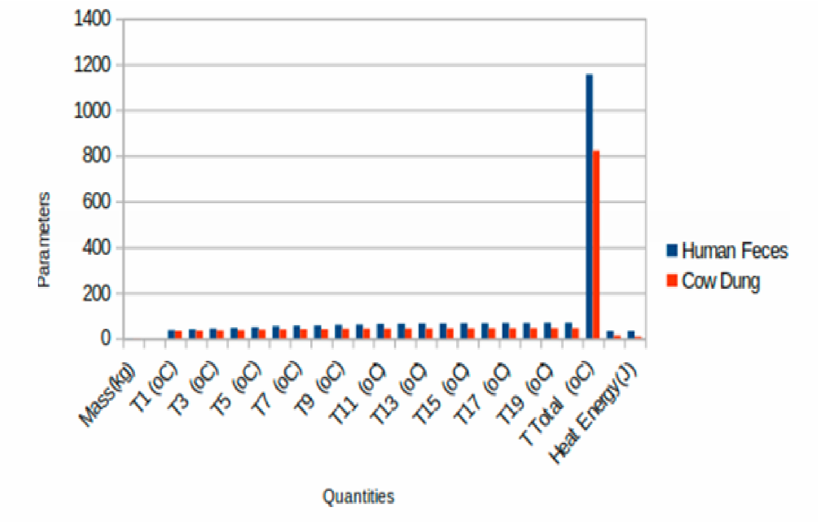

Fig. 2 Biomass parameters againt Biomas quantities

Fig. 2 shows human feces and cow dung temperature variation of 32.2⁰C and 12⁰C respectively. Human feces has higher temperature change even when both samples are subjected to thesame experiment and at thesame mass 0.29kg. This is an indication that human feces has more vital potential for harnessing energy. The computed heat energy as shown in Fig. 2 for both samples human feces (32.2J) is higher than that of cow dung (6.933J). This is intandem with the temperature variation, which further revealed that human feces has more energy potential application for technology advancement. The results agreed with ushie et al., 2016 were he studied dry grass, cattle manure and wood heat energy potential and cattle manure heard more heat energy in his study.

IV. CONCLUSION

Temperature variations of of human feces and cow dung evaluated as 32.2⁰C and 12⁰C, respectively. This suggests that there is more vital potential for using human waste to generate electricity. Human feces had a computed heat energy of 32.2J, which is higher than cow dung's (6.933J). This is coupled with the temperature variation, which further demonstrated the greater energy potential that human waste holds for the development of technology. The heat energyharnessed can be converted to electrical energy and to othersforms of energy. This follows the law of conservation of energy which state thus "energy can neither be destroyed norbe created both can be transferred from one form to another.

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