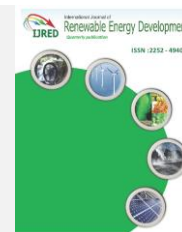




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A Novel Design of Multi-Chambered Biomass Battery

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ABSTRACT: In this paper, a novel design of biomass battery has been introduced for providing electricity to meet the lighting requirements of rural household using biomass. A biomass battery is designed, developed and tested using cow dung as the raw material. This is done via anaerobic digestion of the cow dung, and power generation driven by the ions produced henceforth. The voltage and power output is estimated for the proposed system. It is for the first time that such a high voltage is obtained from cow dung fed biomass battery. The output characteristics of this novel battery design have also been compared with the previously designed battery.

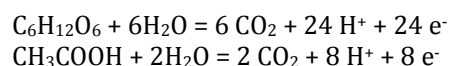
Keywords: anaerobic-digestion, biomass battery, cow dung fed biomass battery, energy storage, renewable energy

1. Introduction

Increasing energy needs and depleting fossil fuel sources resulted in the quest for new energy sources. This has raised a great interest in Biomass sources as a possible candidate for long-term, sustainable, energy generation. Bio-energy is now accepted as having the potential to provide a major part of the projected renewable energy provisions of the future (Schuck 2006; Kaygusuz 2009). It has been reported that organic waste can be a major sources of renewable energy (Mano *et al.* 2003; Liu *et al.* 2004; Shukla *et al.* 2004; Rabaey & Verstraete 2005; Lovely 2006; Logan & Regan 2006). Aquatic weeds have also been used as biomass for the production of energy (Sudhakar *et al.* 2013). In this direction, microbial fuel cells technology for bioelectricity generation is being studied extensively (Rabaey *et al.* 2003; Jang *et al.* 2004; Min & Logan 2004; Liu *et al.* 2005). Microbial fuel cells (MFCs) are devices that can use bacterial metabolism to produce an electrical current from wide range organic substrates (Dalvi *et al.* 2011). It results from the conversion of chemical energy into electrical energy. The bioelectrical current is a flow of ions (atoms or molecules carrying an electric charge), while standard electricity is a

movement of electrons. Bioelectricity can be generated when we use two electrodes with different potential immersed in a biomass substrate.

Reactions taking place in the biodegradation of a biomass is:



Cow dung has the potential to serve as a means to generate electricity in many remote villages. Cow excreta have been identified as viable source of energy with additional quality that greenhouse emissions are reduced significantly.

The provision of electricity in our remote villages in India continues to be a pipe dream. Census-2001 data reveal that only about 43.5 per cent rural households have electricity connections. Several villagers are still facing a major problem of darkness after dusk in this 21st century. Since the cow dung is available in plethora, biomass batteries can be used a power source for lighting. The ultimate aim is to illuminate rural houses using alternative source of energy without using chemical batteries. The biomass battery performs dual roles of storing energy and producing electricity and it-

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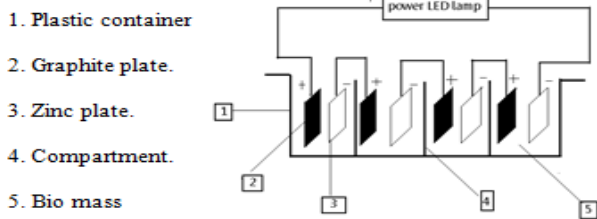


Fig. 1 Biomass battery arrangement

follows the principle of a chemical fuel cell. Biomass battery uses zinc plate and graphite electrodes to convert substrate into electricity through biological process. The Biomass battery setup is shown in Fig. 1. Due to the anaerobic decompositions, voltage difference is obtained at the two terminals. This voltage output can be used to power LED lamp for lighting after dusk. Graphite plate acts as anode positive pole and Zinc plate as cathode of battery. The aim of present study was to investigate the possibility of sustainable power generation which can be relied on.

2. Experimental

2.1 Design

A plastic container having six chambers has been used. Every section comprises of a small grid. These six grids are placed in series. Each grid comprises of seven pair of electrodes placed in parallel as shown in Fig. 2. In every grid the graphite anode and zinc cathodes are placed in parallel. This parallel combination is used to strengthen the voltage output of a single grid and to increase the current of the whole setup. Whole setup of

parallel grids is screwed to the container lid. This enables easy filling and emptying of the container. The connecting wires are connected to two output ports present at the outside of this lid. Output voltage can be obtained from these output ports. Space has been provided between the grids and bottom surface of the battery which allows uniform spreading of the biomass substrate.

Table 1 Specifications

Substrates	Cow Dung, Water Hyacinth
Anode and cathode material	Graphite plate & zinc plate
Surface area of each plate of electrodes	35 (sq. cm)
Total surface area of zinc plate	3360 cm ²
Feeding nature (L/cycle) Batch	0.75

2.2 Analytical Methods

Cow dung was obtained from the nearby village in MANIT district. Cow dung was mixed with water in the ratio 1:4, which was then used as the biomass substrate. 0.75 L of cow dung mixture was fed to the biomass battery. It was assured that substrate spreads evenly.

2.3 Life Cycle Cost Analysis

Current (I), potential (V) and internal resistance (R) measurements were recorded using digital multi-meter (Metravi 901). Power (W) was calculated using the equation $P=IV$, where I is in amperes and V is in mV. Power density (W/m^2) was calculated by dividing the obtained power with the surface area (sq.m) of the battery. The biomass battery was continuously monitored during experiment and readings were taken for 28 days, inoculation time was considered as day 0. The output voltage, current, internal resistance, power density and are compared for different substrates.

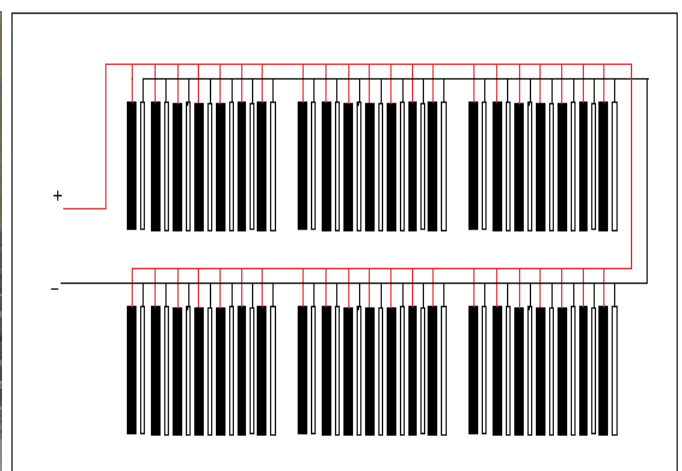


Fig. 2 Grid structure of biomass battery

3. Result and Discussion

The current was produced instantaneously and there was no delay. Fig. 3 shows the output voltage of the biomass battery for the first day.



Fig.3. Output voltage display

The output voltage obtained was stable throughout the span of 28 days. It fluctuated from a maximum of 3.80V to a minimum 3V recorded on the 28th day. On the 17th day maximum voltage of 3.80V was recorded and maximum power density of 0.253W/m² was recorded on 2nd day. The output voltage gradually increased till the 17th day and then continuous decrease was obtained as shown in Fig. 4. The output power density also showed a similar response with an increase in the initial days and then a decrease in the later period of observation (Fig. 5). The major feature of the technology is the continuous power is obtained up to 28 days till the slurry undergoes complete digestion. The output voltage is continuously above 3V throughout the tenure of observation. An average voltage of 3.41V can be obtained from this battery. With this output LED lamps (3 volt) can be illuminated for about 28 days or more without changing the substrate (Fig. 6.). A group of LED lamps can be used for lighting in villages after the dusk. Experimental data showed the feasibility of electricity generation from cow dung using this novel approach.

The cost economics of Biomass battery is listed in Table 2. The production cost of a biomass battery primarily consists of the cost of its raw materials, cost of which very much within economical range. A six compartment plastic container can be procured from any hardware store and costs Rs. 55. Scrap graphite blocks were bought from HEG, Mandideep; a company that manufactures electrodes. The cost of per kilogram is Rs.27 and the total requirement was of 4 kg (based on the density). Thus, total cost of scrap graphite blocks was Rs.108. Zinc plates were bought from a scientific instruments store and the cost per kg was Rs.305. Total

requirement of Zinc plates was of 1 kg. The manufacturing costs include the cost of cutting (e.g. labor charges) graphite blocks and zinc plates and amounted to Rs.50. The production cost of a biomass battery is the sum of these raw material cost and manufacturing cost which amounted to Rs.518.

A biomass battery has numerous advantages over conventional batteries. Its cost of production is low because of inexpensive raw materials and negligible manufacturing costs. It renders the surroundings clean and is itself eco-friendly in operation. It is easy to handle, is portable and there is no need to replace the cow dung every day. It can continuously generate power without the need of an external source of power.

It has a relatively longer life compared to other similar batteries. It has practical applications in rural areas for LED lighting and in remote areas.

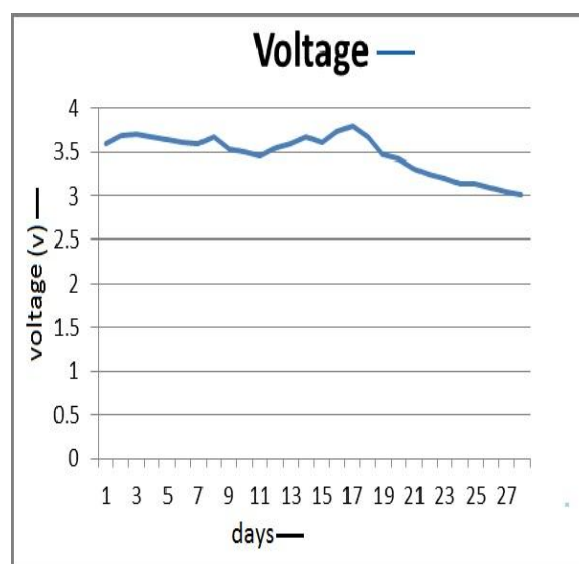


Fig. 4 Output voltage vs day

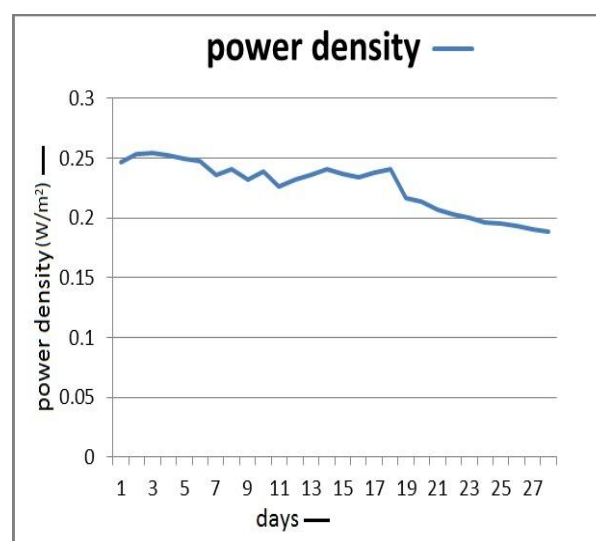


Fig. 5 Power density vs day



Fig. 6 Biomass battery powering a light source

Table 2

Cost Calculation

S. No	Description	Rate	Quantity	Amount
1.	Plastic container with six compartment	Rs 55 each	1	55
2.	Scrap Graphite blocks (7cm x 7cm x 7.5cm)	Rs 27/kg	4 kg	108
3.	Zinc plate (7cm x 5cm)	Rs 305/kg	1kg	305
4.	Miscellaneous			50
Total:		Rs.518		

4. Conclusion

Under present investigation, electricity was successfully generated with cow dung as raw material using Biomass battery technology. The biomass battery fuel cell technology is cost-effective and environmentally sound and sustainable solution for rural villages. The maximum possible power density obtained is 0.25 W/m^2 . The maximum possible voltage obtained is 3.8 V. The Biomass fuel cell technology is still in an early stage of development, but shows great promise as a new method to accomplish both energy

storage and electricity generation. Biomass battery technology may provide a new method to generate electricity for rural household, making the technology more affordable for rural electrification.

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