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Studies on the Feasibility of Cow Dung as a Non-Conventional Energy Source

Raj Kumar Rajak, Bharat Mishra

Abstract**—**Bio-batteries represent an entirely new long-term, reasonable, reachable and ecofriendly approach to produce sustainable energy. In the present experimental work, we have studied the effect of generation of power by bio-battery using different electrode pairs. The tests show that it is possible to generate electricity using cow dung as an electrolyte. C-Mg electrode pair shows maximum voltage and SCC (Short Circuit Current) while C-Zn electrode pair shows less OCV (Open Circuit Voltage) and SCC. We have chosen C-Zn electrodes because Mg electrodes are not economical. By the studies of different electrodes and cow dung, it is found that C-Zn electrode battery is more suitable. This result shows that the bio-batteries have the potency to full fill the need of electricity demand for lower energy equipment.

Keywords**—**Bio-batteries, electricity, cow dung, electrodes, non-conventional.

I. Introduction

TODAY the world is a serious problem which is energy crisis. Traditional sources like coal and oil are getting reduced in the past few decades. Scientists around the world are engaged in developing new sources of energy from non-conventional energy sources [1], [2]. There are many disadvantages of traditional sources; such as, lack of fossil fuel sources, global warming, energy supply safety and risk [3]. Developing a new method is essential for generating electricity from renewable resources without emitting carbon dioxide [1]. It is a primary need to replace conventional sources to the non-conventional sources of energy because non-conventional energy sources make a healthy environment [4].

In order to attain energy security and promote sustainable development, technology that converts bio-waste to energy should be explored [5]. Generally, an electrochemical cell is a device in which a redox reaction to get electrical energy. The electrode where oxidation occurs, is called anode while the electrode where reduction occurs, is called cathode [6]. Recently, techniques are quite evolved to generate energy [7]. The biomass battery is a new technology for electricity the production directly from biodegradable material [8]. Microorganisms actively catabolize substrate, and bioelectricities are produced. In the field of power generation from non-conventional sources, apart from the benefits of this technique, it is still facing practical constraints such as low potential and power [6].

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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 [9]. Here, in bio electrochemical cell oxidation occurs in the carbon electrode whereas reduction in the zinc. Thus electrolyte, oxidants present in cow dung, which participate in the complex biochemical reactions, are apparently in the generation of generation of power [6]-[9]. Reactions taking place in the biodegradation of a biomass is [9]:

$$C_6H_{12}O_6 + 6H_2O = 6CO_2 + 24H^+ + 24e$$
$$CH_3COOH + 2H_2O = 2CO_2 + 8H^+ + 8e$$

Nowadays, low energy-consuming electronic devices (LCD calculators, watch, pocket video graphs etc.) are in demand because they consume power in micro-watt, so scientists are attracted to research in this field [10].

The improvement in potential for digital electronic devices, cost reductions of materials in electricity generation may be performed.

In the field of power generation from nonconventional sources, if this unit of electricity production is integrated, it may be useful and very significant for sustainable power generation [6]. The biomass battery follows the principle of chemical fuel cell i.e. storing and producing the electricity. Biomass battery technology may provide a new method to generate electricity for rural household, making the technology more affordable for rural electrification [9]. In 1911, Potter was the first to demonstrate that electricity can be generated by bacteria [11].

Cow dung has the potential to serve as a means of generating bio-electricity in the remote areas. This can reduce CO2 emissions significantly. The provision of electricity in our remote villages in India continues to be a pipe dream. Since cow dung is available in excess to the nature, biomass batteries can be used as a power source for lighting. The ultimate aim is to illuminate rural houses using alternative source of energy without using chemical batteries [9].

Small amount of electricity (renewal) is necessary for the developing countries due to limited source of coal and fossil fuels [2].The aim of this paper was to investigate the effectiveness and the performance characteristics of cow dung for electricity production in batch and semi-continuous operation.

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II. Materials and Methods

For the study of non-conventional energy, first, the pH of cow wastes has been measured by using electronic pH meter. Then the moisture of cow dung has been measured by using moisture formula. These values are listed in Table I.

Moisture content was calculated as follows [12], [13]: PW = the weight of plate with wet sample, P = the weight of empty plate, PD = the weight of plate with dry sample.

$$\text{Percentage of moisture content} = \frac{(PW-PD)}{(PD-P)+(PW-PD)} \text{ X } 100$$

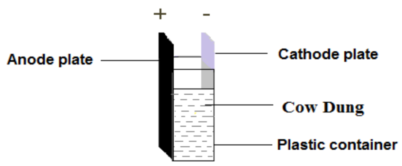

Fig. 1 Schematic representation of a single bio-voltaic cell

Sample of cow dung was collected from Sadguru Sewa Sadan (Dairy) Chitrakoot Satna (M.P.). The cow dung cell (battery) incorporates an anode made up of graphite electrode plate (4 sq.cm, thickness 0.2 cm) and a cathode made up of zinc plate for the purpose of the renewable energy. Graphite plate was perched from Graphite India Ltd. Kolkata whereas different pairs of electrodes Cu, Mg, Zn, Al, and Fe (4 sq.cm, thickness 0.1 cm) were also used in the cow dung cell (battery). It is purchased from local market of Satna. Electrodes are freshly prepared for each experiment.

A plastic aerobic container has been taken which contains 10g cow dung. Electrode plates were used as anode and cathode respectively, which act as a battery cell as shown in Fig. 1. The anode and cathode terminals were connected to digital multi-meter (RISH Multi 14S) and DPM (Agronic34A6) with help of connecting wires for measuring the current and voltage. The power output was monitored according to measuring voltage and current across the anode and cathode. In order to obtain the current-voltage (I-V) curve and current power (I-P) curve, the external resistance changed from 1 Ω - 100 kΩ. The single unit of battery was used for experimental purpose and new battery was used for each experiment. Besides, connection of the wires must be good enough to get the desired output. Similarly, several experiments are performed with different electrode pairs: The C-Mg, C-Zn, C-Al, C-Fe, C-Cu, Cu-Mg, Cu-Zn, Cu-Al, Cu-Fe, Fe-Mg, Fe-Zn, Fe-Al, Zn-Mg, Al-Zn and Al-Mg electrode pairs have been selected to construct the batteries.

The different electrode pairs have been used for further investigation. The results of different electrode pairs for cow dung are presented in Table III.

III. Results and Discussion

When, the concentration of electrolyte changes, the potential of anode electrode is affected much stronger than cathode electrode. The equilibrium potential of anode electrode depends on the pH, water/moisture and concentration of the solution of electrolyte. Table I shows the physical-chemical properties of cow dung.

TABLE I
Physical-Chemical Properties of Cow Dung

SN	Parameter/Content	Cow dung
1	Quantity	10 g
2	pH	7.2
4	Water/Moisture	77%

A. Selection of Electrode Pairs

Table III and Fig. 2 show that, all the electrode pairs have been found quite suitable for developing batteries from cow dung. C-Mg electrode pair shows maximum voltage and SCC while C-Zn electrode pair shows less OCV and SCC. The electrodes were screened on their cost (Table II), durability, availability and electrical behavior. The C-Zn electrode pair is the most suitable in all respect therefore; C-Zn electrode pairs were selected for further investigations.

TABLE II
Cost Analysis of Electrodes

S N	Electrodes	Rs./Kg	Reference
1	Carbon (C)	500	[14]
2	Magnesium (Mg)	1500	[15]
3	Zinc (Zn)	225	[16]
4	Aluminum (Al)	125	[17]
5	Copper (Cu)	406	[18]
6	Iron (Fe)	49	[19]

TABLE III
Comparative Result of Various Electrode Pairs with Cow Dung Battery

S. N.	Electrode pair	OCV (mV)	SCC (μA)	Max. Power (mW)	Internal Resistance(kΩ)
1	C-Mg	1650±100	3900±100	1162	0.6-0.8
2	C-Zn	960± 50	2300±100	273	0.6-2.3
3	C-Al	950± 50	1800±100	155.75	0.9-4.6
4	C-Fe	740± 50	1800±100	138.6	0.7-13.3
5	C-Cu	93± 10	210±50	1.75	0-1.02
6	Cu-Mg	1570±100	2900±100	924.8	0.5-0.8
7	Cu-Zn	906± 50	1500±100	207.6	0.8-1.2
8	Cu-Al	656± 50	650± 50	48.07	1.5-15.7
9	Cu-Fe	150± 50	220± 50	2.79	1.2-2.03
10	Fe-Mg	1360±100	2100±100	521.6	0.7-1.5
11	Fe-Zn	400± 50	660± 50	28.08	0.7-1.6
12	Fe-Al	500± 50	436± 50	69	0.9-4.2
13	Zn-Mg	700± 50	2100± 50	405.6	0.2-8
14	Al-Zn	30± 10	15± 10	3	6-10
15	Al-Mg	956± 50	710± 50	67.85	1.6-8

Electrodes: C-Zn, size 4sq.cm, separation= 1 cm, RT: 25±2°C.

B. Impact of Separation between Electrodes Pairs

Equivalent and rectangular shape electrode pair gives a very good response in terms of power [3]. Fig. 3 presents that the separation of 0.5-1.0 cm between the anode and cathode electrode gives maximum power (mW) value.

C. Effect of Variation in Parallel Electrode Size

We have taken size of anode and cathode electrodes which was showing highest maximum power (mW) value. It was found that when anode and cathode electrodes take equal size, it shows maximum power. We have finally chosen C-Zn paired electrode (4 sq. cm) for further investigation.

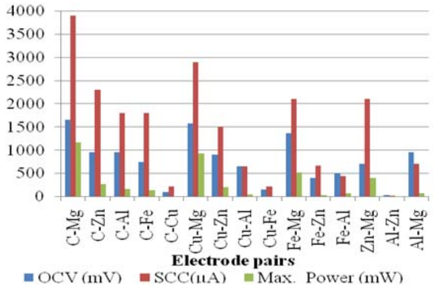

Fig. 2 Comparative result of various electrode pair with OCV, SCC and maximum power

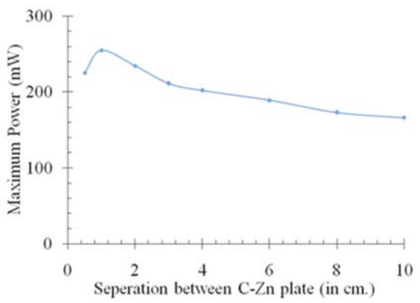

Fig. 3 Separation (in cm) between C-Zn electrode pair (4 sq. cm) plates

Available space through flat (parallel electrode plate) cell design for cathode mixture (electrolytes) can be increased, which the package and electrical contacts are minimized, thereby increasing the energy density.

A rectangular construction reduces wasted space in multi-cell assemblies. The volumetric energy density of an assembled battery using flat cells is nearly twice that of cylindrical cell [3]. The result is represented in Fig. 4.

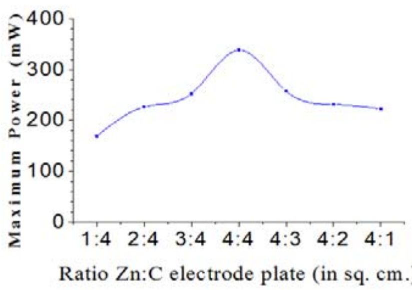

Fig. 4 Effect of variation in parallel electrodes size

D. Characteristics of Cow Dung Battery

In the present study, the resulted characteristics of the cow dung battery have been presented in Fig. 5. The cow dung was found more suitable as it generates approximately 960 mV open circuit voltage (OCV) while short circuit current was found 2300 µA, represented in Table III. Battery was discharged across 100 kΩ load resistance. Time to reach cut-off voltage, energy density and power density were computed from discharge characteristics. Usually the cut off voltage is said at the knee of the discharge curve (i.e. one third of the OCV) [10]. In our work, the cut-off voltage is taken one third of the OCV the discharge curve is presented in Fig 6. We estimated in our study that the cow's dung battery provides services up to 310 hrs. The internal resistance of batteries was found to vary between 0.3 and 0.5 kΩ. The power of battery is determined by connecting external load resistance in the circuit. From the curve of current-power characteristics we have found that the maximum power of cow dung battery was 273m was shown in Fig. 5.

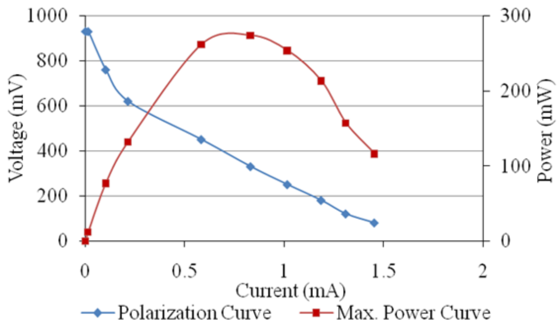

Fig. 5 Characteristics of cow dung battery

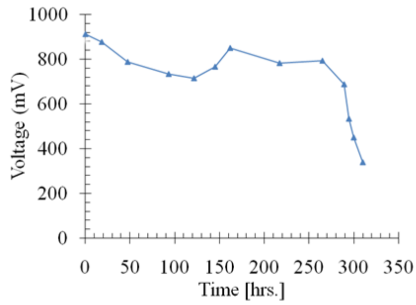

Fig. 6 Discharge characteristics of cow dung battery

IV. Conclusion

In the present study, different types of batteries were made from different electrode pairs for selection of suitable electrode. The effect of size and distance of parallel electrode pair were studied. The maximum power (273 mW) was obtained from bio-battery on combination with C-Zn electrodes. It can be concluded that designed bio-battery may be suitable to energize any low power consuming electronic gadgets. The cow dung battery provides services up to 310 hrs. Therefore, it is concluded that bio-activity plays dominant role in the energy generation mechanism. The performance of the system is satisfactory. We are recommending here that the use of bio-waste to generate energy from non-conventional sources will be in demand. There is lots of opportunity to upgrade the technology in the future.

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