# DESIGN AND FABRICATION OF MICROBIAL FUEL CELL USING COW MANURE FOR POWER GENRATION

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***ABSTRACT:*** *Due to environmental concerns associated with fossil fuel mitigation and political volatility of oil-producing countries, and more recently with the advent of rising fuel costs, biomass energy sources have become of great interest. One of the newest ways in which to harness the energy in biomass is through the use a microbial fuel cell (MFC). MFC technology allows biologically treating wastewater while simultaneously accomplishing power generation directly in the form of electricity. This investigatory research tried to see whether cow manure can be an option of electricity generation and sought out whether cow manure could be an efficient biocatalyst in generating voltage in a MFC, fabricated from very cheap and local materials. MFC analyzed with various concentrations of cow manure (100%, 75%, 50% and 25%). The generated voltage was recorded using digital multimeter and readings were taken on a 2 minutes interval for 40 minutes. The maximum voltage achieved was 0.723V from the 50% cow manure concentration. MFC with 50% cow manure concentration was connected in a single electrical circuit and was used to light up a small light-emitting diode (LED).*

**Keywords:** *Salt Bridge,* Electrical Energy, *Microbial fuel cell, Sewage sludge*

## INTRODUCTION

Due to the continuous exhaustion of fossil fuels and steady increment in the cost of fuels, the world is moving towards the energy catastrophe. However, consumption of fossils fuel cause an increase in pollution level, which is a major cause of global warming [1-3]. So requisition of an alternative source of energy is increasing day by day, which should be economical, reusable and clean [5-7]. The microbial fuel cells provide a promising technology to handle the above two problems by decomposing organic waste to using it [8-11]. For building a practical world we needed to reduce the utilization of fossil fuels. In 1911, M.C Potter observed that bacteria can be used produce electrical energy [12-15]. However, not sufficient research was done to advance this technology during 1911-1967 [16]. But in 1967, John Davis patented the first microbial fuel cell (MFC) technology & possible application and research on microbial fuel cell was began after 1990’s [17]. Most of the patents were issued in 2000’s. MFC innovation shows to another magnification of renewable energy by producing power from bio waste like cow manure [18-20]. MFC is a bioreactor where microbes act as biocatalyst in metabolizing the natural substance containing the organic carbon to produce electricity. Electrons are produce by the oxidation of organic material in which microbes act as catalyst [12-23]. Electrons therefore delivered are exchanged to a terminal electron acceptor, for example, oxygen [16-19]. These terminal electron acceptor are get reduced by these electrons [24]. A new product is formed which can leave the cells when terminal electron acceptors are diffused into the cells. However, there are some microorganisms specially bacteria that can transfer their electrons in the outer space surrounding the cells which are accepted by the awaiting terminal electron acceptors [25-27]. These bacteria are called exogenic and can be used to produce power within a MFC [28]. MFC is generally comprises of two chambers, one of the chamber where oxidation take place is called anodic chamber (anode) and the other chamber where reduction take place is called cathode chamber (cathode) [27-30]. In presence of oxygen, microbes oxidize organic compound to produce $CO_2$ and water, but if the reaction takes place in anaerobic environment then microorganisms decompose organic material to produce $CO_2$ while proton and electrons are produced simultaneously [1-5]. Electrons thus produced are transferred to the cathode through salt bridge. Aim of this research is to generate electricity from different concentrations of cow manure at room temperature using a laboratory scale dual chamber MFC.

## MATERIALS AND METHODS

### Collection of Materials

An amount of cow manure was carefully collected using gloves and was stored in a sterile, sealed container from the Qasimabad Hyderabad.

### Construction of MFC

A MFC comprises of four sections: the anode and cathode chamber, salt bridge and an electrical circuit.

### Framework

Two plastic bottles were used as chambers of an MFC. Two holes were drilled from the sides of the two plastic bottles such that a PVC pipe can be connected rigidly. Each container was about 7 inches high and about 3 inches in diameter. Two holes were also made on the lids of the bottles such that a copper wire can be passed through (Fig. 1).

### Salt bridge

For the fabrication of a salt bridge following materials were used: agar 10g (at concentration of 1000g/L), NaCl salt 10g and distilled water 100ml. in a beaker, 100ml of distilled water was heated until it reached 100$^{o}$C. Then the agar salt mixed to the boiling $H_2O$. Sodium chloride salt mix with the mixture. At that time mixture put into the PVC pipe, while it was hot and before it started to thicken. One end of PVC pipe was fixed and mixture was permitted a short time later to cool and harden. Afterwards, the PVC pipe was connected to sides of the bottles and sealed with epoxy.

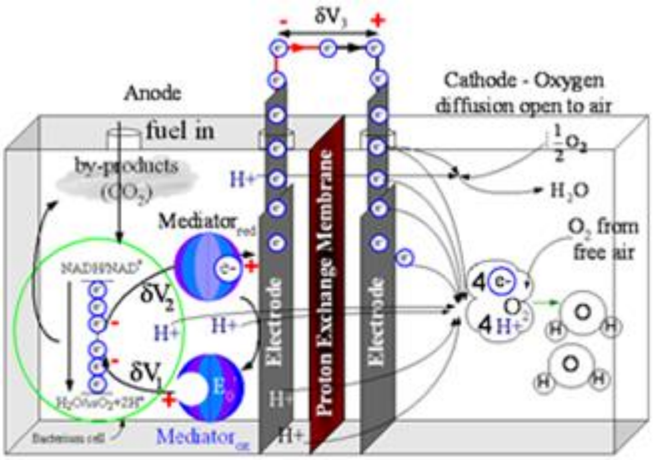


**Fig. 1: Dual Chamber Microbial Fuel Cell [12]**

### Anode and Cathode

Various concentrations of cow manure were prepared by mixing an amount of cow manure with distilled water in a beaker continuously mixed using a stirring rod until a smooth consistency was achieved. Salt solution (400ml), was put into the aerobic chamber (cathode), then electrodes were added in both containers. Microbes which are present in the anodic comportment that metabolite the substrate and during this process electrons were generated. These generated electrons moved by salt bridge. Due to this movement of electrons, electric current was generated over the resister and wire, this generated current was measured by using digital multimeter. It was used to measure voltage. Readings were recorded on a two minutes interval for 40 minutes. Setup was placed at room temperature.

**Table. 1: Constructed MFC setup**

| SUBSTANCE AT ANODE | SUBSTANCE AT CATHODE |
|---|---|
| **400 ml 75% cow manure; 25% $H_2O$** | 400 ml $HC_2H_3O_2$ |
| **400 ml 50% cow manure; 50% $H_2O$** | 400 ml $HC_2H_3O_2$ |
| **400 ml 25% cow manure; 75% $H_2O$** | 400 ml $HC_2H_3O_2$ |
| **400 ml 0% cow manure; 100% $H_2O$** | 400 ml $HC_2H_3O_2$ |

### Circuit

Two copper rods (8cm each) were served as the electrodes of the MFC. These two copper rods were put into both compartments. Following materials were used for this circuit: two copper wire (each 0.5 m), two copper rods (each 8cm) for electrodes, two alligator clips and a digital multimeter. The black wire was for the anode and red wire for the cathode. The black wire was inserted to the gap in one container and was joined with a copper rod while the other end was associated with digital multimeter utilizing an alligator clip. The same methodology carried out with the red wire. The tops of both container were fixed with the epoxy.

## RESULTS & DICUSSION

### Voltage generated by MFC at 100% cow manure and 0% $H_2O$

The voltage generated in a MFC using pure cow manure (100% cow manure). In this experiment cow manure was used totally in solid and dry form therefore in this substrate water is 0%. The MFC was generated an initial voltage of 0.256V and a final voltage of 0.235V (Fig.2). The data were recorded on a two minutes of time interval for 40 minutes of operation. The succeeding records show a sudden decrease and increase in generation of voltages in MFC. The maximum voltage 0.345V was recorded at time is equal to 10 minutes. This might suggest that there was overbeating amount of cow manure for the amount of microbes that have been present.

### Voltage generated by MFC at 75% cow manure and 25% $H_2O$

The voltage generated in a dual chamber MFC with 75% cow manure and 25% $H_2O$. The voltage generated in a MFC with 75% cow manure and 25% $H_2O$. The MFC was generated an initial voltage of 0.473V and a final voltage of 0.558V (Fig.3). A slowbut increasing trend was established. The graph shows that voltage consistently increase as time increase. This suggests that there might have been a sufficient amount of substrate digested by the microbes.

### Voltage generated by MFC at 50% cow manure and 50% $H_2O$

The voltage generated by MFC with 50% cow manure and 50% water by volume. The data were recorded on a 2 minutes interval for 40 minutes. The setup generated an initial voltage of 0.637V and a final voltage 0.657V. The MFC generated the maximum voltage amounting to 0.723V. The voltage generated increase as time (Fig. 4). A rapid increase in voltage generation occurred in the first four minutes and gradually increased since then. The voltage increases exponentially as time increases (Fig.4). MFC achieved the maximum voltage.

### Voltage generated by MFC at 25% cow manure and 75% $H_2O$

The voltage generated by MFC with 25% cow manure and 75% $H_2O$ by volume. The data were recorded on a two minutes interval for 40 minutes (Fig.5). The setup generated an initial voltage of 0.423V and a final voltage 0.459V. The MFC generated the maximum voltage amounting to 0.465V.The MFC with 25% cow manure and 75% $H_2O$ was kept under the same conditions as with other concentrations. As unstable voltage was generated with several rises and falls throughout time. This may suggest that the amount of substrate is insufficient for the microbes present in anode chamber or that there was some sort of capacitance associated with the anodic substance. Results of the study validates the findings from the literature review, that the microbes in the cow manure use the cellulose in their metabolism, they strategically position themselves on the anode surface to form a microbes community called a biofilm. This biofilm which is made up of a complex extracellular proteins, sugars and microbes cells is rich with materials that can potentially transport electrons [23-25]. Results of this study further corroborate the findings of researchers from Arizona State University that the biofilm anodefacilitates the transport of electrons from microbes to the electrode and electrical potential gradient [12-15]. Likewise, findings of the study have shown that the rate of microbial metabolism at the anode increases when the electrical potential of the anode increases, thus, electricity generate in the MFC depends on the rate of microbial metabolism in response to the electrons concentration or the electrical potential [5-7]. To further test if the MFC fabricated in the experiment works, MFC with 50% cow manure concentration was connected in a single electrical circuit and was used to light up LED device with 1.5V requirement. Finally, the study as shown has identified three critical variables to controlling a MFC: the concentration of the cow manure, the accumulation of the biomass on the anodeand the electrical potential in the biofilm anode. Results also show that the MFC generates more voltage at 50% cow manure concentration which again validates the theory that MFC yielded maximum voltage when biofilm thickness is at optimum medium.

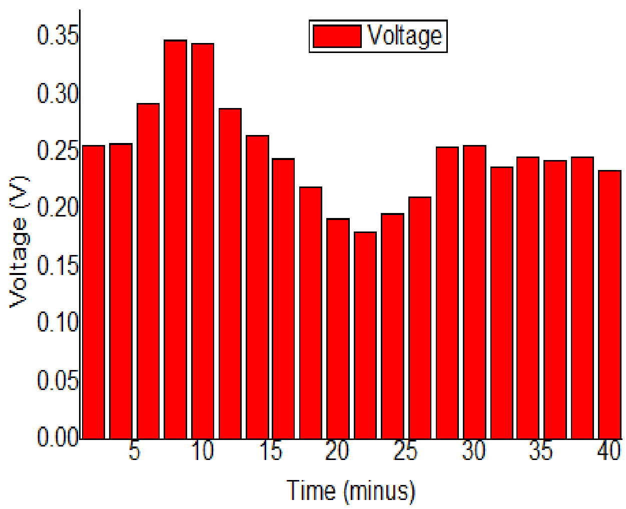


**Fig. 2: Voltage generation from cow manure versus time (100% cow manure and 0%$H_2O$)**

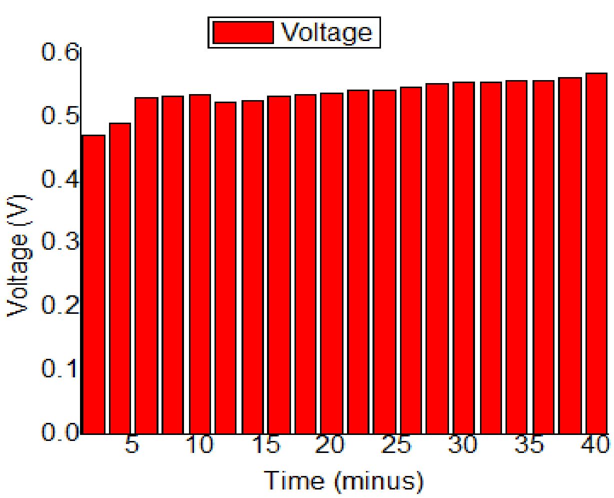


**Fig. 3: Voltage generation from cow manure versus time (75% cow manure and 25% $H_2O$)**

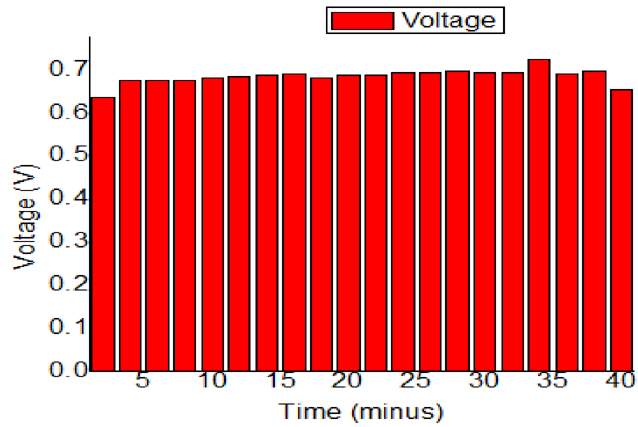


**Fig. 4: Voltage generation from cow manure versus time (50% cow manure and 50% $H_2O$)**

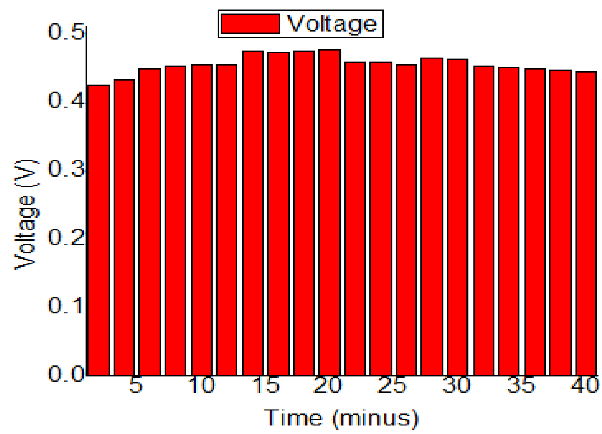


**Fig. 5: Voltage generation from cow manure versus time (25% cow manure and 75% $H_2O$)**

## CONCLUSIONS

The aim of this research is to examine if cow manure can be an efficient biomass in generating voltage in a dual chamber MFC and fabricate a MFC using inexpensive and local materials. Results of the study confirmed that cow manure is an efficient biocatalyst to generate voltages. Likewise results showed that greatest yield in voltage generated by the MFC was obtained using 50% cow manure concentration. Further, the study show that it is feasible to construct a MFC using inexpensive materials as the study made use of wastes like cow manure and recycled PVC pipes. The team only roughly spent 5000 Rupees for the construction of the MFC model. This study would like to recommend the use of cow manure in the production of microbial fuel cell. Likewise additional studies can also be made to further refine the MFC technology using cow manure as biocatalyst, thus contributing to solution of the energy crisis in a developing country like the Pakistan. This study also recommends the isolation and identification of the microbes in the cow manure that were responsible for generating the electromotive force in the MFC. It is also recommended that the materials and configuration of the MFC in the experiment be improved by interested scientists as well as student researchers. Instead of using consumable resources, utilizing this manure is much better because it does not only decrease the pollution in the environment but also helps in the conservation of natural resources.

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