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Comparative Analysis of Microbial Fuel Cell Performance fed by Different Waste Wasters – A Review

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Abstract - *World's predominant source of energy are fossil fuels like coal, petroleum and natural gas all these sources make up about ninety percent of world's energy. Fossil fuels are usually identified as non-renewable resources of energy as the development of fossil fuels takes extremely long time. Furthermore, the use of fossil fuels raises significant environmental concerns. Therefore, there is a need of sustainable, environment-friendly energy sources. Fuel cells are a promising technology. Our project focuses on Generation of electricity using Microbial Fuel Cell (MFC), while simultaneously treating wastewater. Microbial Fuel Cell works by enabling the bacteria to do their work that is to oxidize and reduce the organic matter present in the waste. This is a new type of renewable energy formed from what would otherwise be considered as waste. This technology uses bacteria already present in wastes such as wastewater, sewage and other bio wastes that acts as a catalyst to generate electricity. The purpose of this project is to determine the maximum electricity generated by treating waste water using microbial fuel cell as well as to determine the parameters like potential of Hydrogen (pH), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Turbidity, Total suspended solids (TSS) and Total dissolved solids (TDS) of the treated waste water to know the efficiency of treatment. This study also involves the comparison between the energy generations from different wastewater using fuel cell*

***Key Words*: Fossil Fuels, Microbial Fuel Cell (MFC), electricity, bacteria, treatment, wastewater.**

1. INTRODUCTION

It has nowadays become very important to find out various alternative sources of energy. Around 90% of the world's total energy resource is of fossil fuel, which are non-sustainable, very expensive and has negative impact on environment. Due to the rapid depletion of unsustainable natural sources, we are facing huge energy crisis. So, there is a need of sustainable source of energy which have less impact on environment. As per many researches held before, it is seen that the bacteria present in wastewater helps to generate electricity. Hydrogen, metals, natural gas, methanol, etc. are the chemicals present in wastewater which helps to generate electricity using fuel cell. In this study, we have evaluated trail base scale of 4L MFC (Microbial Fuel Cell) filled with wastewater which is collected from Wastewater Treatment Plant (WWTP) i.e. from grit chamber. MFC is then equipped with graphite electrodes floating in wastewater and also salt bridge as alternative of membrane.

Although the energy that is produced in MFC is not yet practical for a scale larger than simple demonstrations, a thorough understanding is truly helpful to acknowledge how bioenergy works and how it could be integrated into our energy generation systems in the future.

Moreover, this MFC technology is also useful because it is environmentally friendly in all aspects such as how it functions off of natural waste, it does not use any hazardous reactants like the batteries do, but instead it functions off of natural bacteria found in the waste to produce clean energy. It also reduces the BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) of the waste water significantly while producing electricity. Hence it provides two benefits i.e. generate electricity and treat waste simultaneously.

2. LITERATURE REVIEW

The idea behind this project is basically from various research papers related to environment, MFC, Energy sources, wastewater etc. which when combined together to execute this project.

Carbon dioxide emission from fossil fuel negatively affects the nature through global warming [1]. Hydrogen, metals, natural gas, methanol, etc. are the chemicals present in wastewater which helps to generate electricity using fuel cell [2]. The first fuel cell was built in 1839, which described microbial conversion in generation of electricity [3]. The discovery of electricity generation from wastewater has leads to more interest in MFC research field [4]. Advantage of MFC is that they typically have long lifetime (up to 5 years) [5]. MFC plays major role not only for production of bioenergy but also for treating wastewater [6].

The challenge is that the MFC's produce very low energy as compared to chemical fuel cells [7]. The transfer of the electron through microorganism obtained from the metabolism of organic matters in the anode and thereby to the cathode to an external circuit, hence generate electricity [3]. The design of MFC is of two compartments consisting of anodic chamber and cathodic chamber separated by salt bridge to not allow the oxygen to anodic chamber [8]. When sewage sludge is used with graphite electrode, 152mW/m2 maximum power density could be observed [9]. The effect of wastewater concentration on COD and TDS removal efficiency and current generation was observed [10]. Up to 8.5kg COD / m3 of biodegradable organic matter was removed, 344mW/m3 electricity generated [11]. MFC's can be a sustainable source of energy [12].

3. MATERIALS AND METHOD

A. Collection of waste water.

The waste water is collected from various location such as waste water treatment plant or industrial waste water etc. For later comparison of energy produced. The physiochemical characteristics of wastewater is then noted down.

B. Design of MFC

Two chambers having graphite electrodes that is the anode and the cathode were connected in series externally with a copper wire that has been used for this study. The various component of MFC's are as follows

- Electrodes: Two graphite electrode are connected with copper wires having 17cm in length and 1.5cm diameter.
- Copper wires: The electrodes were connected with copper wires.
- Calibrated multimeter: Multimeter is connected with copper wires for measuring the current produced in MFC.
- PVC pipe: For connecting two containers, 120mm length and 3.8cm inner diameter.
- MFC Construction and operation:

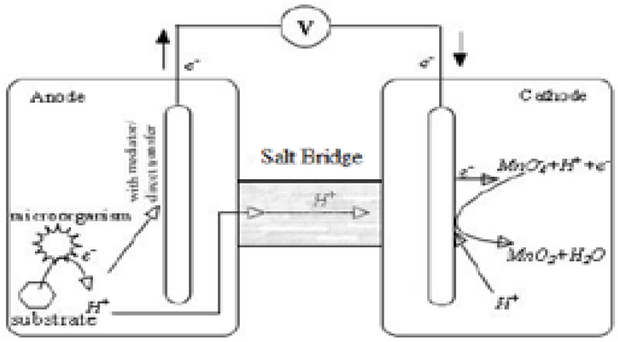

Fig -1: Schematic Diagram of Microbial Fuel Cell

The H-type MFC consists of two chambers, firstly the anaerobic anodic chamber and second is an aerobic cathode chamber. These two chambers were connected by using a salt bridge. Two electrodes are nothing but the graphite rods dipped into the solutions. These two graphite electrodes were separately joined to copper wires which were clamped on crocodile clips. Figure 1 shows the schematic diagram of a H-Type Microbial Fuel Cell. The anode chamber is filled with 4L of sewage (Bio waste) wastewater while; the cathode chamber was filled with 4L of distilled water. The copper wires from these two electrodes are then connected to a digital multimeter to show the generating electricity in volts. Once the MFC shows a repetition in the voltage readings, the anode chamber can be refilled with fresh wastewater and the process can be repeated.

Fig -2: Salt Bridge

The Salt Bridge is made using water, agar agar powder, and salt. 300ml of water is boiled till 5 to 7mins, then 10% of Agar Agar powder is mixed till the powder is fully dissolved. After the powder is totally dissolved, 6g of salt is added to the mix after turning off the burner. After 4 to 5mins, the solution is then poured into the PVC pipe as shown in Figure 2. The thick gel is formed know as salt bridge which helps to transfer hydrogen ion to cathodic chamber.

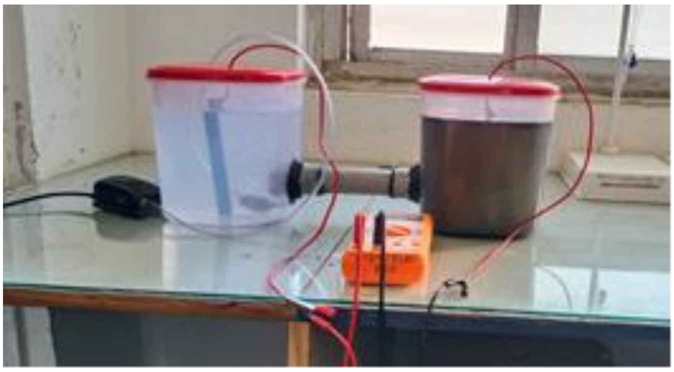

Fig -3: Model of Microbial Fuel Cell

Diffused Aeration System is used to provide oxygen to the cathode chamber for maintaining aerobic condition. Then the multimeter is used to measure the voltage at different time intervals of various wastewater and compare the results to see which type of wastewater generates more electricity. The model of MFC is shown in Figure no.3.

4. EXPECTED RESULTS AND DISCUSSION

The expected result from this study is to generate electricity and to measure the power at different time interval of various wastewater sample for comparing and analyzing the outputs.

From the 4L wastewater filled container should generate less then 1 volt at 5 days and it decreases slowly after 5 days. The 'time vs volt value' graph of various wastewater sample is plotted. From this graph, we can analyze the power produced by various wastewater. MFC can reduce the BOD and COD of wastewater by almost 90 percent. This shows the efficiency and potency of MFC implementation in wastewater treatment.

In this Study, we also have to test the initial and final characteristic of waste waters to examine the changes in characteristics of wastewater. The wastewater was tested, and initial characteristics were analyzed of one wastewater sample as shown in table no. 1.

Table -1: Initial results of raw sewage

Sr. No.	Parameters	Initial reading
1	BOD	180 mg/l
2	COD	328 mg/l
3	pH	7.7
4	TSS	390 mg/l

As we already have the initial characteristics of wastewater, by going through the research papers, the results after execution are shown in table no. 2.

Table -2: Final results of raw sewage

Sr. No.	Parameters	Initial reading
1	BOD	15 mg/l
2	COD	192 mg/l
3	pH	6.5
4	TSS	100 mg/l

Fig -4: Multimeter reading of day 1

Table -3: Open Circuit Voltage and Current for a period of five days

Day	Voltage (mV)	Current (mAx10^-3)
1	0.409	42.9
2	0.251	27.5
3	0.181	25.2
4	0.122	23.6
5	0.105	19.8

When MFC is used in the wastewater treatment plants, a large surface area is needed. Though it will produce comparatively less power density then CFC. Another limitation is that even though microbes grows fast, they are relatively slow transformers. Although this study will somewhat help in further research work, there is a lot to be learned in scaling up of MFC for large-scale application.

Though the Two chambered MFC generated less energy, we can also use multi-chambered MFC to generate more electricity. But for this study, we have used 4L chambered MFC. The success of specific MFC application depends upon biodegradability of organic matter. The major drawback of this project that it generates very low electricity. Hence, a lot more work is required so that this technology becomes efficient, applicable and widely acceptable. In the near future, there will be more research in MFC field and may be become more beneficial result to human being with significant renewable source of energy.

5. CONCLUSION

From the Study it is clear that if we know the constituting elements of wastewater then accordingly, we get to know which type of waste water can give the maximum results required. Therefore, this study should be very advantageous for the study of microbial communities and to enhance our understanding about how the wastewater helps to generate electricity. The work performed in this study will be crucial for research in the field of electricity generation using microorganisms which obliviously gives the scope for the better work in the field of wastewater treatment. Certainly, future works can benefit using this study for producing maximal electricity at economical cost at the commercial wastewater treatment plants on large scale.

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