GENERATION OF ELECTRICITY USING SUGAR MILL WASTEWATER BY MICROBIAL FUEL CELL

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Abstract - The application of microbial fuel cell (MFCs) for power generation is a new technology . This study investigates the use of a single chamber(MFC-1) and double chamber(MFC-2) MFC to generate power from sugar Industrial Wastewater.

Receiving water sources are severely polluted and completely destabilized if wastewaters containing the qualities listed above are not treated before being released. The trash is highly organic and physiologically decomposable, according to wastewater characteristics. In MFC-1 of Sugar wastewater showed 56%COD, 54.2% BOD ,48.9%Chloride, 45.95% TS,46.9% TDS,51.7%Nitrate and 63.01%, Sulphate removal with different feed concentrations. The current, voltage and power generation in the reactor is 0.51mA, 0.31V & 0.009watts/m^2respectively. In MFC-2 of Sugar wastewater showed 49.15%COD, 48.9% BOD, 46.98%Chloride, 43.1% TS,45. 1% TDS,39.05%Nitrate and 59.3%, Sulphate removal with different feed concentrations. The current, voltage and power generation in the reactor is 0.37 mA, 0.26v & 0.0057watts/m^2 respectively.

***Key Words*: MFC, Sugar mill waste water, BOD, COD.**

1.INTRODUCTION

Rapid urbanization and industrialization in emerging countries like India pose serious challenges in terms of wastewater collection, treatment, and disposal. This condition has major public health implications. Unmanaged organic waste fractions from companies, towns, and agriculture breakdown in the environment, contaminating land, water, and air on a vast scale.

Microbial fuel cells (MFC) are one-of-a-kind devices that transform chemical energy into electricity using microorganisms as catalyst. Wastewater treatment and Electricity generation by MFCs can be used for a variety of things, including bioremediation, hydrogen synthesis, and environmental sensing. Domestic sewage, breweries, distilleries, sugar, paper and pulp mills, rice mills, swine wastewater, and phenolic wastewater have all been treated with MFCs. Another advantage of adopting MFCs for wastewater treatment is the possibility to reduce particles output. Microbial fuel cells have piqued interest around the world as a source of energy for generating power from organic and inorganic substances found in wastewater. In a microbial fuel cell, the microorganism metabolizes the fuels or substrates and settles electrons to the electrode's surface.

2. Literature Review

1. Alterman. P, K. Rabaey, P. Clauwaert and W. Verstraete., 2006 Microbial fuel cells have been studied and are developing as a viable technique for wastewater treatment. The efficiency of potential energy conversion is investigated. The energy recovery rates are examined and assessed.

2. **S C Santra et al., 2014**

MFC creates energy without the need of fossil fuels, according to research. Microorganisms are used to transform chemical energy into electrical energy in MFC technology. Because MFCs do not rely on fossil fuels and instead run on sewage and food waste, they are self-sustaining and extremely efficient.

3. OBJECTIVES OF THE STUDY

The study is conducted with the following objectives.

1. The characteristics of Sugar mill wastewater

2. To fabricate Double and Single chambered microbial fuel cell (MFC).

3. The treatment efficiency with respect COD, BOD, Chloride, TS, TDS, Nitrite and Sulphate.

4.Materials and methodology

The materials and methodology used are discussed in detail

A Grab Sample is collected from nearby sugar industry and brought to the laboratory for analysis.

4.1Microbial Fuel Cell(MFC):

Single and Double Chambered Microbial fuel cell(MFC) have been fabricated with the following materials

- Three Non-Reactive, non-conductive &non-biodegradable plastic boxes of Ten lifters capacity
- Agar Agar
- Pencil leads 2mm Diameter 7 & 47mm length
- Copper wire
- PVC pipe 2cm Diameter
- Sealants
- Multi meter

The following are the functions of the ingredients used to make MFC:

• PLASTIC BOXES: Anode and Cathode chambers are prepared in these boxes. The wastewater is held in the anode chamber, which has a capacity of 10 liters and a working volume of 7.5 liters, while the conductive salts solution of KCl 7.5 liter is Poured in the cathode chamber.

• AGAR AGARBACTO: In MFC-1 one end of the agar agar salt bridge which is used as a Proton Exchange System is dipped in wastewater and other end is exposed to the atmosphere. In MFC-2 Apart from the Proton exchange System it is also used to keep the anode and cathode liquid separate.

• CARBON RODS: These materials are employed as anode and cathode materials.

• COPPER WIRE: connects the electrodes to the multi meter, forming an external circuit.

• PVC PIPE: The agar salt(NaCl) combination, also known as the agar salt bridge is placed in the PVC PIPE.

STEP 1: CONSTRUCTION OF MICROBIAL

FUEL CELLS

Material selection for anode and cathode

The above mentioned plastic boxes of following dimensions are used to fabricate the working model of MFC's as shown in Figure1.

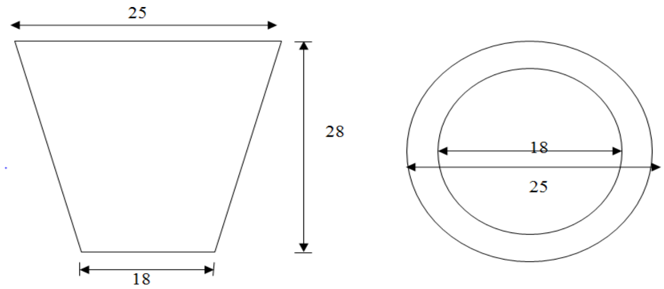

Fig 1- Dimensions of MFC Plastic Boxes

STEP 2: Preparation of Agar Salt Bridge

Common salt, agar, and water are used to make the Agar salt bridge. In a beaker, 650mL of water is boiled, then 65gm of agar and 75gm of sodium chloride are added and the liquid is cooked for another 3-5 minutes. One end of the PVC pipe is wrapped in plastic wrap, while the other end is left uncovered. The PVC pipe is positioned vertically on Petridis, and the plastic wrap is applied to Petridis. The prepared slurry is poured into the PVC pipe's open end. During the pouring process, it's important to keep an eye out for air bubbles. The set-up is let to solidify for a few minutes before being placed in the refrigerator for 24 hours. The same is integrated into the reactors as show in fig 2

Fig-2: Agar salt bridge

STEP 3: Assembling Of Electrodes

Available Carbon electrodes are arranged on a plastic pipe to resemble a carbon brush. This carbon arrangement allows for increased surface area and substrate interaction. Carbon rods have a length of 47mm and a diameter of 2mm as shown in fig 3.

Fig-3: Arrangement of carbon rod from battery

There is no cathode chamber in MFC-1. Instead, carbon rods are placed on an agar salt bridge that is exposed to the air, and copper wire was woven on it. In MFC-1 it is used as cathode. The oxygen in the atmospheric air will aid in the acceptance of electrons from the Anode chamber. A hole is bored in the plastic chamber to connect the anode to the external circuit. On the top of the anode and cathode chambers of MFC-2, holes are drilled in the plastic, to insrt plastic tube to pass copper wire coming from the carbon rods .An airtight seal should be used to prevent air from entering the anode chamber from the atmosphere.

STEP 4: Assembling of Microbial Fuel Cell

Two MFC reactors are being built, one with a single chamber and the other with two chambers. For MFC-1, one end of the PVC pipe holding agar salt was inserted into the anode chamber, while the other end was left open to air, with carbon rods acting as the cathode, the experimental setup of a single chambered MFC as illustrated in fig 4.

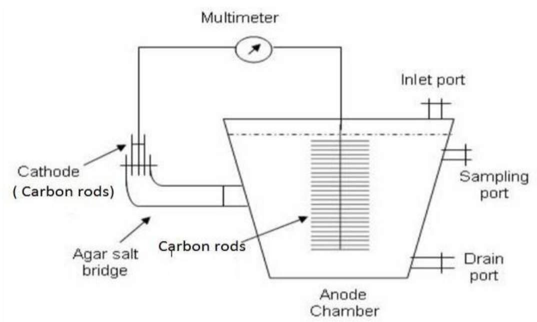

Fig- 4: Schematic diagram of Single Chambered MFC.

In MFC-2 the completed electrodes are placed into the anode and cathode chambers, Circular holes are created on top covers of two chambers to complete the external circuit. Two more circular holes are created on the sides of the working volume of the centre of the plastic boxes for fitting the PVC tubing carrying agar salt bridge. The plastic boxes are then sealed and made airtight. Water leak is being checked in both reactors as shown in Fig 5.

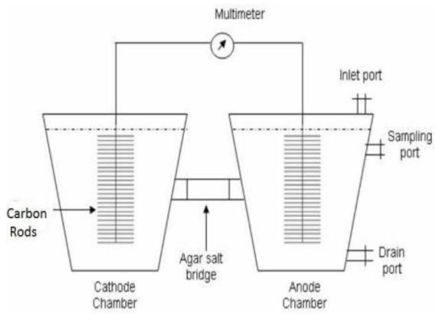

Fig-5: Schematic diagram of Double chambered MFC

5. Results and Discussions

The samples are analyzed in laboratory and characteristics of Sugar Mill wastewater are presented in Table1. Sugar Mill wastewater has Blackish Green color. Wastewaters characterized has average BOD_5 value of 2220mg/L and COD value of 3600mg/L. pH value of 7.6 which indicates alkaline in nature. Total solids, Nitrate, Chloride, Sulphate, Phosphate, TDS is 7000 mg/L,26mg/L, ,2698mg/L,410mg/L, 56.25mg/L,6000 mg/L respectively

The results shows the wastewater is highly strong in nature and BOD/COD ratio(0.61) which indicates it is bio-degradable in nature.

SL.NO	CHARACTERISTICS	UNIT	SUGAR MILL WASTEWATER
1	pH	-	7.6
2	Colour	-	Blackish Green
4	Total Solids(TS)	(mg/L)	7000
5	Total Dissolved Solids(TDS)	(mg/L)	6000
6	Suspended Solids(SS)	(mg/L)	1000
7	BOD_5@20ºC	(mg/L)	2220
8	COD	(mg/L)	3600
9	Chlorides	(mg/L)	2698
10	Nitrate	(mg/L)	26
11	Sulphate	(mg/L)	410
12	Phosphate	(mg/L)	56.25
13	BOD/COD		0.61

Table1: Characteristics of sugar mill wastewater are shown in Table 1

The efficiencies are determined by varying the organic loading rate. The varied feed concentrations like 1050mg/L and 2000mg/L are applied to the MFC-1 & MFC-2 Reactors.

Sugar Mill wastewater showed its potential for COD removal indicating the functions of microbes present in wastewater in metabolizing the carbon source as electron donors. The detention time for MFC-1 & MFC-2 are 5 days. The Removal efficiency of COD, BOD, Chloride, TS TDS, Nitrate and Sulphate , For two different loadings for MFC-1 AND MFC-2 are as shown in Fig 6. In MFC-1 the removal efficiency of COD,BOD, Chloride, TS, TDS, Nitrate and Sulphate are 48.5% , 47.1% , 46.3% , 42.8%, 43.75%,45.3%, 61.4% respectively for COD loading of 1050mg/L. COD,BOD, Chloride, TS, TDS, Nitrate and Sulphate are 56%, 54.2%, 48.9%, 45.95%,46.9% ,51.7% and 63.01% respectively for COD loading of 2000mg/L . Current increased from 0.02 to 0.51 mA, Voltage increased from 0.0 to 0.31 V as the feed concentration increases from 1050mg/l to 2000mg/L . So in the both the reactors the maximum removal efficiency is observed at a loading rate of 2000mg/L it is because of increase in nutrients to the microbes. In MFC-1 & MFC-2 for COD loading of 2000mg/L the current and voltage is high it is because of availability of more nutrients. In MFC-2 the removal efficiency for COD,BOD, Chloride, TS, TDS, Nitrate and Sulphate are 45.69%, 45.87% ,42.66%, 40.66% ,41.67% ,32.96% and 56.38% respectively for COD loading of 1050mg/L. In MFC-2 of Sugar wastewater showed COD,BOD, Chloride, TS, TDS, Nitrate and Sulphate 49.15%, 48.9%,46.98%, 43.1%,45. 1% ,39.05% and 59.3% for COD loading of 2000mg/L. Current increased from 0.04 to 0.37 mA, Voltage increased from 0.0 to 0.26 V as the feed concentration increases as shown in Fig 6.

The current and voltage generation in MFC-1 is high compared to MFC-2 because it is exposed to air, the presence of abundant oxygen which accepts the generated electrons.

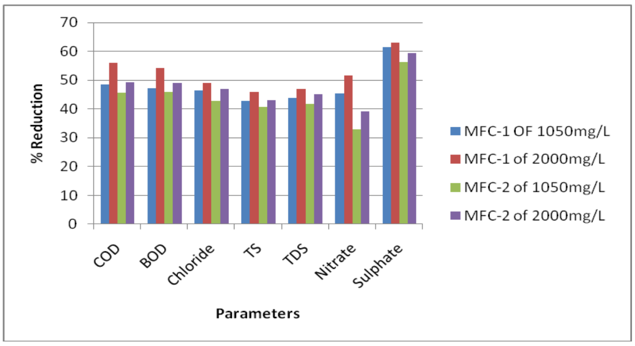

Fig 6:- Efficiency of MFC-1& MFC-2

The voltage (V) and Current (I) in the microbial fuel cell circuit is monitored at 24hour intervals using a millimetre (UNI-T, Model No - DT830D).

The power is calculated by

P= V*I/ Area of Electrode.

Where, I = Current in mA, V = Voltage in Volts, Length of electrode= 47mm and Diameter of electrode = 4mm

Area of one carbon electrode brush = $(2\pi rh + 2\pi r^2)$ X No. of carbon electrode in one brush

$= (2\pi \times 2 \times 10^{-3} \times 47 \times 10^{-3}) + (2\pi (2 \times 10^{-3})^2) \times 27$

A= 16.6×10^{-3} m^2 of each electrode brush.

P= 0.25*0.12/16.6 =0.001 W/m^2 for MFC-1 of COD loading 1050mg/L.

P= 0.19*0.10/16.6=0.001W/m^2 for MFC-2 of COD loading 1050mg/L.

P= 0.51*0.31/16.6=0.009W/m^2 for MFC-2 of COD loading 2000mg/L.

P=0.37*0.26/16.6=0.0057W/m^2 for MFC-2 of COD loading 2000mg/L.

The power generation is more in MFC-1 & MFC-2 for COD loading of 2000mg/L.

6. Conclusions

On analyzing the results based on the laboratory experiments conducted, the following conclusions are drawn.

1. MFC-1 of Sugar wastewater showed 56% COD, 54.2% BOD, 48.9%Chloride, 45.95% TS,46.9% TDS, 51.7%Nitrate and 63.01%, Sulphate removal with different feed concentrations. The current, voltage generation in the reactor is 0.51mA, 0.31V respectively.
2. MFC-2 of Sugar wastewater showed 49.15%COD, 48.9% BOD, 46.98%Chloride, 43.1% TS,45. 1% TDS, 39.05%Nitrate and 59.3%, Sulphate removal with different feed concentrations. The current, voltage and power generation in the reactor is 0.37 mA, 0.26 V respectively.
3. The Sulphate reduction is high With removal efficiency of 63% in MFC-1 & 59% in MFC-2.
4. Voltage and Current generation for both the MFC's are high in second loading.
5. The power generation for MFC-1 & MFC-2 for 1050mg/L & 2000mg/L COD loading are 0.001watts/m^2, 0.001watts/m^2 & 0.009watts/m^2 0.0057watts/m^2

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