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Research paper

Microbial Fuel Cell and its Efficiency in Treating Wastewater - a Novel Technique for Wastewater Treatment

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Abstract

Due to depletion of coal and other natural fuel there is an urgent need to find eco-friendly and workable technology for alternate energy. Microbial fuel cells is considered as assuringmethod to extract energy from various sources of wastewater and to generate electricity. But, due to practical limits, MFCs are still unsuitable to meet high power demands. Since wastewater contains several contaminants including organic substances, therefore, generation of electric energy from wastewater using MFC can offer an alternate solution for electricity issue as well as to reduce environmental pollution. Microbial fuel cells harvest electrical energy from wastewater with the help of microorganisms present within the wastewater. The energy confined in organic matter converted in to useful electric current. In Microbial Fuel Cell electrons from the microorganisms transfer from a reduced electron donor to an electron acceptor at a higher electrochemical potential. The study highlights that wastewater with high organic content found to be more effective and it also gives good energy production. If the same concept implemented in large scale it can help in achieving sustainable development and it helps in achieving 3R formula in the process of wastewater treatment.

Keywords: *Microbial Fuel Cell (MFC), Microorganisms, Wastewater, Energy production, Organic content, 3R formula.*

1. Introduction

Growing human activities, leads to utilization of natural source of energy, which causes depletion of fossil fuel at faster rate. Hence, an alternate source for energy production is required in order to reduce oil and carbon resource. Microbial fuel cells is been considered as a promising technology to extract energy from different sources of wastewater and turn them into electricity as well as simultaneously treat wastewater in the process[1].

Microbial fuel cells harvest electrical energy from wastewater with the assistance of microorganisms, which are naturally present within the wastewater. The energy present in organic matter from the wastewater is been converted into beneficial electrical power. In MFC electrons from the microorganisms transfer from a diminished electron donor to an electron acceptor at a higher electrochemical potential. Hence, it is an ideal solution for sustainable renewable source of energy.

MFCs have many potential applications, such as generation of electricity, production of bio-hydrogen, and for treating wastewater. MFC's have gained importance in the last few years due to their ability to produce generate electricity, from renewable source[2].

2. Materials and Methods

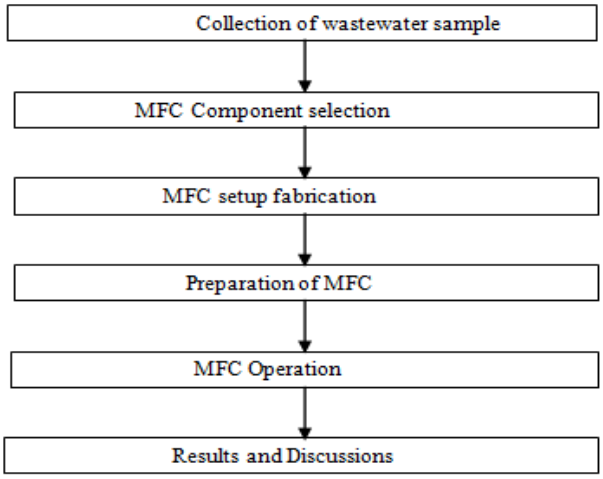

Fig.1: MFC Wastewater Treatment Procedure

Wastewater

In the present study wastewater obtained from distilleryindustry is used, Industry is set up, about 50 KMs from Chennai, in Gummudipondi Taluk, Thiruvallur Dist., Tamil Nadu, has a capacity of 7.50 lakh HectoLitres per annum, and is presently producing around 500,000 cases per month[1,2]

MFC components

Microbial Fuel Cell normallyconsist of Electrodes. Which has two chamber Anodic chamber and Cathodic chamber as well as an salt bridge which connect the two chamber. Anodic chamber generally contains wastewater and Cathodic Chamber contains Distilled water[3]. Salt Bridge placed in between both the Chamber in order to assist in transfer of ions.

MFC Setup Fabrication

A Dual-chambered Microbial Fuel Cellwas fabricated. Two plastic containers with the length of 12cm and Breadth 12cm where taken and considered asanode and cathode. Around 2.2mmdiameter a hole is been made on each of the lids for the addition of the salt bridge with the container and electrodes. 1000 mL of the Effluent Treatment Plant inlet where used in the anode container and 1000 mlin the cathode container[4], distilled water solution was used, and the opening of the anode container were closed airtight and sealed in order to ensure anaerobic reaction . Copper wire twisted graphite rod of length 7cm and diameter 1cm were used in anode and cathode

Preparation of salt bridge

A water solution of 70ml containing concentration of about 2.2 grams of NaCL and 1.12 grams agar was taken. The solution was boiled for around 3 to 5 minutes the hot solution was then poured in to a Polyvinyl Chloride pipe the mixture was allowed to cool for 2 hours and then it is fixed in to the setup and sealed.

MFC operation

In anodic chamber,1000ml of wastewater solution is been added and then anodic chamber is sealed completely in order to create anaerobic conditions. In the cathode chamber 1000 ml distilled water is added cathodic chamber and maintained in aerobic condition. Electrodes (copper rods) where inserted in both chambers. Microorganism consumes organic matters, which are present in wastewater, and then microorganism release electrons, these released electrons where transferred from anode to cathode with the help of copper wire. Protons where exchanged between two chamber microbial fuel cell with the help of salt bridge. And by this method, voltage isgenerated. The generated voltage is recorded in Digital Voltmeter (Figure 1). Three trails where carried out and the readings were taken for the period of six days each.

3. Results and Discussion

Characteristics of wastewater

The characteristics of the wastewater collected from the distilleries was identified by laboratory analysis. The analysis was based on TNPCB Norms for testing of Industrial Waste Water [5]. The wastewater parametersof Distillery Industries are as follows:

Table 1: Characteristics of Distilleries Wastewater

PARAMETERS	VALUES			UNIT
pH		5.94		-
Total Suspended Solids		514		mg/ l
Total Dissolved Solids		964		mg/ l
Chlorides		980		mg/ l
Sulphates		370		mg/ l
Oil & Grease		<1		mg/ l
BOD at 27'C for 3 days		36		mg/ l
COD		288		mg/ l
Potassium		5		mg/ l
Zinc		5.12		mg/ l
Copper		<0.0015		mg/ l
Candium		<0.0008		mg/ l
Total Iron		14.56		mg/ l
Nickel		<0.006		mg/ l
Total Chromium		<0.01		mg/ l
Ammonical Nitrogen		<0.03		mg/ l
Manganese		0.433		mg/ l
Total Phosphate		<0.15		mg/ l
Nitrite Nitrogen		<0.05		mg/ l
Nitrate Nitrogen		<0.015		mg/ l

Table 2: Voltage Generated From Distilleries Wastewater

Time(Days)	Volts (mV)		
	TRIAL 1	TRIAL 2	TRIAL 3
1	28.8	34.2	32.4
2	72.5	90.6	101.8
3	211.3	201.2	234.8
4	207.9	198.01	210
5	111.9	98.01	115.1
6	51.1	60.6	58.9
7	31	34.6	28.9

Table 2 shows the voltage generated by the MFC for the period of six days. Total of three trails where carried out with the Microbial Fuel Cell for distilleries wastewater in order to ascertain the voltage recorded in the voltmeter while the operation was carried out[6].

Table 3: Characteristics of Treated Wastewater

PARAMETERS	VALUES			UNIT
pH		8.25		-
Total Suspended Solids		80		mg/ l

Total Dissolved Solids		810		mg/ l
Chlorides		580		mg/ l
Sulphates		366		mg/ l
Oil & Grease		<1		mg/ l
BOD at 27'C for 3 days		11		mg/ l
COD		80		mg/ l
Potassium		3		mg/ l
Zinc		1.104		mg/ l
Copper		<0.0015		mg/ l
Candium		<0.0008		mg/ l
Total Iron		6.02		mg/ l
Nickel		<0.006		mg/ l
Total Chromium		<0.01		mg/ l
Ammonical Nitrogen		<0.03		mg/ l
Manganese		0.041		mg/ l
Total Phosphate		<0.15		mg/ l
Nitrite Nitrogen		<0.05		mg/ l
Nitrate Nitrogen		<0.015		mg/ l

Table 3 Shows the Parameter of the treated wastewater from the MFC after the period of six days [5].

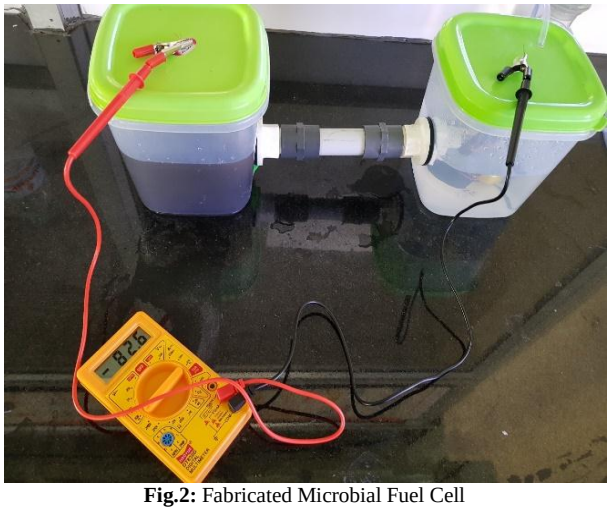

Fig.2: Fabricated Microbial Fuel Cell

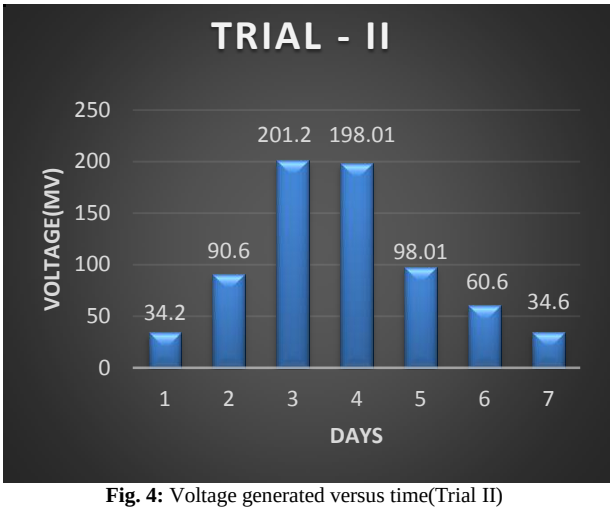

Fig. 4: Voltage generated versus time(Trial II)

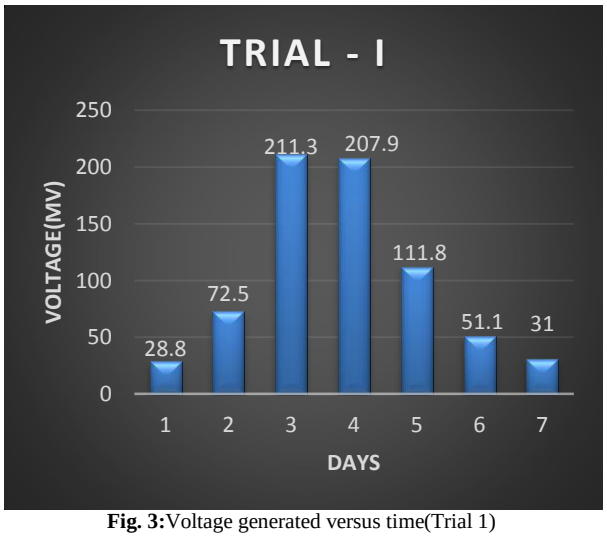

Fig. 3: Voltage generated versus time(Trial 1)

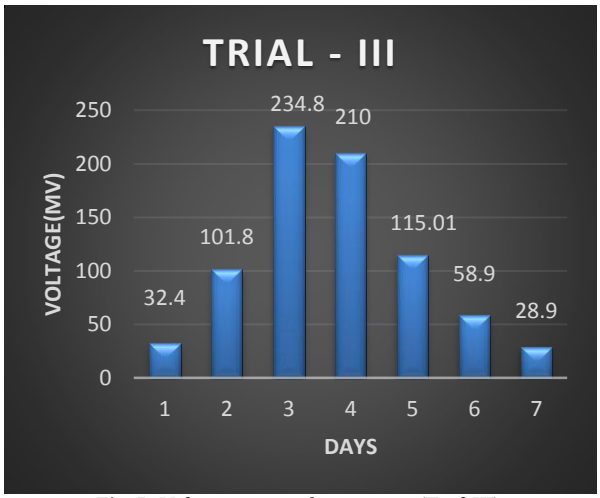

Fig. 5: Voltage generated versus time(Trial III)

Figure 2 shows the Fabricated model of Microbial Fuel Cell with Salt Bridge;
Figure 3 show the voltage generate by Microbial Fuel Cell for the period of 1 week in Trial I, Figure 4 and Figure 5 for Trial II & Trial III.The result from the trial clearly shows that the voltage generated is high during the period of 3rd and 4thday [7]. And the voltage was reduced significantly for the remaining days for the all the trails.

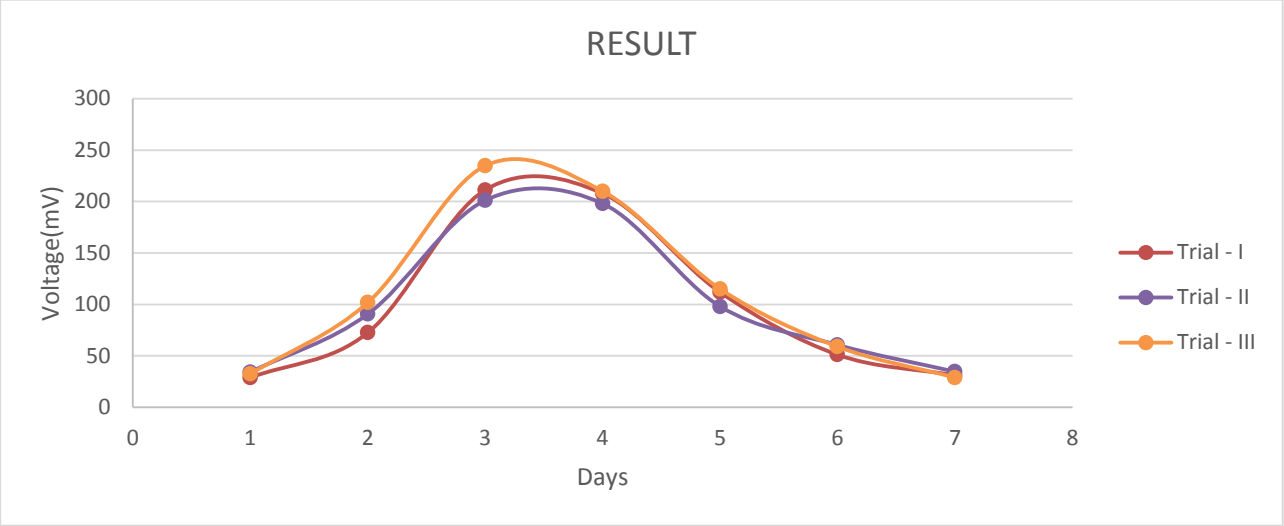

Fig. 6: Voltage generated versus time(Trial I, II, III)

In the experiment conducted by microbial fuel cell, with the distilleries wastewater in two chamber microbial fuel cell the maximum voltage generated was 234.8 mV (Table 2). Three trials were carried out with the one litter distillerieswastewater for the period of one week each. From the observation based on the three trials it can determined that the voltage generated from the distilleries wastewater was increased with time (Figure 6) and then it showed an gradual decrease in voltage due to unstable electro genic population. All the trails where carried out with salt bridge based Microbial Fuel Cell. For the voltage generation one liters of distilleries waste utilized in theSaltBridge based dual chamber Microbial Fuel Cell[8]. After a period of three days average voltage generated in the three trial was 213.57mV (Table 2), and then MFC showed gradual decrease in voltage during the remaining days of operation[9]. The drop in Voltage generation after three days of operation probably due to the restriction of stable electro genic population. Therefore the treated waste water from Microbial Fuel Cell shows good improvement in PH value of 8.25 which shows that activity of microbes where minimum when pH value is 6 or below. Moreover, a good reduction in BOD and CODTable 3.

4. Conclusion

In the currentstudy, an attempt was madeto use Industrial Wastewater in two chamber microbial fuel cell where salt bridge is used for transfer of electron. Therefore, wastewater from distillery where proven to generate electricity by using already present microorganism in the wastewater. As well as Microbial Fuel Cell can be combined with the existing wastewater treatment so that to generate electricity in initial wastewater treatment. As the study show, MFCs can be used as a standalone process to remove the organic compound. Industries shows better result in generation of electricity as well as the output characteristic of wastewater shows good reduction in organic waste and change in pH value as well as reduction in BOD,COD and total suspended solids. However, this technology is in research stage and more research is required [10] before Microbial Fuel Cell based on industrial wastewater can be made available for commercialization.

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