Treatment of Dairy Wastewater Using MFC Followed By Filtration And Aeration

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Abstract- *Microbial Fuel Cell (MFC) can replace conventional method of treatments efficiently. This paper represents MFC as a true technology that can be adopted in treating dairy wastewater. The basic object of this paper "Treatment of Dairy Wastewater using MFC Followed by Filtration and Aeration" is to find out the performance of two chambered MFC which has continuous supply of wastewater Milk Dairy wastewater is considered as a substrate component. Optimized components of experimental set up was developed by checking the performance of Zinc electrode for various detention times along with Agar NaCl normal salt bridge as a Proton exchange membrane. Zinc electrode consisting of 123.4 sqcm surface area was employed. Six hours detention time showed highest efficiency in treatment of wastewater introduced. The experiment was further continued by fitration along with aeration process where two hours aeration was noticed as a feasible time of treatment and for three hours aeration time maximum removal efficiency of COD, BOD, EC, TDS, and Oil and Grease were 90.65 %, 87.56 %, 86.96 %, 80.66 % and 84.28 % respectively .The results found proved that MFC have got capacity to replace conventional methods along with synthesis of energy.*

Keywords- Microbial Fuel Cell, Dairy wastewater, Agar NaCl Salt Bridge, Zinc Electrode, Filtration, Aeration.

I. INTRODUCTION

Modernization, urbanization, industrialization and population growth is leading to increase in the demands of energy in day to day life. Fossil fuels are being extracted to meet the demand, but they have their own ill impacts when utilized in excess, on environment by the liberation of carbon di oxide gases. To avoid such ill impacts one has to find out new methods to meet the required demands. Non conventional energy sources like solar, wind and tidal provides an uninterrupted supply of materials required for generation of energy. Now a day's more research works are being carried out on generation of energy from biomass. Huge amount of biomass is generated from sewerage waters and industrial wastewaters. This can be employed in generation of energy along with treatment. Bio Electrochemical System (BES) can be employed in generation of current by using bacterial actions. Without providing any energy as input it works as Microbial Fuel Cell leadind to both treatment and energy generation process.

It is important to examine the probability of choosing various substrates and electrodes for improving the analysis to a large extent and now an effort is made to investigate the impact of MFC with dairy industry effluent for distinct detention time, Zinc electrodes and impacts of filtration along with aeration process. Possibility of microbial cells in treating of Dairy wastewater is analyzed for every single variable intrigue and an endeavor is made to know the perfect components. Other than treatment of the waste, MFC electrical qualities are considered in the generation of electric current and power.

II. HISTORY

In 1911 Potter was the first to find out the degradation of organic substance and generation of electrons from ERB (Electrode Respiring Bacteria). He identified that disintegration of organic substance by microbes was followed by discharging of electrons. It depends on various factors say temperature, pH, concentration of nutrients and active microbes. After 1999 an effort was applied to increase power generation from MFC's and it was found successful. It was noticed that for larger area cathodes the generation of power reached up to 6.9 Wm^{-2}.

By employing metals as catalysts, fuel cells works as substitute source of energy. BES consists of microbial fuel cells which in an anaerobic condition convert chemical energy into electrical energy by microbial activities. Generation of energy along with treatment is the main advantage of MFC technology. The methane gas produced during process is off gas and causes no harm.

To generate high voltage current MFC's can be operated under different conditions of, say pH, size of reactor, time of operation, electron acceptor, electrodes surface area.

Components of MFC are Anode, cathode compartments, salt bridge, electrodes, substrate, digital multimeter, and copper wire. Anaerobic unit is anode and cathode is aerobic unit. Separation of both chambers is achieved by placing Proton Exchange Membrane which helps in transfer of Hydrogen ions from anode to cathode.

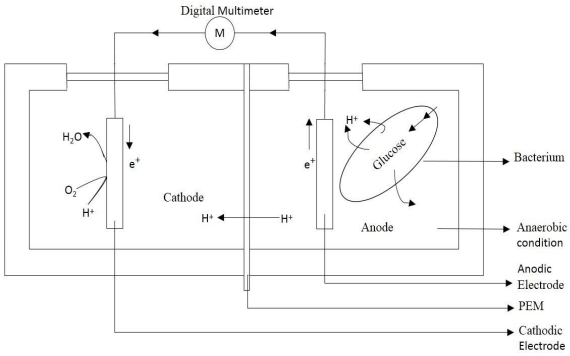


Fig: Dual Compartment Microbial Fuel Cell

Usually Agar salt bridge is used as PEM. Digital multimeter is used to connect electrodes externally.

The energy required for microbes to degrade organic matter is obtained two steps. Electrons are released by degration of organic matter in first step whereas in second these are reduced in cathode to form Oxygen or Nitrogen.

Anodic reaction:

$C_{12}H_{22}O_{11} + 13H_2O \longrightarrow 12CO_2 + 48H^+ + 48e^-$ (Oxidation).

Cathode reaction:

$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$ (Reduction)

The efficiency of MFC can be expressed interms of generation of current, power, voltages and by testing various parameters of the effluent collected at the outlet.

III. STUDIES AND FINDINGS

For both treatment and production of energy MFC was employed and it requires the following prerequisites for the development of cell. They are: Acrylic sheets for the development of anode and filtration chamber, Plastic container with half open lid as cathode chamber, pebbles for filtration, aeration chamber, air pump, Aspirator Bottles, Pinch clips to maintain flow rates, Zinc electrodes, Polyvinyl Chloride pipes, Copper wires, Flexible pipes, Digital multimeter with DT830 series.

Collection and Analysis of Wastewater

The effluent was collected from nearby Bathi Milk Dairy Davangere. After analyzing the initial parameters it was placed in refrigerator to avoid further microbial activity.

Development of Agar NaCl Bridge

Take 3gms of Agar and add it into the container having 50ml 1ml NaCl solution for dissolving. Now heat the container upto the formation of a uniform solution. Pour the mixture into a pipe having a diameter of about 2cm and length say 10cm. plaster on both ends in refrigerator to obtain uniform setting of mixture.

Table: Initial Characteristics of Dairy Effluent

Serial No.	Parameters	Results
1	COD (milligram/litres)	7380
2	BOD_3 (milligram/litres)	5430
3	EC @ 25^0 C (µs/cms)	752
4	pH	5.9
5	TDS (milligram/litres)	402
6	Oil and Grease (milligram/litres)	39.45

Preparation of Inoculums and seeding

Three liters of water was taken in anode unit into this 100ml of sample and 5gms of cow dung was added. It was kept for 7 days without disturbance. After that the substrate was introduced by replacing the initially added components.

Working Principle

To obtain uniform composition of wastewater the sample was kept was stirring for about 25mins using magnetic stirrer unit.

Aspirator bottles were used for introducing substrate. Agar NaCl bridge was used as PEM. Flexible pipes supplied the sample from botlles to anode unit. Plinch clips were used to maintain the flow rate. Anode was completely in anaerobic condition whole cathode was filled with distilled water to

provide aerobic condition. 5cm distance was maintained between PEM and electrodes.

using copper wire electrodes were connected to external circuit where mutimeter was placed. Digital readings of voltage in mV and current in micro amp were taken for every 30mins of duration of time and the treated effluent was collected and kept in fridge for further analysis.

Filtration along with diffused aeration was done for the effluent having high percentage of efficiency in treatment of wastewater. Aquarium air pump was used which had 3 l/min maximum output. Pebbles of 1-2 cm were used as filter media. Aeration was done at three different duration of time say 1hr, 2hr and 3hrs, after treatment the effluent was collected separately and tests were carried out to check the parameters by which efficiency of cell was defined. Efficiency interms of generation of power and energy was expressed in percentage.

IV. RESULTS AND DISCUSSIONS

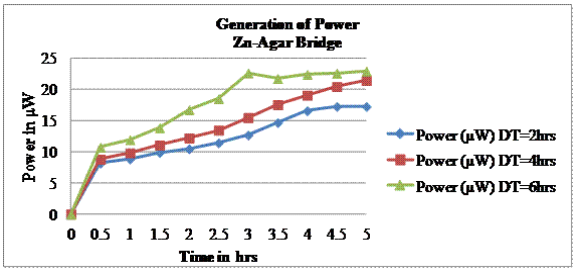
Zinc electrode of 12x5x0.1 cm having surface area of 123.4 sqcms was used as electrode in both anode and cathode compartment. PEM was developed by Agar NaCl salt bridge.

Table: Final Effluent Characteristics

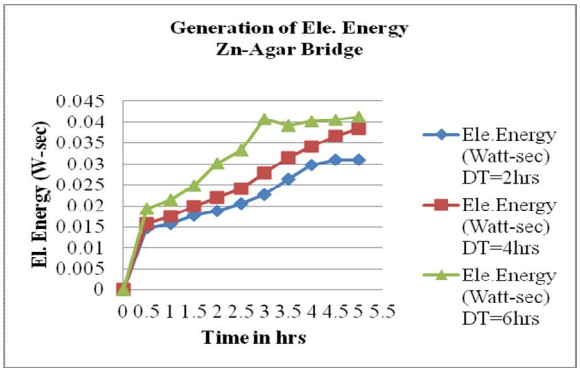
Parameter	Concentration and Efficiency of effluent at distinct DT					
	DT_1=2hrs		DT_2=4hrs		DT_3=6hrs	
	C_{eff}	η%	C_{eff}	η%	C_{eff}	η%
COD	3430	53.52	2400	67.47	950	87.12
BOD	2780	48.80	1780	67.21	1250	76.97
EC	325	56.78	268	64.36	129	82.84
TDS	228	43.28	149	62.93	73	81.84
Oil and Grease	18.83	52.26	15.08	61.77	9.08	76.98
pH	6.93		7.34		7.49	

From above Table it can be noticed that for DT=6hrs the maximum removal efficiency of the cell is observed and for DT=2hrs least removal efficiency is noticed. Maximum removal efficiency of COD, BOD, EC, TDS and Oil and Grease are 87.12%, 76.97%, 82.84%, 81.94% and 76.98% respectively.

Maximum voltage generation of current 409mV and 64 µA are found to be obtained for flow rate 0.651 lts/hr having 6hrs as DT. When detention time increases from 2 to 4 hrs maximum power generation was increased by 20mV and there was an increase of 64 mV of power generation when detention time got increased from 4 to 6hrs. Gradual increase in efficiency of treatment and generation of power and electrical energy is shown in Figure 4.1 and 4.2.The highest electrical energy generated was 0.0412272 Wsec and electrical power generated was 22.904 µW for DT = 6hrs.



Generation of Power (Zn- Agar NaCl Bridge)



Generation of Ele. Energy (Zn- Agar NaCl Bridge)

From the selected optimized experimental set up the effluent collected was further treated with filtration along with diffused aeration to note the parameters characteristic filtrated cs. The effluent collected was allowed to enter into the filtration chamber at the rate of 0.651lt/hr where it got filtered and entered into aeration chamber. Using aquarium air pump diffused aeration was carried out for three distinct intervals of time say one, two and three hours. The effluent was analyzed after every interval of time and the obtained values are tabulated in the Table below.

Filtration and diffused aeration have got good impact on treatment efficiency of effluent. From the above Table 4.19 for three hours aeration time maximum removal efficiency of COD, BOD, EC, TDS, and Oil and Grease are 90.65 %, 87.56 %, 86.96 %, 80.66 % and 84.28 % are observed. Compared to two and three hours AT there is no much changes in results obtained thus from the economic point of view adopt two hours aeration time.

Table : Impact of Filtration and Aeration on Treatment efficiency

Parameter	Concentration of effluent from MFC C_{eff}	η (%) of MFC	Concentration and Efficiency of effluent at distinct AT (Aeration Time)					
			AT_1=1hrs		AT_2=2hrs		AT_3=3hrs	
			C_{eff}	η%	C_{eff}	η%	C_{eff}	η%
COD	950	87.12	863	88.30	715	90.31	690	90.65
BOD	1250	76.97	920	83.05	750	86.18	675	87.56
EC	129	82.84	118	84.30	110	85.37	98	86.96
TDS	73	81.84	89	77.86	80	80.09	78	80.66
Oil and Grease	9.08	76.98	7.46	81.08	6.45	83.65	6.2	84.28
Ph	7.49	7.49	7.49		7.49		7.49	

V. CONCLUSIONS

- Microbial fuel cell proves itself to be successful in treatment and generation of power.
- Zinc proves to be a suitable electrode for MFC.
- Six hours detention is suitable for treatment as it has got high efficiency of removal as compared to two and four hours by employing Zinc electrode.
- For optimized experimental set up continued with filtration and aeration process the maximum efficiencies obtained in removal of COD, BOD, EC, TDS and Oil and Grease were are 90.65 %, 87.56 %, 86.96 %, 80.66 % and 84.28 % .
- Lastly it is concluded by saying MFC can replace conventional treatment methods of treating wastewater along with off grid energy generation. It can be adopted in treating dairy wastewater. Some of the changes have to be done to increase the efficiency of treatment and generation of energy say by increasing the area of electrode.

VI. ACKNOWLEDGMENT

The authors wish to acknowledge their sincere thanks for the lab facilities provided for their work in the Department of Studies in Civil Engineering, U.B.D.T College of Engineering, Davangere and also for the encouragement and assistance provided for the completion of project work.

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