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Performance Evaluation of MFC in Treating Dairy Wastewater and Electricity Generation Using Zinc and Copper Electrodes

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Abstract: *In present days BES (Bio Electrochemical System) is found as an alternative process for conventional methods of treatment of wastewater. Among BES Microbial Fuel Cell (MFC) is the most described one. It performs on the basis of metabolic activities carried out by microbes. Microbes can be both aerobic and anaerobic based on working conditions adopted. For detention time six hours, Agar NaCl Salt Bridge as Proton Exchange Membrane (PEM) electrodes Zinc and Copper maximum efficiency of treatment of Dairy wastewater which was employed as substrate component. The maximum efficiencies obtained by Zinc and Copper electrodes for COD 87.12%, 71.74%, BOD 76.97%, 67.60%, EC 82.84%, 49.73%, TDS 81.94%,43.78% and Oil and Grease are76.98%,68.87% respectively. Since Copper is good conductor of electricity the electrical properties obtained by employing Copper as electrode is more as compared with that of Zinc electrode. The maximum power and electrical energy generated from Zinc and Copper are power22.904 µW, 55.118 µW ad electrical energy 0.0412272 Wsec, 0.0992124 W-sec respectively.*

Keywords: *Microbial Fuel Cell, PEM, Zinc and Copper electrodes, Agar NaCl Salt Bridge.*

1. INTRODUCTION

India is one of the developing countries which is facing energy crisis due to developments achieved in industrial area as well population growth and modernization of life style. Other fact is huge amount of wastewater is generated from industries which is burden on treatment units, pollution and disposal problems. Thus there is a need to find a new technology which treats as well produce off grid energy generation besides conventional methods which requires large amount of funds. MFC is one such technology which performs promisingly in treatment as well as generation of energy. But still is its infancy stages and need to be adopted for large scales with required modifications that are found to be necessary for betterment output obtained.
In this experiment MFC is supplied with dairy effluent as substrate where it treats efficiently and proves it as an alternative technology for conventional methods.

2. LITERATURE REVIEW

Nurettin et al., (2017) examined the impact of using Zinc as electrode in MFC's. The experimental part included Zinc as anode and graphite as cathode. Maximum power density obtained was 5.33 Wm^{-2}. But there was formation of corrosion on the surface of Zinc caused due to biological and electrochemical reactions. From the experiment conducted it was finalized that Zinc acts as a promising anode electrode in MFC's. [12]. **Drisya. C. M. and Manjunath. N. T** (2017) have carried out an experiment on treatment of dairy industrial wastewater along with generation of electric current by utilizing MFC. The experiment was carried out by employing distinct electrodes, surface area and detention time. For stainless steel having surface area of 15x5x0.1 cm at six hours detention time, maximum electrical energy and power generated was 0.0677 Wsec and 37.651 µW respectively. Efficiency in removal of COD, BOD, EC, Oil and grease and TDS was 93.98%, 90.63%, 73.06%, 83.82% and 72.66% respectively. From the experiment it was incurred that MFC is efficient in treating dairy industry wastewater.[4]. **Anand Prakash** (2015) developed a two chambered MFC to generate voltage by considering biowaste as substrate. The study was carried out to know the molar concentration impact of salt bridge and yeasts Saccharomyces cerevisae, Hansenula anomala on efficiency of MFC. The experiment was conducted for 96hrs having 1M KCl as salt bridge. The results obtained were 1.9 mV by Hansenula anomala and 1.4 mV by Saccharomyces cerevisae. By this it was conferred that MFC can transfer chemical energy into electrical energy efficiently and can replace fossil fuels as source of energy. [2]. **Ganesan Vijiyan Siva et al.,** (2015) using grape waste extract as substrate and electrodes namely Magnesium, Copper, Zinc and Graphite a single compartment MFC was constructed with or without mediators influence like neutral red, thionine and toludine blue was considered in study. For Magnesium electrode and thionine as a mediator the maximum volt reading of 2.5 V was noticed. while for neutral red it was 2.2 V and for toludine blue it was 2.35V. Graphite as cathode and Magnesium as anode is the most suitable combination of electrode was the conclusion. [5].

3. MATERIALS AND METHODOLOGY

For both treatment and production of energy MFC was employed and it requires the following prerequisites for the

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development of cell. They are: Acrylic sheets for the development of anode chamber, Plastic container with half open lid as cathode chamber, Aspirator Bottles, Pinch clips to maintain flow rates, Zinc and Copper electrodes, Polyvinyl Chloride pipes, Copper wires, Flexible pipes, Digital multimeter with DT830 series.

3.1 Development of Salt Bridge

Materials required for developing normal salt bridge are 250ml capacity container., Extra pure Sodium Chloride, Poly vinyl pipes, Stirrer, Agar.

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.

3.2 Sample Collection and Working Principle

The effluent was collected from Bathi Dairy, Davangere. Initial parameters were tested and then refrigerated to avoid degradation of organic matter. Dairy effluent is highly organic in nature.

Table 1: 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

Table 1 shows the initial effluent characteristics obtained from analyzing.

Seeding is done by utilizing cow dung of 5gms and inoculums are prepared. Anode is kept in anaerobic condition by proper packing. After 7 days of seeding remove the excess seed from anode and substrate is introduced through flexible pipes. Aspirator glass bottles are used for continuous supply of substrate. Pinch clips are used maintain flow rate to achieve desired detention time. Electrodes are kept at 5cm distance from salt bridge. Copper wire is used to connect electrodes to digital multimeter which shows current and volt generated. Take readings for every half an hour.

Figure 1: Electrodes used in MFC

Figure 1 shows picture of Copper and Zinc electrodes. It seen that Copper is fully corroded where as Zinc just started to corrode.

4. RESULTS AND DISCUSSIONS

Zinc and Copper electrodes 12x5x0.1 cm size having surface area of 123.4 sqcms was used as electrodes in both anode and cathode compartment. PEM was developed by Agar NaCl salt bridge. Detention time maintained was six hours having flow rate of 0.651lt/hr.

Table: 2 Final Effluent Characteristics

Parameter	Zinc		Copper	
	C_{eff}	η%	C_{eff}	η%
COD	950	87.12	2085	71.74
BOD	1250	76.97	1759	67.60
EC	129	82.84	378	49.73
TDS	73	81.84	226	43.78
Oil and Grease	9.08	76.98	12.28	68.87
Ph	7.49		7.48	

Table 2 shows the final effluent characteristics obtained by treating dairy wastewater by employing Zinc and Copper electrodes. 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 was obtained for zinc and for Copper it is 71.74%, 67.60%, 49.73%, 43.78% and 68.87% are the removal efficiencies obtained for COD, BOD, EC, TDS and Oil and Grease respectively. There is less efficiency for Copper when compared to Zinc this is because of corrosion problem in Copper.

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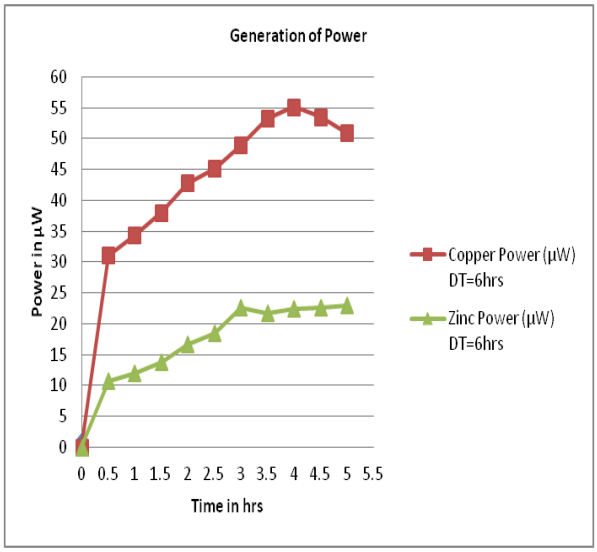

Figure 2: Generation of Power

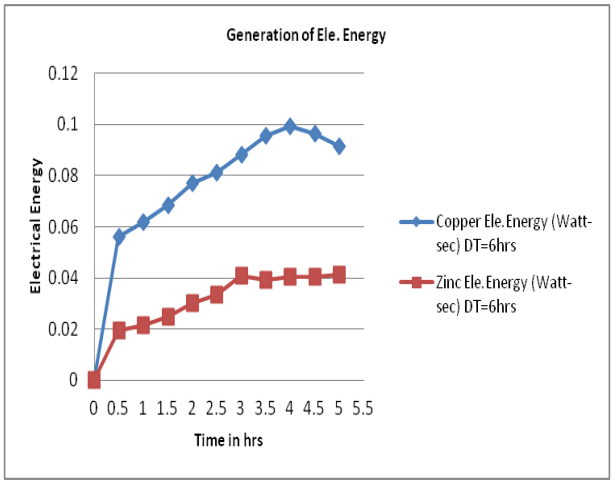

Figure 3: Generation of Electrical Energy.

Figure 2 and 3 shows the power and electrical energy generated using Zinc and Copper Electrodes. Since Copper is good conductor it produces more power and energy when compared to Zinc. The highest electrical energy generated for zinc was 0.0412272 Wsec and electrical power generated was 22.904 µW for DT = 6hrs and for copper it is Highest power and energy generated was 55.118 µW and 0.0992124 W-sec for detention time of 6hrs.

5. CONCLUSIONS

Following are the conclusions obtained from the experiment conducted,

- Microbial fuel cell proves itself to be successful in treatment and generation of power.
- Antimicrobial nature and corrosion are the drawbacks of Copper even though it's a very good conductor.
- Both in cost wise and efficiency wise Agar Bridge is best choice when compared with other bridges.
- Six hours detention is suitable for treatment as it has got high efficiency of removal as compared to two and four hours by employing Copper and Zinc electrodes.
- For optimized experimental set up the maximum efficiencies obtained for in removal of COD, BOD, EC, TDS and Oil and Grease were 71.74%, 67.60%, 49.73%, 43.78% and 68.87% and for Zinc it is are 87.12%, 76.97%, 82.84%, 81.94% and 76.98% respectively.
- From the above results it is concluded that MFC can treat dairy wastewater along with generation of energy.
- Corrosion problem can be overcome by employing corrosion resistant metal as electrode or by providing corrosion resistant coating to copper.

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WINGS TO YOUR THOUGHTS.....

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