Generation of Electricity Using Paper Waste Water by Microbial Fuel Cell
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Abstract— The application of microbial fuel cell (MFC) for electricity generation has been developing recently. This research explores the application of single chamber MFC in generating electricity using paper wastewater. The different concentration of wastewater has been performed. The maximum current, voltage, BOD, COD, pH and TDS obtained with respect to time. MFC of paper mill wastewater showed removal efficiency 68.1% COD, 67.3% BOD and 56.6% TDS with different feed concentration. The current, voltage and power generation in the reactor is 1.40mA, 1.24 V and 0.46 watts/m² respectively.

Key words: Microbial Fuel Cell (MFC), Paper waste water, Energy Recovery.

I. INTRODUCTION
Rapid urbanization and industrialization in the developing countries like India pose severe problems in collection, treatment and disposal of effluents. This situation leads to serious public health problems. Unmanaged organic waste fractions from industries, municipalities and agricultural sector decompose in the environment resulting in large scale contamination of land, water and air. These wastes not only represent a threat to the environmental quality but also possess a potential energy cane crushed. Because of high value which is not fully utilized despite the fact that they are cheap and abundant on most parts of the world.

With the continued increased consumption of paper products and other natural fiber products, the recycling and use of recovered paper is growing worldwide. The strength of wastewater in a paper production plant generally increase with the percentage of production content. Thus, an increase in the amount of paper produced will lead to increased energy demands for wastewater treatment using conventional treatment processes. In addition, this wastewater contains soluble organics and particulate matter such as cellulose which are not effectively degraded by traditional wastewater treatment technologies.

One new promising method for wastewater treatment is the use of microbial fuel cells (MFCs).

Microbial fuel cells (MFC) are unique devices that can utilize microorganisms as catalysts for converting chemical energy into electricity, representing a promising technology for simultaneous energy production and wastewater treatment. MFCs have wider applications including wastewater treatment, production of electricity, bioremediation, hydrogen production, and as environmental sensors. MFCs have been used to treat various kinds of wastewater such as domestic sewage, brewery, distillery, sugar, paper and pulp, rice mill, swine wastewater and phenolic wastewater. An additional advantage of using MFCs for wastewater treatment is the potential for reducing solids production compared to aerobic processes.

II. MATERIALS AND METHODOLOGY
Wastewater collection: Wastewater is collected from nearby paper industry.

A. Microbial Fuel Cell (MFC):
Single (MFC) Microbial fuel cells have been fabricated for the treatment of paper industry wastewater.

1) Materials used for the fabrication of MFC:
Various materials used for the construction of MFCs were as follows:
- Three Non-Reactive plastic boxes of seven liters capacity
- Agar
- Pencil leads 2mm Diameter
- Copper wire
- PVC pipe 2cm Diameter
- Sealants
- Multimeter

Functions of the materials used for the fabrication of MFC:
- Plastic boxes: are used to prepare anode and cathode chambers. The anode chamber holds the wastewater and the cathode chamber holds a conductive salt solution.
- Agar: It is used to prepare agar salt bridge i.e., proton exchange member for keeping the anode and cathode liquid separate. This membrane is permeable so that protons produced at anode can migrate to the cathode.
- Pencil leads: These are used as anode and cathode materials.
- Copper wire: is used to connect the electrodes to the multimeter which form external circuit.
- PVC pipe: holds the agar salt mixture, which is called as agar salt bridge.
- Sealant: PVC pipe was connected to the sides of the plastic boxes and sealed with epoxy.
- Multimeter: is used to measure the current and voltage.

2) Construction of Microbial Fuel Cell
Step 1: Selection of Anode Chamber
Non-reactive, non-conductive and non-biodegradable plastic box were selected as anode chambers the dimensions of plastic box are shown in figure

[Diagram of anode chamber dimensions]
Fig. 1: Plastic box. (All dimensions are in cm)

Step 2: Preparation of Agar Salt Bridge

The Agar salt bridge was constructed using common salt, agar and water. 650 ml of water was boiled in a beaker, 65 grams of agar and 75 grams of salt were added to the boiling water, and the mixture was further boiled for 3-5 minutes.

The mixture is placed in PVC pipe and allowed to solidify and was kept in the refrigerator for 24 hours.

Step 3: Assembling Of Electrodes

The graphite rods from pencils have been used as anode and cathode materials. The arrangement of electrodes were done on a plastic pipe in such a way that it looks like a graphite brush as shown in fig 2. The length and diameter of the graphite rods will be 90 mm and 2 mm respectively.

In MFC, there was no cathode chamber. Instead, the graphite rods from pencils have been placed on agar salt bridge and the copper wire was wound on it. This acted as cathode for MFC. The oxygen in air would help in accepting the electrons from anode chamber. Hole was drilled on the top of anode chamber so that plastic pipe containing the graphite rods can pierce through the hole.

Fig. 2: Arrangement of Electrodes

Step 4: Assembling Of Microbial Fuel Cell

MFC reactor was constructed as shown in fig 3. The assembled electrodes were placed into the anode and cathode chambers, a circular groove was made at the centre of plastic box for fitting the PVC pipe containing agar salt then sealed and made air tight. The reactors are checked for water leakage.

Fig. 3: Single chamber MFC

III. RESULTS AND DISCUSSION

A. General

The characteristics of sugar and paper wastewater and the experimental data relating to single chambered microbial fuel, double chambered microbial fuel cell are discussed in this chapter.

B. Characteristics of Sugar And Paper Wastewater

The characteristics of sugar and paper wastewater are presented in table 1.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Characteristics</th>
<th>Unit</th>
<th>Paper Wastewater</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ph</td>
<td></td>
<td>7.5</td>
</tr>
</tbody>
</table>

Table 1: Characteristics of sugar and paper wastewater

C. Treatment and Current Generation Using Various Concentrations of Paper Wastewater in MFC

Paper wastewater diluted to get desired feed concentrations. The varied feed concentrations of wastewater were given as the substrate for MFC.

The influent(I), effluent(E) and percent removal(%) of chemical oxygen demand, Total dissolved solids and Biochemical oxygen demand for various feed concentrations for MFC are presented in tables below.

Table 2: Treatment efficiency of paper wastewater and current generation for various feed concentration in MFC

Paper wastewater showed its potential for COD removal indicating the functions of microbes present in wastewater in metabolizing the carbon source as electron donars. Continuous COD,BOD,TDS removal was observed. In the COD removal efficiency increased from 36.1% to 68.1% , BOD removal efficiency increased from 34.2% to 67.3% TDS removal efficiency increased from 26.1% to 56.6% and pH increased from 6.8 to 8.5 randomly as the feed concentration increases from 200 mg COD/L to 2200 mg COD/L.

Current increased from 0.20 to 1.40 mA, Voltage increased from 0.16 to 1.24 V as the feed concentration increases from 200 mg COD/L to 2200 mg COD/L.

D. COD Removal Efficiency of Paper wastewater for Various Feed concentrations

Paper wastewater showed its potential for COD removal indicating the functions of microbes present in wastewater in metabolizing the carbon source as electron donars. It is experimental data that current generation and Cod removal showed relative compatibility. Continuous COD removal was observed, the COD removal efficiency increased from 36.1% to 68.1% as the feed concentration increase from 200 mg COD/L to 2200 mg COD/L respectively as shown in fig 4.

The COD removal efficiency improved with the increase in feed concentration. COD efficiency for various
feed concentrations has been attained equilibrium after 4-5 days with respect to time.

Fig 4: COD Reduction of paper wastewater at Various Feed concentrations

E. BOD Removal Efficiency of paper wastewater for Various Feed concentrations

The BOD of paper wastewater was reduced in MFC. BOD was analyzed on the first day and final day for each feed concentration. For MFC, the BOD removal efficiency increased from 34.2% to 67.3% as the feed concentration increased from 200 mg COD/L to 2200 mg COD/L respectively as shown in fig 5.

BOD efficiency for various feed concentrations has been attained equilibrium after 4-5 days with respect to time.

Fig 5: BOD Reduction of paper wastewater at Various Feed concentrations

F. Total Dissolved solids Removal Efficiency of paper wastewater for Various Feed concentrations

During the operation considerable reduction in total dissolved solids increased with increase in feed concentration from 200 mg COD/L to 2200 mg COD/L. The total dissolved solids the BOD removal efficiency increased from 26.1% to 56.6% as the feed concentration increased from 200 mg COD/L to 2200 mg COD/L respectively as shown in fig 3.8

Total dissolved solids efficiency for various feed concentrations has been attained equilibrium after 4-5 days with respect to time.

Fig 6: TDS Reduction of paper wastewater at Various Feed concentrations

pH Variation of paper wastewater for Various Feed concentrations

Paper wastewater showed its potential for increments of pH. Continuous increment was observed in MFC, the pH increased from 6.8 to 8.5 as the feed concentration increased from 200 mg COD/L to 2200 mg COD/L respectively as shown in fig 7.

The increment of feed concentration showed a positive effect in increment of pH. pH variation for various feed concentrations has been attained equilibrium after 4-5 days with respect to time. pH was bought to neutral daily.

Fig 7: pH Variation of paper wastewater at Various Feed concentrations

G. Current and voltage Generation of paper wastewater for various feed concentrations

The average value of current and voltage for each feed concentration in MFC is given in the fig 8 and fig 9. The current and voltage showed a gradual increase with respect to increase in feed concentration. The highest average values of current obtained 1.40mA and 1.24V. The power produced for 1m² area is watt. Current and voltage generation for various feed concentrations has been attained equilibrium after 4-5 days with respect to time.

Fig 8: Current Generation of paper wastewater at various feed concentrations

Fig 9: Voltage Generation of paper wastewater at various feed concentrations

IV. CONCLUSION

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

- MFC of Paper industry wastewater showed 68.1% COD, 67.3% BOD and 56.6% TDS with different feed concentrations.
- The current, voltage and power generation in the reactor is 1.40 mA, 1.24 V and 0.46 watts/m² respectively.
- pH was increased randomly from 6.8 to 8.5.

REFERENCES