Treatment of slaughterhouse wastewater using microbial fuel cell

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ABSTRACT

Increasing human activities are consuming the natural energy sources leading to depletion of fossil fuels. The present-day energy scenario in India and around the globe is precarious. The need for alternate fuel has us to initiate extensive research in identifying a potential, cheap and renewable source for energy production. Proper treatment of animal waste and resource recycling to reduce its environmental impact is currently important issues for the livestock industry. Slaughterhouse wastewater contains organic matter available for microbial energy recovery. Hence it is an ideal solution for treatment of slaughterhouse wastewater and energy recovery. A microbial fuel cell is expected to play two roles in both wastewater purification and energy recovery. It is a device that converts chemical energy into electricity through the catalytic activities of microorganisms. It also breaks the organic matter present in the wastewater by degrading into less harmful forms. The results demonstrated that the organic matter removal efficiency of MFC using copper electrode was 80.2% and the maximum amount of electricity generation is 2.10 Volts and Copper is the suitable electrode for maximum electricity generation and maximum organic matter removal.

Keywords— Microbial fuel cell, Slaughterhouse wastewater, Wastewater treatment, Electricity generation

1. INTRODUCTION

Global energy demand is increasing. Problems of pollution and global warming associated with petroleum products are acting as a major impetus for research into alternative renewable energy technologies. The proper treatment of slaughterhouse wastewater to reduce its environmental impact is also an important issue for the livestock industry (Jeffery et al., 2009). It contains organic matter available for microbial energy recovery. Reducing the COD value in it is necessary for its purification. Microbial fuel cells offer a possible solution to this problem. MFC treatment can reduce the COD in the wastewater by degrading the organic matter (Liu et al., 2004). Microbial fuel cells seek to add the diversity of microbial catalytic abilities to this high-efficiency design, allowing the waste organic matter to be converted into electricity (Wingard et al., 1982). They are an alternative to conventional methods of generating electricity, for small-scale applications (Bennetto, 1990). Microbial fuel cells have the potential to generate electricity from organic wastes while oxidizing into less harmful forms (Moon et al., 2006). Thus MFC technology plays two roles: wastewater purification and energy recovery (Yokoyama et al., 2006). Microbial fuel cell usually comprises four major components– anode compartment, a cathode compartment, proton exchange membrane, and the electrodes. Anode compartment forms the biological compartment of MFC, as it consists of microbes either pure/mixed form (Bond and Lovely, 2003, 2005; Chaudhuri and Lovely, 2003), which oxidizes the organic substances in the wastewater and release free electrons. The bacterial growth in this chamber produces the necessary protons and electrons through metabolic reactions. The cathodic compartment is the abiotic compartment of MFCs where the released electrons (from anode) are transferred to oxygen as a terminal acceptor. The ion exchange membrane helps in the transfer of protons from the anode compartment to the cathode compartment and helps to physically block oxygen diffusion into the anode chamber (Chae et al., 2008). Hence it is generally called proton exchange membrane (PEM). Commonly used proton exchange membranes are Nafion or Ultrex. Since PMs are costly, here we have used salt – bridges to maintain electro-neutrality and allow current to flow (Brook et al., 2005). The salt bridge contains a saturated solution of some inert salt, usually sodium chloride. The salt is chosen specifically to be inert based on the rest of the reagents. The major role of electron transfer is due to electrodes Some commonly used electrodes are carbon rod, carbon/graphite sheet (Venkatamohan et al., 2008), stainless steel, glassy carbon etc.

2. MATERIALS AND METHODS

2.1 Collection of wastewater

Slaughterhouse wastewater was collected from Kalanivasal slaughterhouse, Karaikudi municipality, Sivaganga District, Tamilnadu (India).

2.2 Fabrication of reactor

A two-chambered fuel cell was constructed. Two plastic containers each with a diameter of 75 mm were taken and
marked as the cathodic and anodic chamber. Two holes of diameter 7 mm and 2 mm were made on each of lids for the insertion of salt-bridge and electrodes as shown in Figure(1). Salt-bridge was made with 5 mm diameter U-tube. The salt-bridge contained 3% Agar. The mixture was sucked into the U-tube. This salt-bridge was inserted into both the containers through one hole on both containers. Copperplate with a size of 5 cm X 5 cm used as electrodes to collect the electrons in both anode and cathode with copper wire connections. Stainless steel plate of 5 cm X 5 cm and Mild steel plate of 5 cm X 5 cm were also used as electrodes. These electrodes were relatively inexpensive and easily available. The electrodes were first soaked in 100% ethanol for 30 min. After this electrode was washed in 1M Hydrochloric acid followed by 1M Sodium hydroxide, each for 1 hour to remove possible metal and inorganic contaminations and to neutralize them. They were then stored in distilled water before use.

![Fig. 1: Schematic Diagram of the MFC](Image)

**Table 1: Initial characteristics of slaughterhouse wastewater**

<table>
<thead>
<tr>
<th>S. no</th>
<th>Characteristics</th>
<th>Unit</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>-</td>
<td>7-8</td>
</tr>
<tr>
<td>2</td>
<td>TS</td>
<td>mg/L</td>
<td>2350</td>
</tr>
<tr>
<td>3</td>
<td>TSS</td>
<td>mg/L</td>
<td>1510</td>
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<tr>
<td>4</td>
<td>TDS</td>
<td>mg/L</td>
<td>840</td>
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<tr>
<td>5</td>
<td>VSS</td>
<td>mg/L</td>
<td>2110</td>
</tr>
<tr>
<td>6</td>
<td>FS</td>
<td>mg/L</td>
<td>240</td>
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<tr>
<td>7</td>
<td>Alkalinity</td>
<td>mg/L</td>
<td>550</td>
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<tr>
<td>8</td>
<td>Chlorides</td>
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<tr>
<td>9</td>
<td>BOD</td>
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<tr>
<td>10</td>
<td>COD</td>
<td>mg/L</td>
<td>1131</td>
</tr>
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</table>

3.2 Organic matter removal efficiency of various electrodes

Organic matter removal efficiency Microbial Fuel Cell increases with time of operation and the maximum removal efficiency is obtained for various electrodes. The maximum removal efficiency of Microbial Fuel Cell was obtained at a certain time interval and after that, a decrease in removal efficiency is observed. This decrease in efficiency may be decreases in the concentration of microorganisms in the anaerobic chamber. The efficiency of organic matter removal efficiency for various electrodes shown in Figure 2.

![Fig. 2: Organic matter removal efficiency of various electrodes](Image)

3.3 Electricity generated using various electrodes

The Electricity generated using Microbial Fuel Cell increase with the time of operation and the maximum amount of electricity generated by various electrodes was obtained. Electricity generated by various electrodes shown in Figure 3.

![Fig. 3: Electricity generated by various electrodes](Image)

4. CONCLUSION

Slaughterhouse wastewater can be treated using Microbial fuel cell technology. It also used to generate electricity. MFC yielded the maximum amount of Organic matter removal efficiency 80.19% using copper as an electrode and as well as
the maximum amount of electricity generation 2.10 V. The construction of MFC is easy with the utilization of Salt-bridge instead of Proton exchange membrane is more economical, cost-effective and easily available. These results revealed that MFC could be a sustainable approach for Simultaneous wastewater treatment and power generation using copper electrode is more efficient.

5. REFERENCES


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