Effective Utilization of Cow Dung with Distillery Waste Water as Substrate in Microbial Fuel Cell for Electricity Generation

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Abstract
Pakistan facing serious problem of electricity couple with handling of waste water generated from industries. In this regard study was focused to investigate the reduction of waste water from industry couple with energy generation from that source. Different blending ratio of cow dung manure was used with distillery waste water to make substrate for electricity generation in microbial fuel cell. Microbial fuel cell was used alternative environment for anode and cathode chamber. An aerobic condition for anode and aerobic condition for cathode chamber, fish pump is used for creating aerobic condition in cathode chamber for oxidation of proton coming from anode chamber through salt bridge. The maximum power production was measured at 50/50 about 2300 mv/l and minimum 230mv/l. The addition of cow dung manure could benefit for power generation with distillery waste water.

Key words: Cow Dung Manure; Distillery Waste Water; Power Generation; Microbial Fuel Cell

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INTRODUCTION
Microbial Fuel Cell (MFC) is a bio-electrochemical reactor in which electro-active bacteria convert the energy stored in various chemical substrates, into electricity (Bennetto et al., 1983). Several factors are influencing the overall MFC performance and complex mathematical models have been proposed to describe these systems (Fang et al., 2013). The MFC technology is a sustainable way of producing energy, which has been used in a variety of applications, the most common of which include treating wastewater and nutrient recovery (Kim et al., 2015; Rabaey and Verstraete, 2005). It was also shown that urine can be successfully treated in MFCs (Ieropoulos et al., 2012), and in some other examples, H₂ production has been reported (Liu et al., 2005). Treating urine in MFCs was recently scaled up to pilot scale (Ieropoulos et al., 2016). Our studies showed that power was sufficient to power LED lights and that urea was not contributing to the generation of power. So far, successful transformation of urea into electrical energy was only demonstrated in conventional fuel cells, including solid oxide fuel cells (Cinti and Desideri, 2015). An interesting example of a hybrid technique using MFCs was described by Chen et al. (2013) who reported an electro-dialysis system, consisting of an MFC used for alkali production and demonstrated its use for biogas upgrading. Bioelectric-chemical systems (BESs) can also be employed to techniques for sustainable synthesis of chemicals in a process known as microbial electro-synthesis (Rabaey et al., 2011), as well as for the recovery of valuable metals by reduction on the anode surface as demonstrated by (Wang et al., 2013). The cathodic reactions may also lead to the removal of toxic hexavalent chromium as reported by Xafenias et al. (2015). Regardless of the design and application, the essential parts of every MFC are the anode and the cathode. These elements determine the overall performance of the MFC and both are susceptible to dynamic changes taking place during their operation. These changes include increasing the biofilm thickness as well as precipitation.
and adsorption of chemical compounds on the electrode surface (Malvankar et al., 2012; Rismani-Yazdi et al., 2008). The present work explains the growth with saccharomyces service and cow dung manure contain organism.

MATERIALS AND METHODS

Materials

Microorganism

Yeast *S. cerevisiae* M-9 (Shah, 2010) was purchase from local market with analytical grade. Inoculums of yeast were prepared from following composition with 250 ml medium which contained in g.l-1: glucose, 10; (NH₄)₂HPO₄, 0.64, and yeast extract 2.5; at pH 5.5 and incubated for 18 h on an orbital shaker at 150 rpm at 30°C. Above composition of inoculum were inserted into anode chamber for degradation of organic matter couple with different operational condition.

Distillery effluent characteristic

Distillery effluent were collected from Al Abbas distillery plant and analyzed given in table 1.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Average value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>3.99</td>
</tr>
<tr>
<td>Colour</td>
<td>Dark Brown</td>
</tr>
<tr>
<td>BOD3 (mg/L)</td>
<td>36666</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>89833</td>
</tr>
<tr>
<td>Total Solids(mg/L)</td>
<td>74033</td>
</tr>
<tr>
<td>Dissolved Solids (mg/L)</td>
<td>59733</td>
</tr>
<tr>
<td>Chlorides (mg/L)</td>
<td>6933</td>
</tr>
<tr>
<td>Conductivity (mS/cm)</td>
<td>20.2</td>
</tr>
</tbody>
</table>

Cow dung manure

Cow manure, known also as cow dung, is the feces of the bovine species. These species includes the cow, buffalo, ox, and bullock. Cow dung is basically the digested residues of herbs and other plants that they eat. The resultant fecal matter is rich in minerals. Color of the manure ranges from greenish blackish and sometimes it turns yellow due to chemical changes, fastened by sunlight.

Methodology

Configuration of MFC

The H-shaped MFCs were fabricated with two polycarbonate bottles (500 mL) as chambers and a PVC pipe (5 cm × 1 cm) for preparing a salt bridge. The slat bridges were prepared by filling boiled sodium chloride (10 %) solution containing 5 % agar. The salt bridges were fixed to the bottles with the aid of epoxy adhesive. The electrodes were inserted into respective chambers while circuit connections were set with the copper wires fixed into the drilled holes of the electrodes and sealed with epoxy resin to avoid corrosion of copper wire (Kim et al., 2002; Zou et al., 2007). The fabricated MFCs were sterilized with Ethanol (70 %) and irradiated with UV for 15 min. The electrolytes were added up to the brim of the respective chambers to maintained air free condition.

Preparation of anode and cathode chamber

Two chambers were prepared with carbon electrodes, aerobic condition were maintained in cathode and anaerobic in anode. The air fish pump was used for oxidation of proton coming from anode to cathode chamber for water formation. Under different PH of anode chamber were maintained for power generation to make best condition for microbial growth in MFC. Cathode chamber were maintained with aerobic condition for promoting proton coming from anode chamber for oxidation.

Preparation of salt bridge

Salt bridge was prepared from different salt such are NaCl KCI and agar salt for making gel like membrane for transferring of proton from anode to cathode chamber. salt bridge. Different agarose concentration were utilized for optimal energy generation as discussed by (Jatoi et al., 2016a; Jatoi et al., 2016b).
Running of MFC
Distillery effluent and cow dung manure were added at different ratio of blends in anode chamber under anaerobic condition with inoculums prepared for growth of *saccharomyces cerevisiae* as biocatalyst for utilizing organic matter for bio-generation of electricity. Cathode chamber were maintained by salt water under aerobic condition with addition of oxygen by fish pump to promote oxidation of proton coming from anode chamber. Electron transferred occurs with installing carbon electrode through external resistance.

**Figure 1:** Typical MFC Camera View

**Figure 2:** Basic operation of MFC

Analysis of MFC

**pH**
In MFC different parameter were analyzed during experimental work. pH were analyzed using pH meter to set the desired condition for microbial growth, because if the pH increases above the 8.5 and below the 6 there will be effect on microbial growth in MFC.

**Oxygen flowrate**
Oxygen flow rate were analyzed with the help of flow meter to know about the oxygen enter in the MFC cathodic chamber, because we make cathodic chamber aerobic condition.

**Voltage generated**
Current was analysed by using multimeter, different concentration and pH were used to saw the behavior of the system, at what concentration and pH had maximum output of power generation. Voltage was continuously measured by a multimeter with a data acquisition system. Current (I) was calculated from the voltage (V) by \( I = \frac{V}{R_e} \), where \( R_e \) is the external resistance. Power (P) was calculated as \( P = IV \) (Wei et al., 2012).
RESULTS AND DISCUSSION

During running of MFC different process parameter effect on electricity generation. different parameter of MFC were tested and analyzed. Voltage generation from MFC were measured by volt meter and current, current density, power, power density were calculated by following relation.

\[ P = VI \]

Power density = power/ area of anode
Current density = current generated/ area of anode

In table 02 current and power generation were listed with different oxygen flowrate and pH ranges the maximum electricity were observed at 250ml/min of oxygen flowrate 0.98mA and for pH the maximum generation of bioenergy at 6 with voltage generation 0.82 Volts.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Oxygen flow rate (ml/min)</th>
<th>pH value</th>
<th>Substrate % w/v</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
<td>4.5</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>5.5</td>
<td>75</td>
</tr>
<tr>
<td>Current (mA)</td>
<td>250</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Voltage (volts)</td>
<td>0.81</td>
<td>4.5</td>
<td>25</td>
</tr>
<tr>
<td>Power (mW)</td>
<td>0.77</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Power density (mW/m2)</td>
<td>0.6237</td>
<td>5.5</td>
<td>75</td>
</tr>
<tr>
<td>Current density (mA/m2)</td>
<td>50.43</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>61.53</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>71.98</td>
<td>5.5</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>78.42</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>49.375</td>
<td>60</td>
<td></td>
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<tr>
<td></td>
<td>54.64167</td>
<td>50</td>
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<tr>
<td></td>
<td>58.7667</td>
<td>63.04167</td>
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<td></td>
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<td></td>
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<td>48.71667</td>
<td></td>
</tr>
<tr>
<td></td>
<td>53.25833</td>
<td>53.25833</td>
<td></td>
</tr>
</tbody>
</table>

Power generation from distillery effluent with cow dung manure

During MFC running operation different substrate concentration was used to investigate optimize percent of substrate for electricity generation. at 25%w/v of cow dung manure were tested and analyzed the open circuit voltage generated about 504mv, for 50%w/v of cow dung manure voltage generated maximum due to a substrate that need this amount of substrate and dilution for growth of microbes space in anode chamber. The minimum voltage generated at 100%w/v of cow dung manure. In this regard different slurry concentration was measured in order to get optimized condition for maximum voltage generated. In Figure 3 different slurry w/v of cow dung were used maximum electricity generation obtained at 50%w/v.

Effect of oxygen flow rate on power generation

In MFC operation were successful with addition of air in proper into cathode chamber for oxidation proton coming through salt bridge from anode chamber. Different ranges of oxygen were under investigation for promoting energy generation from distillery effluent. From 100-250ml/min of air flow rate tested and analyzed the maximum voltage generated at 250ml/min with 0.98 v/l. In Figure 4 it highlights after 56 hour the line in decreasing way due to the changing in dissolved oxygen, because during running of MFC different parameter effect regarding dissolve oxygen because at that time temperature of cathode chamber increasing it decrease the voltage generation.

Effect of pH on power generation

Acidic and basic nature had importance regarding microbial growth in MFC. Regarding biocatalyst saccharomyces specie for their nature it active in acidic nature of the solution and could survive pH ranges from 4-6.5. Highlighting this problem effect of pH under consideration for maximizing the activity of biocatalyst. For power generation from distillery effluent the maximum power production observed at pH6 about 0.85 v/l. it could helpful for meeting environmental condition for generating power from distillery effluent and decreases the percentage of waste water promoting renewable energy. pH is a significant factor that affecting the activity of microbes. Growth and development of microbe's maximum at optimum pH. The experiments show that at pH 6 and below, activities of microbes minimum when compared with the result recorded at higher pH. This is by the neutralization of proteins or active sites under acidity. These results demonstrate that there is also impact of pH on voltage Generation (Shah, 2010).
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**Figure 3:** Voltage generated at different ratio of distillery waste water with cow dung manure

**Figure 4:** Time vs Voltage generation
Effect of substrate concentration

Different Substrate concentration was tested in MFC for power generation by utilizing distillery effluent as substrate. From 20-60% w/v of substrate were used in MFC for identifying the range where maximum power production maximum. From Figure 6 observation suggest when concentration of distillery effluent increases up to 60% power generation maximum, this could be due to the decreasing organic compound present in distillery effluent and microbial activity could inhibit by changing the concentration of substrate and maximum power generation observed when substrate concentration 60% about 0.82m.

Figure 5: Effect of pH on power generation from MFC at 50/50 of sludge and distillery waste water

Figure 6: Effect of Substrate Concentration on power generation from MFC
CONCLUSION
Due to rapid depletion and escalation of prices of conventional fossil fuel, the entire world is urgently looking for an alternative source of energy, which is renewable and can be produced in an economical manner with respect to material and operation cost. In this context, energy produced from a potential organic bio-waste is an attractive option. Keeping this view, the present work has been undertaken to produce electrical energy from cow dung as bio-waste in microbial fuel cell. The maximum energy generation observed with the proper utilization of distillery waste water with cow dung manure about 2300 mv/l. Further study could be carried out throughout the commercialization process of microbial fuel cell with respect their internal components. Microbial fuel cell could be a tool for treatment of waste water for decreasing water pollution.

REFERENCES
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