

# Bio-electricity generation from different biomass using microbial fuel cell

## Abstract

As Pakistan is facing serious problem of energy crises there is need to be identify new technology and renewable energy source to fulfill the energy requirement. Due to increased aberrance about environmental problems, biofuel production is echo friendly. Microbial fuel cell is getting interest nowadays due to its application in utilizing biomass and generate electricity from it. In this regard work is done on sewage sludge taken from waste water treatment plant is taken as substrate for electricity generation and comparing it with other biomass sources. Best possible results come from experiments at 2500 mV/L for sewage sludge and when compare it other sources the yield is 270mV/L for carbo manure, 229mv/l for waste water 330mV/L for cow manure. Sewage sludge contains organic compound higher percentage of glucose, due to this will give the good results for power generation and environment.

**Keywords:** sewage sludge, organic compound, biomass, electricity generation, microbial fuel cell

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**Abbreviations:** MFC, microbial fuel cell; CE, coulombic efficiency; TCOD, total chemical oxygen demand; DOM, dissolved organic matter

## Introduction

As world is going towards renewable energy sources, microbial fuel cell getting attention nowadays. In microbial fuel cell biomass is utilize and give energy (electricity), and also a good option for treatment for waste water. Fuel recovery from sewage sludge is a promising energy production method, which can simultaneously address energy issue and environmental concerns associated with waste treatment.<sup>1</sup> Microbial fuel cell (MFC) can be used as a pretreatment method to remove dissolved organic matter (DOM) from polluted lake water and simultaneously generate electricity.<sup>2</sup> In Microbial fuel cell various factor is affecting on power generation effect of substrate concentration is very much important regarding anodic chamber and for power generation. If we utilize the higher percentage of substrate will effect on electricity generation, but both of them would be inhibited at high substrate concentrations.<sup>3</sup> Microbial fuel cells (MFCs) with biotic cathodes require expensive catalyst (such as Pt) or Catholyte (such as hexacyanoferrate) to facilitate oxidation reactions. Study deals with the incorporated biocathodes into a three-chamber MFC to yield electricity from sewage sludge at maximum power output of 13.2-1.7mW/m<sup>2</sup> during polarization, much higher than those previously reported. After 15d operation, the total chemical oxygen demand (TCOD) removal and Coulombic efficiency (CE) of cell reached 40.8-9.0% and 19.4-4.3%, respectively.<sup>4</sup> Two-chambered microbial fuel cell (MFC) with potassium ferricyanide as its electron acceptor was utilized to degrade excess sewage sludge and to generate electricity. Stable electrical power was produced continuously during operation for 250h. Total chemical oxygen demand (TCOD) of sludge was reduced by 46.4% when an initial TCOD was 10.850mg/l. The MFC power output did not significantly depend on process parameters such as substrate concentration, cathode Catholyte concentration, and anodic pH.<sup>5</sup> Batch tests were conducted to enhancing simultaneous electricity production and reduction of sewage sludge in two-chamber MFC by aerobic sludge

digestion in cathode chamber and sludge pretreatments (sterilization and base pretreatment) prior to sludge addition to anode chamber, respectively. During the stable stage, the voltage outputs and power densities of MFC increased from 0.28-0.31V to 17.3-21.2mW/m<sup>2</sup> to 0.41-0.43V and 36.8-40.1mW/m<sup>2</sup>, respectively, when aerobic sludge digestion occurred in the cathode chamber. When the sludge added to the anode chamber was sterilized or base pretreated, the voltage outputs and power densities of MFC increased from 0.30-0.32V and 19.9-22.6mW/m<sup>2</sup> (raw sludge) to 0.34-0.36V and 25.5-28.6mW/m<sup>2</sup> (sterilized sludge), 0.41-0.43V and 37.1-40.8mW/m<sup>2</sup> (base pretreated sludge), respectively.<sup>6</sup> Single-chamber air-cathode microbial fuel cells (MFCs) were used to generate electricity from fermented primary sludge. Fermentation (30°C, 9days) decreased total suspended solids (26.1-16.5g/L), volatile suspended solids (24.1-15.3g/L) and pH (5.7-4.5), and increased conductivity (2.4-4.7mS/cm), soluble COD (2.66-15.5g/L), and volatile fatty acids (1.9-10.1g/L). To lower the COD and increase pH, fermentation supernatant was diluted with primary effluent before being used in the MFCs. The maximum power density was 0.32±0.01W/m<sup>2</sup>, compared to 0.24±0.03W/m<sup>2</sup> with only primary effluent. Power densities were higher with phosphate buffer added to the supernatant (1.03±0.06W/m<sup>2</sup>) or the solution (0.87±0.05W/m<sup>2</sup>).<sup>7</sup> The main purpose of this research work to generate electricity from sewage sludge and other biomass that are waste water, cow manure, and carbo manure comparatively.

## Materials and methods

### Materials

The whole work was done in Chemical Engineering Department MUET Jamshoro. *Saccharomyces cerevisiae* is taken as biocatalyst in MFC for power generation and sewage sludge is taken from waste water treatment plant, amount of sewage sludge that were taken about 1L and other biomass also taken from different region of Sindh province for analysis and treatment.

### Microbial fuel cell construction

Microbial fuel cell that was used to carry out experimental work is

two chambers (Figure 1). One is anodic chamber in which an aerobic condition is used, that contain substrate and biocatalyst. Cathodic chamber containing salt water and aerobic condition is used.<sup>6</sup> Electrodes are used to transfer the electrons and salt bridge is used to transfer the proton. Salt bridge made from agar and common salt Two chamber is taken between them salt bridge is used to transfer proton from cathodic chamber to anodic chamber.



Figure 1 Microbial fuel cell.

### Operational conditions

Sewage sludge that are used taken from waste water treatment plant, because we know the composition of sludge that are produced from treatment of waste water. Pure starin of saccharomyces servisae is used to carry out the process. Air is used in cathodic chamber to oxidize the proton coming from anode chamber. Salt bridge is used to transfer the proton from anode chamber to cathodic chamber and external circuit is used for transfer of electrons coming from anode chamber.

### Analysis

In MFC different parameter were analyzed during experimental work on it.

**pH:** pH were analysed 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 flow rate:** Oxygen flow rate were analysed 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 millimeter, 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  $I=V/R_e$ , where  $R_e$  is the external resistance. Power (P) was calculated as  $P=IV$ .<sup>8</sup>

## Results and discussion

### Electricity generation from different biomass

After 24h operation current of cell shown on multimeter after few hours' time period maximum electricity generation observed (2500mV/L) (Figure 2) and after few minutes there is decline in power output, because cell growth decreases their efficiency. After the MFC treatment, the total organic carbon concentrations<sup>9</sup> in sewage sludge utilize to produce electricity. In MFC, microorganisms oxidize

organic matter in the anode chamber (anaerobic conditions) producing electrons and protons. Electrons transfer via the external circuit to the cathode chamber where electrons, protons and electron acceptor (mainly oxygen) combine to produce water.<sup>10</sup>

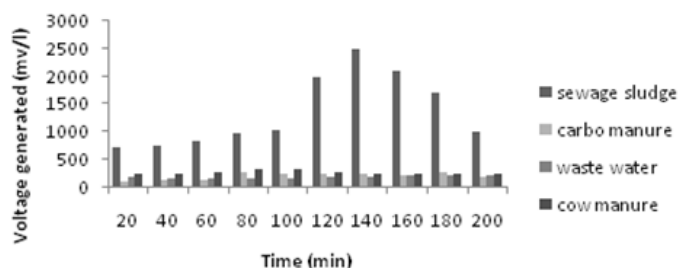


Figure 2 Generation of Voltage vs time.

### Effect of oxygen flow rate on voltage generation

Different flow rate of oxygen were studied to know about the effect of oxygen flow rate on electricity generation from sewage sludge comparison with other biomass In Figure 3, the maximum flow rate of oxygen that were given high yield of electricity is 45ml/min. Reason behind that when we increase oxygen flow rate there will be increase in power generation due to acceptance of proton from anodic chamber and decrease in oxygen flow rate will decrease in acceptance of electron.

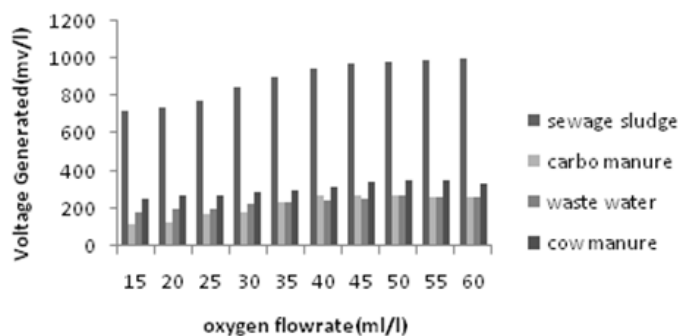


Figure 3 Generation of voltage vs oxygen flow rate.

### Effect of pH value on voltage generation

Voltage generation from sewage sludge using MFC had effected from pH value. Different pH value were used to identify the effect of pH on voltage generation. The maximum yield of voltage 2500mV were obtained at the pH of 8.5 (Figure 4). The effect of pH on voltage generation due to variation ionic form of active site. If there is decrease in pH value there will be decrease the activity of cellulosic nature of biomass so that's why pH below 7 must be tolerated.

### Effect of concentration of sample on voltage generation

Concentration of substrate has effect on power generation due to variation in organic matter present in biomass. As we know that organic matter present in sewage sludge mainly glucose, when we decrease the percentage of substrate there will be change in voltage output from MFC. Concentration has also effect the microbial activity of microbial fuel cell. Effect of concentrations given in Figure 5.

### Comparison of Power Output from the Sewage Sludge and from other Biomass

Different biomass was studied to identify the suitable biomass for power generation. Fuel recovery from sewage sludge is a promising

energy production method, which can simultaneously address energy issue and environmental concerns associated with waste treatment.<sup>11</sup> So as for sewage sludge was concerned maximum yield of power generation obtained. Pre-treatment has shown significant improvement in MFC electricity productivity.<sup>12</sup> Activated sludge and algae biomass are used as substrates in microbial fuel cell (MFC) to produce electricity. And also<sup>13</sup> cattle dung as a substrate.<sup>14</sup> As for other biomass was concerned gave the lesser power output due to the organic matter or we can say that lower in glucose concentration. Different types of biomass that were under study are cow manure, carbo manure, waste water and sewage sludge. The maximum power generation was obtained 2500 mV/L using Sewage sludge as a biomass source and for other biomass concerned maximum power generation obtained from carbo manure, cow manure and waste water 270mV/L, 229mV/L and 330mV/L respectively (Figure 6). The voltage output from waste water about to be 203mV/L<sup>15</sup> it means that voltage generated from sewage sludge was maximum.

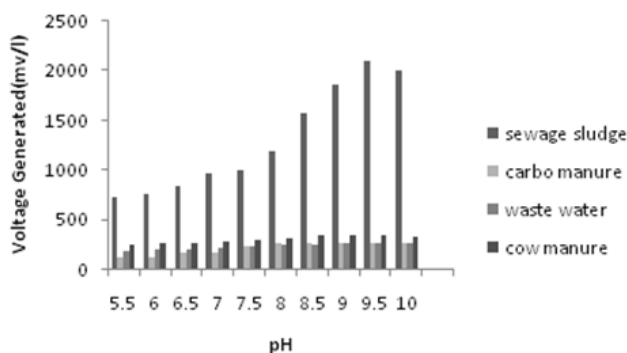


Figure 4 Generation of voltage generation vs pH.

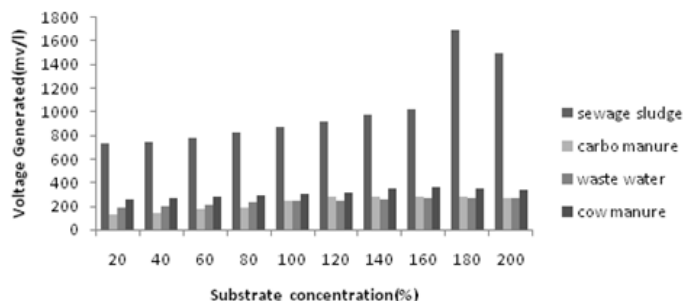


Figure 5 Generation of voltage generation vs concentration.

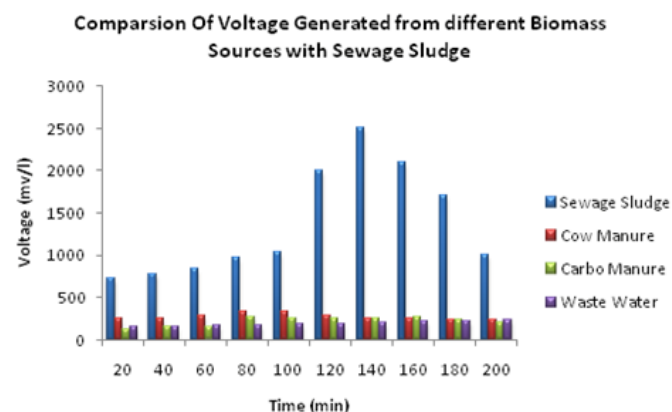


Figure 6 Comparison of different biomass used in MFC for power generation.

## Conclusion

Sewage has potential for power generation using MFC over other biomass resources.

- The maximum electricity generation from sewage sludge is 2500mV/L.
- Other biomass sources maximum output are Carbo Manure (270mV/L)
- Cow Manure(229mV/L) and
- Waste Water (330mV/L).
- We can treat waste water by using Microbial fuel cell
- We can reduce waste from environment
- The electricity generation from sewage is higher due to contain higher percentage of organic matter

## Future recommendations

If we use this technology we reduce the environmental problem regarding waste water or reduce waste. We will fulfill energy requirement regarding to overcome energy crises by using Microbial Fuel cell. We can commercialize it to fulfill the energy requirement.

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## Conflict of interest

The author declares no conflict of interest.

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