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Generation of Electricity from Kitchen Waste Using Single Chambered Microbial Fuel Cell with Candle Wax Salt Bridge

Sunil Umachagi¹, Jadka Momhammed Lateef², Hrishikesh Patnaik³, K M Mouna⁴, H Thriveni⁵

Assistant Professor, Department of Civil Engineering, RYM Engineering College, Ballari, Karnataka, India¹

UG Students, Department of Civil Engineering, RYM Engineering College, Ballari, Karnataka, India^{2,3,4,5}

ABSTRACT: Disposal of wastes and their management is the most important environmental problem faced by the world today, wastewater from the domestic activity creates variety of wastewater pollutants and their treatment is difficult. Characteristics of wastewater and their level of pollutants vary from waste to waste. Rapid urbanization in developing countries like India propound major problems in generating the electricity, now a day's collection and disposal of waste are very difficult, this leads to public health problems and other environmental problems, for constructing a sustainable world we require to minimize the uses of fossil fuels and waste generation, for that we need to think alternative way of waste management technique. Microbial fuel cell is the best alternative technique to reduce waste generation and to produce electricity. Agricultural waste, household waste is the best substrates for energy production as they are rich in organic contents. In this study maximum voltage, current and power generation were up to 2.4V, 0.024Amp, 0.0576W. COD and BOD removal efficiency were 62%, 61%.

KEYWORDS: Single Chambered Microbial Fuel Cell [SCMFC], Candle Wax Salt Bridge [CWSB], Electricity, Kitchen Waste

I.INTRODUCTION

The role of renewable energy will have significant effects on the mitigation of global environment problems. Microbial fuel cell (MFC) is one of green technologies holds a great promise as a sustainable biotechnological solution to future energy needs and wastewater treatment. By using microorganisms as catalyst to directly generate electricity from the oxidation of organic matters or various substrates in wastewater, clean electricity and wastewater treatment can be accomplished simultaneously. Anaerobic digestion is a preferred method with several advantages, including volume reduction, waste stabilization, and biogas recovery [1]. Prof. M C Potter in 1911 gave the idea of obtaining energy from bacteria, he discovered how microorganisms degrade the organic matters and produces electrical energy, he trying to stock this source of energy for human use. In recent years many people are working to improve the types, electrode materials, combination of bacteria and their types, mechanism of electron transfer in Microbial Fuel Cell

“Microbial fuel cells are bio-reactors that can utilize microorganisms for converting chemical energy into electrical energy under anaerobic condition”.It Consist two compartments one is anode and the other is cathode, these two compartments are separated by proton exchange membrane. In anode chamber, substrate is oxidized by using microorganisms, producing electron, proton and carbon dioxide (CO₂), electrons are transferred from anode compartment to cathode compartment through an external circuit and protons are transferred from anode to cathode compartment through proton exchange membrane (as salt bridge) in cathode compartment, protons, electrons are consumed and combining with oxygen (O₂) to form water.

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II. RELATED WORK

Hampannavar U.S et al., (2011) says that Single chamber MFC was efficient and found to be producing maximum current of 0.84 mA, power density of 28.15 mW/m² where as double chambered MFC produced a maximum current of 0.36 mA and power density of 17.76 mW/m². Double chambered MFC was efficient in the removal of COD (64% removal) when compared with single chamber MFC which attained 61% COD removal efficiency.[2]

Dr. Sashikant. R. Mise, Sandhya Saware (2015) says that the technology of Microbial Fuel cells is the latest method for producing electricity from biomaterial by using microorganisms, microbial source uses Textile wastewater as a substrate and is inoculated with cow dung for the production of electricity and used to remove the concentration of COD, BOD and Solids. The maximum current, voltage and power produced were respectively 4.32mA, 3.12V and 0.812W/m² at 28th day and 1750 mg COD/L feed concentration. The maximum removal efficiency of COD, BOD₅, TS, and DS was respectively achieved at 79.6%, 74.7%, 66.7%, and 63.3% [3].

Preeti Arakeri et al., (2016) says that new treatment approach of using Microbial fuel cell (MFC) has been developing recently. The technology of Microbial Fuel cells is the latest method for producing electricity from biomaterial by using microorganisms. The maximum current, voltage and power produced were respectively 5.56mA, 4.89V and 1.637W/m² at 30th day and 6000 mg COD/L feed concentration. The maximum removal efficiency of COD, BOD₅, TS, and DS was respectively achieved at 79.51%, 76.52%, 72.56%, and 75.07%.[4]

Bruce E. Logan et al., (2015) says that efficient treatment of domestic wastewater is possible under continuous flow conditions using microbial fuel cells. Two MFCs in series were compared at theoretical HRTs of 8.8, 4.4 and 2.2 h using two different brush-electrode MFC configurations: a full brush evenly spaced between two cathodes (S₂C); and trimmed brush anodes near a single cathode (N₁C). The MFCs with two cathodes produced more power than the MFCs with a single cathode, with 1.72 mW for the S₂C, compared to and 1.12 mW for the N₁C at a set HRT ¼ 4.4 h. The single cathode MFCs with less cathode area removed slightly more COD (54.2 ± 2.3%, N₁C) than the two-cathode MFCs (48.3 ± 1.0%, S₂C). However, the higher COD removal was due to the longer HRTs measured for the MFCs with the N₁C configuration (10.7, 5.3 and 3.1 h) than with the S₂C configuration (7.2, 3.7 and 2.2 h), despite the same theoretical HRT. The longer HRTs of the N₁C MFCs also resulted in slightly higher coulombic efficiencies (37%) than those of the S₂C MFCs (29%). While the S₂C MFC configuration would be more advantageous based on electrical power production, the N₁C MFC might be more useful on the basis of capital costs, brush anode and Activated carbon can be used as effective and inexpensive electrode materials in MFCs. Closely spaced electrodes and specific surface areas have been shown to improve generation in MFCs.[5]

Kavyashree.R.Doddamani et al.,(2014) says that 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 sugar 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 sugar mill wastewater showed removal efficiency 69.3% COD, 68.1% BOD and 56.35% TDS with different feed concentration. The current, voltage and power generation in the reactor is 1.28 mA, 0.9 V and 0.304 watts/m² respectively. pH was increased randomly from 7.1 to 8.2 with respect to different feed concentration.[6]

III. MATERIALS AND METHODOLOGY

MATERIALS:

Hollow Plastic Box:

Hollow plastic Box is used to build the anode chamber and Hollow plastic pipe is used to build cathode, anode chamber holds the kitchen wastewater and cathode holds a candle wax and salt solution.

Candle wax and Common salt:

Common salt and Candle wax are used to construct Candle wax-salt bridge.

Graphite rods from pencil (pencil leads) :

Camlin pencil leads are used as both anode electrode material and cathode electrode material. Length and diameter of the anode and cathode materials are 90mm, 2.0mm.

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Wires (Copper wires):

Copper wires are used to connect the electrodes to a recording devices (Ex.DT-830D Digital multimeters).

PVC Pipes:

PVC pipes are used to hold the salt and Candle wax mixture.

Length and diameter of the pipes are 220mm,32mm.

Rubber pipes:

Pipes are used to make sampling ports and to transfer the wastewater from MFC to effluent collection tank

Sealant:

To prevent the leakages M-seal is used.

Multimeter:

DT-830D Digital multimeter is used to measure the voltage and current.

METHODOLOGY

Construction:

1] Selection of anode and cathode chamber:

Hollow Plastic box is selected as anode materials, PVC pipe is selected as cathode material and both must be non biodegradable, non reactive, non conductive materials. The anode chamber is having 25 liters capacity with working volume of 20 liters.

2] Construction of candle wax-salt bridge:

Materials required for the construction of candle wax-salt bridge are water, candle wax and common salt.162.5 ml of water is boiled in a clean beaker, 16.25gm of candle wax and 18.75gm of common salt are slowly added to the boiling water, the whole mixture is further boiled for 4-5 minutes. Mixture is poured into open end of PVC pipe, other end of pipe is kept closed by using plastic wrap, after pouring the mixture into PVC pipe, pencil leads are placed in a mixture, whole set up is allowed to solidifies and is kept 24 hours in refrigerator. Length and diameter of the salt-bridge are 110mm, 32mm, figure 1 shows Candle wax-salt bridge..



Figure 1. Candle wax-salt bridge.

3] Arrangements of Electrode materials:

Pencil leads are selected as both anode and cathode electrode materials, length and diameter of the electrode materials are 90mm, 2mm. In this set up 32 numbers of electrodes are used in anode chamber and 12 numbers of electrodes are used in cathode chamber, figure 2 shows arrangements of electrode materials.

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Figure 2. Arrangements of electrode materials

4] Fabrication of Microbial Fuel Cell:

A 25 liter capacity of Single chambered microbial fuel cell with candle wax salt bridge is constructed for the treatment of domestic (kitchen) wastewater and generation of electricity. The electrodes were placed into the anode chambers and cathodes, at the centre of reactors a circular groove was made for fitting the candle wax-salt bridge, salt bridge is used to enhance the maximum power output, In this reactor sampling ports are provided at top and bottom to study the characteristics of wastewater, then the whole set up is sealed and made air tight, after fabrication work is completed reactor is checked for water leakage, figure 3 shows experimental model of MFC.



Figure 3. Experimental model of MFC

Methodology

Operation:

1. Microbial fuel cell reactor is fed with kitchen wastewater which is collected from RYMEC Boys hostel
2. Inoculum in the reactor is (1/3rd of the volume of the reactor) Cowdung which is collected from Ballari.
3. Sodium Bicarbonate (NaHCO₃) is used to maintain the p^H 6.5-7.5
4. Graphite rods are used as anode and cathode electrodes and are linked by salt bridge these two electrodes are connected to external resistor of 100 ohms
5. Power is calculated by using formula $P=V \times I$ or $P=I^2 \times R$ where P=power in w, V=voltage in v, I=current in amp. Voltage and current were monitored on daily basis.
6. Measure the COD and BOD removal

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IV. EXPERIMENTAL RESULTS

Voltage and Current generation in MFC

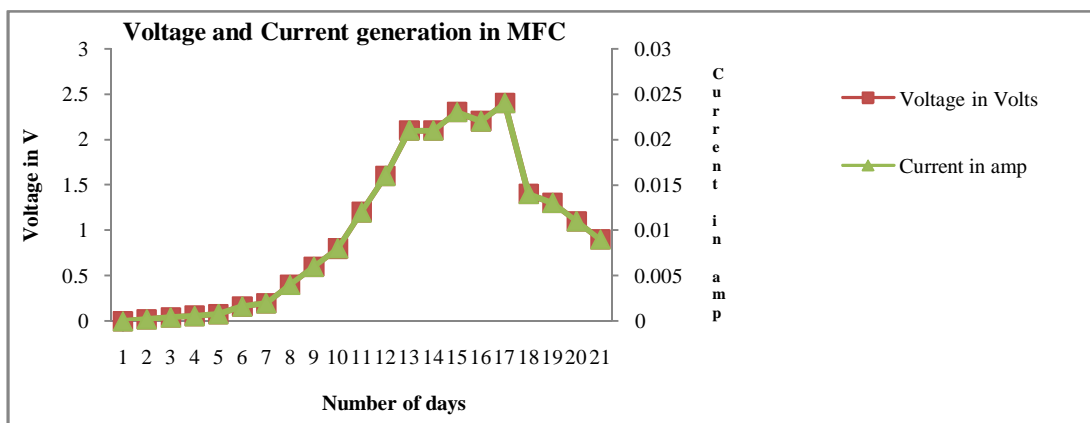


Figure 4. Voltage and Current generation in MFC

Domestic wastewater was given as the substrate for MFC, 17th day MFC reactor was showed maximum voltage and current generation, similarly reduction in voltage and current generation were observed after 17th day, this indicates that 17th day onwards microorganisms will stop their microbial activity and they may be in inactive stage, this may be leads to reduction in voltage and current. Maximum Voltage and Current generation from Single Chambered Microbial fuel cell with candle wax salt bridge were 2.4v and 0.024amp. at this stage maximum power output was 0.0576W. Figure 4. Shows Voltage and Current generation in MFC.

COD and BOD removal efficiency

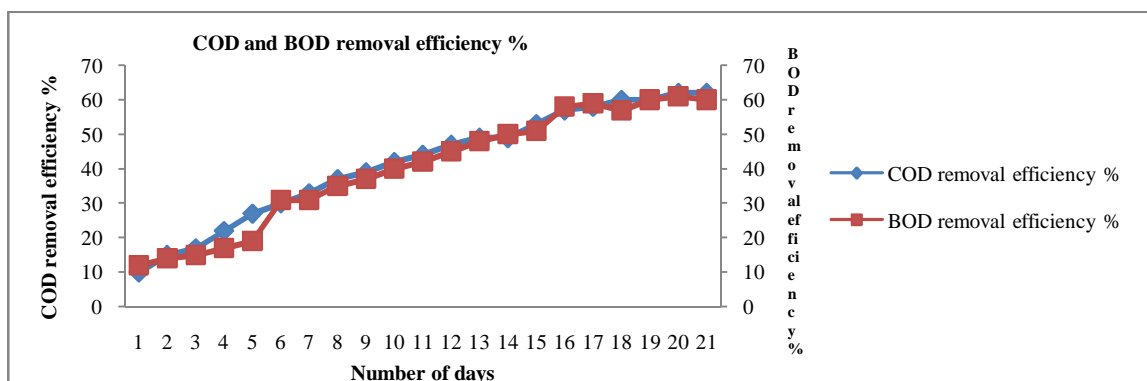


Figure 5. COD and BOD removal efficiency

BOD and COD were analysed on first day and last day, 21th day it was observed that COD and BOD removal efficiency were 62% and 61%. Initial days it was showed less COD and BOD removal efficiency, this is because of microorganisms are not active they were adjusting to anaerobic condition for that they need sufficient time, after some days it was showed maximum COD and BOD removal efficiency as compared with initial days, during these days p^H was maintained using Sodium Bicarbonate ($NaHCO_3$), p^H was maintained in-between 6.5-8.5 Figure 5 shows COD and BOD removal efficiency.

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V. CONCLUSION

On analysing the results based on laboratory experiments conducted, the following conclusion were drawn,

- 1] Based on 21 days of study period, 17th day reactor was showed maximum voltage, current and power generation, similarly reduction in voltage, current and power generation were observed after 17th day.
- 2] 21th day COD and BOD were analysed, it was observed that COD and BOD removal efficiency were 62% and 61%.
- 3] Maximum Voltage, Current and Power generation from Single Chambered Microbial fuel cell with candle wax salt bridge were 2.4v, 0.024amp and 0.0576watts.
- 4] Based on above results, we conclude that using candle wax salt bridge in single chambered MFC produces more electricity. COD and BOD removal efficiency is also more. During study period generation of methane gas was also observed.

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