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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 down 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-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 (Brooki *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.

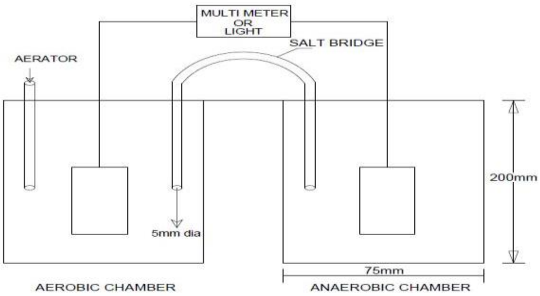

Fig. 1: Schematic Diagram of the MFC

2.3 Operation of MFC

In the anodic chamber, 450 ml of the slaughterhouse wastewater and 50 ml of raw sludge was used and in the cathodic chamber 500 ml of 0.1M Pottasium permanganate solution was used and the container lids were closed and sealed with tape. The electrodes are placed in the cell and connected through a Multimeter (KROS-S DT830D) to determining the voltage generated by the Microbial Fuel cell. The microbes present in the Sludge will oxidize the organic matter present in the wastewater and generate electrons and protons. The electrons absorbed by the electrodes and are transported to the cathode through an external circuit (Z. Du et al., 2007) moving of electrons called as current. The current was measured by the multimeter connected in the external circuit of the Cell. The salt bridge act as a proton exchange membrane, it should allow only the protons into the cathodic chamber. The protons combine with the oxygen present in the cathodic chamber to form water. The voltage generated by the cell was noted down. The removal of organic matter present in the wastewater was tested by the standard methods and noted down. All the operations were carried out with different electrodes. The MFCs were operated at a room temperature of 28°C. The continuous aeration gave the cathodic chamber to enhance the dissolved oxygen content in the catholyte solution.

3. RESULTS AND DISCUSSIONS

3.1 Initial characteristics of slaughterhouse wastewater

The slaughterhouse wastewater collected was characterized to determine pH, Total Solids, Total Suspended Solids, Volatile Suspended Solids, Fixed Suspended Solids, Biological Oxygen Demand, Chemical Oxygen Demand, Alkalinity and Chlorides as per the standard methods (American Public Health Association) and Permissible values taken for discharge of wastewater in surface water bodies as per Indian Standards (IS 2490-1974) seen in Table 1.

Table 1: Initial characteristics of slaughterhouse wastewater

S. no	Characteristics	Unit	Value
1	pH	-	7-8
2	TS	mg/L	2350
3	TSS	mg/L	1510
4	TDS	mg/L	840
5	VSS	mg/L	2110
6	FS	mg/L	240
7	Alkalinity	mg/L	550
8	Chlorides	mg/L	200
9	BOD	mg/L	650
10	COD	mg/L	1131

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.

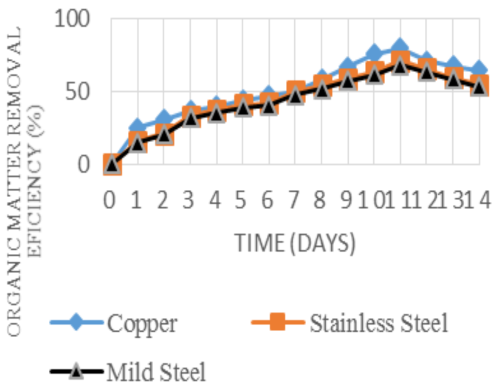

Fig. 2: Organic matter removal efficiency of various electrodes

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.

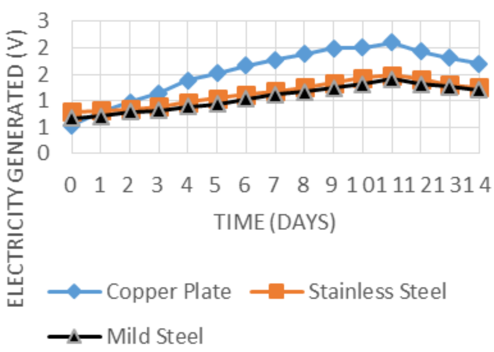

Fig. 3: Electricity generated by various electrodes

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

[1] Abhilasha Singh Mathuriya, J.V. Yakhmi, "Microbial fuel cells to recover heavy metals", Environ. Chem Lett, 12:2014, pp. 483-494.
[2] Benneto, H.P., "Electricity generation by microorganisms". Biotechnical Ed,1:1990, pp. 271-290.
[3] B.G Mahendra, Shridhar Mahavarkar, "Treatment of wastewater and electricity generation using microbial fuel cell technology", International Journal of Research in Engineering and Technology, 2013, pp. 277-282.
[4] Bond, D.R and Lovely .D.R, "Electricity production b Geobacter sulfurrendunces attached to electrodes", Appl.environ. Microbial, 69:2003, pp. 1548-1555.
[5] Bond, D.R and Lovely .D.R, "Evidence for involvement of an electron shuttle in electricity generation by Geothrix fermentans". Appl.environ. Microbial, 71:2005, pp. 2186-2189.
[6] Booki.M, Shaoan. C, Bruce. L, "Electricity generation using membrane and salt-bridge microbial fuel cells", Water Res,39 (9):2008, pp.1675-1686.
[7] Carlo Santoro, Catia Arbizzani, Benjamin Erable, Ioannis Ieropoulos, "Microbial fuel cells: From fundamentals to applications. A review", Journal of Power Sources, 356:2017, pp. 225-244.
[8] Chae. K.J, Choi. M, Foulsho. F.A, Wooshin. P, Chang, I.S, "Mass transport through a proton exchange membrane in microbial fuel cells. Energy.Fuels 22(1):2008, pp.169-176.
[9] Chaunduri. S.K and D.R.Lovely, "Electricity generation by direct oxidation of glucose in mediatorless microbial fuel cells". Nat. Biotechnol, 21:2003, pp. 1229-1232.
[10] Ciro Fernando Bustillo – Lecompte, Mehrab Mehrvar, "Slaughterhouse wastewater characteristics, treatment and management in the meat processing industry: A review on trends and advances", Journal of Environmental Management, 161:2015, pp. 287-302.
[11] Ghanapriya. K, Sachindri Rana, P.T.Kalaichelvan, "Electricity generation from Slaughterhouse wastewater using microbial fuel cell technology", Adv. BioTech, 2012.
[12] Jeffery. J.F, Miriam. M, Largus. T.A, "Electric power generation from municipal, food and animal wastewaters using microbial fuel cells". Electroanalysis, 10:2009, pp.1002.
[13] Liu. H, Ramanarayanan. R, Logan. B, "Production of electricity during wastewater treatment using a single chamber microbial fuel cell". Environ.Sci.Technol. 38:2004, pp.2281-2285.
[14] Moon. H, Chang. I.S, Kim. B.H, "Continuous electricity production from artificial wastewater using a mediator-less microbial fuel cell". Biores.Technol. 97:2006, pp. 621-627.
[15] P Singh, A Srivastava, N Srivastava, "Generation of Electricity Using Non-Mediated Microbial Fuel Cell by Utilizing Different Types of Wastewater", Journal of Scientific & Industrial Research, 76:2017, pp. 512-514.
[16] Parkash A, "Utilization of Different Types of Wastewater of Production of Electricity Using Non-Mediated Microbial Fuel Cell". MOJ Proteomics Bioinform, 4(1):2016.
[17] See Harshad Thakur, Pallavi Patil, Sunil Sangam, "The Design of Microbial fuel cell", International Journal of Engineering Research and Technology, 10:2017, pp. 240-245.
[18] Venkata Mohan. S, Veeraraghavalu. S, Sarma, P.N, "Biochemical evaluation of bioelectricity production process from anaerobic wastewater treatment in a single chambered microbial fuel cell employing glass wool membrane". Biosens. Biotechnol, 23:2008, pp. 1326-1332.
[19] Wingard. L.B, Shaw. C.H, Castner. C.F, "Bio electro-chemical fuel cells", Enzy. Microb. Technol, 4:1982, pp. 137-142.
[20] Yokoyama. H, Ohmori. H, Ishida. H, Waki. M, Tanaka. Y, "Treatment of cow-waste slurry by a microbial fuel cell and properties of the treated slurry as liquid manure", Animal Sci, 77:2006 pp.634-638.
[21] Zhuhai Du, Haoran Li, Tinguye Gu, "A state of the art review on microbial fuel cells: A promising technology for wastewater treatment and bioenergy", Biotechnology Advances, 25:2007, pp.464-482.

