



## Utilization of Microbial Fuel Cells for Electricity Generation from Gwagwalada Abattoir Wastewater

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### Abstract

*This study explores the use of microbial fuel cells (MFCs) for electricity generation and wastewater treatment using wastewater from the Gwagwalada abattoir. The research aimed to assess contamination levels, develop an MFC system, and evaluate its performance over 240 hours. Key parameters analysed are: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), conductivity, and pH, before and after treatment. The MFC was constructed based on established designs and its electrical output voltage and current was monitored throughout the experiment. Results showed a significant reduction in BOD and COD by 69.8% and 68.8%, respectively. The MFC also produced a maximum voltage of 94 mV and current of 0.2 mA. These findings demonstrate that MFCs can simultaneously treat abattoir wastewater and generate electricity, suggesting a promising avenue for sustainable waste-to-energy technologies with potential for further enhancement.*

**Keywords:** Electricity generation, microbial fuel cells, abattoir wastewater, total dissolved solids, pH.

### 1.0 Introduction

The harmful effect of the wastewater from abattoirs on the receiving water bodies and the environment as a whole cannot be overemphasised. Gwagwalada abattoir's environment is unsightly, and odour from its operations attracts flies, mosquitoes, rodents, and other disease vectors which cause a nuisance in the neighbourhood. The abattoir is characterised by improper channelling of wastewater which results in muddiness of the land within and around the abattoir and surface water bodies are also polluted by wastewater from the abattoir operations due to poor channelisation [1].

A microbial fuel cell (MFC) is a bio-electrochemical device that can generate electricity by the use of electrons obtained from the anaerobic oxidation of substrates [2]. Microbial fuel cells (MFCs) show promise for sustainable wastewater treatment and contaminant removal, attracting growing interest. In general, contaminants can be removed either as an electron donor via microbial-catalysed oxidation at the anode or removed at the cathode as electron acceptors through reduction and thus, MFCs can be used for wastewater treatment since organic materials can be easily oxidized as fuel in the anode compartment [3].

Bioelectric potentials are generated by a variety of biological processes and generally range in strength from one to a few hundred millivolts [4]. Bacteria can be employed in MFCs to generate power while also degrading organic materials. Basically, the fuel cell consists of four parts: the anode, cathode, Proton-Exchange Membrane (PEM), and external circuit. The anode contains bacteria and organic material in an anaerobic environment. The cathode contains a conductive saltwater solution. As part of the digestion process, bacteria produce protons (H<sup>+</sup>) and electrons (H<sup>-</sup>). The benefits of employing MFC over a typical battery are that it uses a renewable source of energy and does not need to be recharged. Furthermore, it can operate in mild environments (20 - 40°C) and at pH levels around 7.0 [5]. This research explores the use of Microbial Fuel Cells (MFCs) for treating Abattoir wastewater from Gwagwalada.

### 2.0 Materials and Methods/Methodology

#### 2.1 Sample Collection and Characterisation

Abattoir Wastewater was collected from New Kutunku, Gwagwalada, FCT, Abuja, Nigeria, using a sterilised 5-liter plastic. The sample was characterised by conducting Physiochemical analysis. The pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and conductivity were determined using standard laboratory methods outlined by the American Public Health Association [6]. The physiochemical analysis was carried out on the sample and after treatment. The wastewater served as an inoculum and organic substrate for the Microbial Fuel Cell.

## 2.2 Description of the Microbial Fuel Cell Setup

The MFC was constructed based on the designs outlined by [7] and [8]. Two 1.5 L plastic containers were used as the anodic and cathodic chambers of the dual-chamber MFC. One container was configured as an anaerobic chamber with a sealed cover, functioning as the anode (negative terminal). The other container was set up as an aerobic chamber with an air supply to the cathode.

Stainless Steel Mesh (SSM) with the dimension 8 cm by 9 cm was used as the electrode material (the anode and the cathode), and copper wires were attached to both electrodes. Openings were made on the lids of the plastic containers (anode and cathode chambers) to insert the copper wires holding the electrodes. An additional opening was also made on the cathode lid to allow aeration and maintain aerobic conditions. The lids containing the suspended SSM electrodes were then inserted into each chamber and sealed. The wire on the anode lid was sealed with epoxy glue to prevent oxygen ingress and ensure anaerobic conditions in the anode. The multimeter was connected to the hanging copper wires from the lid of each chamber.

A proton bridge was used to connect the two chambers of the MFC. In this research, a salt bridge was used as the proton exchange bridge. This salt bridge was prepared in a 10 cm (length) and 2 cm (diameter) polyvinylchloride (PVC) pipe. The salt bridge contained 5% agar and 1M Potassium chloride (KCl). This was done by dissolving 5 g of agar-agar in 100 mL of 1M KCl [9]. The schematic diagram of the H-Shape Double-chamber MFC is shown in Figure 1.

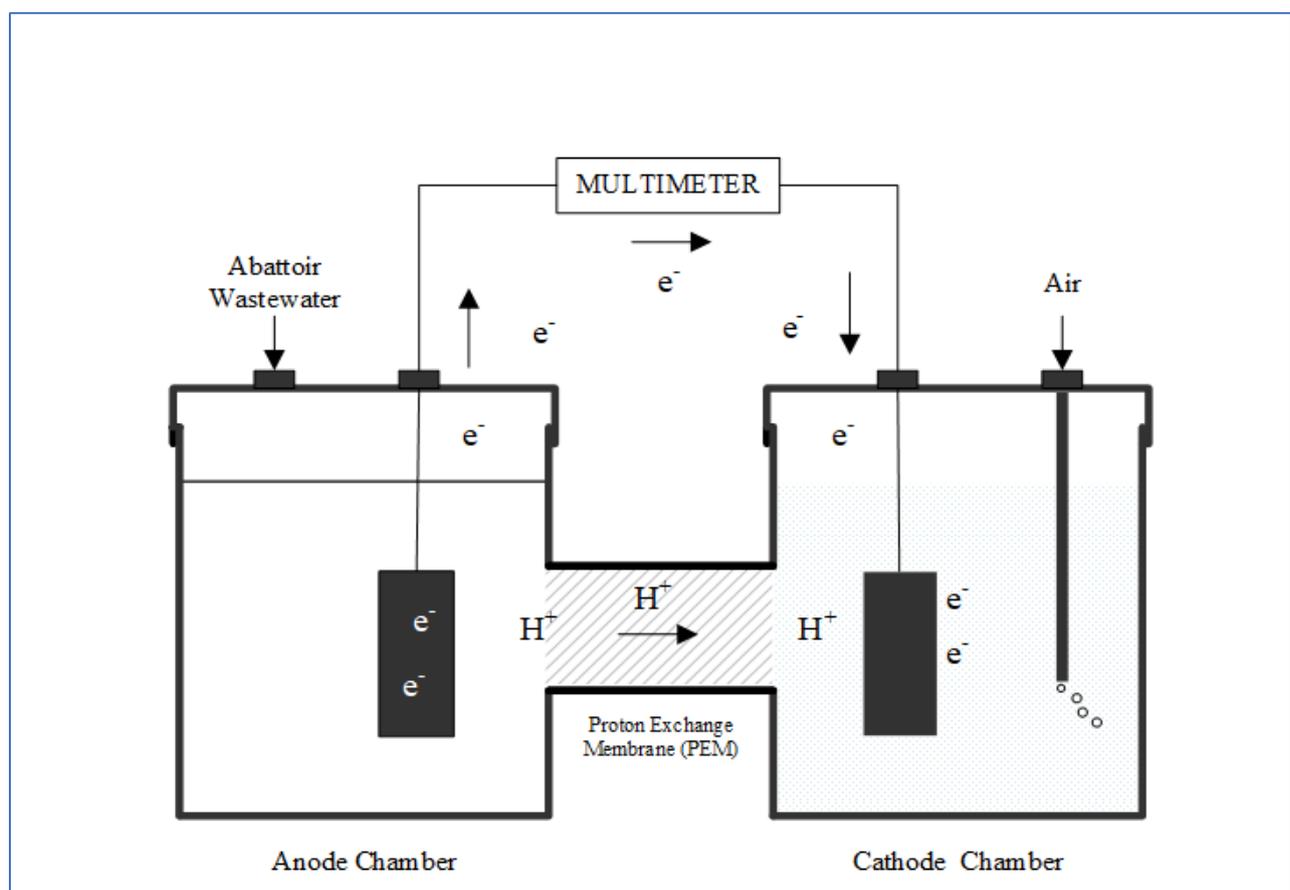


Figure 1. Schematic diagram of the H-Shaped double-chamber MFC

## 3.0 Results and Discussion

The pH of the wastewater initially measured 5.91 (slightly acidic) and increased to 6.52 as indicated in Table 1. pH is critical for MFC performance as it supports the growth of electrogenic microorganisms, with an optimal range between 6.5 and 7.5, and performance peaking at pH 7 due to microbial adaptations [10],[11]. The pH increase may result from protein breakdown in abattoir wastewater during microbial metabolism, producing amino acids and ammonia ( $\text{NH}_3$ ) through deamination.

Table 1. Result of physiochemical analysis of abattoir wastewater

S/N	Parameter	Before Treatment	After 10 days Treatment in MFC
1	Biochemical Oxygen Demand (mg/L)	5.3	1.6
2	Chemical Oxygen Demand (mg/L)	32	10
3	Conductivity ( $\mu\text{S}/\text{cm}$ )	1083	6624
4	TDS (mg/L)	503.5	3235
5	pH	5.91	6.52
6	TSS (mg/L)	488	420
7	Temperature ( $^{\circ}\text{C}$ )	28	26.9

The initial BOD of the abattoir wastewater aligned with findings by [4], where wastewater was used for electricity generation. After MFC usage, BOD and COD decreased by 69.8% and 68.8%, respectively. This compares favourably to [12], who reported a 65.56% BOD reduction, and exceeds [5], who observed lower COD reduction using swine wastewater in Microbial Fuel Cell (MFC). The BOD reduction is attributed to oxygen consumption by indigenous microorganisms, while COD reduction reflects microbial decomposition of organic matter. There was also a 13.93% reduction in TSS of the abattoir wastewater. In contrast, TDS and conductivity increased after MFC operation as also shown in Table 1, which is in consistent with [12], who suggested this could result from mineralization during MFC activity. The rise in TDS and conductivity indicates higher concentrations of dissolved substances, likely due to microbial degradation of organic compounds into smaller ionic species, which enhance conductivity.

From Figures 2 and 3 it shows there was a rise and fall in voltage and current generation during the ten days observation. The low voltage compared to previous studies by [4] and [12] could be attributed to the lower organic content in the wastewater used or the high internal resistance of the H-shaped dual-chamber MFC [13]. Further research work is needed to reduce internal resistance and develop better electrodes and devices for scaling up electricity production. According to [14], bacterial colonization of the electrode and the production of enzymes or structures for electron transfer take time, especially in mixed cultures where different bacteria grow and set varying potentials. This explains the extended acclimatization period observed in this experiment.

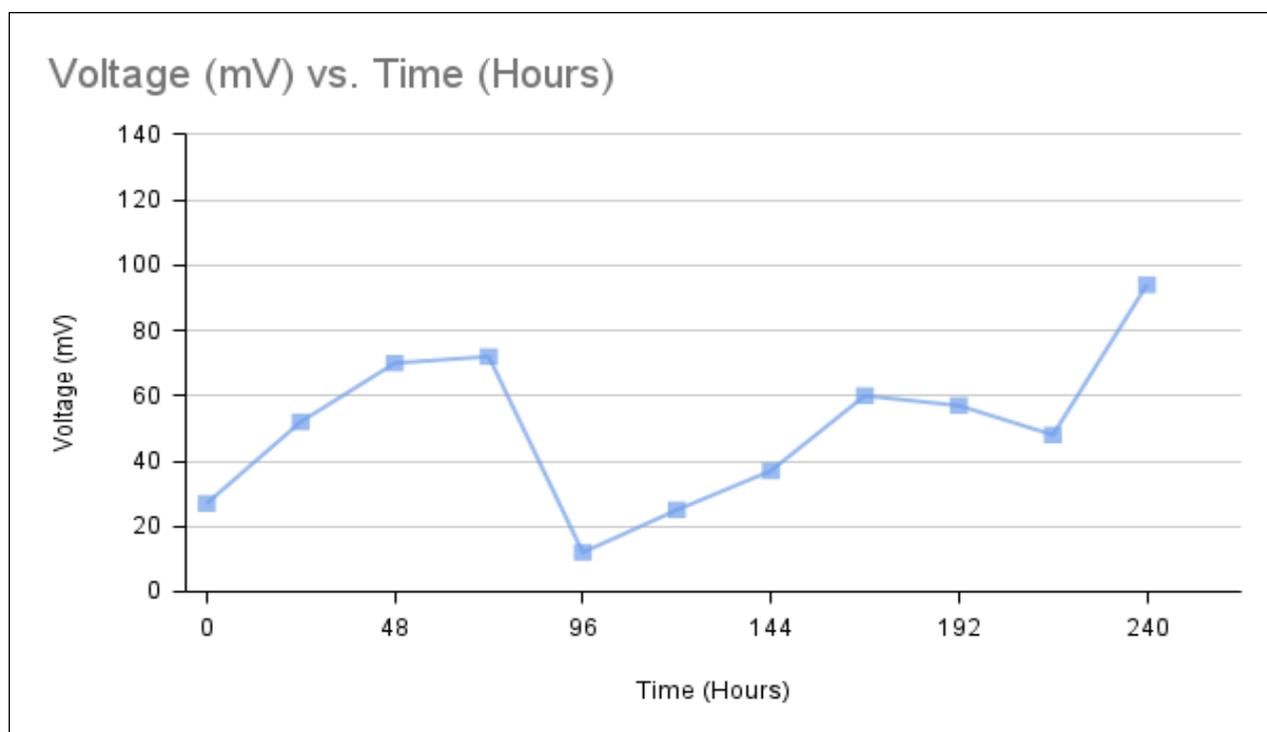


Figure 2. Trend of voltage (mV) generation in 10 days

Previous studies [4], [12], [15] show that voltage and current eventually decline as the bacteria deplete the organic matter and toxic metabolites accumulate, leading to inter- and intraspecies competition and the decline phase of growth [16],[17],[18]. However, since this study lasted only 10 days, the organisms likely had not yet entered the decline phase, which explains the absence of a consistent current and voltage drop seen in longer studies [12],[19],[20].

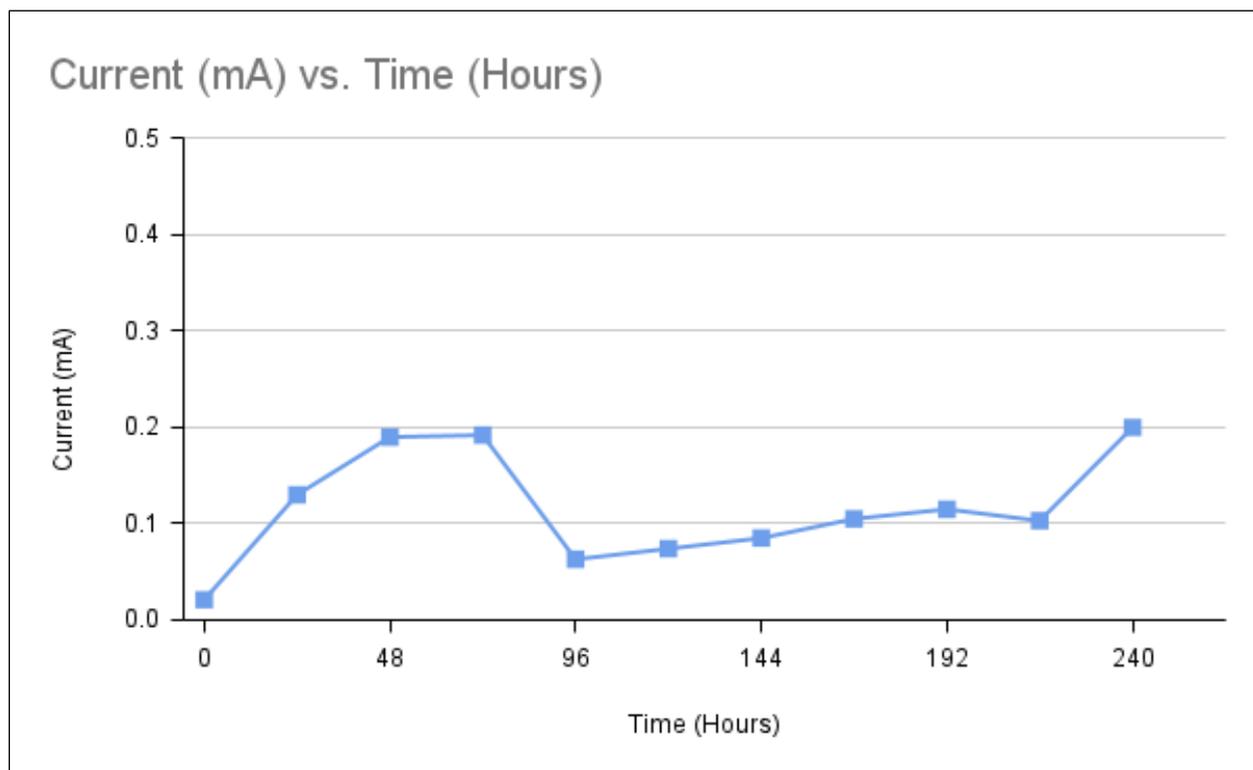


Figure 3. Trend of current (mA) generation in 10 days

#### 4.0 Conclusion

Abattoir wastewater from Gwagwalada is rich in organic matter essential for the growth of microbial communities. Microbial Fuel Cells (MFCs) used these microorganisms to breakdown organic materials in the abattoir wastewater, converting chemical energy into electrical energy in a single step. This study demonstrated that abattoir wastewater can generate voltage, current, and power, with the required microorganisms already present in the wastewater. Power generation from waste is now possible. The MFC used in this research achieved a 69.8% reduction in BOD and a 68.8% reduction in COD, indicating satisfactory wastewater treatment performance. It recorded a peak voltage of 94 mV and a peak current of 0.2 mA. These findings confirm that MFCs can treat Abattoir wastewater and generate energy through the microbial oxidation of organic matter.

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