WASTE TO WATTS FOR SUSTAINABILITY: A NOVEL APPROACH TO MICROBIAL FUEL CELLS (MFCS)

Project Reference Number: *49S_BE_4089*

College: *Jain College of Engineering and Technology (JCET), Hubballi*
Branch: *Department of Civil Engineering*
Guide: *Prof. Sunil Umachagi*
Student(s): *Mr. Abhishek R Gudageri*
Mr. Md Sameer M Naragund
Mr. Mohan H Kalburgi
Mr. Nitishkumar S Patil

Keywords

Microbial Fuel Cell (MFC), Wastewater Treatment Bioelectricity, COD Removal, Renewable Energy

Introduction

Wastewater management has become a major environmental concern, especially in rapidly growing urban regions. Domestic wastewater contains a high concentration of organic matter, which can be utilized as a potential resource for energy generation. Conventional treatment methods consume large amounts of energy and do not recover useful by-products.

Microbial Fuel Cells (MFCs) represent an innovative and sustainable technology that enables simultaneous wastewater treatment and electricity generation. In MFCs, microorganisms break down organic matter present in wastewater and release electrons, which are captured to generate electrical energy.

This project explores the feasibility of using domestic wastewater collected from the Gabbur Sewage Treatment Plant, Hubballi, as a substrate for bioelectricity production. Both single-chambered (SCMFC) and double-chambered (DCMFC) systems were designed and analyzed.

The study focuses on improving power output, enhancing microbial activity, and maximizing Chemical Oxygen Demand (COD) removal efficiency. By integrating waste treatment with energy recovery, this approach contributes to sustainable environmental management and renewable energy production.

Objectives

1. To identify and collect suitable domestic wastewater samples from the Hubli-Dharwad region by analyzing their initial physicochemical characteristics.
2. To design and fabricate a single-chambered Microbial Fuel Cell (MFC) for the treatment of wastewater and bioenergy generation.
3. To optimize the generation of biogas (methane) and maximize electrical power output from the MFC system.
4. To determine the maximum Chemical Oxygen Demand (COD) removal efficiency achieved during the treatment process.

Methodology

Domestic wastewater was collected from the Gabbur Sewage Treatment Plant (40 MLD SBR system), Hubballi. The collected sample was inoculated with 0.33% cow dung to enhance microbial growth and activity.

Six MFC units were fabricated: three SCMFCs and three DCMFCs. Different electrode materials such as graphite, aluminum, and stainless steel were used. Initially, all reactors operated in batch mode for 3–5 days to allow biofilm formation on electrode surfaces.

After stabilization, the system was switched to continuous feeding mode to ensure steady substrate supply. The MFCs were connected to a 100 Ω external resistor, and voltage output was measured using a digital multimeter.

Biogas (mainly methane) generated during anaerobic digestion was collected using a gas pouch. Key wastewater parameters such as pH, turbidity, total solids, DO, COD, and BOD were analyzed periodically.

Performance evaluation was carried out based on power generation and COD removal efficiency. Comparative analysis was performed between SCMFC and DCMFC systems with different electrode materials.

Results & Conclusions

1. The study demonstrated successful electricity generation along with wastewater treatment. Maximum power output of **1919 mW** was achieved in SCMFC (MFC-V) using stainless steel electrodes.

2. Graphite electrodes showed balanced performance with the highest COD removal efficiency of **72%** in DCMFC (MFC-II). Aluminum electrodes showed moderate performance but are cost-effective.
3. SCMFC systems produced higher power due to lower internal resistance and better microbial-electrode interaction. However, DCMFC systems achieved slightly better COD removal efficiency due to better separation of reactions.
4. Overall, the results confirm that electrode material and reactor configuration significantly influence MFC performance. The integration of wastewater treatment and energy generation makes MFC a promising sustainable technology.

Project Outcome & Industry Relevance

This project demonstrates a sustainable solution for wastewater treatment combined with renewable energy generation. The technology can be applied in:

- Municipal sewage treatment plants
- Rural wastewater management systems
- Decentralized energy production units

MFC technology reduces treatment costs, recovers energy, and minimizes environmental pollution. It has strong potential in smart cities and green infrastructure development.

Industries can adopt this system for treating organic waste while generating electricity, making it economically and environmentally beneficial.

Working Model vs Simulation/Study

Working Model Developed (Physical MFC units fabricated and tested)

Figure: Working Model

Project Outcomes and Learning’s

- Understanding of bioelectrochemical systems
- Practical experience in wastewater analysis
- Knowledge of reactor design and fabrication
- Insight into renewable energy generation
- Importance of material selection in engineering design
- Data analysis and performance evaluation skills

Future Scope

1. The project can be further enhanced by scaling up the MFC system for real-world applications. Future work can focus on improving power density using advanced electrode materials such as carbon nanotubes or graphene.
2. Integration with solar or hybrid renewable systems can increase efficiency. Automation and IoT-based monitoring can be implemented for real-time performance tracking.
3. Research can also explore the use of different waste substrates such as industrial effluents and agricultural waste. Long-term durability and cost optimization studies are needed for commercialization.
4. Large-scale implementation in sewage treatment plants can significantly reduce energy consumption and promote circular economy practices.