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Application of Plant Microbial Fuel Cell (Pmfc) to Agricultural Industry in Contribution to Green Energy

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Abstract:** Most of the innovation used by humans depends on electricity, thus becoming a crucial necessity. It enables people to live harmoniously and comfortably with the help of electricity which gives life to human inventions. Without electricity, most human inventions would be useless or nonexistent. Microbial Fuel Cell was conducted to test the efficiency of the generated current of microbes living inside the wet lands. By the use of the existing MFC series circuits, the researchers found out that there is an enough current that the MFC generated through electrodes (Zinc and Copper). The present study experimentally investigated the efficiency of generated current in MFC enough to power up low electronic materials such as: LED Light bulbs and Ditrio LED Lights. The farm lands will serve as the main source of electricity where the sludges will be taken and gathered to create a series circuit composed of two different prototypes.The global need for energy is always rising. In this case, carbon-based fuels have in one way or another provided for a significant share of the total energy requirement. As a result, fossil fuel resources have been severely depleted, which is now contributing to an ecological imbalance. Additionally, the burning of fossil fuels produces a significant amount of carbon dioxide, a significant greenhouse gas that has severe effects on the climate. MFC Systems or Microbial Fuel Cells Systems is a set of technology that uses microorganism as catalysts to oxidize organic and inorganic matter and generate current. Basically, wastewater such as sludge could carry these bacteria so it would be suspended to the system to generate current. It works as a battery where stacking multiple MFCs would create a higher voltage enough to power a household (Chaturvedi, Bioresources & Bioprocessing, 2016). This allows bacteria to facilitate in electron transfer processes as the propose application of Plant Microbial Fuel Cell to Agricultural industry especially in farmlands is to assess the feasibility as potential source of electricity. The MFC system in farmlands may serve as an additional source of renewable green energy in contribution to

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fight against climate change.

Keywords:* *Microbial Fuel Cells, Agricultural Industry, Microorganisms, Bacteria, Electrodes.

1. INTRODUCTION

Background of the Study

Electricity is a very important necessity that enables most of human technology to work. It allows humans to live harmoniously and with ease. Most innovations created by humans are useless or in existent if electricity did not come into play. However, this came with serious environmental threats such as global warming, which is a consequence of an increase in greenhouse gases caused by burning of nonrenewable resources, most notably of fossil fuels. In 2014, approximately 78 % of US global warming emissions were energy-related emissions of carbon dioxide. Of this number, approximately 42 % was from oil and other liquids, 32 % from coal, and 27 % from natural gas (Energy Information Administration, 2016).

In the Philippines, as of 2014, about 54 % of Greenhouse gas emissions were caused by the energy sector (USAID, 2016) of which was due to the extensive use of fossil fuels of roughly about 62.43 % (IEA Statistics).

MFC Systems or Microbial Fuel Cells Systems is a set of technology that uses microorganism as catalysts to oxidize organic and inorganic matter and generate current. Basically, wastewater such as sludge could carry these bacteria so it would be suspended to the system to generate current. It works as a battery where stacking multiple MFCs would create a higher voltage enough to power a household (Chaturvedi, 2016).

The researchers propose the application of Plant Microbial Fuel Cell to Agricultural industry especially in farmlands to assess the feasibility as potential source of electricity. The MFC system in farmlands may serve as an additional source of renewable green energy in contribution to fight against climate change.

Objectives of the Study

The researchers aim to assess the feasibility of agriculture industry especially in farmlands to generate electricity using PMFC systems. Specifically, the study aims to:

1. Determine the materials needed to create a working prototype;
2. design a schematic diagram of the prototype;
3. create a working prototype of the MFC system in application for farmlands; and
4. Assess the efficiency of the prototype in terms of voltage output.

Significance of the Study: This study was conducted to be able to determine the efficiency of the PMFC System for electricity generation in Bayugan City, Agusan Del Sur. This study will give significant benefits to the following:

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Bayugan City Denr: This study is significant and will benefit Bayugan City's DENR because determining the efficiency of the PMFC System among the researchers of the community will provide data that may help create or discover more renewable electricity-generating microbes.

Horticultures/Horticulturist: It is significant because it will benefit them if the study will be successful in the future as it provides a small-scale amount of electricity that would serve as an additional source of green energy enough to power low electronic devices.

Future Researchers: Future research can benefit from the study's conclusions. researchers studying electricity-generating microbes and MFC systems. This study's findings may also provide preliminary data that future researchers can use in their future research.

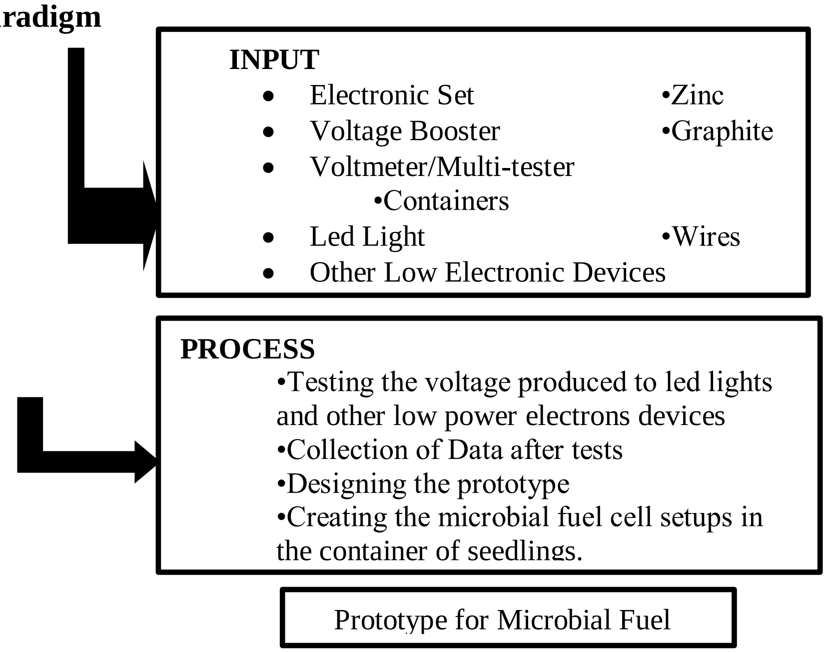
Scope and Limitation

This study limits its coverage of Bayugan City Farmlands and the use of PMFC systems for electricity generation. This study only aims to assess and investigate the capability of the area's sludge to generate electricity. Thus, the researchers shall neglect any other alternative methods of electricity generation that are applicable in the area. Specifically, the study will only take place in the municipality of Bayugan City, Agusan del Sur of which also touches the farmlands. The collection of the sludge will only take place in the pit lands of the farmlands in Bayugan City, Agusan del Sur where there are less risks.

Conceptual Framework

Shows the output in conducting the experiment of Microbial Fuel Cell. The diagram depicts the entire process of this study. The materials used in conducting the study to the process and result of this study. Finally, data from the conducted study will be collected.

Research Paradigm



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Review of Related Literature

Microorganisms in Sludge

The microorganism merges with wastewater through the sludge activation process. The biodegradable substances in the wastewater come into contact with the microbes and are eaten as food. Additionally, the bacteria produce a slimy covering around their cell walls, making them cling together and creating bio-solids or sludge, which is then separated from the liquid phase. The efficiency with which the bacteria break down the organic matter and their capacity for adhering to one another, forming flocs, and settling out of the bulk fluid will determine how effectively wastes are removed from the water. The inactivated sludge of the microorganisms can aggregate and form solid masses big enough to sink to the bottom of the settling basin due to the flocculation (clumping) properties of the material. The settling and wastewater treatment both get better as the sludge's flocculation properties get better. Beyond the aeration process in the basin, the wastewater and microbial mixture (mixed liquor) pass into a clarifier or settling basin wherein sludge is permitted to settle. Returned Activated Sludge (RAS), a portion of the sludge volume is continually recirculated from the clarifier back to the aeration basin so as to maintain an adequate amounts of microorganisms in the aeration tank. The microbes are reactivated to eat organic nutrients when they are combined with incoming wastewater once more. Then, the procedure is repeated. Thus, there are five main categories of microorganisms involved throughout the sludge process within the aeration basin: protozoa, bacteria, metazoa, filamentous bacteria, algae, and fungi. The majority of the time, bacteria are in charge of extracting organic nutrients from wastewater. By eliminating and digesting freely floating scattered microbes and other suspended particles, protozoa play a crucial function in the therapy process. The visibility of the wastewater discharge is improved as a result. Protozoa are similar to bacteria in that some can thrive without oxygen while others only need a tiny amount. Larger than most protozoa and composed of several cells, metazoa plays very little role in the removal of organic matter from wastewater. They do consume bacteria, but they also devour algae and protozoa. Longer-established systems, like lagoon treatment systems, typically have a metazoan predominance. Although they have a minor role in the sludge that has been activated treatment system, their presence does provide information about the state of the system. When operational circumstances suddenly alter, filamentous bacteria are present. These bacteria start to acquire an advantage when they develop in lengthy filaments. These bacteria can be impacted by adjustments to pH, temperature, DO, sludge age, or even the availability of nutrients like nitrogen, phosphate, oils, and grease. Sludge-settling issues may result from filamentous bacteria predominating within the active sludge treatment system. When there are too many filamentous microorganisms present, floc settling can occasionally be hampered and the sludge can thicken. This thickening sludge settles slowly and produces a turbid effluent as a byproduct. Foaming in the clarifiers and aeration basin may be brought on by specific filamentous bacteria. The presence of algae and fungi, which are both photosynthetic organisms and typically do not cause issues in sludge that has been activated by treatment processes, is frequently a sign of issues with pH shifts and older sludge (Theobald, 2014).

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Local Studies

Plant Microbial Fuel Cells–Based Energy Harvester System for Self-powered IoT Applications

Sensor networks with wireless connectivity (WSN) built on Internet of Things (IoT) technology are made up of tiny sensor nodes that are dispersed around an area to gather real-time data on things like temperature, salt, stress from water, and humidity. When the stored energy is low or depleted, traditional IoT-based WSN systems must recharge or replace their batteries, and the replacement process might be challenging or even impossible. The creation of a suitable energy extraction (EH) system is one of the major issues facing this technology. In light of this, EH systems are essential for the most advanced electrical applications, including IoT, smart cities, wearable electronics, biosensors, and autonomous WSNs. Additionally, the application of IoT-based and energy harvesting systems has been suggested as a solution to a variety of engineering issues, including monitoring of cattle and honey bees, automated irrigation, early insect identification, and structure health monitoring, among others. To provide endless power supplies that can be a desirable and effective option to replace the highly polluting batteries used in IoT systems, self-sustaining harvester systems have begun to collect energy from sources such as wind, sunlight, and motion, among others. The consumer electronics industry and wireless sensor networks both benefit greatly from the excellent cost-effectiveness and scalability of these energy harvester approaches. However, in indoor settings, ambient-based (such as solar and wind power) and piezo-motion systems are hardly ever available (De la Rosa, O et al).

Foreign Studies

Microbial Fuel Cell Studies

A microbial fuel cell, also known as an MFC, is a device that uses microorganisms' catalytic abilities to transform chemical energy into electrical energy. Although MFCs have a lot of potential as a source of renewable energy, a cutting-edge method of treating wastewater, and a biosensor for contaminants and oxygen, further tuning is necessary to fully realize the microbial potential. The primary issues that restrict MFC functioning are listed in this article, along with recommendations for improving efficiency (Kim B. C., 2007). Another study used two-chambered microbial fuel cells using ferricyanide from potassium as its electron acceptor to break down extra sewage sludge and produce power. Throughout operation for 250 hours, reliable electric power was produced constantly. Sludge's complete chemical oxygen demand (TCOD), which was initially 10,850 mg/l, was decreased by 46.4%. The MFC-generated power was closely correlated via the soluble chemical oxygen requirement (SCOD) of sludge but didn't significantly depend on process variables like the amount of substrate, cathode catholyte concentration, or anodic PH. Additionally, the TCOD removal rate in the MFC was boosted and organic matter dissolution was hastened by ultrasonic pretreatment of sludge, although power output was only marginally improved. This study shows that this MFC can produce energy from sewage sludge under various conditions (Jiang, 2009). They are employing microbial fuel cells to turn biomass into electricity, which is the same idea as in the study mentioned above. The experiments of a two-chambered salt bridge MFC using Enterobacter cloacae IIT-BT 08 in MYG medium are the subject of the current paper. On the power generation in MFCs, the effects of various electron mediators, the mediator's

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concentration, the medium's ionic strength (salt concentration), and the surface area of the salt bridge in contact with the anode and cathode chambers are documented. The voltage generation was 0.4 V in the case of methyl viologen (MV) (0.1 mM) as the electron mediator, but no current was found. Methylene blue (MB) at various concentrations was also investigated as the mediator. At 0.05 mM MB, a maximum voltage of 0.37 V and a maximum current of the instance of 0.03 mM MB with a voltage of 0.34 V, and power of 56.7 A and 19.2 W, respectively, were measured; the corresponding power density and current density were 9.3 mW/m2 and 27.6 mA/m2, respectively. The power output rose proportionally from 19.2 to 708 W when the salt bridge's surface area in contact with the anode and cathode chambers was increased. The greatest power density and current density, which are considered to be extremely promising for a salt bridge MFC, were reported to be 236mW/m2 and 666.7mA/m2, respectively (Mohan, 2008).

2. MATERIALS AND METHODS

This chapter contains the study's methodology.

Materials

Plywood	
Zinc	Electronic Set
Nail	Voltage booster
Graphite	Voltmeter
Wood boxes	Led Light
Wires	Other Low power devices

Process

Selection of plants

The first step in the data gathering procedure for PMFCs is the selection of appropriate plant species for the experiment. The plant species should have a high concentration of organic matter in their roots, such as wetland plants like cattails, bulrushes, or reeds.

Soil preparation

The soil should be prepared by adding nutrients to enhance the growth of microorganisms. This can be done by adding organic matter, such as compost or manure, to the soil.

Assembly of the PMFC

The PMFC can be assembled by connecting two electrodes, an anode and a cathode, with a proton exchange membrane.

Preparation of Sludge

Before putting the sludge in each container. It should be fed first by a brown sugar in a big container for maintaining the bacteria and microorganisms.

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Placing the Zinc and Copper in Every Container

The assembled bottles should have two alternative Zinc and Copper attached to another bottled with enough soil.

Monitoring the prototype

The PMFC should be monitored regularly to measure the voltage and current output. This can be done using a multimeter.

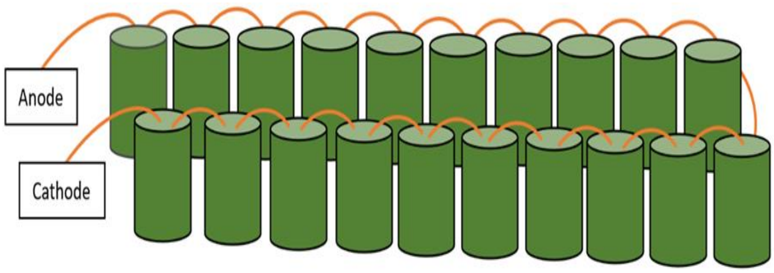
3. RESULTS AND DISCUSSIONS

Result and Discussion

The study was able to test the efficiency of farmlands in generating current as renewable energy.

Prototypes

The two prototypes are composed of two different styles and counts of chambers. The first prototype is composed of twenty-four chambers with a size of 8cm x 9cm in each chamber. These chambers are built up with pure glass to avoid groundings of the current during voltage testing of the MFC. Each chamber of the prototype contains two wirings of electrodes, a cathode, and an anode. This will help the MFC to generate its current throughout the whole series circuit. The second prototype is created in pure 1L bottles with long and sharp Copper and Zinc in each chamber. It will help the MFC to maintain the same amount of voltage in a maximum of time while it is used for testing. The second prototype is attached with two alternate wirings of electrodes to avoid failures in collecting currents in the MFC. With the use of a voltmeter, the generated current will be recorded and measured before, during, and after testing the two prototypes.



Power output

	Day 1 of testing	Day 2 of testing	Day 3 of testing	Day 4 of testing
Power Outputs	17.8 volts	16.8 volts	15.9 volts	13.79 volts

Table 1. Power Outputs observation

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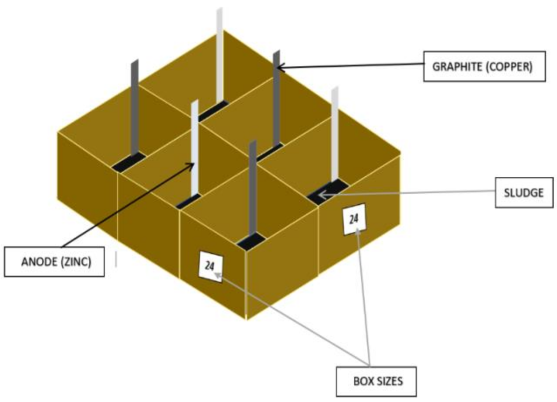
The prototype generated approximately 17.8 volts by using a series circuit of twenty chambers on a microbial fuel cell using the prepared electrodes which the Zinc (anode) and Copper (Cathode). The prototype generated a stable power output which was a great result for an MFC system. The prototype was able to light up a 3-volt LED light with an input voltage of 1.6 volts. When it is connected to a Ditrio LED Light to test its efficiency, the input voltage decreased. After 4 days of observation, the power of the Ditrio LED Lights is still stable.

Prototype A [1] Result
The first prototype generated 4.8 volts (0.2 volts per chamber) by using a series circuit with 24 chambers of MFC which is unstable. These twenty-four chambers had its unstable volts and the power generated from the prototype keeps decreasing overtime.

Prototype B [2] Result
In the second trial of a new pair of electrodes where Zinc represents as (anode) and Copper for (cathode). This prototype generated approximately 17.8 volts (0.89 volts per chamber) by using a series circuit of twenty chambers. The power output of the second pair of electrodes is much greater and more stable than the first pair of a prototype.



Summary, Conclusion and Recommendation
This chapter presents the summary of findings, conclusions, and recommendations drawn by the researcher from the results obtained in this study.

Summary of Findings
The experimental Microbial Fuel Cell was conducted to test the efficiency of the generated current of microbes living inside the wetlands. By the use of the existing MFC series circuit, the researchers found out that there is enough current that the MFC generated through electrodes (Zinc and Copper).

1. There are lots of effects that the MFC gives on out Agricultural industry, especially in the farmlands. The farmlands will generate more microbial organisms once it's always used as our alternative source of electricity. Farmers that had their own farmlands will create another one or much wider than the first farmlands they have. As these farmlands will

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multiply, the more there will be lots of sources of electricity and the growth of organisms in the soil will help the rice field to grow healthier without having chemical fertilizers.
2. The source of currents that the sludge generated from its living organisms is only enough to power up low electronic materials. While in wetlands it generated a higher amount of voltage to power up house light bulbs and other higher electronic materials.
3. The amount of voltage that the MFC system generates is 17.8 in the final testing of the second prototype which lights up a 3-volt LED Light.

4. CONCLUSIONS

Current Generation: The experiment demonstrated that microbes living in wetlands can generate electricity through the process of microbial metabolism. The MFC effectively captured and harnessed this electricity, converting the microbial activity into usable electrical current.
Efficiency: The efficiency of the generated current in the MFC was evaluated. It was observed that the efficiency varied depending on various factors, such as the type and density of the microbial community, environmental conditions, and electrode design. Further optimization of these parameters can potentially enhance the efficiency of the MFC system.
Renewable Energy Source: The experiment confirmed that microbial fuel cells hold promise as a renewable energy source. Wetlands, which are abundant in microbial life, can serve as natural sources of electricity generation through MFC technology. This offers a sustainable and eco-friendly alternative to conventional energy generation methods.
Environmental Benefits: Utilizing MFCs in wetlands can have additional environmental benefits. The process of electricity generation through microbial activity does not produce harmful byproducts or greenhouse gases. Moreover, the MFC technology can potentially help in the treatment of wastewater, as microbial communities play a vital role in breaking down organic matter.
Potential Applications: The results of the experiment indicate that MFC technology has various potential applications. Apart from wetlands, MFCs can be deployed in other environments with high microbial activity, such as wastewater treatment plants, agricultural settings, and even in remote areas where access to conventional power sources is limited.
Further Research: Although the experiment provided valuable insights into the efficiency of MFCs in wetlands, further research is needed to optimize and scale up the technology. Investigating the long-term performance, stability, and scalability of MFCs, as well as exploring different electrode materials and system configurations, can pave the way for commercial applications of microbial fuel cell technology.

Recommendations

Based on the conclusions of the experimental study on microbial fuel cells (MFCs) in wetlands, the following recommendations are made: optimize MFC design by exploring different electrode materials and configurations, conduct long-term performance analysis to assess stability and identify potential issues, scale up and commercialize MFC technology while maintaining efficiency, monitor the environmental impact of MFC implementation, explore integration with wastewater treatment processes, foster collaborative research efforts,

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and promote education and awareness about MFC technology among various stakeholders. Implementing these recommendations will advance MFC technology, leading to improved efficiency, expanded applications, and increased adoption of this sustainable energy source derived from wetland microbial communities.

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