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Smart Plantation using SMFC

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***Abstract*: We generate electric power from coal and fossil fuels or nuclear plants through hydroelectric plants. Each method has its downside – be it water shortage, fouling the environment with pollution dust and greenhouse gases, or safety issues with radioactive damage. Can we at all have a pollution-free and nature-friendly power plant? Biology appears to suggest a way method that generates electricity from living plants and the microbes that live beneath them in the soil, where the plants drop their roots. The objective of the project is to use some of this organic material coming out of the plants into the ground, metabolize them, and, in the process, generate carbon dioxide and hydrogen ions and electrons. Renewable energy is needed as a source of electrical energy. One interesting topic for renewable energy is Microbial Fuel Cell (MFC) because it doesn't produce carbon emission and does not need energy input, instead, a small amount of electrical power is generated. We have performed the simulations and the results and different topologies are further discussed in detail. We are replacing the conventional battery system with SMFC because it doesn't produce carbon emissions and a small amount of electrical power is generated. This small amount of power-delivering cells is connected in series to get a larger output voltage and also increase the voltage by using a boost converter.**

***Keywords*: Smart plantation.**

1. Introduction

Producing energy from organic waste is becoming increasingly important because energy production from fossil fuels has become more expensive and not environmentally friendly, and this causes climate change problems. Microbial fuel cells (MFCs) present as an alternative environmentally friendly technology to produce bioelectricity directly from materials that naturally decompose, such as organic acids, proteins, and carbohydrates. However, there are still some obstacles in the commercial production of these cells, such as the cost of fuel cell construction, the problem of increasing size, and the problem of increasing the ability to produce power density and contribute to an increase in output voltage. In MCF systems, the configuration of the anode and cathode catalyst can play a crucial role in improving the power density. Other important technical parameters in the design of MFCs include the distance of the two electrodes from the fuel cell (Logan & Rabaey, 2012; Pant et al., 2011; Choudhury et al., 2017), the anode and the cathode membrane separator (Biffinger et al., 2007), the use of membrane-electrode assembly (Park, 2000), cathode type (Cheng et al., 2011),(Rahimnejad et al., 2015), (Ömeroğlu & Sanin, 2016), and the operating conditions of the system being operated, including pH (Zhang et al., 2013) as well as the sustainability of batch versus flow system operation. Research on power density values in the range of 1–2.4 W/m2 has been published about the design of the MFC, with the addition of several parameters (Logan et al., 2015; Helder et al., 2012). The production of MFCs has several advantages when compared with material cell production, such as low cost and the absence of toxic mediators. For instance, a good system can be successfully made without the use of expensive selective membranes. The use of mixed membrane materials has been investigated in several articles about MFCs, and more recently, bioelectricity has been produced using energy sources from wastewater (Tharali et al., 2016). With this substrate, the power density that can be produced by MFCs is in the range of 10–14 mW/m^2, whereas MCFs that use mixed media is reportedly producing slightly larger power density values from 0.3 to 3600 mW/m^2. Several researchers conducted a study by inserting artificial wastewater into a reactor (He et al., 2016; Xu et al., 2016; Asai et al., 2017) with mud media, and they observed a 20-fold increase in current density over 30 days, which made it possible to select beneficial organisms, even though the power density produced was not large enough at 1.3 mW/m2. Microbial fuel cells have previously used a two-compartment system, where aerated cathode compartments contain chemical solutions of iron and oxygen and anode compartments contain bacterial cells, electron mediators, and reduced substrates (Ucar et al.,2017; Song et al., 2019). Other soil substrate materials, such as paddy soil and river sediments, have been reported (Aziz, 2015; Xia et al., 2017). In MFCs, the substrate is one of the most critical factors that can influence bioelectricity generation because it functions as a source of nutrition and energy for the growth of the microorganisms involved. In most MFC studies, pure compounds, such as glucose (Rabaey et al., 2003), amino acids from cysteine (Logan et al., 2005), and ethanol (Kim et al., 2007), have been used for electricity generation. Other compounds that have been used include complex substrates, such as domestic wastewater (Liu et al., 2009), starch processing wastewater (Min & Logan, 2004), and marine sediments (Min & Logan, 2004). The mixture of organic compounds in wastewater has provided information that a diverse microbial community plays an essential role in oxidizing organic matter because most exo-electrogenic bacteria can only survive if supported by various types of

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substrates (Wrighton et al., 2010). Therefore, this study aims to evaluate the potential of local rice fields and river sediments mixed with plastic soil in enhancing the bioelectricity produced by MFCs and maintaining the survival of MFCs by adding softened mung bean sprouts as a nutrient. We chose to use mung bean soy sauce as a nutrient in the MFC system because it contains vitamin C compounds, β-carotene, free amino acids, and reduced levels of flatulence-causing oligosaccharides and mineral-binding phytic acids (Liu, 2008)

2. Literature Review

Few researchers published papers on Earth-Battery. The soil provided a small amount of electric power that was focused on their paper. Combinations of Magnesium anode and Coke cathode; Zinc anode and Graphite cathode; Aluminum anode and Carbon cathode; Zinc anode and Copper cathode have experimented with in their papers. As a result, a small amount of power was produced from that system. In 2019, Nnebedum et al. [3] proposed the Earth's Earth-Battery from Earth's surface in an open-air environment with combinations of magnesium anode and coke cathode. In 2017, Yang et al. [4] released a paper on the technology used to generate electricity from bacteria using individual reactors—an anode brush made of Carbon (Graphite). In 2018, Belov et al. [5] published a work entitled Earth-Battery as a renewable energy source. In 2017, Bose et al. [6] research was carried out using Himalayan mud and microbial fuel cells to obtain a small amount of energy.

3. Methodology and Modeling

The soil's electrical conductivity is an indirect measurement that is very well related to various soil physical and chemical characteristics. Two electrodes use wet soil as an electrolyte in an Earth-Battery cell, which is created by two different electrodes. Earth-Batteries components such as soil, cell container, connecting wire, Anode, Cathode, water, multimeter, and ampere meter are readily available in this prototype. Anode and Cathode were used as dipole electrodes to generate this initial force for electron movement. Carbon (C6) was used as an Anode, and Aluminum (Al13) was used as a Cathode in a single soil container. Anode attracts electrons that repel the electrons that allow Cathode to bear (ve) charges for its attraction–repulsion status compared to Cathode [7]. Carbon (C6) electron conductivity is 2105 s to 3105 s, and the electron affinity of Carbon (C6) is (153.9 kJ mol), and Aluminum (Al13) conductivity is 3.8107 s with electron affinity (−41.8 kJ mol). The voltage and distance between two electrodes are correlated with each other, expressed with Coulombs Law's relief. A sample prototype diagram of a Standard Series–Parallel cell design & Coulombs law's diagram with expression has shown in Fig. 1. In a single cell of Earth-Battery, Carbon (C6) and Aluminum (Al13) were used as an electrode due to their high electron mobility. Approximately 1 V (DC) was produced from each cell. The single-unit cell of Earth-Battery and the 3D Model

The velocity of the electrons affects the resulting current rate. When the velocity of the electrons increases, the resulting current increases as well, and when there is an extra force on the electrons, the electron's movement increases, then the resulting current also increases. Potential Energy, Ep=mgh, also Potential Energy can be expressed as, V=IR [R is a constant] and V I. So here, the more of the potential energy, the more output current. Kirchhoff's Voltage and Current law can also be applied to the following Equations

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4. Proposed System

A. Planning of the Project

The plan of the project is to cover a significant agricultural area to form compartments in the soil and figure a way out to obtain voltage across this land. The initial method of obtaining this electricity was by performing simple tests on a small portion of contained soil. The soil is kept inside a plastic container. The plan was to test the resistivity of the soil and the microbial level of the soil. The soil present on agricultural land is basically high in nutrients and fossils as well as the fertility of the soil and oxygen present in the soil is essential for the rapid growth of plants.

1) Working principle

The SMFC is a bioelectrochemical system formed by inserting the anode electrode into the sediment to allow the indigenous microorganisms to connect directly to the anode and use sediment organic matter (OM) as a source of electron donors in the aquatic ecosystem to generate bioelectricity. Tbioelectricitycity is then stored and amplified to a required stable electric potential.

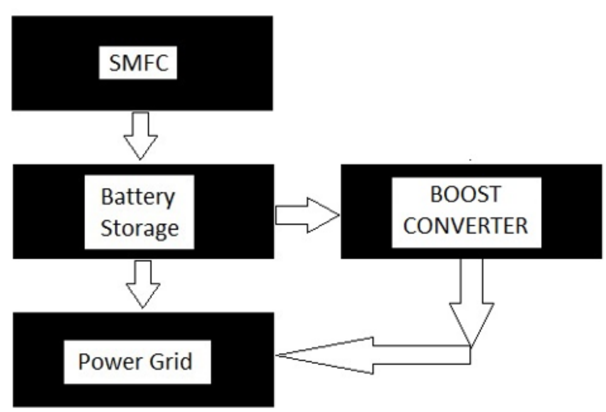

Fig. 1. Block diagram of the proposed system

5. Hardware Implementation of the Model

All the components are mounted on the sensor board. The components required on the sensor board are:

1. SMFC
2. DC source
3. MOSFET
4. Linear transformer
5. PWM Generator (DC-DC)
6. Constant
7. RMS
8. Display
9. Voltage measurement
10. scope
11. Diode
12. Capacitor
13. R load

A. Soil Microbial Fuel Cell

The MFC technology is used to convert chemical energy to electrical energy from organic wastes or carbon sources, which are carried out by oxidation process and electrochemically active bacteria. generates electricity by utilizing electrons produced from the anaerobic oxidation process of substrates. It consists of two chambers, such as anode and cathode. They are separated by a specific membrane called the exchange membrane. The microbes used in the MFC technology are bio-electrochemically active bacteria. The power density generated by MFC is 1kW/m^3 of reactor volume

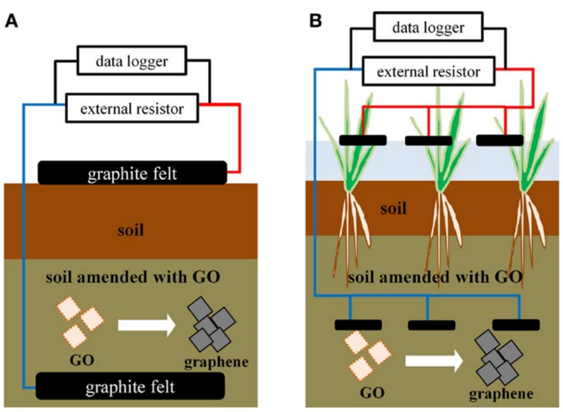

Fig. 2. Soil microbial fuel cell

B. Boost Converter

A boost converter is a type of DC-DC power converter that increases the voltage of an input DC voltage to a higher output voltage. It works by storing energy in an inductor and then releasing it to the output through a switching element (typically a transistor) and a diode.

The basic working principle of a boost converter can be described as follows:

1. The switching element (transistor) is turned on, causing current to flow through the inductor and build up a magnetic field.
2. The transistor is then turned off, causing the inductor to release its stored energy to the output through the diode. The diode allows current to flow in only one direction, from the inductor to the output.
3. The output voltage is regulated by controlling the on and off time of the transistor. This process is repeated rapidly (typically several thousand times per second), leading to a steady output voltage that is higher than the input voltage.

A boost converter's specifications include input voltage range, output voltage range, output current, efficiency, and switching frequency. These define the range of input voltages the converter can accept, the range of output voltages and the maximum current it can deliver, the efficiency of power conversion, and the frequency of the switching element. They are widely used in a variety of applications where a higher voltage is required, such as in battery-operated devices, solar panels, and DC-DC power supplies.

6. Connections and Interface

Here the DC source is the SMFC battery connected with an N channel MOSFET which gives a pulsating output signal where the switching frequency of a PWM Generator is 25000 Hz. The linear Transformer is connected with a parallel combination of resistive load and capacitor. The voltage measurement tool is used to measure the output voltage of the converter and it is attached with a scope that shows the output graph of the boosted signal. This output signal is also fed to an RMS calculator tool which gives us the RMS value of the output signal. The RMS value is displayed on the DISPLAY tool.

7. Conclusion

Soil has a positive impact on electricity generation in a microbial fuel cell. From the two soils tested (sand, and clay) the clay was most promising, with a peak voltage of 644 mV and a peak power density of 0.0885 (mW/mm^2). The one-to-one, soil-to-compost ratio configuration worked the best for electricity generation. The pure compost MFC did generate electricity, but the SMFC's which had a soil-compost ratio outperformed the pure compost configuration. Further investigation is required to better understand the mechanisms by which the soil type affects the electricity generation in the SMFC. The type of soil media can greatly influence the electric power generated and the incubation period of the MFC unit. Soil types that contain organic matter produce more power density than ordinary soil types that have low organic matter content. An MFC can be regenerated to produce more power than previously untreated land. The maximum power density of 22.4–23.4 mW/m^2 was produced by an MFC with rice field soil, which contains a lot of organic waste with a life cycle of> 3 (20 days) after the addition of glucose nutrition. More research is still needed to study various types of substrate or types of agricultural waste to get greater power density values and longer life cycles.

like turning on and off lights, raising or lowering the temperature, etc. Other future scopes include A jacket design based on this idea which will be able to recognize the movements and gestures of animals and a Virtual Reality application that will be able to replace traditional input devices like joysticks in video games with a data glove which will be similar to our proposed model.

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