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Research on biodegradable waste as a substrate for microbial fuel cell with focus on renewable energy micro grid set up

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Abstract-Renewable energy is the prominent solution for environmental carbon foot printing control. Conventional energy generation plants are causing a reduction in fossil fuels, and such precious fuels need to be controlled. Fossil fuels are also responsible for the increase in carbon footprinting. Much research focuses on the development of a new model, but it is necessary to evaluate the existing research and identify the gaps to make it more usable. Hence, this paper aims to re-develop and test the performance of biodegradable microbial fuel cell biodegradable substrates, which can be used to set up the renewable energy microgrid. Power output is important to set up any microgrid; hence, we identified and compared two single-chamber microbial fuel cells with biodegradable substrate materials: pineapple waste and dairy waste water. The paper also discusses the applicability of renewable energy resources depending on the availability of natural resources in a particular geographical region.

Keywords—component, formatting, style, styling, insert

I. INTRODUCTION

Renewable energy sources (RESs) can provide energy solutions by net-zero carbon energy, dealing with the global worries bordering the transformation of the environment. Microgrids (MGs) have currently been enforced and managed in the power system's low voltage (LV) sphere, handling the issue of just how to incorporate these kinds of solutions right into the power system [1]. Considering the stable progress of load requirements, the rigid power strength considerations, and the hitting demand of carbon emission decline, microgrid enlargement future planning to look at all those elements has turned out to be relevant. A new framework for long-lasting microgrid development arrangements, in which a microgrid functions as a backup power system in the situation of primary grid failures from the views of industry, durability, and greenhouse gas release, is suggested by well-known studies [2].

The challenges of conventional power systems have paved the way for new methods of electrification, which involve incorporating micro-generation sources near the consumption point. The latter is a more feasible solution to overhauling the whole system. This technology is known as micro-grid, a future building block of the smart/intelligent grid. [3].

As we focus on the RE microgrid, the biggest concern for microbial fuel cells (MFCs) is increasing energy conversions and production power. The anode component and

composition influence microbial probation, substrate oxidation process, and extracellular electron transfer (EET) levels. Boosting all these elements may be a practical strategy to strengthen MFC efficiency [4]. Lately, key developments have adhered to technological know-how that satisfies energy requirements with minimal waste generation. MFC is a technology that suggests monetizing waste materials as a base and generating electric energy. Work completed in the location of fuel cells has various constructions and modifications depending on categories of base employed, microorganisms linked with electrodes, and design of MFCs [5].

Besides this, various points are identified as allies to environmental wreckage. Nonetheless, these consist of but are not limited to, syndication, the usage of alternative solutions, farming techniques, and renewable energy. The recent analysis explores the detailed associations between these parameters and CO2 exhausts [6].

MFC is a modern bio-electrochemical technology formulated to effectively produce bio-electricity from natural and organic waste materials, employing bacteria as catalysts. Topsoil can generate electrical energy in MFCs, which convert compound energy from topsoil biological substances into energy with the aid of catalysis by soil-derived microbes. Nevertheless, it encounters functional obstructions just like poor power and current density [7]. Residue microbial fuel cells (RMFCs) are Bio electrochemical models that have the potential to generate bioelectricity. However, the level of poor biological matter residue confines their output power. Aside from that, another aspect that triggers low Power generation potential in Residue microbial fuel cells is the poor conductivity of the catholyte [8].

MFC technology has a rather wide advancement potential in the arena of oceanic emergency power supply, aligning with the effect of geographical elements of electron transfer of MFC on the resulting voltage [9]. Consequently, evaluating the MFC results with diverse criteria like electrode structure, materials, and catalysts is vital.

II. Literature Review

The concept of MFCs, established in the 1960s, has commenced to adopt core steps, considering that this concept enables the usage of several sorts of waste materials as resources to obtain bioelectricity. Because of the satisfactory potential, MFCs have a significant volume of patterns; however, normally, they comprise two compartments (anodic and cathodic), which are practically often segregated by a proton exchange membrane, and within the chamber, electrodes are installed on the exterior by an electronic circuit [10].

Mitigating environmental transformation without sentencing the undesirable global impact to never-ending poverty is the leading concern of energy policy today. Our civilization depends intensively on fossil energy, with about 80% of major energy coming from fossil fuels. Their burning is adding to a quick boost in the globe's average temperature. Persisting large-scale production of fossil fuels poses serious risks for human civilization; however, preserving and increasing an affluent civilization needs a particular level of energy supply. The standard claim is that renewable energy has become an essential notion within the areas of energy policy as well as climate change mitigation and has a key role in driving the logic within these areas [11].

Renewable energy solutions are deemed clean and severely essential because of their environmentally friendly characteristics. Because of the rise in consciousness of a clean ecosystem, it is assumed that common reliance on fossil fuels has targeted carbon dioxide (CO2) exhausts, greenhouse gas (GHG) challenges, and geographical pollution. RES can encapsulate residential energy expectations with the potential to present energy solutions with almost zero release of air pollutants and GHGs. Crucial responsibilities like ecological development of remote areas in the desert and hill zones and setting up the requirements to accomplish international agreements associated with environmental security are anticipated to be fixed with the development of RE [12]. RESs and ESSs are the key systems for smart grid uses and offer great possibilities to de-carbonize metropolitan aspects, control consistency and voltage deviations, and respond to critical times if the load exceeds the generation [13].

ASEAN nations have also founded particular renewable energy objectives. In 2014, 9% of ASEAN's electricity usage was via renewable energy that involved significant hydropower. Nations can profit from the recent motivation to establish a regional adjoining grid, the ASEAN Power Grid [14].

Currently, the 100% RE approach is being pushed among various stakeholders. Cases are generally determined in Sweden, where the aim is to achieve 0 % net exhausts of greenhouse gaseous elements through 2045, and then in Denmark, the objective is to attain 0 % net exhausts by 2050 at the latest. Additionally, countries focus on 100% alternative electricity by 2045 or 2050.

Changing renewables, including solar photovoltaic and wind power, is an important system for obtaining the de-carbonization of the electricity sector. Nevertheless, they vary considerably from standard power generation resources. As the share of changing renewables rises, these variations result in various difficulties in power systems. The inability to cope with these difficulties may endanger the power system's credibility or the accomplishment of de-carbonization goals. Different solution systems are obtainable to minimize these issues [16]. The author details the evaluation of the Stirling engine efficiency by evaluating biomass and solar energy as alternative renewable energy resources. A program code was formulated in the MatLab® to resolve the thermal model of an alpha-Stirling engine, accounting for the constraints in the heat transfer procedures in the regenerator and the deficits because of pumping results. The solar energy resource was patterned as a concentric solar dish collector, considering a receiver based at the key position and built to absorb the maximum possible solar radiation [17].

The author evaluated the purpose of distinct expertise-acquiring approaches for development in two technology domains, particularly solar and wind power. The link between alternative expertise acquiring and development capabilities is observed to rely on acquiring tactics and concept areas. Outcomes brought to the analysis of

methodology structure by featuring that solar power development gains from a wide-ranging quest methodology pulling on a significant number of outer experience sources, even though wind power innovations are likely to flourish with the aid of intense usage of a considerably more modest amount of alternative resources. The author produced significant innovations and energy policy [18]. The key global concern for all these parts is to give cost-effective and trustworthy energy solutions to non-urban areas. Electricity has been identified as a critical base for individual maintainable development. The setup and source of grid electricity are economically inviable or impossible for such sparsely inhabited remote environments. Even though people in this kind of non-urban sector have different electricity disruptions, many still have no electricity access [19].

A hybrid microgrid (HMG) is a small-scale power system consisting of distribution generations (DGs) and loads operating as one controllable unit about the grid. It gives advantages such as a reliable power supply, lesser carbon emission, and being environmentally friendly. The author proposed a fractional order proportional-integral-derivative (FOPID) controller to enhance the power quality of an HMG, including a wind turbine, aqua electrolyzer, fuel cell, load, and BESS. Due to the computational simplicity of the genetic algorithm (GA), it is employed to tune the gains of the FOPID. The author focused on coastal region electrification using microbial fuel cells. The author found that developing single-chamber microbial fuel cells (MFC) can convert Sargassum species and be utilized for electricity generation. The author also included and analyzed the impact of organic catalyst materials on electricity generation using Sargassum [20].

The author offered dynamic modeling of numerous elements of a modest remote solution. The dynamic modeling of this nonlinear 45 Vdc energy unit is implemented with Simulink. The simulation results and the limitations of a fuel cell energy system are reviewed. Fig. 1 shows the common workings of a single-chamber MFC.

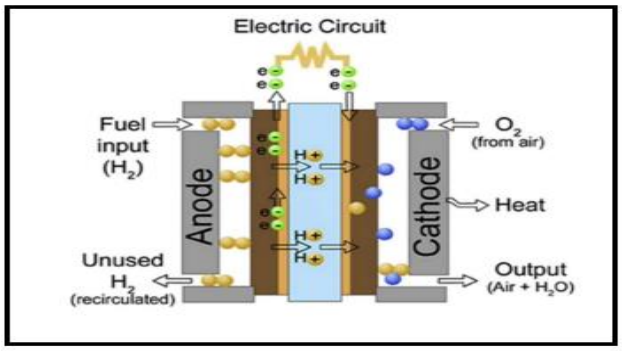


Fig. 1: Working of Fuel Cell

Fuel cells enhance the chemical energy of hydrocarbon fuels right into immediate recent electrical energy; due to their high-power density, substantial efficiency, and geographical friendliness, the Polymer Electrolyte Membrane Fuel Cell (PEMFC) is a possible alternative power generator [21].

III. Proposed Methodology

The proposed research aims to identify the optimum biodegradable material for energy generation by comparing the performance of MFC with different waste materials tested by earlier research. Fig. 2 shows the proposed analysis framework. Concerning earlier research, we initially identified the various components that affect the MFC performance. *Such components* are materials used to design electrodes along with the shape of a particular electrode, substrate, catalyst material used to boost the power output, and environmental impact (like temperature and humidity).

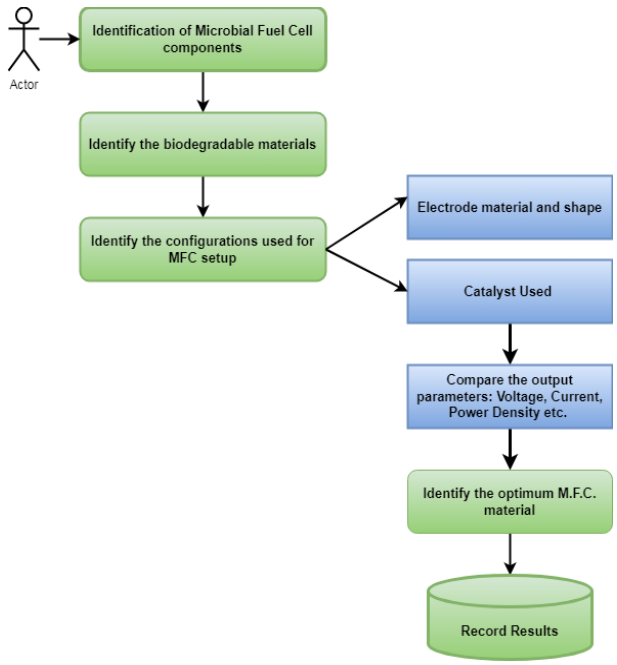


Fig. 2: Proposed Analysis Framework

Out of the identified components, the substrate and catalyst are important biodegradable components that benefit the power output. Further, it is important to identify the identical MFC configurations and electrodes we shortlisted for precision comparison execution. The pineapple waste and Dairy-based wastewater processing for energy generation compared with single chamber microbial fuel cell at constant room temperature. It is noted that the reproduction of results proves that the chosen substrates perform identical values to earlier research results. Due to the effect on temperature, output is stable.

IV. Result Analysis

As MFC can be an effective element of renewable energy microgrids, the suggested analysis shows the diverse base functionality for producing the mixed base to enhance total efficiency. The author applied single-chamber microbial fuel cells with zinc-copper electrodes and pineapple waste materials as fuel (base) in an existing study. Recorded values as current and voltage peaks of 4.95667 ± 0.54775 mA and 0.99 ± 0.03 V, correspondingly, with the substrate working at an acid pH of 5.20 ± 0.17 and a conductivity of 144.16 ± 9.85 mS/cm. Refer to Fig. 2 for the performance graph.

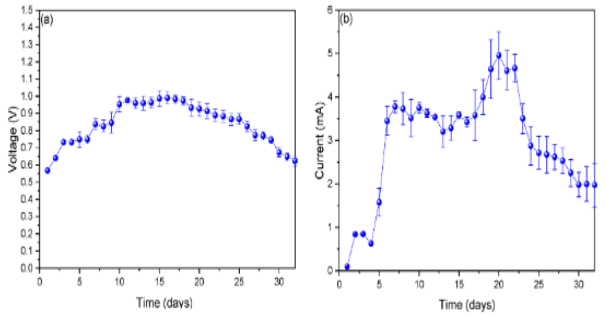
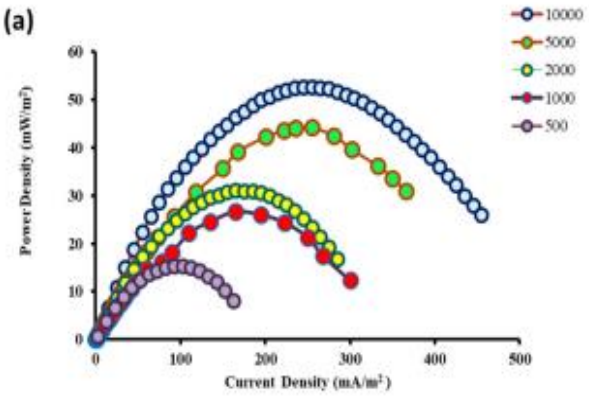


Fig.3: MFC results with substrate as a pineapple waste

Consequently, it was additionally identified that the internal resistance was 865.844 ± 4.725 Ω, and an optimum power density of 513.98 ± 6.53 mW/m2 was produced at a current density of 6.122 A/m2 [22].

We constructed a single-chamber mediator-less [23] MFC and utilized it to evaluate the MFC efficiency for electricity generation. Research on the use of pineapple waste and wastewater as a base indicated that using the mixed substrate using the anaerobic predicament procedure raises the performance of the MFC. Also, the mixed substrate comprises distinct microbes and can be conveniently biodegraded and applied as a combined steady substrate in MFCs. Dairy-based sewage resources and pineapple waste are utilized at room temperature for a single-chamber MFC by optimizing the designs to boost results. Relating to the known analysis, the feasible usage of dual-chamber [24] MFC for chemical substance extraction and then produced power from the substrate in several circumstances is explored. DC-MFC is controlled with sludge as an activated biocatalyst in an anode, an aerobic cathode. The efficiency is identified with several concentrations of substrate. Refer to Fig. 3 below.



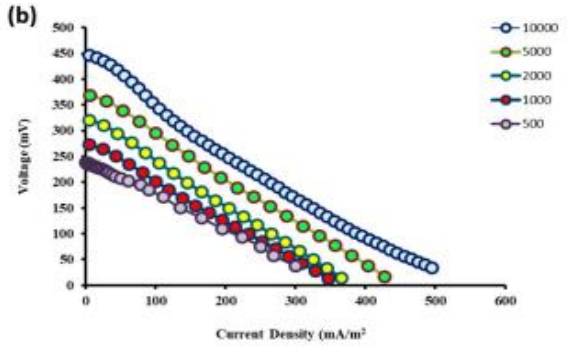


Fig. 4: Representation of (a) Power density (b) Voltage

Model tested with mixed biodegradable substrates that can be used in MFCs for bio-energy production and so the impact of their use on power density and performance improvement. Furthermore, an assessment of the formulated blended substrate carried out for energy generation through MFCs is shown. Potential aspects for processing and cost evaluation can assist scale-up procedures satisfying waste-treatment effectiveness and energy-output densities [25].

V. Conclusion

As discussed in this paper, the shortlisted substrate materials, like dairy and fruit waste, perform better than any other wastewater microbial fuel cell. Each component of the MFC can lead to huge research; hence, we proposed biodegradable substrate analysis, which has a higher impact on energy generation. The research showed the effective voltage, current, and power density suitable for microgrid setup with other renewable resources. These microbial fuel cells can be set up as a micro-grid component in remote/rural areas for small electricity needs. The existing research also discussed identifying the better substrate option for single-chamber MFCs with air cathode membranes. The future study can be tested for series and parallel connections of microbial fuel cell grids for household electrification. Also, electrode size and shapes can be studied for higher performance of renewable energy microgrids.

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