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Assessment of Energy Production by Using Microbial Fuel Cells Substrate of Domestic Wastewater Development of the Renewable Energy

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Abstract: Biodegradable materials are used in microbial fuel cells to produce energy when microbes are present. Large amounts of organic material found in wastewater can be oxidized in MFCs to provide power. In the current situation energy crisis is a growing problem throughout the world, which necessitates the creation of alternative energy sources that generate less carbon dioxide and benefit the ecosystem, like the use of wastewater best solution for such challenge. The goals of the study were examined through laboratory-based experimentation. The capacity of microbial fuel cells and the type of substrate employed were evaluated using experimental research designs. Experimental methods were used to determine the amount of electric current generated by wastewater during treatment. Maximum Voltage Output or OCV (open circuit voltage) values of 118.93 mV, 144.84 mV, and 89.76 mV are attained for MFC1, MFC2, and MFC3, respectively, when the resistance is infinite. The MFC that employed graywater as a substrate produced the least amount of electricity of the three, but it was the most stable. COD reduction was highest in urine waste, at roughly 65.83%, compared to 56.69% and 58% for blackwater and graywater waste, respectively and BOD_5 removal of substrate urine, blackwater and graywater are 67.79%, 69.18% and 28.89% respectively value. MFC 2 had the highest maximum power output, with a value of 0.00655 W/cm^2 equating to 0.00453A/cm^2 of current. It found the following values for the other fuel cells: 0.00442 W/cm^2, and 0.00251 W/cm^2, corresponding to current values of 0.00372 A/cm^2, and 0.00281 A/cm^2 are respectively value of MFC1 and MFC3 are respectively value.

Keywords: Bacteria, Electricity, Electrode, Microbial Fuel Cell, Power, Substrate, Voltage, Wastewater

1. Introduction

Microbial fuel cells (MFCs) have the capacity to produce electricity and are fully self-sufficient. Although full-scale systems for the underdeveloped global market have not yet been constructed, low-cost systems are now feasible because to advancements in MFC research [2]. More than 2.6 billion people in low- and middle-income countries lack access to sanitary facilities that keep excrement away from people and more than one billion of them urinate in public [43].

Wastewater contains a large amount of organic matter that can be oxidized in MFCs to produce electricity [1, 9, 18]. In the current situation, energy crisis is a growing problem throughout the world, necessitating the creation of alternative energy sources that generate less carbon dioxide and benefit the ecosystem, such as the use of wastewater [1, 4]. Because of depleting resources a growing number of countries are turning to renewable energy sources like wastewater [3, 9]. Microbial fuels cell that are renewable and carbon neutral are important for environmental and economic sustainability [10]. Sustainable energy sources are essential for achieving energy security and combating climate change [7]. Human being all over the world must be work to create safe environment so that looking for eco-friend energy frameworks in which renewable energy sources can play a key role, allowing them to transition to a more stable, efficient, and sustainable energy route [16, 24, 44].

Electricity in Rural Ethiopia villages has not been connected to the electricity grid that is powered by Ethiopia electrical power (EEP). Ethiopia currently has a 45 percent electricity penetration rate, with decentralized solutions providing access to 11 percent of the population; however the majority of Ethiopians use expensive kerosene for their primary light source, with solar lights/rechargeable lamps as the second-most used light source [33].

The worldwide community must be searching for alternatives to meet the global energy demand due to the depletion of fossil fuels, the quantity of waste, the effects of climate change, and the exponential rise of human population [27]. Water, nutrition, and universal education are all critical components of growth. These other businesses, on the other hand, would fail without widespread electrification. Obtaining the progress needed for the country's development [39].

A microbial fuel cell is a renewable device that uses organic wastes to generate power or merely to purify water. The purpose of this study is to evaluate the feasibility of a MFC in a typical rural home which would eventually help provide energy to the house's heaters and electrification [11]. Focusing on this research is primarily motivated by the socio-environmental impact. The consumption of energy is growing, so it's critical to keep looking for alternatives far apart with fossil fuels [1].

As biogas digesters, microbial fuel cells (MFCs) can generate energy from waste. They're not like biogas digesters in that they are built to produce electricity without producing any intermediate gas. MFCs use bacteria to transform the biochemical energy in organic matter into usable electrical energy, allowing them to produce electricity anaerobically from organic matter. MFCs have been identified as a promising technology for use in developing countries because of their ability to use waste as a fuel source and to treat wastewater without the use of electricity. Organic materials such as manure, food waste, and human waste have all been successfully used as MFC substrates and are widely available in rural and urban Ethiopia. MFCs can be stacked to increase voltage, or an energy harvesting system can be used, but a minimum voltage must be achieved to operate an energy harvesting system, and a necessary power output must also be attained for the electricity to be usable from in this study laboratory output. As a result, the emphasis of this study was on the possible use of a basic household MFC one made entirely of low-cost or locally available materials [5, 11, 21, 28, 29].

Growing the development of renewable energy while lowering costs, energy use, land use, and waste generation (sludge) are this type of the technologies that can help solve these problems and lead treated wastewater to conservation. Biogas, biomass, fertilizers, and compost are some of the technologies that can help solve these problems and lead treated wastewater to conservation. Reduced greenhouse gas emissions, high efficiency, versatility in installation and service, production of renewable energy resources, reduced demand for foreign oil, and enhanced environmental quality are all advantages of microbial fuel cells [30].

The scope of the study is limited to the study of microbial fuel cell for generating of electricity using of human waste as input. This research was included three types of substrate such as urine, blackwater and graywater and for each three microbial fuel cell was studied. The study focused to evaluate the stated study objectives Development of microbial fuel cell for electricity generation using human wastes. The studied first analysis physiochemical and biological each substrate before and after treatment of wastes and second analysis electrochemical analysis of MFCs of each type of substrates in the study include voltage, electric current, current density power, power density and resistance of MFCs [25, 38, 45]. Data were prepared for study groups that involved through laboratory experiments. Analysis was conducted to interpret and evaluate the study variables and instruments [28]. The key finding from this study was used to establish development of microbial fuel cell for electricity generation using human wastes serving electricity rural community of Ethiopia [36, 43].

2. Method and Material

2.1. Sampling Area

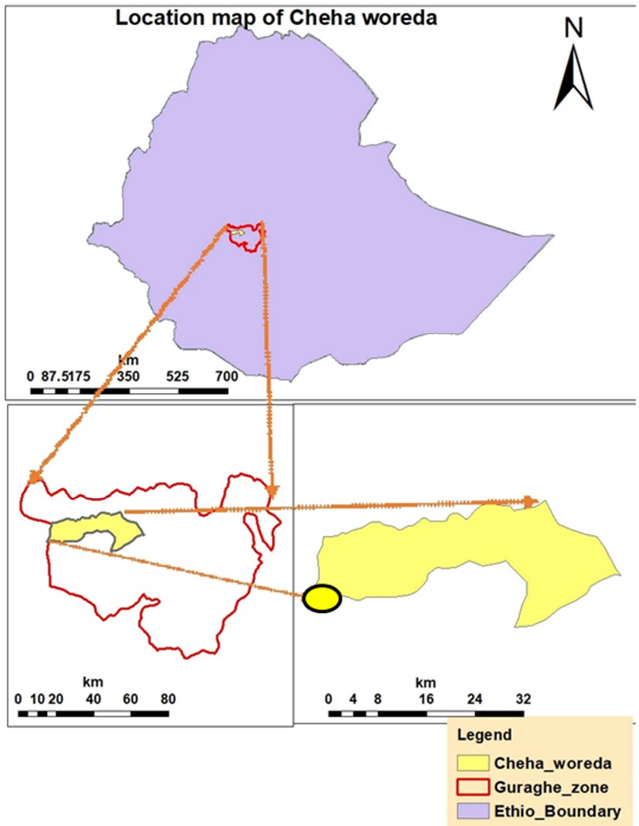

Figure 1. *Map of study area.*

The study was conducted in Wolkite University is located in South Nation Nationality People Regional state (SNNPR) in Guraghe zone in cheha woreda sub-city Gubere town and separate woreda in south-western Ethiopia. Wolkite town found in the administrative center of the Gurage zone of the Southern Nations, Nationalities and Peoples' Region (SNNPR), this town has a latitude and longitude of 8°17′N 37°47′E and an elevation between 1910 and 1935 meters above sea level.

2.2. Materials

2.2.1. Plastic Bottles

Plastic bottles are low-cost, lightweight, and long-lasting materials that may be easily molded into a number of products for a variety of uses. For this study plastic bottle are hold 2000ml of wastewater samples for each chamber of the microbial fuel cell. First, a two-chamber MFC was chosen because it is easier to manipulate and more adaptable than a single chamber MFC. To alter and experiment with different electrodes, it is more convenient to do so in a double chamber MFC. Have been utilized plastic kitchen food containers and water bottle with a 2L capacity for both the anode and cathode chambers. Plastic is less expensive than most ceramics, including glass, which can break and cause leaks.

2.2.2. Electrode

Electrodes are crucial components in electrochemical systems. Some of the most significant materials from both dual chambers of MFC (metals) electrodes have been used. The electrode materials of choice are metals and their alloys. For this study have been used metal electrodes which are aluminums and stainless steel so those electrodes with greater qualities than their counterparts, and electrode material development trends [19].

2.2.3. Anode Electrode

Some significant elements must be considered while choosing an anode material; the material should then be: For large-scale applications, it is cost-effective, high conductivity, high porosity, non-corrosive, and bacterial growth-friendly.

Different materials can fit this criterion, and we were able to test three of them. Aluminum is usually employed as the anode in most studies because it is extremely conductive, non-corrosive, and porous, therefore it is characterized by its non-brittleness, which is its main advantage. Steel plates or rods, which have a high conductivity, have also been employed in various investigations.

Have been employed and tested aluminum and steel for our MFCs, with corresponding surface areas are the same 32 cm^2. The latter three ingredients were accessible in the chemistry lab; for the electrodes, we purchased a huge metal mesh from a hardware store in Wolkite town.

2.2.4. Cathode Electrode

The cathode, like the anode, must have two main properties: conductivity and non-corrosion. Steel sheets and aluminum can thus be used in place of the anode. The only difference in this research without application of the chemical a catalyst, but another study show that usually platinum, is used frequently to boost the reduction reaction at the cathode in MFC digestion. Typically scientists were utilizing a standard carbon cathode with platinum on one side in contact with water and the other in contact with air. It did not use any catalysts in our case since it is difficult to get on the market and requires specific expertise in materials coating to manufacture in the lab. As a result, the materials used as cathodes in our series of studies are aluminum and and steel.

2.2.5. Salt Bridge

A salt bridge is an important component in an MFC because it keeps the anode and cathode separated. This is important because water in the cathode contains dissolved oxygen, and we want to keep the anode anaerobic. Furthermore, it must allow for spontaneous proton migration from the anode to the cathode. As a result, selecting a membrane is not as simple as it appears. When we employ a solid, the cathode and anode are effectively separated, but protons are unable to migrate. Another issue for the membrane is preventing other substances from passing through, such as electrons or the substrate [47].

The anode and cathode processes are separated by the microbial fuel cell (MFC) membrane, which prevents oxygen from entering the anode chamber while allowing selective ion transport between the anode and cathode.

Because of its strong proton conductivity, Nafion 117 is the most commonly used material. The biggest downside is the high cost (\$1400/m^2) of the property [11]. As a permeable membrane, we utilized a cotton rope (1m long) purchased from a curtain shop in Wolkite town and twisted multiple times (end length of 25cm) for each MFCs.

With a volume of 2000 ml plastic bottles and a diameter of 15 mm PVC pipe was used to connect both the cathode and anode chambers for MFC. Each pipe has 15mm holes for solution addition as well as salt bridge inlets. To prevent air from entering the anode side, the holes were sealed with a tiny cup.

2.2.6. Copper Wire

Copper is used for the external circuit that connects the cathode and anode, as it is in most studies. The copper wires were attached to the electrodes with electric tape on both electrodes side chambers of the MFC.

2.2.7. Extra Material

Finally, a glue gun was being required to join the MFC's various components. Furthermore, ‘Parafilm' was employed to reduce salt bridge leaks. The salt bridge was also covered with a variety of tapes, primarily electric tape. Finally, for data collection, we employed a digital multimeter. The many different varieties of glassware used in an analytical laboratory are one of the first things that most people notice when they go into one. Each piece of glassware is designed to serve a specific purpose. Glassware commonly encountered in an analytical laboratory includes have been used the following: Beaker, Graduated Cylinder, Pipet, Burets, Flask and Bottle.

In every work of laboratory, a pH meter is one of the most common pieces of analytical equipment. A pH meter is a device that determines the acidity or basicity of a sample by measuring its pH. Because changes in pH can have a major impact on the success of many treatment techniques, measuring pH is critical have been used for this study.

Spectrometer is devices that analyze the different parameter. A Spectrometer measures a sample's absorbance/transmittance. Chemical reagents are used to react with the substance to be measured. The various materials in the sample determine have been used. Dissolved oxygen and conductivity tests were performed on digital spectrometer.

Balances have been used to weigh solids analysis objects like dry chemicals, filters, and crucibles of wastewater samples.

Samples that would degrade if kept at ambient temperature prior to analysis can be kept in the refrigerator. COD, microbiological, organic, and other analyses are some examples.

Temperature measurements are made with a thermometer used, which can have a substantial impact on waste sample several treatment operations in microbial fuel cell.

Crucibles are used to keep the sample contained while it is being heated on a burner.

Ovens are used to bake chemical reagents or samples in order to dry them out or remove unwanted elements from them.

A desiccator is a glass container with a tight-fitting lid. The desiccator is used to keep samples dry by filling it with desiccant. Typically, a sample is dried in an oven and then placed in a desiccator to cool before being weighed or going through further processing.

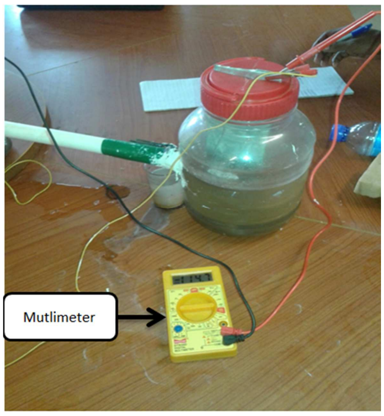

Figure 2. Mutlimeter.

2.2.8. Substrate

Study was tested three distinct substrates for microorganisms: urine, blackwater, and graywater. All of the sludge was collected from a deep sewage on campus; however the sludge contained more water than the real substrate. As a result, the sludge used in this research was gathered from various areas of the Wolkite University compound. 2L was measured and utilized for all substrates.

2.3. Study Design

The study's objectives were investigated a laboratory-based experimental work. The capacity of microbial fuel cells and the type of substrate employed were evaluated using experimental research designs. The quantity of electric current produced by wastewater during treatment was measured using an experimental approach. The cross-sectional methodology was used to inspect the capability of each type of substrate's power generation capability during the research design.

The MFC is made up of main four parts:

1. Anode: The bacteria and organic debris are kept in an anaerobic condition in the anode chamber.
2. Cathode: Container containing a conductive water solution
3. Proton-exchange membrane: Salt is a proton-exchange membrane that divides the anode and cathode and allows protons to flow between the two chambers.
4. External circuit: permits electrons to enter the cathode and serves as a conduit for them to go through when they are extracted out of the anode's solution.

As part of their digestive process, bacteria in the anode chamber produce protons and electrons by oxidation. Microbial Fuel Cells (MFCs) are well-known for their ability to transfer chemical energy from organic substrates into electricity. This is due to the so-called Electrogenic bacteria' unique metabolic activity. Anode and cathode are connected by an external circuit and split into compartments by a proton exchange membrane in a conventional Microbial Fuel Cell [31, 46, 47].

The following are the procedure has been used to construct the double-chamber MFCs:

Step 1: A salt bridge is first created by soaking a 1m cotton rope in a very saturated salt solution for 2 hours at 95°C, then allowing it to absorb the fluid overnight (24 hours). Before being taped with two different types of tape, the rope was twisted multiple times. Both ends of the salt bridge were left exposed

Step 2: When using fire, prepare two holes in both plastic containers for the salt bridge to be inserted into. Ensured that there were no microscopic gaps by utilizing the glue gun to apply hot glue across the salt bridge

Step 3: Two more holes were incised at the top of the cathode container, one for the conducting wire and the other for the aquarium air pump shaft. Initially, an air pump was employed, but all of the findings were obtained without it.

Step 4: After the compartments have been set up, the electrodes are formed of aluminum by folding the mesh numerous times to obtain a surface area of 32 cm^2 (8*4), then securing the folds with paper clips. (Another stainless steel electrode had been made previously.)

Step 5: Copper wires are joined to the electrodes for both electrodes using a glue gun and electric tape.

Step 6: The electrodes were placed in their compartments while the anode chamber was sealed and the cathode was left aerated. After that, both wires were connected to an optical multimeter, which was used to detect the electric potential and other characteristics.

Step 7: Sludge is placed in the anode chamber and water is placed in the cathode chamber until the anode chamber is closed. Both water and sludge should cover the salt bridge and electrodes.

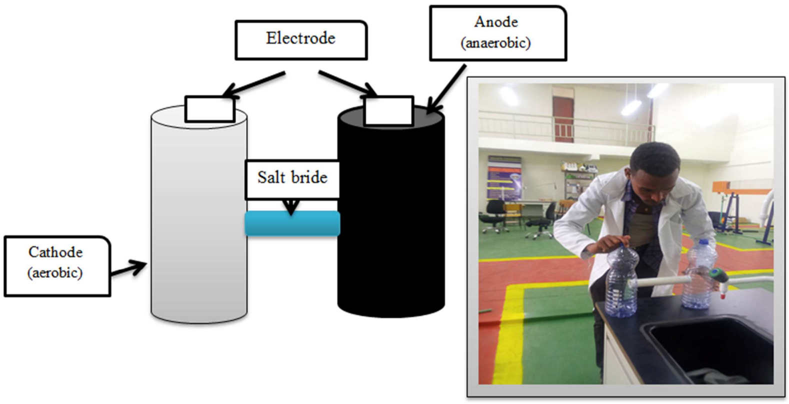

Figure 3. *Diagram of MFC system setup.*

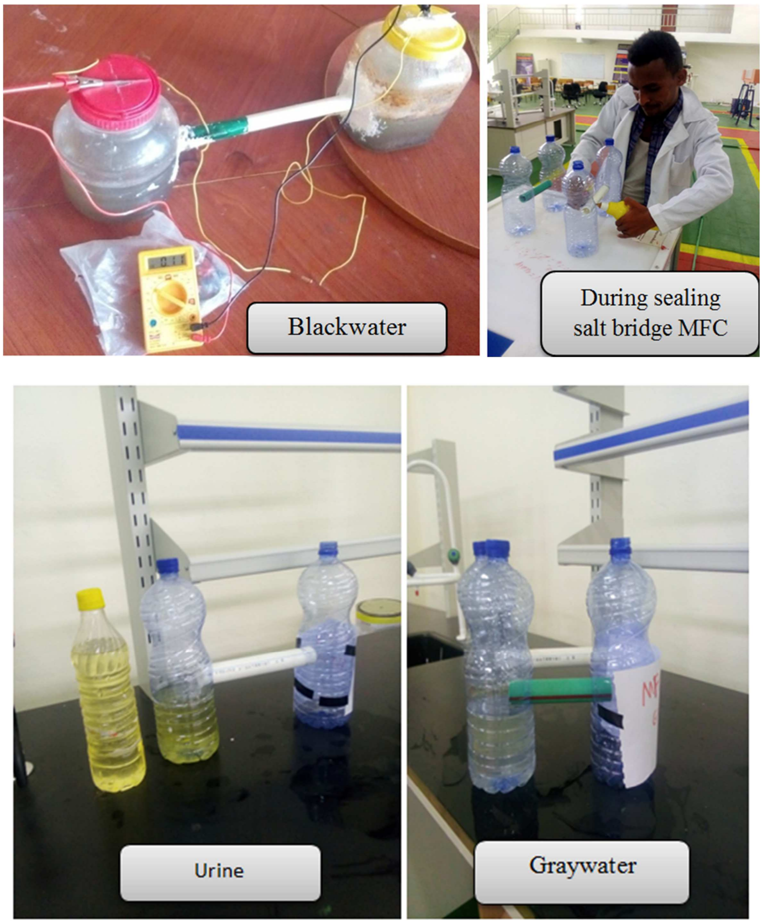

Figure 4. *Laboratory built of dual chamber of microbial fuel cell.*

2.4. Sample Size and Sampling Procedure

Sample size

Samples were collected by purposive sampling technique from three wastewater source. For the sample selection important criteria were considered: Main source of wastewater stream in Wolkite University compound have taken samples from different polluting sources like waste disposal sites, and sewer line different manhole were considered.; Elevations, Longitude, and altitudes of selected sample sites were determined on the field using a GPS model 60.

First, we chose a two-chamber MFC because it can be easily manipulated and more flexible than the single chamber one. It wants to change and try different electrodes and for that reason, it is more convenient to do so in a double chamber MFC. For both the anode and cathode chambers, we used kitchen food containers made of plastic with a volume of 2L each (Figure 5). Plastic is cheaper than most ceramics including glass that can be subjected to cracks and therefore leakages.

Figure 5. *Health adult urine sample collected from WKU chemistry staffs.*

Table 1. *The Sample point of the substrate.*

Sample code	Name of the location	Size of sample in liter	GPS Reading		
			Easting	Northing	Elevation (m)
MFC1 (Urine)	WKU Chemistry lab staff	2 liter	36°C 49	8°40	1400
MFC2 (Blackwater)	WKU Block7manhole	2 liter	36°C 49	8°59	1401
MFC3 (Gray Water	WKU Block 4 student bath room	2 liter	36°C 49	8°39	1700

Sampling procedure

Wastewaters samples were collected various hours in the days. This was to ensure that the wastewaters had not been disturbed much through bacterial growth which can affect the temperature and content of total dissolved solids. All plastic bottles were cleaned with warm water and soap then rinsed with distilled water three times. Wastewater samples for microbial analysis were collected with 1000ml plastic bottles and holding in black box to prevent bacterial contamination. Wastewater samples were taken from Wolkite University compound found in Ethiopia samples are in well-mixed typical samples. To limit sample fluctuation, the WW was collected for one day in a row, in the morning, midday, and evening. The volume of WW collected in the morning, midday, and evening was then combined to create a single sample of wastewater for that day. The morning, lunch, and evening volumes of wastewater were then mixed to generate a single day's sample of wastewater. Then after that day, the samples were collected brought into laboratory. The collected samples were maintained in the refrigerator at 4°C to avoid any changes in the results during the experiment.

The sample for the mixed waste representative was collected for three days in a succession and prepared one day representative and the next two days representative using the same procedure. To keep the results consistent, it's then filtered and stored in the refrigerator. MFC, suitable fittings, and other measurement devices were prepared before to collecting samples from each site. During the experiment, the sample was prepared, different parameters were tested and recorded (pH, Conductivity, TS, VS, Turbidity, and voltage), several mixes were prepared, and ultimately the experimental data were collected. At a temperature range of 22 – 40°C, the pH of the solution (slurry) was adjusted over the course of the production time to a standard pH (5-8).

2.5. Sample Preservation, Measurement and Analysis Processes

2.5.1. Sample Preservation

The samples were put at 4 degrees Celsius for 2 days in their original water-based suspension. Prior to the trials, sludge samples were mixed together and left to acclimate at room temperature before inoculating the entire connected stack (3 MFCs) with 2000ml of sludge added through the MFC inflow and allowed to flow down.

For each parameter, the maximum holding duration was retained until the beginning of the laboratory measurement process. Almost all compounds that are being examined must be maintained if the analysis cannot be completed immediately. A qualified laboratory will offer you with the essential types of sample bottles, as well as the required preservative, when you need to collect a sample. The maximum holding time was kept and performed based on the WHO/UNEP, 1996 standard protocol.

2.5.2. Analysis of Wastewater Sample

A variety of analytical procedures have been utilized in the laboratory. Five of the most common techniques used in a WW lab include ion specific analysis, gravimetric analyses, spectrometric analyses, titration analyses, and volumetric studies. In most ion specific analyses, an electrode and a voltmeter are utilized. Typically, the electrode is ion-specific, detecting only the ion of interest. The signal from the electrode is picked up by the multimeter, which is a millivolt meter. The meter's millivolt value rises in proportion to the sample concentration. In ion specific analyses, pH, voltage, and D. O. are commonly utilized. After a sample has been submitted to an analytical method, gravimetric analyses are utilized to determine its mass or change in mass.

A spectrometer used the ability of various substances to absorb or transmit different wavelengths of light to create a measurement. The amount of analyze in the sample determines how much light of a certain wavelength is transmitted or absorbed. To change or enhance light transmittance or absorbance, a reagent and/or indicator are frequently added to the sample. A titration analysis is a method of analyzing a sample by adding a specified amount of a standard solution to it. The concentration of analyze in the sample is proportional to the amount of standard solution added. The overall volume of the sample and the volume of analyze in the sample were compared using volumetric analysis. This method is used in several sludge tests.

2.6. Data Collection Process

A sample must first be obtained before it can be analyzed while it may seem self-evident, the significance of gathering a representative sample cannot be emphasized. If the sample isn't representative, the analysis isn't only worthless; it could be misleading, leading to unneeded and potentially harmful treatment changes. In order to meet the thesis objectives, this procedure incorporates both secondary data (desk) and primary data (field investigation) for the collection of relevant data. It includes the techniques used to achieve the theme. The deskwork comprises a review of modeling publications, books, and past work.

3. Result and Discussion

3.1. Experimental Result of Physiochemical and Biological Parameter

Prior to Treatment Raw Wastewater Is Characterized

Graywater, blackwater, and urine are all extremely different in terms of volume, quantity, and quality. Urine has the highest nutritional concentration, and its isolation allows for recovery from a much less volume. Despite that graywater makes up the bulk of domestics trash, it is rather clean and hence appropriate for reuse. Light graywater, which does not include kitchen wastewater, has very low particle, organic content, and nutritional levels. Blackwater contains the most organic matter, making it ideal for energy recovery. Urine, blackwater, and graywater quality are summarized in tabular form the shown findings, with further details provided later in this chapter.

Table 2. *Source and primary contaminant human waste product.*

	Urine	Blackwater	Graywater
Source	Toilet, urinals (with or without flush water)	Toilet (with flush water), kitchen sink, dishwasher	Non-kitchen sinks,
Contaminant	Nutrients, pharmaceuticals, hormones, salts	Solids, organic matter, pathogens, nutrients	Personal care products, detergents

Graywater accounts for the bulk of domestic wastewater, but because it is largely uncontaminated, it can be reused without further treatment. Kitchen wastewater and brown water contain the most organic elements that can be converted to energy (feces, flush water). Urine has a high concentration of nutrients in a small amount of liquid.

Tables 4, 5 and 6 shows the physiochemical and bacteriological parameters of the wastewater utilized before treatment in the investigation, as well as the experimental results. As a result, the value list in tabular form here are below three different substrates.

On average, an adult produces 0.8-1.5 Liter of urine each day, whereas a toddler produces around half that amount. Water makes up 95% of the mixture, with dissolved salts accounting for 5%. Food determines the quality of urine output per capita, yet scientifically established design values have emerged. While urine makes up only 1% of total residential wastewater, it contains 50-80% of total nutrients (75-80% nitrogen, 50-55 percent phosphorus, and 70 percent potassium), as well as the majority of pharmaceuticals and their metabolites. Adults are principally responsible for the elimination of macronutrients (nitrogen, potassium, phosphorus, and sulfur [37].

Table 3. *Composition of urine wastewater before treatment.*

Nọ	Parameter	Unit	Mean value
1	pH	-	6.3
2	TS	mg/l	385
3	VS	mg/l	213
4	BOD_5	mg/l	208
5	COD	mg/l	600
6	DO	mg/l	3.9
7	TK	mg/l	2740
8	TP	mg/l	1600
9	TN	mg/l	8830
10	TC	Col/100ml	$215*10^4$
11	FC	Col/100ml	$98*10^4$
12	Conductivity	µS/cm	19067

Col = colonies

In this research, blackwater is defined as wastewater from kitchen sinks and feces. Brownwater refers to the excrement part (together with flushing water and toilet paper). Brownwater has a high organic and sediment content, pharmaceutical and hormone residues, pathogens and indicator microorganisms in high concentrations, and lower nutritional loading than urine.

Toilet paper generates BOD_5, TS and COD, and its cellulose component makes it difficult to breakdown.

Along with its high organic content, kitchen sink effluent is frequently combined with brownwater (relative to other graywater streams). Food residues, cleansers (detergents, drain cleaners, bleach, etc.) and oils/fats are all found in kitchen sink and dishwasher effluent. It is one of the most little polluted graywater streams (VS, COD and BOD).

The fact that it contains the greatest amount of nutrients and pharmaceutical/hormone residues (more than half) while being the smallest in volume is the main motivator for urine source separation [35]. Blackwater (feces and kitchen wastewater) contains high levels of organic and nutritional content, as well as sediments, bacteria, and pharmaceutical/hormone residues. Graywater is the lowest polluted of the three streams yet contributes the most to total volume. The most detergents and personal care items are found in light graywater, which is also low in nutrients and pathogens. It's also low in organic content because it's not made with kitchen garbage (S. Bakhri, 2015).

Table 4. *Composition of black water before treatment.*

Nọ	Parameter	Unit	Value (mean)
1	pH	-	6.7
2	TS	mg/l	3982
3	VS	mg/l	1231
4	BOD_5	mg/l	902
5	COD	mg/l	1600
6	DO	mg/l	2.56
7	TK	mg/l	1112
8	TP	mg/l	500
9	TN	mg/l	1388
10	TC	Col/100ml	$513*10^4$
11	FC	Col/100ml	$317*10^4$
12	Conductivity	µS/cm	27894

Col = colonies

The wastewater from non-kitchen sinks, laundry, and showers is called to as graywater in this study. This is known as "mild graywater" in the scientific community. When compared to other graywater sources, “dark graywater” comprises kitchen sinks, which are the most polluting. 40-60% of the pollution load is contributed by kitchen wastewater (VS, COD, BOD, total oil, and active substances). Graywater's physical and chemical quality varies and is based on its source, according to the lab experiment. This is due to the fact that the quality of cleaning and bathing products, the number of people in a household, and other sink disposal procedures and personal behaviors all have an impact on quality (S. Bakhri, 2015).

When split from urine, graywater is low in particles and nutrients, while blackwater wastewater has a BOD of 902 mg/L and a COD of 1600 mg/L. The variation of these values in relation to the source is clearly seen. Cleaning goods, shampoo/soap, perfumes, and cosmetics have limited biodegradability and can include a lot of micropollutants. Surfactant (detergent) concentrations vary as expected based on graywater sub-stream. Dishwashers and washing machines can provide a high Phosphorus loads if phosphorus is included in detergents; however there is a widespread movement to remove phosphates from detergents. Graywater may also contain significant levels of heavy metals (from plumbing) and salts (from detergents). Pathogens are generally lower in light graywater (as compared to all other home sources), however fecal indicator bacteria and skin/mucus pathogens eliminated during a bath/shower can be present for microbiological bacteria of concern in graywater). If cloth diapers are washed in the same machine as the rest of the laundry, fecal contamination is almost certain to occur; hence this should be factored into the treatment system's design. Graywater flow unpredictability and temperature changes are important factors to consider when designing a treatment system.

Graywater study is a rapidly growing topic, tanks to water reuse applications; hence there is a wealth of knowledge available. The majority of the qualitative data available is for mixed graywater, although a growing number of researches are distinguishing between “light” and “dark” graywater. Apart from quality, there is a wealth of information about treatment and reuse.

Table 5. *Composition of Graywater before treatment.*

Nọ	Parameter	Unit	Value (mean)
1	pH	-	7.4
2	TS	mg/l	56
3	VS	mg/l	37
4	BOD_5	mg/l	45
5	COD	mg/l	900
6	DO	mg/l	3.9
7	TK	mg/l	5564
8	TP	mg/l	1352
9	TN	mg/l	564
10	TC	Col/100ml	$0.3*10^4$
11	FC	Col/100ml	$0.1*10^4$
12	Conductivity	µS/cm	12271

3.2. After Treatment, Raw Wastewater Is Characterized

Tables 6, 7 and 8 summarizes the physicochemical and bacteriological parameters of the wastewater feedstock’s following digestion in MFC. The found values were wastewaters after digestive in MFC as tables described.

Change In Urine Quality During Storage

Urine from a healthy person is usually consistent and germ-free. However, bacteria may be present in the collection system or via cross-contamination with excrement once urine has been redirected and stored. Urine's high concentration of biodegradable organic compounds may act as a food source for aerobic or anaerobic microorganisms, resulting in urea hydrolysis and the associated consequence.

The principal contributors to the transformation of urine after it has been discharged, redirected, and stored are microbial urea hydrolysis, mineral precipitation, and ammonia volatilization. By catalyzing the hydrolysis of urea to ammonia and bicarbonate, urea-hydrolyzing bacteria have the largest impact on the modification of urine quality. Prior to this transformation, roughly 85% of the nitrogen in urine is fixed as urea and around

5% as ammonia, however after urea hydrolysis, 90 percent of the nitrogen is fixed as ammonia. The effects of this shift include a quick rise in pH from around 6 to 9, ammonia volatilization (if the urine is not in a closed storage tank designed to prevent volatilization), and precipitation.

The choice of urine treatment/reuse technologies is influenced by a change in pH and subsequent precipitation. First, because up to 33% of total ammonia is volatile, there will be ammonia losses and odor difficulties when stored pee is transported and applied to the ground (the buffer capacity is so high that acid addition to prevent this is uneconomical). A change in phosphorus concentration, which is a good indicator of precipitation, would be another concern. Undiluted urine contains 30% soluble phosphorus in the solid phase of the precipitates, although this fraction rises with dilution. Calcium and magnesium concentrations limit phosphorus precipitation, and preserved urine normally contains all calcium and magnesium. Because the partitioning of phosphorus into soluble and solid phases is crucial when considering alternative recovery strategies, the hardness and volume of flushing water are elements to consider in urine collecting selections. Calcium and magnesium addition is another promising phosphorus recovery strategy [37].

Full information found in appendix b laboratory work result listed there in tabular forms.

Table 6. *Summarizes the physicochemical and bacteriological parameters of the urine after treatment.*

Nọ	Parameter	Unit	Value (mean)
1	pH	-	6.8
2	TS	mg/l	156
3	VS	mg/l	78
4	BOD_5	mg/l	67
5	COD	mg/l	205
6	DO	mg/l	4.2
7	TK	mg/l	1231
8	TP	mg/l	764
9	TN	mg/l	3423
10	TC	Col/100ml	$134*10^4$
11	FC	Col/100ml	$54*10^4$
12	Conductivity	µS/cm	9645

Full data of blackwater substrate laboratory output found appendix c

Table 7. *Summarizes the physicochemical and bacteriological parameters of the blackwater.*

Nọ	Parameter	Unit	Value (mean)
1	pH	-	7.1
2	TS	mg/l	1256
3	VS	mg/l	874
4	BOD_5	mg/l	278
5	COD	mg/l	693
6	DO	mg/l	4.8
7	TK	mg/l	636
8	TP	mg/l	230
9	TN	mg/l	879
10	TC	Col/100ml	$302*10^4$
11	FC	Col/100ml	$125*10^4$
12	Conductivity	µS/cm	11092

Data of blackwater substrate laboratory output found appendix d

Table 8. *Summarizes the physicochemical and bacteriological parameters of the graywater after treatment.*

Nọ	Parameter	Unit	Value (mean)
1	pH	-	7.2
2	TS	mg/l	38.2
3	VS	mg/l	21.6
4	BOD_5	mg/l	32
5	COD	mg/l	378
6	DO	mg/l	4.2
7	TK	mg/l	3674
8	TP	mg/l	589
9	TN	mg/l	332
10	TC	Col/100ml	$0.13*10^4$
11	FC	Col/100ml	$0.04*10^4$
12	Conductivity	µS/cm	4515

3.3. Electrochemical Analysis

3.3.1 Electric Voltage Production

The three sets of MFCs were tested for maximum voltage output in laboratory experiment such as urine, blackwater, and graywater at ambient temperatures ranging from 22±10°C. For all three sets, the voltage output was measured using a calibrated multimeter (Model No 8NF6R) across a 1000 ohm resistor at regular intervals of 24 hours until the output voltage dropped to zero already for month.

In study developed MFC model, the blackwater substrate produces the maximum voltage output when all three substrates are run under the identical environmental conditions. The voltage change for blackwater substrate is significantly more powerful than for other substrates, and electricity generation practically reduced after 13 days, which is much less time than both urine and graywater, which takes to generate maximum voltage. The MFC that employed graywater as a substrate produced the least amount of electricity of the three, but it was the most stable. COD reduction was highest in urine waste, at roughly 65.83%, compared to 56.69% and 58% for blackwater and graywater waste, respectively and BOD_5 removal of substrate urine, blackwater and graywater are 67.79%, 69.18% and 28.89% respectively so that the value maximum BOD_5 removal happened in blackwater substrate and the lowest occurred in graywater substrate.

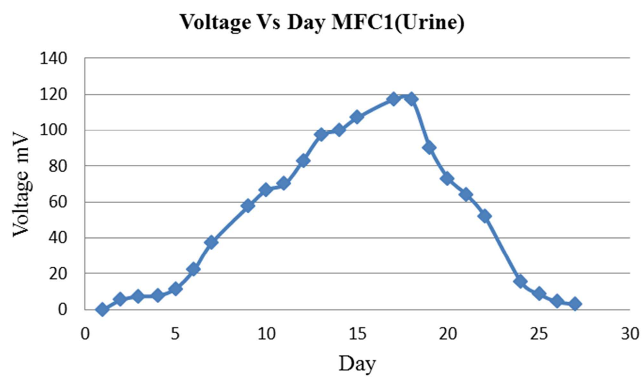

Figure 4. *Urine substrate voltage produced.*

3.3.2. Urine Substrate Voltage Produced

The maximum voltage output of the MFC employing urine waste is 118.93 mV, which is achieved on the sixteen day (384hrs.). After 16 days, the rate of electricity generation was significantly slowed. At the end of the experiment, the pH was increased from 6.3 to 6.8 and COD levels were reduced from 600 to 250 mg/L on average. Here below interpret in excel graph analysis of verses per day shown on next page.

3.3.3. Blackwater Substrate Voltage Produced

The highest voltage output of the MFC utilizing blackwater 144.84 mV, which it was reached on the 13 days (312 hrs.). After 13 days, the rate of electricity generation had significantly slowed. On the eleventh day, the pH was raised from 6.1 to 7.1. COD levels were reduced from 1600 mg/L to 693 mg/L on average while BOD removed 69.18% from microbial fuel cell treatment.

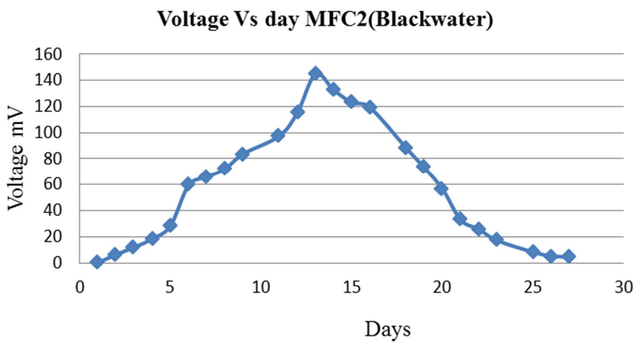

Figure 5. *The blackwater substrate voltage produced.*

Graywater substrate voltage produced

The maximum voltage output of the graywater MFC is 89.76 mV, which it reached on the eighteen day (432 hours). The electrical production was maintained for over a month. The pH was reduction from 7.4 on the first day to 7.2 at the conclusion of the experiment. COD elimination was reduced from 45 mg/L to 32 mg/L.

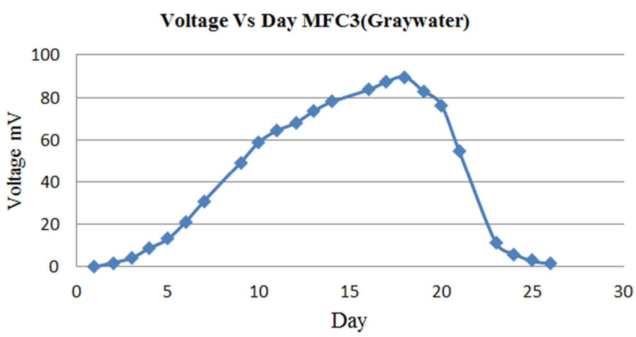

Figure 6. *The graywater substrate voltage produced.*

3.4. Polarization Curve

A polarization curve is used in electrochemistry to depict current density as a function of voltage (the electric potential of the electrodes). A wide range of external resistances is linked to the external circuit to form a polarization curve. As a result, as the load changes, the fuel cell's voltage changes, meaning that the current changes as well (Khaloufi and Elasli, 2019).

It utilized the identical set of resistances for all MFCs, recording the voltage levels at each one. This was done with the help of a multimeter. The current was calculated using Ohm's law. The current density is then normalized by the electrode surface (the anodic surface), keeping the unit of (mA/cm^2). Utilized the excel graph tool to create a curve with the proper linear fit, which illustrated below graph.

Ohm law V=I×R Where I=Current

R=Resistance

All three the microbial fuel cells are generated polarization curve by using excel tool graph.

Graphing tools in Excel were used to create polarization curves for urine of the microbial fuel cell.

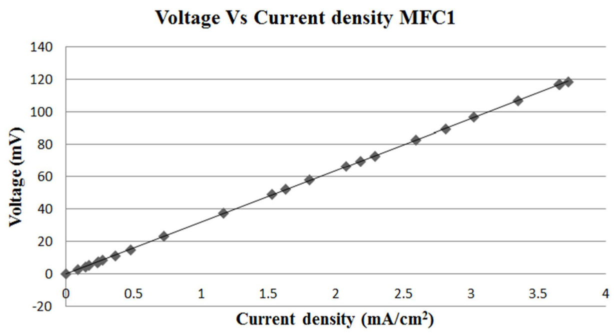

Figure 7. *Polarization curves for urine of the microbial fuel cell (MF1).*

Graphing tools in Excel were used to create polarization curves for blackwater of the microbial fuel cell.

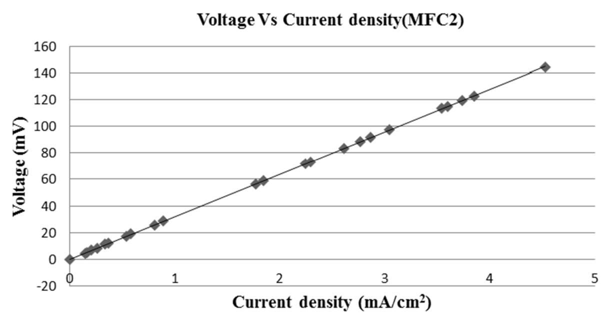

Figure 8. *Polarization curves for blackwater of the microbial fuel cell (MFC2).*

Graphing tools in Excel were used to create polarization curves for graywater of the microbial fuel cells.

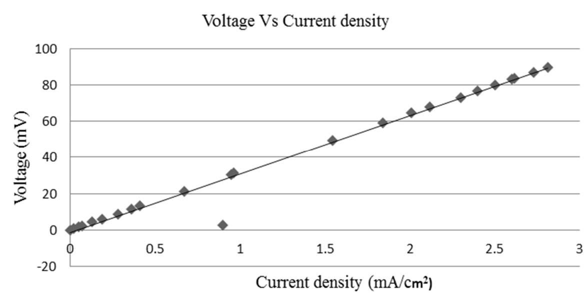

Figure 9. *Polarization curves for graywater of the microbial fuel cell (MFC3).*

As a function of current density, these graphs show how well microbial fuel cells maintain the electric potential. The three polarization lines show that there are linear relationships. Each graphic depicts a linear region all MFC with a constant voltage drop for all MFCs. Maximum Voltage output or OCV (open circuit voltage) values of 118.93 mV, 144.84 mV, and 89.76 mV are attained when the resistance is infinite for MFC1, MFC2, and MFC3, respectively.

It can see that the voltage for MFC1 drops dramatically after one to 117.11 mV, which corresponds to a current density of 0.00366 A/cm^2. Following the swift voltage drop, it can see a linear path that represents the all-region. Similarly, it see before a dramatic voltage drop for MFC2 and MFC3, corresponding to the maximum current densities of 0.0453 A/cm^2, and 0.00281 A/cm^2, respectively.

It's crucial to understand the components that influence cell voltage in order to better understand linear line in the polarization curve [34]. First, because the fuel cell has an internal resistance that affects the power generation process, the recorded OCV at infinite resistance does not represent the maximum theoretical electric potential. There were able to identify linear all region by the same MFCs polarization curve to the one discovered in the experiment [26].

1. A significant potential drop occurs at high resistances.
2. A somewhat straight route indicating a reduction in electric potential following the quick drop.
3. At low value resistances, there is yet another dramatic and quick potential drop beyond the linear fall.

As a result, a more exact equation defining the voltage of a fuel cell at any resistance and current should be considered.

$V=Vo-(\Sigma Van + \Sigma Vcat + I + R\Omega)$

Where: Van=anode over potential

Vcat cathode over potential

I= current generated by cell

RΩ=internal resistance of fuel cell

The electrodes over potentials cause some of the voltage losses, which change as the current changes. Activation losses, bacterial metabolism, and mass movement are three types of voltage losses that could cause the electrodes to over-potential [12, 22].

1. Activation losses: In order to continue with the oxidation-reduction reactions, an energy barrier must be overcome, and energy in the form of heat is lost in the process. Furthermore, we observe further energy loss as a result of electron migration from the bacteria to the anode surface, either directly or indirectly [22].
2. Bacterial Metabolism: Represents energy losses as a result of the bacteria's demand for energy to carry out its metabolic activity, namely the generation of the proton gradient in its electron - transport chain [22].
3. Losses in mass transfer: There are two sub-issues that can result in energy losses. First, the mass transfer (also known as flux) of the reactant-representing substrate to the anode is frequently insufficient. Second, protons' migration from the anodic to the cathodic chambers is occasionally restricted, resulting in a buildup of H^+ and lowering the pH at the anode while increasing it at the cathode [22, 23, 29].

Lower the activation losses by using a variety of bacteria at the anode to limit energy losses due to electrodes over potentials. New bacteria can be added to the substrate to compensate for voltage losses; these bacteria may have a more efficient metabolism [35, 42, 47]. Finally, we can use effective proton exchange membranes to facilitate protons' migration to the cathode while retaining a sufficient buffer capacity to avoid mass transfer losses (resistance to pH change)[22].

Discovered another sort of energy loss termed Ohmic Losses in addition to electrode over-potential losses. The internal resistance of the electrode material and the wire causes energy loss during the transmission of electrons from the electrode through wires at the point of contact of the electrodes and the conducting wire [22]. The potential loss due to Ohmic losses can be computed using the equation below.

$$\Delta V = \frac{\nabla W \times I}{\delta}$$

Where: ∇W: The distance between anode and cathode

I: Current normalized to anodic surface (A/cm^2)

δ: Represent the solution of conductivity (μS/cm)

As a result, if it can boost solution conductivity, it may be able to lower Ohmic losses as well. Furthermore, the shorter the distance between the electrodes, the lesser the Ohmic losses both chamber of MFC. Nevertheless, Ohmic losses are sometimes unavoidable; for example, because bacteria can only operate within specified boundaries and conductivity ranges, it is impossible to raise the solution conductivity at random. Furthermore, low-internal-resistance electrode materials can be costly [17].

3.5. Power Density Curve

MFCs operate in the same way as traditional electricity generators, generating a current and a certain cell potential. Because generators are designed to produce useful power, it is natural to try to optimize the fuel cell for power generation. To do this, we employed a variety of external resistors of varying values to determine the optimal current and potential for maximizing power.

Power described as following equation.

$P=V\times I$

Where; P: Power

V: Voltage

I: Current

The following alternate equation is used to express the power in this laboratory research $P = \frac{v^2}{Rex}$ where R is the applied external resistance and V is the cell potential. Alternatively we can express power by $P = I^2 \times R_{ext}$.

The electrodes utilized, as previously noted, do have the same surface area. Electrode were used an 8cm×4cm cathode and anode using aluminum electrodes, giving us a total surface area of 32 cm^2. In terms of surface area, it can consider both sides of the electrodes, but for computations, it only needs to consider one side. Steel electrodes are 8 cm long and 4 cm wide, with 32 cm^2 surface area. The anodic surface area is frequently used to standardize the unit of power. As a result, power density is expressed as:

$$P = \frac{v^2}{Aan \times Rex}$$

Where Aan: The anode’s surface area

V: Electric Voltage

Rex: External Resistor

Normalizing power to the cathode surface area, if either is greater than the anode, is also important. The fuel cell volume, including the cathodic chamber volume, should be used to normalize power. This enables for a more precise study of the fuel cell's power output. However, in order to acquire correct results, we kept the reactor volume and substrate amount constant.

The goal of this part is to figure out how much power each MFC can produce, thus it has made “power density as a function of current density” graphs for each one

The power density curve for excel expression MFC1 (Urine).

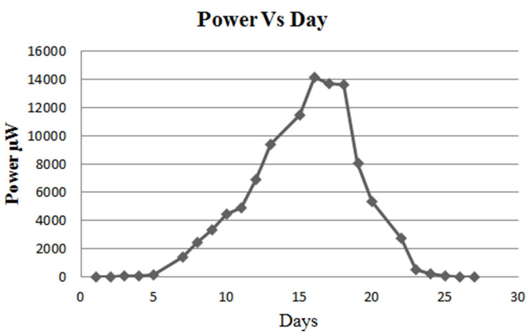

Figure 10. *Power Vs day MFC1 (Urine).*

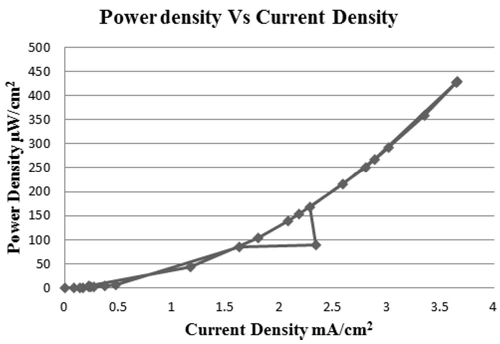

Figure 11. *Power density curve for MFC1 (Urine).*

Power density curve for MFC2 (Blackwater)

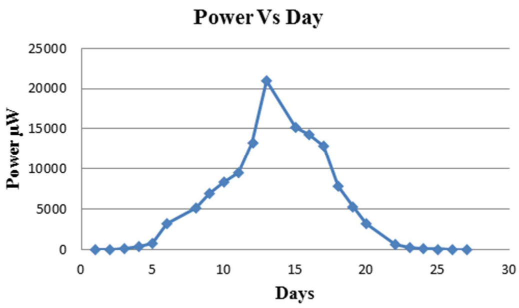

Figure 12. *Power Vs day MFC2 (Blackwater).*

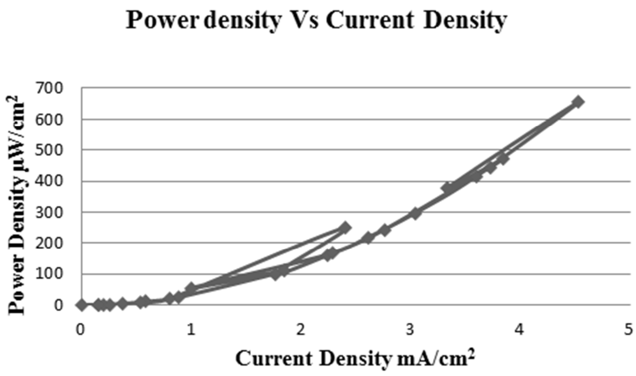

Figure 13. *Power density curve for MFC2 (Blackwater).*

The Power density curve for MFC3 (Graywater) excel graph interpretation.

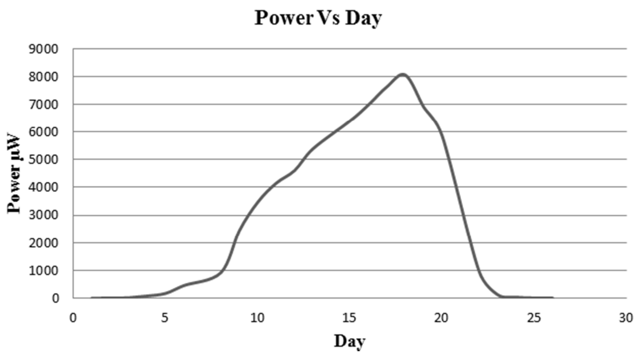

Figure 14. *Power Vs day MFC3 (Graywater).*

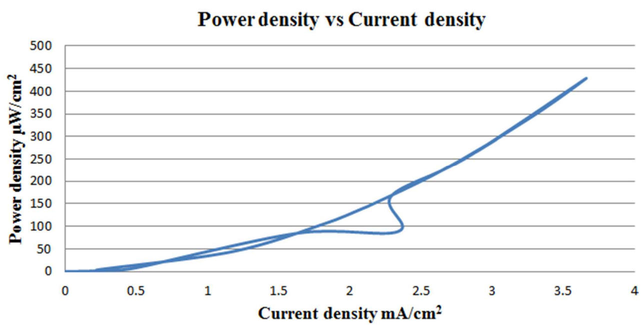

Figure 15. *Power density curve for MFC3 (Graywater).*

Power curves as a function of day usually take on a nonlinear-shaped shape, allowing us to establish the maximum power density as the plot's peak value. There were able to produce a similar but not perfect liner shaped curve after normalizing the modest amounts of power to the anodic surface area.

MFC 2 had the highest maximum power, with a value of 0.00655 W/cm^2 equating to 0.00453A/cm^2 of current. There were found the following values for the other fuel cells: 0.00442 W/cm^2, and 0.00251 W/cm^2, corresponding to current values of 0.00372 A/cm^2, and 0.00281 A/cm^2 are respectively value of MFC1 and MFC3.

Therefore, conclude that the best evaluated system in terms of maximum power generation is the one that stack MFC2 in series (Blackwater), followed by the MFC1 where it used aluminum electrode at the anode and aluminum at the cathode with used substrate mixed one. Then, MFC3 where it has steel at the anode and aluminum at the cathode with graywater substrate produced low power density. Because MFC1, MFC2, and MFC3 all operated under the same conditions with the only difference being the substrate source, it may conclude that blackwater outperformed them all in studied tests. Finally, because the electrodes in the graywater substrate are the different as in MFC 3, the lowest maximum power density value was observed.

3.6. Internal Resistance

Internal resistance is a significant element that can influence MFC performance. To put it another way, some MFCs can have the same reactor volume, and hence the same quantity of substrate, but produce different currents. The total maximum power is calculated in theory as $P=\frac{OCV^2}{R\,in+R\,ex}$. The principles of electric circuits reveal that when Rint = Rext, we can record the maximum power; thus:

$$P_{max}=\frac{OCV^2}{4*R\,int}$$

This equation can be used to calculate the MFC's internal resistance. In early experiments [47], a variety of external resistances were used to construct the polarization and power density curves. Each MFC's internal resistance is determined by recording the maximum power output and comparing it to the external resistance. That internal resistance is what we're up against. The internal resistances of the study MFCs (1-2-3) are 1kΩ, 1kΩ, and 1kΩ, respectively, as indicated in the early figures. The MFC3 is the best single MFC among the other single MFCs since study goal is to reduce internal resistance in the fuel cell. This result is consistent with MFC2's highest maximal power among single MFCs. Furthermore, the high internal resistance of MFC 3 can be justified by the high internal resistance of MFC 1, which is connected to MFC 2.

3.7. Columbic Efficiency

The columbic efficiency is an important parameter to consider while evaluating the MFC's performance. Goal this research is to harvest as many electrons as possible from the anode's biodegradation of organic materials. The bacteria and the system as a whole are more efficient when the columbic efficiency is high.

Described by this equation $Ce=\frac{\text{electron recovered}}{\text{total electron in biomass}}$

The term "electrons" refers to the charge of an electron in coulombs.

For MFCs' the columbic efficiency defined as following equation used to described.

$$Ce=\frac{8\int I\times dt}{F\times Van\times\Delta COD}$$

Where F: Faradays constant

Van: Substrate volume in anode chamber

COD: proportional to substrate concentration 8 is constant value

It is critical to know the COD before estimating the columbic efficiency of the fuel cells. It kept Micrbial fuel cells running for 24 hours and then recorded the current, voltage, and other parameters. As a result, the COD change must also be documented after 24 hours. However, because the working period was insufficient to record a significant value, the average COD in urine, blackwater, and graywater was sought.

Table 9. *Average COD value of substrates.*

No	Type of substrate	Average COD value
1	MFC1 (urine)	58.33%
2	MFC2 (black water)	56.69%
3	MFC (Graywater)	28.89%

Table 10. *Columbic efficiencies of experimented value of each MFC.*

No	Type of MFC	Columbic efficiency (Ce)
1	MFC1 (urine)	40%
2	MFC2 (black water)	58%
3	MFC (Graywater)	32%

The instantaneous current value after 24-hour operation duration was used to calculate the columbic efficiency of the examined MFCs. It didn't utilize any external resistance because it didn't want to restrict electron flow. According to the results of the experiment, the MFC2 has the maximum columbic efficiency because blackwater is the major substrate and both chambers are aluminum.

3.8. Electrode Influence in Microbial Fuel Cell

The kinetics of the electrode reactions within the fuel cell determine the performance of MFCs, and the performance of the electrodes is greatly impacted by the materials used to make them (Mustakeem, 2015). To enhance the productivity of MFC, a variety of materials have been investigated.

For MFCs to operate well in terms of bacterial attachment, electron transfer, and electrochemical efficiency, the electrode material must be chosen carefully. Various electrode factors, including as biocompatibility, active surface area, high conductivity, and the nature of the electrode surface, all influence the performance of an MFC.

This Study was discovering materials for MFC; the desire for cheaper electrode materials is creating chance MFC technology from being implemented outside of the lab. Material for the electrodes Metals such as aluminum and steel can boost power generation, and their widespread use would result in lower cost of materials [5,19,26]. Because it is a hub for critical bioelectrochemical reactions and a mediator of electron transport from exoelectrogens to electrode, an MFC's efficiency is largely determined by its anode performance. As a result, it's critical to concentrate on the anode materials and design. Surface area, chemical resistivity, lifespan, and electrical conductivity are all anodic factors that have a substantial impact on MFC performance. This study used two types of electrode in anode and cathode to improve MFC performance and lower costs. It has been determined that reactor design has a substantial impact on MFC performance. In terms of power generation and longevity, aluminum electrodes outperform steel electrodes.

3.9. All Over Experimental Result

The main goal of this research was to generate electricity energy from human waste. study were able to demonstrate that stacking a particular number of microbial fuel cells in series using different electrodes in the two compartments of the fuel cell is the ultimate way to produce a minimum useable power by testing several types of electrodes and stacking two separate MFCs together in series.

This result suggests that MFCs can be used as generators in the real world. Can it, on the other hand, directly research laboratory outcomes into real-world implementation? Is it true that increasing the amount of sludge and the size of the electrodes also increases the power output?

Table 11. *All over experimental result.*

No	Types	MFC1	MFC2	MFC3
1	Substrate	Urine	Blackwater	Graywater
2	Anode material	aluminum	aluminum	steel
3	Cathode material	aluminum	aluminum	aluminum
4	Anode surface area (cm^2)	32	32	32
5	Cathode surface area (cm^2)	32	32	18
6	Voltage maximum output (mV)	117.1	144.84	89.76
7	Maximum current density (mA/cm^2)	3.66	4.53	2.81
7	Maximum power density ($\mu W/cm^2$)	13712.4	20978	8056.86
8	External resistance	1kΩ	1kΩ	1kΩ
9	Columbic efficiency	40%	58%	32%

4. Conclusion and Recommendation

The overall goal of this research was to see if MFCs were technically possible as a power source in Ethiopia. The data also provide a strong indication of MCF viability, providing hope for a future generation free of green gas effect energy sources. As a result, the purpose of this feasibility study was to see if more research on MFCs for usage in underdeveloped nations in general and distant areas in particular should be done, rather than to recommend MFCs as a solution to Ethiopia's electrical problems. The study's objectives were investigated a laboratory-based experimental work. The capacity of microbial fuel cells and the type of substrate employed were evaluated using experimental research designs. The quantity of electric current produced by wastewater during treatment was measured using an experimental approach. The cross-sectional methodology was used to inspect the capability of each three type of substrates power generation capability during the research design. Maximum Voltage output or OCV (open circuit voltage) values of 118.93 mV, 144.84 mV, and 89.76 mV are attained when the resistance is infinite for MFC1, MFC2, and MFC3, respectively.

The MFC that employed graywater as a substrate produced the least amount of electricity of the three, but it was the most stable. COD reduction was highest in urine waste, at roughly 65.83%, compared to 56.69% and 58% for blackwater and graywater waste, respectively and BOD_5 removal of substrate urine, blackwater and graywater are 67.79%, 69.18% and 28.89% respectively value. MFC 2 had the highest maximum power output, with a value of 0.00655 W/cm^2 equating to 0.00453A/cm^2 of current. It found the following values for the other fuel cells: 0.00442 W/cm^2, and 0.00251 W/cm^2, corresponding to current values of 0.00372 A/cm^2, and 0.00281 A/cm^2 are respectively value of MFC1 and MFC3 are respectively value.

This Study was discovering materials for MFC; the desire for cheaper electrode materials is creating chance MFC technology from being implemented outside of the lab. Material for the electrodes Metals such as aluminum and steel can boost power generation, and their widespread use would result in lower cost of materials.

Based on laboratory analytical result the study will recommend the following important point to be considered and applied. This study scope was restricted to the relatively modest Wolkite University complex in Ethiopia. Understanding what individual organisms are degrading organic matter requires identifying the microbial community structure in the anode and cathode from the lab-based pilot system will be needed. More research will be done to see if pathogens may be eliminated from the MFC digestion. MFCs may be employed as an alternative substrate used for effective wastewater digestion in MFC. However, in order to improve the feasibility of producing electric current from wastewater, better suited material should be sought for and tested. It is also suggested that this research be carried out by another Jimma University researcher. Research should be conducted on a regular basis to ensure that the method is feasible. All of the findings in this study show that more research on MFCs should be done by the researcher in order to learn more about how MFCs are seen and if they are fully functional. Finally, in order to address the influence on the MFC treatment viability, attention will be focused on the user interface problems in Ethiopia for the MFC. MFC is considered for efficient generation of energy from constantly growing wastewater oxidation, according to the conclusions of this research study.

According to the findings of this investigation, the rate of energy generation varies type substrates in addition to producing organic fertilizer. This could be due to an increase in organic materials, which would provide a more favorable environment for anaerobes, or the addition of nutrients to the wastewater. As a result, more research is needed to justify the reasons for the increases in energy generation variety of substrate type of bacteria used for treatment.

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