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Microbial Fuel Cells in Generating Electricity from Sewage Wastewater

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Abstract:- The growing concern of environmental pollution due to the excessive exploitation of fossil fuel has shifted attention to a more renewable source of procuring energy one of them being the microbial fuel cells. The development of MFC is essentially based on the potential of bacteria to generate electrons by metabolizing the substrate (sewage wastewater, here). The mechanism of working of microbial fuel cells is mentioned. The use of sewage wastewater to tap electricity while simultaneously decreasing the COD (Chemical Oxygen Demand) level in the water for it's safe disposal with efficient materials for the PEM (Proton Exchange Membrane), cathode, mediators etc. have been reviewed. The best mode of operation of MFC to generate maximum power density in both single and double chambered MFC has been explored.

Keywords:- *Microbial fuel cell, Bioelectricity, power density, Microorganisms.*

I. INTRODUCTION

Microbial fuel cells (MFCs) are bio-electrochemical devices where chemical energy present in organic substrates can be converted into electrical energy by microbes. It is one of the most wellknown biological energy technologies. The biological mechanisms of energy production encourage the idea of employing microbes to create power in fuel cells. Organic substances are degraded by microorganisms by taking electrons from them (oxidation) and releasing them to a final receptor like oxygen. Certain bacteria, however, can transmit electrons from organic compound oxidation to systems outside the cell even in the absence of oxygen. These bacteria, also known as exoelectrogenic bacteria, have found use as biological catalysts in MFCs (Passos et al., 2016).An MFC consists of an anode and a cathode which is separated by a proton exchange membrane (PEM). Organic substrates are oxidized by the active biocatalyst present in the anode resulting in the release of protons and electrons (Rahimnejad et al., 2015).

MFCs can be a preferable option for energy generation because of their great efficiency, safety, cleanness, and quietness. MFC combined with wastewater treatment has the potential to improve the environment, particularly in terms of reducing stress on wastewater treatment plants. For power generation, MFC technology takes advantage of the natural metabolism of microorganisms found in wastewater. Organic matter found in wastewaters has been found to be useful for bioelectricity generation and simultaneous wastewater treatment. MFC was discovered to be a very successful and cost-effective method for removing TDS, TSS, BOD, COD, sulphates, and chlorides from wastewater (Naik &Jujjavarappu, 2020).The principal components of sewage that must be treated before release are dissolved solids, suspended particles, and alkalinity as CO3 $^{1-}$), sulfate (as SO4 $^{2-}$), nitrates (NO^{3-}), phosphates (PO_4^{3-}) with organic loads of sodium (Na^{2+}), calcium (Ca^{+2}), magnesium (Mg), potassium (K^+), chlorine (Cl^-), ammonia (NH_3^{1+}), and trace quantities of manganese, copper, and zinc, all of which contributes to mg-COD/L of wastewater.(Bose et al., 2018)

This review paper highlights the comparison between single and double chambered MFC in terms of their power density to generate electricity from waste water.

II. ELECTRODE MATERIAL

The selection of proper electrode material is important for the performance of MFCs. Though criteria for the selection of anode and cathode are different, generally, electrode should have following common properties:

- Surface area and porosity
- Electrical conductivity
- Stability and durability
- Cost-efficiency and accessibility
- Biocompatibility

(Kalathil et al., 2018)

A. Anode material

The anode material impacts formation of bio-film and electron transport between material and the microbe. Carbon electrode is mostly commonly used anode material.(Zhou et al., 2011)

B. Conventional carbon-based materials

Carbon materials like graphite rods and brushes, carbon fabric, carbon paper, carbon felt, and reticulated vitreous carbon are frequently utilised as anodes in MFCs because of their large specific surface area, high electrical conductivity, biocompatibility, chemical stability, and cost effectiveness.

C. CNT-based material

One of the forms of carbon, known as a carbon nanotube, is a material that presents a promising option for MFC electrodes due to its exceptional electrical conductivity, chemical stability, biocompatibility, high specific area, and catalytic characteristics. The p-p stacking between the carbon atoms of graphite and the pili of microbes is said to give CNTs their strong cell adhesion, attachment, and growth features. Microbes grown over CNTs exhibit good charge transfer characteristics as a result. A highly conductive MFC anode with a sizable surface area was made by coating CNT on carbon cloth, and as a result, the maximum power density was increased by 250 percent. Incorporating CNTs with a conductive polymer is said to have a synergistic effect. CNT– polyaniline is such an example. Another study found that deposition of carbon nanotubes on carbon paper boosts power density by six times when compared to a standard graphite electrode. (Erbay et al., 2015)

D. Material treatments

The productivity of the anode must be enhanced through material treatment in order to increase power generation. Surface modification: Surface modifications for anode components in MFCs improve microbial adherence. Surface treatments frequently involve the use of ammonia. Ammonia-treated electrodes displayed a significant increase in power density.

Acid treatment: The protonation of functional groups over the anode surface occurs when the anode surface is exposed to concentrated inorganic acids. Additionally, acid treatment causes fractures to emerge, which improves MFC's performance.

Electrochemical oxidation treatment formed new functional groups on the anode surface, leading bacteria to form peptide bonds with electrodes and so opening a pathway for the bacteria to enter the cell. (Rinaldi et al., 2008)

E. Cathode

The oxygen is reduced at the three-phase interface of air, electrolyte, and electrode in MFC, to get to converted to either water or hydrogen peroxide. Three layers make up a typical MFC cathode: a diffusion layer, a conducting support material, and a catalyst. Although most anode materials can potentially be utilised as cathodes, MFC cathodes should have the following qualities for best performance:

- High mechanical toughness;
- Catalytic ability.
- High conductivity of electrons and ions.

High over potential is caused by a low oxygen reduction rate at neutral pH and low temperature, which hinders the operation of MFC. Due to the low catalytic activity of carbon-based materials, an extra catalyst is required to enhance the reduction reaction.

F. Cathode with Pt-based catalyst

Due to its large surface area and low overpotential for oxygen reduction reaction, platinum is nearly always the catalyst of choice for oxygen reduction reactions.

G. Cathode with non-Pt-based catalyst

Although platinum is a common cathode catalyst, its high cost prevents it from being used commercially. Other limitations with platinum include pH sensitivity, sulfide poisoning and nonsustainability made it necessary to develop non-Pt-based catalysts as an alternative.

Transition metal catalyst iron phthalocyanine can be used as alternative catalyst, taking the advantage of the p–p interaction between the metal and carbon of the aromatic ring which leads to rapid electron transfer.

Metal macrocyclic compounds such as cobalt, and lead dioxide can also be used as an alternative to Pt as a catalyst. Those are cost-efficient and in addition, it also shows four times higher power densities as compared to conventional Platinum electrodes. In addition to platinum, transition metal-based oxide catalysts have emerged as a viable option. Recently, palladium, platinum-like transition metal, is being tested for use as a cathode due to its excellent catalytic properties and cost efficiency.

H. Quantitative Analysis of the Organic Content of the Wastewater

The previously mentioned organic compounds, including TOC, COD, and BOD, can be quantified using the traditional techniques outlined in the sections below.

The first step is to inoculate a water sample with aerobic bacteria (1 to 2 cc of sewage per litre). Some of the organic debris is consumed by these aerobic bacteria as food. The DO in the waste water is used to accelerate the aerobic decomposition of the residual organic matter. The amount of organic stuff in the waste water directly relates to how much DO the bacteria use. Thus, the amount of organic matter can be determined using the BOD test in terms of the oxygen needed to turn it into CO2 and H2O.

I. Biochemical Oxygen Demand

- The BOD test is the most common and classic method for determining the content of organic matter in wastewater samples (i.e., relative strength).
- BOD is based on the idea that if there is enough oxygen, aerobic biological decomposition (i.e., the stabilisation of organic waste) by microbes will continue until all of the waste is consumed.
- The BOD test is sometimes known as the "BOD5" test since it is based on a precise measurement of DO (dissolved oxygen) at the start and conclusion of a five-day period in which the sample is kept in dark, incubated conditions (i.e., 20°C or 68°F).
- The "oxygen demand" for respiration by the aerobic living microorganisms in the sample is represented by the change in DO concentration over five days.
- The test's five-day completion window is a drawback since it prevents wastewater treatment plant workers from making real-time operational adjustments.
- In some wastewater permits, an extended UBOD (ultimate BOD) test that quantifies oxygen consumption after 60 days or more is required.

J. BOD Test Procedure

- To achieve optimal biological activity during the BOD test, a wastewater sample is necessary:
  - ✓ It must not contain chlorine. Before testing, a dechlorination agent (such as sodium sulfite) must be used if the sample includes chlorine.
  - ✓ The pH range should be 6.5 to 7.5 S.U. • A sufficient microbial population must already exist; if the sample is outside of this range, acid or base must be added to make up the difference. If the microbial population is insufficient or unknown, a "seed" solution of bacteria is supplied along with a necessary nutrient buffer solution.
- Specialised 300 mL BOD bottles with an airtight seal and the ability to be fully filled without an air gap are used. The test sample or dilution (distilled or deionized)

water is added to the bottles, along with varying volumes of wastewater sample to represent the results.

The initial dissolved oxygen concentration (mg/L), which needs to be at least 8.0 mg/L in each container, is measured using a DO metre. The following five days were spent keeping each bottle in a 20°C, dark incubator. The ultimate dissolved oxygen concentration (mg/L) must be reduced by at least 4.0 mg/L after five days (three hours), as determined by the DO metre.

The final DO concentration is subtracted to determine the BOD concentration (mg/L).

K. What does DO (dissolved oxygen) stand for?

As the name suggests, a DO test quantifies the quantity of oxygen dissolved in a water or wastewater sample. The most popular way to measure DO is with an electronic metre equipped with a dedicated DO probe. The concentration of DO in a water sample is significantly influenced by the following variables:

- **Temperature:** As water temperature rises, DO decreases (i.e., water holds less oxygen as it warms)
- **Salinity:** DO diminishes when the salinity of the water rises (i.e., as water gets saltier, it holds less oxygen).
- **Pressure in the atmosphere:** As pressure rises, so does DO (i.e., water holds less oxygen as you increase altitude).

L. What is COD

The COD test has a substantial advantage over the 5-day BOD test in that it can be completed in only a few hours. COD can be used by the wastewater treatment framework work force as a basically constant functional change boundary.

The COD test should not be seen as a replacement for the BOD test but rather as an independent component of the natural matter in wastewater. Since only natural mixtures are burned through during BOD testing, the COD test uses a synthetic (potassium dichromate in a half sulfuric corrosive arrangement) that "oxidises" both natural and inorganic substances in a wastewater test, resulting in a higher COD focus than BOD fixation for a comparable wastewater test.

M. Procedure

- Before concluding the COD test, KHP (potassium hydrogen phthalate) is used to arrange a development of realised guidelines. Norms of 100, 250, 500, and 1000 mg/L are often prepared because the majority of wastewater tests will fall in the high reaches. Additionally, COD principles can be purchased.
- In order to allow the two instruments to settle, a colorimeter and a COD reactor/warming (150°C) block are both turned on.
- Depending on the expected results, pre-arranged low-range (3-50 ppm) or high-range (20-1500 ppm) vials are selected for the COD test. On the odd occasion that expected results are unclear, the two areas can be used.
- One vial is designated as a "clear," and three or four vials are designated with known standard levels. The wastewater test is then performed on two separate vials to create a replica run. Notably, about 10% of wastewater tests that are conducted repeatedly are replicated.
- Each vial receives an addition of 2 mL of liquid. 2 mL of DI water is added due to the "clear," The corresponding vials are filled with 2 mL of each standard. In the event that the wastewater test is successful, 2 mL is then added to the relevant vial. In the event that weakening is necessary, subsequent dilutions are carried out, and 2 mL of the weaker sample is then put to the comparison vial.
- Each vial is well mixed before being placed in the reactor block for two hours. The vials are removed from the square after two hours and placed on a cooling rack for about fifteen minutes.
- Each vial is placed in the unit, and the COD fixation is read, and the colorimeter is set and adjusted in accordance with the specific requirements for that unit (i.e., proper frequency, clarity, and principles). The comparing duplication is done assuming that the example was watered down.

N. TOC

TOC test is becoming more and more popular because it can be completed in 5–10 minutes, the . Once a consistent TOC to BOD ratio has been established for a particular wastewater stream, the TOC test can be used to quickly estimate BOD concentration (see "Can I use my COD results to predict my BOD?" in the COD section).

A carbon analysis equipment that looks at the total organic carbon in a wastewater sample is the main part of the TOC test.

There are numerous techniques for measuring TOC, each specifically designed for the carbon analysis tool being used. These methods include heat and oxygen, UV radiation, and chemical oxidant-based approaches.

In the TOC test, carbon dioxide (CO_2) that has been transformed from organic carbon is then quantified using an infrared analyzer.

O. Concentration Versus Loading

Concentration (commonly expressed as mg/L or ppm in wastewater samples) indicates how much of a chemical (for example, mg of BOD) is present in a given volume of wastewater (e.g., 1 Liter). However, concentration does not convey how much (i.e., mass or weight) of a chemical is going down the drain, thus it isn't the complete storey. Loading is a term used to describe the process of adding items to a cart.

While wastewater pollutant concentrations are normally reported in milligrammes per litre (mg/L) or parts per million (ppm), wastewater pollutant loadings are typically calculated and reported in pounds per day (lbs/d), and are calculated using the formula:

Flow Million gallons per day (MGD)**X** **Concentration** mg/L or ppm **X** **8.34** Weight (Lbs) of 1 gallon of water (MGD)=**Lbs/day**

P. Relationship between COD and BOD

Despite the fact that COD should be considered a separate test from BOD and will produce a higher fixation reading than BOD for a particular wastewater test, it is generally accepted that COD and BOD have an experimental relationship. The COD to BOD ratio of a particular wastewater will remain constant throughout time, according to a broad perception of the COD and BOD levels on a similar wastewater.

Basically, run both COD and BOD on a few wastewater tests to build up the COD: BOD proportion. The important thing to remember is that the COD test can be used to predict BOD with reasonably consistent accuracy whenever a normal COD: BOD proportion for wastewater stream has been established. (H. Kiepper, 2017)

III. METHODOLOGY

Allowing microorganisms to oxidise and reduce natural atoms is how microbial energy units function. Fundamentally, the movement of electrons during bacterial breath is one big redox reaction. Any time there are moving electrons, there is a good chance that an electromotive force can be used to do useful tasks. Anode and cathode components of an MFC are separated by a cation explicit layer. In order to create a current, microorganisms at the anode oxidise the natural fuel, releasing protons that go through the layer to the cathode and electrons that travel through the anode to an external circuit. The trick is evidently collecting the electrons that minuscule creatures release when they breathe. Two types of MFCs result from this: arbiter and mediator less.

All together for any power module to work you need to have a method for finishing a circuit. On account of the MFC you have a cathode and an anode isolated by a cation particular film and connected along with an outside wire. At the point when a natural "fuel" enters the anode chamber, the microorganisms set to work (oxidizing and decreasing), they naturally make a difference to create the life supporting ATP that fills their cell apparatus. Protons, electrons, and carbon dioxide are delivered as results, with the anode filling in as the electron acceptor in the microscopic organisms' electron transport chain(ETC).

A. Single chambered microbial fuel cell

The Microbial energy part, an advancement that utilizes the waste water to make power with the help of movement of microorganisms is by and large being focused on as another choice source to create and fulfil the interest for power all throughout the planet. (Ou et al., 2016)

It overcomes the constraints of the current arrangement yet moreover gives more noticeable yield and a field-tested strategy of the MFC. The central issues examined in the current plans are low voltage and current creation, utilization, fluctuating current besides, voltage, non-field-tested strategy and the results are not assuredly reproducible. These issues are settled by us by using novel metallic materials which helps with reducing a portion of the issues defied like fluctuating current and voltage and reproducibility of the results andlights most of them like are low voltage and current creation, utilization and non-commercial arrangement. (Saee& Thakur, 2017). Since the Proposed arrangement is business, with further and more bare essential surveys it might be presented in organizations that produce Microbial Waste water accordingly to make control and reuse the waste water for different cycles after treatment.

The unique model is a solitary chambered arrangement that uses the actual chamber as an anode (cathode) which is made of metal and carbon as another terminal (anode). The arrangement chips away at the non-interceded instrument of MFC. A huge part of the metals are an essential piece of the animal's enhancement essential which when gotten in higher concentration than required, cell destruction occurs. (Le et al., 2021) Metals are significantly oxidized by the living creatures which achieves the metals getting devoured viably all through time period. Hence choice of material for the chamber was settled based being researched and botch by using five particular metals for arranging the chamber then again the cathodic space of the MFC and the yield from all of the five models were investigated in regards of yield, utilization rate, viability, space of holders, working volume, and cost of creation and the material of advancement for cathode was picked. (Jinisha et al., 2020)

All being single barrel molded chambered, the genuine chamber went probably as a cathode where anaerobic conditions were stayed aware of and the anodes were implanted into the front of the chamber. Various anodes were implanted to convey most noteworthy surface district contact with waste water and addition the yield. (Wuana&Okieimen, 2011)

The goal of this showing effort and related examinations is to portray and look at the relationship among a couple of components, to perceive the overwhelming factors which affect COD corruption and power yield, and to obtain information that can incite a further created plan of the MFC. This exploration additionally concentrates on the impact of a few boundaries, for example, anode sizes and kind of microbial energy unit on the presentation of MFC. (Rasep et al., 2016) This review was done by utilizing a single MFC. In actuality, on cathode size, the 8×8 cm gives the most elevated greatest current age which is 0.72 mA and most noteworthy COD evacuation productivity of 62.96%. For impact of types MFC, single chamber microbial energy component gives the most noteworthy greatest current age which is 0.78 mA and most elevated COD evacuation proficiency of 64.20%.

The plentiful electron acceptor that is oxygen accessibility noticeable all around is the justification behind the higher current age. (Bailey-Serres et al., 2019) The benefit of air-cathode microbial energy units is that oxygen move to the cathode happens straightforwardly from the air and hence oxygen doesn't need to be disintegrated in water. (Anupama &Hampannavar, 2011, Jayashree et al., 2015)The goal of this showing effort and related examinations is to portray and look at the relationship among a couple of components, to perceive the overwhelming factors which affect COD corruption and power yield, and to obtain information that can incite a further created plan of the MFC. The soluble COD was found to have a substantial decrement from 764mg/L to 383.83mg/L. The substrate being domestic sewage, accordingly was accompanied by the Rhodospeudomonassp of bacteria. The power density hence calculated regarding the same gave readings of around 382.5mW/m2.

The single MFC had parts of 4 cm width × 4 cm length from the air interface on the cathode to the current expert on the anode. The MFC cathode properties have basic ramifications for power age, therefore the materials and development are of phenomenal interest. In this audit, the single MFC reactor is made from a couple of layers, depicted from the air side to the anaerobic anode: a hydrophobic PTFE layer for water the board, hydrophilic carbon material that is submerged with advancement medium, and the Pt/C driving force layer where the ORR occurs. (Choi & Hess, 2015) The PTFE layer is decently thick and hydrophobic, which doesn't allow colossal liquid water gathering under customary working conditions. The carbon texture layer is inconsistently made from penetrable, reticulated carbon strands, enabling spread of split up species and conduction of electrons. The Pt/C impulse layer involves agglomerates of force nanoparticles secured on carbon microparticles with high convolution and porosity. The cathode biofilm is believed to be reliably affixed to the driving force layer. The carbon texture likewise, Pt/C impulse layers are both doused with liquid in customary working conditions. (Obileke et al., 2021, Humoud et al., 2020) The cathode biofilm rivals the microbial anode for the carbon source, achieving an unfavorable result on MFC execution; regardless, the cathode biofilm moreover consumes oxygen, restricting the attack and mixture of oxygen to the anode, achieving a net valuable result on cell execution. The cathode biofilm is made from two wide masses – autotrophic aerobic biomass (AAB) and heterotrophic aerobic biomass (HAB). The AAB gets electrons clearly from the terminal while eating up oxygen; the HAB consumes the carbon source (like acidic corrosive inference) in challenge with the anode while moreover gobbling up oxygen. (Teixeira-Santos et al., 2021)

The single MFC is made out of two compartments, the cathode and the anode, isolated by a leading film. The microorganisms benefited from the carbon substrate inside the anode chamber. The electrons at the anode travel through an outside circuit to the cathode. To endure this cycle, electroimpartiality should be noticed, i.e., transport of electrons to the cathode should be remunerated by transport of an equivalent measure of positive charge to the cathode chamber. The expected distinction between the respiratory framework and the cathode chamber creates a voltage and flow which thus gives bioelectricity. (Choudhury et al., 2017)

The electrons created during the respiratory cycle travel through a succession of respiratory catalysts in the phone, hence delivering power as ATP. These electrons inside the cell are moved and made accessible to the anode by arbiters. Execution of MFC was explored as far as power thickness and interior obstruction by, where they utilized methylene blue (MB), impartial red (NR) and 2-hydroxy-1,4-naphthoquinone (HNQ) go between at various focuses and observed that inward opposition changed with arbiter fixation. Info and yield ports used to exchange information between the front board and square chart. (Sun et al., 2010) The front board is the UI for the VI. It very well may be guaranteed that the pattern of the current is similar to that of the voltage; the not really settled from Ohm's law (I = V/R; I is the current in Ampere (A), V is the voltage in volts (V) and R is the obstruction in ohms). The power P is determined by: P = V × I= V2/R(Minutillo et al., 2021)

B. Double chambered mfc:

Various sorts of materials, such as plastic and stainless steel, can be used to design and manufacture two chambered MFCs. It consists of anode and cathode electrodes that are submerged in separate chambers separated by a Proton Exchange Membrane(PEM). The proton exchange membrane primarily serves as a proton transfer medium between the two chambers. The kind of PEM is an important parameter as the fouling of this membrane can impact the MFC performance. Nafion 117 is the most often utilized form of PEM because of its superior selective permeability. Nafion 117 is very expensive hence limiting its application on a wider scale. Hence a cation exchange memebrane (CEM) like CMI-7000 is utilized. (mention the study where they compared PEM and CEM)[Furthermore, whereas PEM only enables protons to get through, other cations such as Mg2+, K, and Na might compete for space on the active sulfonated sites, resulting in membrane fouling. Membrane fouling causes an increase in a charge imbalance between the two chambers, resulting in a rise in internal resistance and a reduction in power density.](Flimban et al., 2019) This PEM completes the reaction and ensures that the anode does not come into touch with oxygen or any other oxidizers.

Viruses (Enteroviruses), bacteria (*Salmonella spp.*, *Vibrio cholerae*, *Shigella* spp., and Fecal coliforms), protozoa (*Entamoeba histolytica* cysts), and Helminths have all been found to be present in sewage wastewater at thermophilic temperatures (20-30°C). These bacteria have a 30day to 100-day survival period. A basic pH is more favorable for bacterial colonization on the electrode, producing enzymes or structures (nanowires) required for electron transport from the cell to the anode. While sewage is unlikely to be acidic (pH 4), different bacteria can grow in mixed cultures, resulting in diverse potentials. The pH variation has an impact on membrane potential, ion concentration, proton migration, and biofilm stability. Furthermore, it is important to realize from a commercial standpoint that chemical dosing is not a sustainable technique because it requires a lot of energy. (Bose et al., 2018)

C. When is a mediator required?

If bacterial electron transfer is not possible, the presence of a mediator in an anode chamber becomes critical. Synthetic mediators (chemical mediators) and spontaneously produced mediators (bacterial mediators) are both possible. Mediators are found in oxidized form in the anolyte and attempt to reduce themselves by capturing electrons. They become oxidized after releasing an electron to the anode electrode, and then strive to grab another electron to reduce themselves, and so on. Methyl viologen (MV), Neutral red (NR), thionine, and methylene blue (MB) are examples of chemical mediators. Electrochemical mediators are commonly used to ensure that electron transport from the microbial cells to the electrode is as efficient as possible. Because mediators are usually expensive and might be hazardous to microorganisms, long-term commercial use of mediated MFCs for wastewater treatment may be limited. (Ghangrekar& Shinde, 2008)

They usually operate in batch mode, using a chemically defined medium such as glucose or acetate solution to create higher energy power output, and they can be used to provide electricity in a variety of inaccessible situations. (Flimban et al., 2019) There are two shapes or designs that exist for the double chambered microbial fuel cells

- The U-shaped design with cathode on one arm of the tube and anode being in a different arm. The electrode can then be placed in each chamber. Both electrodes are separated by means of an ion selective membrane, Like the PEM, which permits only protons to pass through it and not solutions or microbes (Saravanan & Karthikeyan, 2017)
- The H type of MFC is quite a common design. The electrode might be made of carbon or graphite. Anode is in one of the facets and the cathode in the other, again separated by the PEM.

As an electrode, a carbon brush or carbon clothing can be utilized. External cables connect the anode and cathode electrodes to complete the electrical circuit.

H-shape frameworks are useful for investigating critical parameters such as force creation using new materials or the types of microbial groups that arise during the decomposition of specific mixes, but they often give modest power densities. The surface range of the cathode in relation to that of the anode, as well as the surface of the membrane, determine the amount of power generated in these frameworks. High internal resistance and cathode-based losses usually limit the power density P provided by these frameworks.

IV. BASIC WORKING

Electron transfer and electricity production in a system are controlled by the anode and cathode electrodes. In the anode chamber, where microorganisms break down the fuel (substrate) in anaerobic conditions to produce electrons and protons (H+), the fuel is fed. The electrons are then transmitted to the cathode electrode, which is connected to the anode electrode by a conductive wire with an external resistance, and flow to the anode electrode. Unless the microorganisms are anodophilic, mediators are required to transport electrons to the anode electrode surface. To move free electrons to the anode electrode surface, one can alternatively use nanowires made by Geobacter or Shewanella species.

(Bose et al., 2018) conducted a study where the utilization of the two-chambered microbial fuel cell to treat sewage wastewater has reduced the COD content from an initial 830 ± 20 mg/ L to around 200 mg/L while maintaining the pH at 7.4, with an open circuit voltage of 800mV , essentially proving that the system has the potential to treat wastewater while further generating electrical power in the process with a peak power density in the range of 204 ± 0.38 mW/m2. They associated this good performance to the Nafion-117 membrane and its properties such as high conductivity for cations, and thermal and mechanical conductivity, use of the carbon cloth electrode was also an additional factor due to their non-corrosive nature. High porosity (no accumulation of bacteria) and nonfouling and high surface area. The accepted level of COD in wastewater discharge is <200mg/L with the pH ranging from anything between 7 and 8.5. which is consistent with this system. The development of biofilm is an essential factor in efficient conversion, faster COD removal rates and the possibility for extracellular electron transfer (EET)(Read et al., 2010). And their stable formation is shown to related to the external resistance with the usage of voltage with difference of 50 Ω the setup showed greater voltage peak varied and this is directly attributed to faster COD removal for water treatment. (Bose et al., 2018)

As of now we have seen the potential of sewage wastewater in the generation of maximum electricity. (Nayak et al., 2018) carried out research on the H-type microbial fuel cell in the treatment of distillery spent wash(DSP) along with sewage wastewater(SWW) at different ratios of each of them which was then fed as a substrate to the microbial fuel cell in anaerobic conditions. They utilized microalgae (*Scenedesmus abundans*) for the metabolization of the substrate and generation of electricity. In this investigation, the maximum power density (836 mW/m2) (and maximum OCV 745.13 mV) were shown to be relatively greater when compared to earlier findings. Microalgae could utilize CO2 produced by the breakdown of organic and inorganic chemicals to boost their development as well as oxygen generation at the cathode.Higher MFC efficiency may be due to dilution of highly organic distillery wastewater with sewage wastewater and effective adaption of both bacteria and algae in both chambers separately. This research implies that optimal distillery wastewater dilution and optimum microalgae growing conditions could be a promising strategy to increase MFC power output.

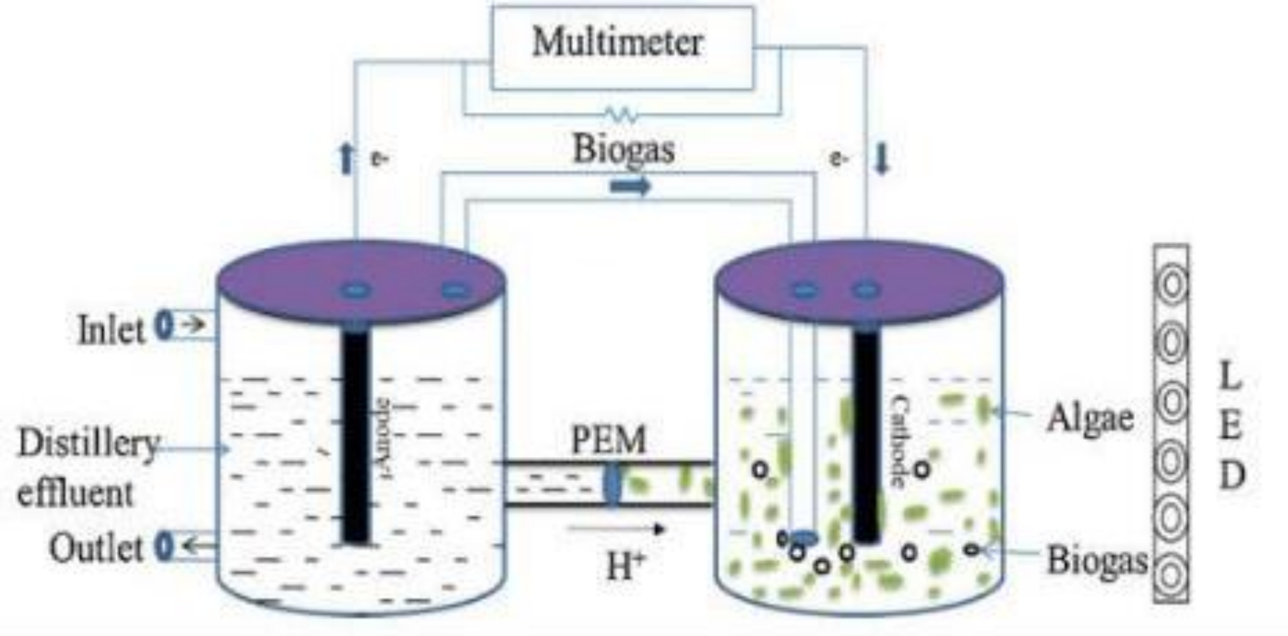

Fig. 1: Diagram of the H-type MFC used in their study (Nayak et al., 2018)

Table 1: Comparison

Substrate	Microorganisms utilized	Configuration of MFC	COD Removal	Power Density	References
Domestic Sewage wastewater	*Rhodopseudomonas spp.*	Single chambered	Soluble COD was brought down from 764 to 383.83 mg/l	382.5 mW/m^2	(Sevda et.al.,2013)
Sewage wastewater	Klebsiella pneumoniae	H-type dual chambered MFC	Soluble COD was brought down from 830 ± 20 mg/ L to around 200 mg/L	204 ± 0.38 mW/m^2	(Bose et al., 2018)
Sewage Wastewater+ distillery wastewater	*microalgae (Scenedesmus abundans)*	H-type dual chambered MFC	Total COD was brought down from 36750 mg/L to 7842.45 mg/L	836 mW/m^2)	(Nayak et al., 2018)

V. CONCLUSION

The wastewater treatment and working of a single chambered Microbial fuel cell has been briefly discussed. Effective power density can be obtained by using appropriate working materials, suitable microorganisms, wastewater source and improved type of MFC configuration. Proton specific membrane is generally used to address the problem of high internal resistance. The implementation of a MFC in treatment of wastewater decreases the energy demand required in the treatment alone as well as eliminates the amount of sludge produced, by anaerobic production the MFC can allow the recovery of chemical energy from wastewater and converts the energy into electrical energy, by utilizing microorganism. Thus along the same lines, the employment of an appropriate biofilm becomes a prime contributor in the MFC performance. In the case of sewage wastewater we saw that the power density of a double chambered microbial fuel cell is significantly high when compared to the single chamber fuel cell, the design of the double chamber MFC also plays a part in the final output.

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