A review on the emergence of single-chamber microbial fuel cell on wastewater treatment

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Abstract. The principle of generating electrical energy using biomass forms the basis of Microbial Fuel Cells (MFCs). This new technology not only produces electricity but also cleans up the waste. Based on the number of chamber units, MFCs are mainly divided into single chamber (SCMFC) and double chamber (DCMFC). This paper reviews particularly about SCMFC. The fundamental components of SCMFC like anode and cathode and the various microbes used in the fuel cell are explained in this review. This paper details about the materials used for the synthesis of anode and cathode. Also, the applicability of SCMFC for the purification of synthetic and real wastewater is discussed.

1. Introduction

Energy exists in different forms such as chemical energy [1], light energy [2], heat energy [3], mechanical energy [4], gravitational energy [5], electrical energy [6], sound energy [7], nuclear or atomic energy [8] and so on. Of all these energies, electrical energy plays a vital role in our routine life [9,10]. With the increasing population of the world, the demand for energy is also increasing which leads to an energy crisis [11–13]. For the past years, the energy was mostly obtained from fossil fuels [14–16]. Now there is depletion of these fuels since they are non-renewable. So, energy from renewable energy sources is preferable [17]. One such renewable energy source is fuel cell [18]. It is an open thermodynamic equipment in which electrical energy is produced from chemical energy [19,20]. Among the existing types of fuel cells, biofuel cells are the most popular [21]. They are minuscule fuel cells that employ biological organisms as catalysts for the production of electrical energy [22,23]. Biofuel cells are broadly classified into enzymatic biofuel cells, in which enzymes of living organisms are used and the entire microbial cell of organisms is used for oxidation of fuel in microbial fuel cells. Among the mentioned types of biofuel cells, Microbial Fuel Cells (MFCs) are largely utilized because of two major advantages that involve production of clean electrical energy and treatment of wastewater. It has been used widely in the treatment of sludge [24], saline wastewater [25], dairy industry wastewater [26], Purified terephthalic acid [27] wastewater from the petrochemical industry, urine wastewater [28], slaughterhouse wastewater [29], livestock wastewater [30], dyestuff wastewater [31] and so on. The other use of MFC is as a biosensor it is employed in the online wastewater quality monitoring [32]. MFC technologies are able to convert chemical energy directly to electricity through a biological pathway [33]. It can generate clean electricity directly and also there is no necessity for purification, segregation and energy product aleration [34]. It is a bioreactor in which chemical energy that is available in the chemical bonds gets converted to...
electricity via the reactions of anaerobic microorganisms which act as catalysts [35]. One such example for a microorganism which can generate electricity and also accomplish treatment of wastewater is bacteria [36,37]. The vital components of an MFC are an anode compartment, a cathode compartment, an external circuit of wire which connects anode and cathode, a Proton Exchange Membrane (PEM) and microorganisms [38]. Anode and cathode electrodes are placed in anode and cathode compartments respectively. In an MFC, the community of microbes present in the anode compartment catalyzes the oxidation process of the organics that is provided in the anode chamber. When this oxidation process takes place, protons, electrons and also CO2 are generated [39]. The resultant electrons are moved to the cathode chamber through an external electric circuit, while protons are moved to the cathode chamber through a membrane called proton exchange membrane (PEM) [40]. This PEM allows the diffusion of the protons which are produced in the anode compartment to the cathode compartment. In this cathode area, water is formed by the reaction between protons, electrons and oxygen. Oxygen will not allow electricity generation. Therefore, in the anode chamber, the anaerobic condition is maintained compulsory. But, the cathode chamber is exposed to oxygen to enhance water formation [41]. The reactions that take place in both the chambers are shown in equations 1 and 2 [42].

At anode electrode: \( \text{CH}_3\text{COO}^- + 2\text{H}_2\text{O} \rightarrow 2\text{CO}_2 + 7\text{H}^+ + 8\text{e}^- \)  \( (1) \)

At cathode electrode: \( \text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O} \)  \( (2) \)

MFCs have two categories of classification depending on the number of chambers as single chamber microbial fuel cells (SCMFC) and two chamber/dual chamber microbial fuel cells (DCMFC) [43]. The main difference is that the former MFC consists of only one anode compartment with no definite cathode compartment [33,44] while the latter has both anode and cathode compartments [45–47]. Many review papers have been published regarding MFC and its developments till date. But this paper reviews only the SCMFC which is simple and cheap [48].

2. **Fundamental Features of SCMFC**

The illustration of simple SCMFC is shown in Figure 1. The principle of the design of this reactor is similar to a hydrogen fuel cell. In hydrogen fuel cells, there is direct contact between the cathode and PEM. The cathode takes oxygen from the atmosphere. In single compartment microbial fuel cells (SCMFC), there is only one anode chamber in which wastewater to be treated is placed along with the microbial catalysts. It is maintained in anaerobic condition for the survival of anaerobic microorganisms present there. External wire conducts the electrical ions to the cathode that is generated in the anode. In SCMFC, air is directly exposed to the cathode, thus taking oxygen from the atmosphere [49]. Sometimes, to separate the two electrodes, Gas Diffusion Layer (GDL) or PEM is attached to the cathode. The basic features of SCMFC are the two electrodes - anode and cathode, micro-organisms and membrane [50] which are explained below.
2.1. Microorganisms

Normally blended bacterial culture is utilized in SCMFC since a wide scope of substrates can be dealt with. Yet, there are a few reactors wherein single bacterial species are utilized [48]. Depending upon the exchange of created electrons from the substrate to anode by microbes, SCMFCs can be grouped into two sorts. The first is SCMFCs with a mediator, where outer chemical mixes are utilized for electron movement in the anode chamber and the subsequent one is, mediator-less MFCs where the mediator is missing [43,51]. The creation of power by Shewanella putrefaciens without the help of external acceptors of electrons was analyzed in an SCMFC with various kinds of anodes and alternative physical conditions by Park and Zeikus [22]. It was discovered that power creation was subject to anode organization, type of electron donor and concentration of cells. A most extreme current density of 10.2 mW/m\(^2\) and 2.5 mA current was acquired with an anode of Mn\(^{4+}\) graphite, 3.9 g cell protein/ml cell concentration and sodium lactate of 20mM. Current generation by S. putrefaciens was upgraded 10-times when graphite anode was joined with Mn\(^{4+}\) which is an external mediator of electron. In an investigation, for the ongoing and consistent estimation of Cr\(^{6+}\) ions, three-stage SCMFC biosensor was created. Exiguobacterium aestuarii YC211 was inoculated in this sensor. At a liquid detention time of 2 mins, when Cr\(^{6+}\) concentration was increased from 5 mg/L to 30 mg/L, the voltage yield reduced. By providing three separate SCMFCs in a single arrangement, upto 90 mg/L concentration of Cr\(^{6+}\) can be estimated. As per the cutting edge sequencing analysis, Cr(VI) in real tannery wastewater can be precisely quantified by this biosensor with less fluctuations. The solid accomplishment of this sensor is due to the stable bacterial network present in the MFC. Thus, for ongoing and persistent Cr\(^{6+}\) estimation of wastewater from tanneries, the three-stage SCMFC biosensor can be used extensively [52]. An MFC was worked with a pure culture of Lactobacillus pentosus and a synthetically prepared wastewater which was similar to an actual dairy industry wastewater. The general exhibition was assessed via COD degradation percentage and the power output. With the operating conditions of 61 cm\(^2\) anode area, 25 cm\(^2\) area of Nafion, yeast extract of 50 mg/L and a batch cycle of 2 days, a most extreme density of power of 5.04 mW/m\(^2\) was accomplished. Even though after trying several operating conditions, only the power output from the MFC gets affected but treatment capacity of L. pentosus remains unaffected. For different operating conditions,
the COD degradation percentage of dairy industry wastewater were somewhere between 42% and 58% [53]. Further in a study, the performance of membraneless single chamber microbial energy units were concentrated under anaerobic condition using the synthetic glucose substrate to produce power. The biofilm of organism Bacillus firmus – NMBL-03 over plain graphite terminals was utilized as a biocatalyst. When worked with an outer resistance of 1000 Ω, the MFC created the most extreme power output of 0.88 mW/m² and a normal power output of 0.19 mW/m² for 500 hrs [54]. Microbial energy components recognized by various strains of species of Pseudomonas; MFC-I:Pseudomonas aeruginosa and MFC II:Pseudomonas fluorescens were examined by Ilamathi et al. [55]. From the results, it have been demonstrated when 0.5 mM of dye was used as substrate, MFC I delivered the greatest power output of 2.87 mW m⁻² for mono-azo reactive color and 1.91 mW m⁻² for di-azo reactive dye and MFC II delivered a power output of 1.9 mW m⁻² for mono-azo reactive color and 1.1 mW m⁻² for di-azo reactive dye over a time of 360 h. Decolorization ability of MFC I was 98% for mono-azo reactive color and 95% for di-azo reactive dye. The use of external mediator phenazine diminished color reduction. The bioadhesion ability of Pseudomonas aeruginosa species on the anode electrode decreased the MFC inside resistance. In 2017, Khater et al. researched the working of acetate feed membraneless SCMFC and physiological portrayal of the biofilm present on the surface of anode was studied utilizing 16S rRNA analyzer and Scanning Electron Microscope (SEM). The working of SCMFC was explored utilizing an anode made of carbon paper and a cathode of 0.3 mg/cm² area carbon paper treated with Teflon. The most extreme open circuit voltage (OCV) was seen as 791 mV. This framework effectively uncovered a higher power output of 86 mW/m² at a constant current density of 354 mA/m² with 65% coulombic effectiveness. COD removal percentage was observed as 96%. SEM analysis of the anode electrode exposed the presence of thick layer of microorganisms on the surface. Sequencing results from 16S rRNA analyzer showed that the biofilm on anode surface consists of a blend of different species of microbes instead of single microbial species. The predominant phyla are Alpha Proteobacteria, Firmicutes, Gamma Proteobacteria, Actinobacteria, with ten prevailing microbial strains: Bacillus firmus, Bacillus safensis, Bacillus isronensis, Micrococcus endophyticus, Brevundimonas bullata, Pseudomonas putida, Planococcus citreus, Acinetobacter tandoii, Shewanella profunda and Shewanella xiamenensis [56]. Microbial community examination in an investigation by Dai et al. demonstrated that Proteobacteria (80.7%), Gammaproteobacteria (48.1%), and Dokdonella (29.5%) ruled at the phylum, class, and family levels, respectively, on the anodic biofilm. This investigation offers a possible choice for the treatment of unmanageable recalcitrant organics, azo dyes and sulfide pollutants utilizing single-chamber air cathode MFCs [57]. In another study, direct production of power from lignocellulosic monosaccharides biomass was inspected utilizing SCMFCs with air cathodes. Power was produced from all the sources of carbon tried, including three pentoses and two uronic acids, one aldonic corrosive and mainly six hexoses. Even though the transformation time changed from one hour to seventy hours, the blended culture of bacteria adjusted with all the tried sources of carbon. The higher density of power acquired from these tried sources varies from 1240 to 2770 mW/m² with density of current varies from 0.76 to 1.18 mA/cm². The most minimal power output was brought about by d-Mannose and the most elevated was produced by d-glucuronic corrosive. Coulombic proficiency ranges from twenty one to thirty seven percentage. The assessed most extreme voltage output varied somewhere in the range between 0.26 and 0.44 V. Chemical oxygen demand (COD) was reduced by more than 80% for all the tried sources of carbon [58]. In another study, Bacillus subtilis species was used in an SCFM without air cathode under anaerobic conditions. Here 1 mM of glucose was taken as the source of carbon and 1 mM of nitrate was taken as the electron acceptor. When the nitrate concentration was decreased in the MFC, a diminished current was noted. Further addition of nitrate, recuperated the current output. This demonstrated the reliance of Bacillus subtilis bacterial species on the electron acceptor i.e., nitrate to effectively create power. At an external resistance of 220 Ω, a power output of 1.9 µW/cm² was accomplished. Cyclic voltammograms (CV) demonstrated mediators in the MFC directly contribute to electrons. Because of glucose fermentation, low coulombic effectiveness (CE) of 11% was ascribed primarily. These outcomes showed that power can be
retrieved from wastewater containing nitrate [59]. Saccharomyces cerevisiae as a biocatalyst in an MFC anode chamber was assessed for waste degradation and power generation. This MFC was worked in a single compartment design without external mediators utilizing graphite without catalysts as anodes. Two organic loading rates, 910 g COD/m²·day (OLR-I) and 1430 g COD/m²·day (OLRI-II) were taken. Maximum output of current was seen at pH 6.0 [160 mA/m² for OLR-I and 282 mA/m² for OLR-II] than pH 5.0 (137 mA/m²) and pH 7.0 (129 mA/m²) [60]. Similarly, the ability of mixed microbial culture was assessed under various values of pH i.e., pH 6 (acidic), pH 7 (neutral) and pH 8 (alkaline) during synthetic wastewater purification in a mediatorless SCMFC. It was operated at room temperature of 29±2°C. Here only the bio-culture was used as anodic biocatalyst and the electrodes were non-catalyzed graphite terminals. It was found that the degradation relies upon the pH input. Maximum density of current was seen at pH 6 [acidic; 186 mA/m²] contrasted with pH 7 [neutral; 146 mA/m²] and pH 8 [alkaline; 135 mA/m²]. Despite what might be expected, substrate reduction was discovered to be successful at neutral conditions (pH 7). Acidophilic activity indicated higher CE and powerful transfer of electrons at moderately higher resistance contrasted with neutral and alkaline pH examined [61]. As of late, Vilela et al. led an investigation for using a nanocomposite made of polyelectrolyte dependent on bacterial cellulose (BC) and poly(4- styrene sulfonic corrosive) (PSSA) as a sustainable PEM for application in MFCs. The use of the individual culture of Shewanella frigidimarina and PSSA/BC nanocomposite layer in a lab-scale SCMFC yielded OCV of 436 mV and a higher power output of 2.42 mW/m². These results were found to be far more superior to the results accomplished with a commercial Nafion® membrane as a PEM for MFCs [62].

2.2. Anode
In the effective design of SCMFC, the efficiency of electrode materials plays a pivotal role. The best anode material must have a large surface area, good electrical conductivity, toughness and mechanical strength [63]. Traditionally, carbonaceous materials in various forms are the most widely used anode materials. Non-catalyzed plain graphite electrodes were also used as anode materials in SCMFC. A setup was demonstrated for the purification of synthetic and real chemical wastewater from various industries. Here graphite plates of 70 cm² surface area were used. In this setup, always the bottom layer of the anode is immersed in wastewater [64]. Anodes made of plain graphite plates without catalysts were also used for bioelectricity production and it was documented that a voltage of 379 mV and a current density 538 mA/m² was generated under aerobic metabolic function [65]. In a work, activated carbon fiber (ACF) felt anode was used in a membraneless, air-cathode single-chamber MFC. Experiments were also conducted after treating ACF anodes with nitric acid and ethylenediamine and the results were compared [66]. Zhang et al. [67] in 2011 adopted a carbon paper modified with mesoporous carbon (MC) as a novel anode and checked its performance in an SCMFC. He constructed this anode by the method of layer-by-layer self-assembly. Carbon-based multiwalled nanotubes were also employed as anode materials for the purification of wastewater from distillery industry. During this work, the efficiency of nanotubes was compared with an anode, the surface of which was coated with carbon nanopowder and plain graphite anode. It was found that nanotubes were found to be more effective among the anodes [68]. For the treatment of dairy industry wastewater, spiral anode made of graphite-modified stainless steel mesh was used. When compared with previous studies, this novel anode is more effective which is confirmed by the higher power density of 20.2W/m² produced by them [69]. Simple untreated carbon in the form of brush and cloth were used for the degradation of acetate, glucose, domestic wastewater, etc [70–72]. An extreme power density of 1444 mW/m² was obtained with acetate as the substrate. 1540 mW/m² was obtained when glucose was used as substrate and 464 mW/m² when actual wastewater from domestic areas was used as pollutant. Xu et al. 2019 used carbon brush as anode after 30 min heat treatment at 450°C and used it to study the development of the microbial community [73]. In 2019, Geethanjali et al. [74] synthesized NiWO₄ and reduced graphene oxide (NWG) nanocomposite by the one-pot solvothermal method and used them as an anode in SCMFC for treating glucose. At optimum operational parameters, 1458 mW/m² of highest density of power was obtained when NWG modified anode was used and it was 8.5
times more than the power density obtained with unmodified carbon cloth. Apart from these carbon-based materials, some natural materials were also used as anode electrode material. One such example is the usage of "JinHao" as an anode. It is a brand of bamboo charcoal. This compound is made from bamboo. Bamboo’s outer area consists of a compact protective layer, a corneum and a layer of gelatinous structure. This will remain on its surface even after carbonizing it. The preparation of this low-cost electrode is as follows. First, the bamboo charcoals were polished and immersed in 1 N HCl overnight and washed with deionized water. It was then immersed in 1 N NaOH for one full night. Finally, it was cleansed in deionized water for many times. This prepared electrode was tested in an SCMFC fed with artificial wastewater [75].

2.3. Cathode

From Figure 2, it is concluded that the overall cost of SCMFC mainly depends on electrode materials, particularly cathode. Hence, the selection of cathode material plays a prominent role.

![Figure 2. Cost analysis of SCMFC][76]

The cathode may be either present along with Proton Exchange Membrane (PEM) or membrane-less. In order to improve Oxidation Reduction Reaction (ORR), cathode may sometimes coated with a catalyst. In 2017, JadHAV et al. explored the efficiency of certain catalysts like palladium, manganese oxide, zirconium oxide and their composites in an SCMFC. Among the catalysts, Mn/Zr-Pd-C-based composite proved to be efficient since it generated a maximum power output of 1.28 W/m³ [77]. Carbon electrodes coated with platinum are the most popular cathode materials. But they are costly. Thus, some low-cost cathode materials were prepared and employed in SCMFC. In a study by Chang et al. 2019 [78], an innovative biochar air cathode was utilized. This cathode was made from chips of Balsa wood after the method of pyrolysis at 800 °C. After pyrolysis, these chips become highly porous and also possess high ORR property. From the biochar air cathode SCMFC, a highest density of power of 200 mW/m² was reached. In these experiments, chips of biochar are used directly as air cathode without any binders, catalyst and GDLs. Similar work was carried out by Sciccaria et al. [79] in which biochar was prepared from olive mill waste. Such SCMFCs achieved a highest power output of 271 ±34 mW/m². It was then found that these results were 15 fold better than the power density obtained with commercial carbon cathodes. In another work by Allam et al. 2019 [80] Water Hyacinth Biochar
(WHB) was prepared by the process of pyrolysis at 900°C. This WHB was placed in an air cathode SCMFC to act as ORR catalyst. The ability of production of power density by this catalyst was compared with another ORR Pt/C catalyst. The results showed that when compared with a costly Pt/C catalyst, this cheap WHB ORR catalyst generated two times higher power density. It demonstrated that in MFCs, cheap WHB is a good option as catalyst.

3. Applications of SCMFC in wastewater treatment
SCMFCs can be used in the purification of wastewater. Wastewater may be either synthetic which is prepared in the laboratory for research purposes or real which is produced in the industries during various processes.

3.1. Synthetic Wastewater
Khater et al. 2017 [56] designed a membraneless SCMFC and used acetate as a substrate. This MFC degraded 96% of acetate by generating 354 mA/m² constant current density, 86.1 mW/m² maximum power density and 65% coulombic efficiency. In the same year, another synthetic wastewater containing cefazolin sodium (CFZS) was prepared by Zhang et al. in 2018 [81]. From the studies, it was found that SCMFC fed with CFZS generated electricity and removed the contaminant to a great extent. This SCMFC also had high tolerance with this contaminant which is usually present in hospital wastewater. When 100mg/L of CFZS was loaded in MFC, a highest output of power of 30.4±2.1 W/m³ and a stable power density of 18.2±1.1 W/m³ was obtained. Ethanolamine which has been used in the production of emulsifiers and detergents can be treated using SCMFC. This has been proved by An et al. in 2020 [82]. When 100 mg/L and 250 mg/L of ethanolamine were used in the SCMFC as substrates, considerable removal of COD and ammonia were attained. Synthetic human black water is also treated using SCMFC [83]. The mean power density over the external load was 153 ± 29 mW/m². Wen et al. 2011 [84] prepared synthetic wastewater with three compounds viz. glucose, penicillin and a combination of both penicillin and glucose. These wastewaters were fed into a single chamber MFC with open air-cathode and experiments were conducted by using them as fuel. From the outcomes, it was revealed that the simultaneous degradation of penicillin and the generation of electricity took place. In this demonstration, the awful factor is that these combination of penicillin and glucose produced electricity effectively. The highest power output for the mixture of 50 mg/L of penicillin and 1 g/L of glucose (101.2W/m³) was 6 times more than the power output from 50 mg/L of penicillin (2.1 W/m³) and 1 g/L of glucose (14.7 W/m³) when used as separate fuels.

3.2. Real Wastewater
So far, several forms of wastewater collected from various industries have been tried in SCMFC and their removal efficiency and electricity production is studied. Applications of SCMFCs in actual wastewater treatment with their performances are listed in Table 1.

| Wastewater      | SCMFC Configuration | Substrate concentration | Performance/Result                                                                 | Reference |
|-----------------|---------------------|-------------------------|------------------------------------------------------------------------------------|-----------|
| Swine wastewater| Single chamber air  | Soluble COD = 8320 mg/L | 261 mW/m² of highest power density was accomplished                                 | [85]      |
| Beer Brewery wastewater | Single chamber air cathode MFC | COD - 2239 mg/L                     | Maximum power density of 483 mW/m²                                                 | [86]      |
| Swine wastewater | Single chamber MFC  | Soluble COD = 8270 mg/L         | Maximum power density of 228 mW/m² was generated and removed 84% of the organic matter | [87]      |
| Confectionery wastewater | Single chamber air cathode MFC | COD - 1000 mg/L            | Maximal power density of 373 mW/m² and 92% COD removal was                           | [88]      |
| Waste Type                                      | System Description                                      | COD Value          | Obtained                                                                                           | Reference |
|------------------------------------------------|---------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------|-----------|
| Starch processing wastewater                   | Single chamber air cathode MFC with membranes            | COD - 4852 mg/L    | Maximum voltage output and power density of 490.8 mV and 239.4 mW/m² was reached                  | [89]      |
| Composite wastewater from different industries | Single chamber mediatorless open air cathode MFC         | COD - 9.1 g/L      | At acidic condition, a high density of current of 186.34 mA/m² was noted in comparison with the neutral condition where a density of current of 146 mA/m² and alkaline condition where a current density of 135.23 mA/m² was obtained. | [61]      |
| Fermented wastewater                           | Single chamber MFCs with air cathodes                    | COD – 1.92g/L      | At the organic loading rate (OLR) of 1.92 g/L, real fermented wastewater produced a power density of 1884 mW/m³. When the OLR of fermented wastewater was increased to 3.84g/L/d, the value of power density increased to 2981 mW/m³. | [90]      |
| Different industrial wastewater                | Single chamber open air cathode MFC                      | COD values:        | SCMFCs filled with wastewater from paper industry generated the maximum density of current of 125 mA/m² when compared with the SCMFCs filled with wastewater from dairy (25 mA/m²), bakery and brewery industries (10 mA/m²). | [91]      |
| Dairy wastewater                               | Annular Single Chamber MFC                              | COD - 2500 to 5000 mg/L | Maximum power density of 20.2 W/m³ and 91% COD removal was achieved                             | [69]      |
| Olive mill wastewater                          | Single-chamber air cathode MFC                           | COD - 56.7 g/L     | A maximum voltage of 381 mV was produced. The removal efficiencies of COD and phenolics were 65 % and 49 % respectively. | [92]      |
| Distillery wastewater                          | Membrane-Less Air cathode single chamber MFC             | COD - 125 to 3000 mg/L | Resultant current varies from 0.005 to 0.055 mA depending upon the concentration of distillery wastewater. 29.5-56.7% of soluble chemical oxygen demand (SCOD) and 35% of total solids was reduced. | [93]      |
| Dye textile wastewater                         | Air-cathode single-chamber MFC                           | COD - 45.6 g/L     | Maximum volumetric power density achieved was 123.2 ± 27.5 mW/m³.                             | [44]      |
| Dye processing wastewater                      | Single chamber air cathode MFC                           | COD - 2100 mg/L    | 515 mW/m³ of extreme power density was attained. Coulombic efficiency of 56 % and the high potency of total COD, soluble COD and TSS removal of about 85%, 73% and 68% respectively were reached. | [94]      |
| Petroleum Refinery                             | Single chamber air cathode MFC                           | COD - 2150 mg/L    | 132 mW/m³ of highest density of power was attained.                                           | [95]      |
4. Future Perspectives
From the review of earlier works, it is found that more importance should be given for the commercialization of SCMFCs. Power densities obtained from the studies already conducted were only a few thousands which is not enough for practical applications. These MFCs need to be stacked so that increased power output can be obtained. Research works need to be done on the use of low cost materials for the fabrication of MFC chamber and for the preparation of electrodes.

5. Conclusion
Microbial Fuel Cell is a novel technique used to purify wastewater and to generate electricity. It eliminates the wastewater which is a major pollutant of our environment. Also, the growing energy demand of the world is reduced by the production of electrical energy. This review paper emphasizes Single Chamber Microbial Fuel Cell, a type of MFC. The components, construction and working of SCMFC are discussed. The application of these MFCs for the treatment of synthetic and real wastewater is stated in this paper. The performance of these MFCs based on percentage of COD removal, power density, current density, coloumbic efficiency and voltage output is also mentioned.

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