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ELECTRICITY FROM MICROBIAL FUEL CELL - CHALLENGES IN IMPLEMENTING THE CELL IN RURAL INDIA

P. Sridhar Acharya* & P. S. Aithal**
Srinivas Institute of Management Studies, Pandeshwar, Mangalore, Karnataka

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Abstract:

Microbial Fuel Cell (MFC) is also referred as a biological fuel cell which produces electricity from the bacteria using a chemical reaction. Here the bacteria used for such reaction may be extracted from the fermented soil which acts like nutrient rich anodic media. The sediment Microbial Fuel Cell (SMFC) can generate electricity while decontaminating wastewater. The basic concept of generating electricity from MFC gives a clear idea that the contaminated soil or waste water which are required for generating electricity are available in large quantity in the rural areas of India wherein people depend on such soil or water for agriculture needs. This paper contains the challenges in designing the MFCs in rural India and the amount of electrical energy thus generated and the use of the same. The cost factor involved in designing MFCs is high to provide the adequate energy for the people in the rural area.

Index Terms: MFC, Microbial Fuel Cell, SMFC, Wastewater & Bacteria

1. Introduction:

A Microbial Fuel cell which is also called biological cell is a system which is used to generate electricity from bio-electrochemical activity [1]. Here the electricity is generated using bacterial interactions found in nature. There are two categories of MFCs they are mediated and unmediated. In the case of mediated MFCs, there is a mediator which chemically transfers the electrons from the bacteria to the anode [2]. This can be implemented using wastewater treatment [3]. This idea is more suitable in rural villages where there will be a good collection of wastewater through human waste, cattle waste, agricultural waste etc. MFC generates electricity by the action of microorganisms [4]. The MFC uses either the oxidation process to separate the components of the cathode or reduction process to separate the component of the cathode. The electrons generated during the oxidation process then transferred to the electrode. Most of the MFCs use organic electron donor where CO_2, protons, and electrons are generated [5]. There are different methods of generation of an electron from the MFC. Some of them are mediated wherein MFCs are electrochemically inactive. Electrons are generated and moved towards concerned electrodes using the mediators like methyl viologin, thionine, humic acid, methyle blue and neutral red. The major problems with this type are expensive and toxic mediators are used [6], Mediator-free wherein the electrons are generated by the bacterial repository enzymes move directly to the electrode without any mediators. Mediator free MFCs are not well characterized. The mediator-free MFCs can run in waste water. The energy can be directly derived from certain plants [7]. Another method is soil based. In this method, the soil is acting like a high nutrient anodic media. Here the anode is placed at a particular depth within the soil and the cathode is placed at the top of the soil and it is exposed to air. One more method is the phototrophic biofilm whereas an anode is made out of a biofilm containing the photosynthesis microorganism. Here the electron is produced by means of photosynthesis [8]. Another method is the nanoporous membrane in which nanoporous polymer membrane is used [9]. MFCs can also be achieved through a ceramic membrane which functions like photosynthesis membranes. The electron generated through microorganism when they consume sugar in aerobic condition produce CO_2 and water. In addition to CO_2, they produce protons and electrons. The formula is as given below [10]:

$$C_{12}H_{22}O_{11} + 13H_2O \rightarrow 12CO_2 + 48H^{+} + 48e^{-}$$

2. Objective:

The objective of this paper is to suggest a model for MFC to improve the efficiency and to incorporate the same in rural part of the country to partially fulfill the need of electrical energy using green technology.

3. Methodology:

- ✓ The efficiency can be improved by selecting the appropriate material for the cathode of MFC.
- ✓ The sunlight to the waste water is more concentrated to improve the production capacity.
- ✓ The area of MFC culture is increased to increase the power of production.

The crops in the rural area include rice, sugar cane, vegetables etc. The grasses of these materials are used for the generation of electricity from MFC. The production of electricity is highly influenced by both light (photon) as well as the environment temperature. The increase in the sunlight increases the production of electrons. The optimum temperature for the maximum production of the electrons is 40^{o} Celsius. Figure 1 shows the production of electrons using the microorganisms with the help of the plants in the field using cathode and anode. In the rural area, the main activity is agriculture. The maximum share of the land is meant for agriculture purpose. The research studies show that by using sewage sludge and Platinum and polyaniline-modified anode and Escherichia coli as a cathode with a single chamber we can generate the maximum electrical energy of 6000 mW/m^2 [11]. The model suggests to design a separate plant in the portion of the field dedicated for energy generation as the cathode, anode and the membrane is toxic.

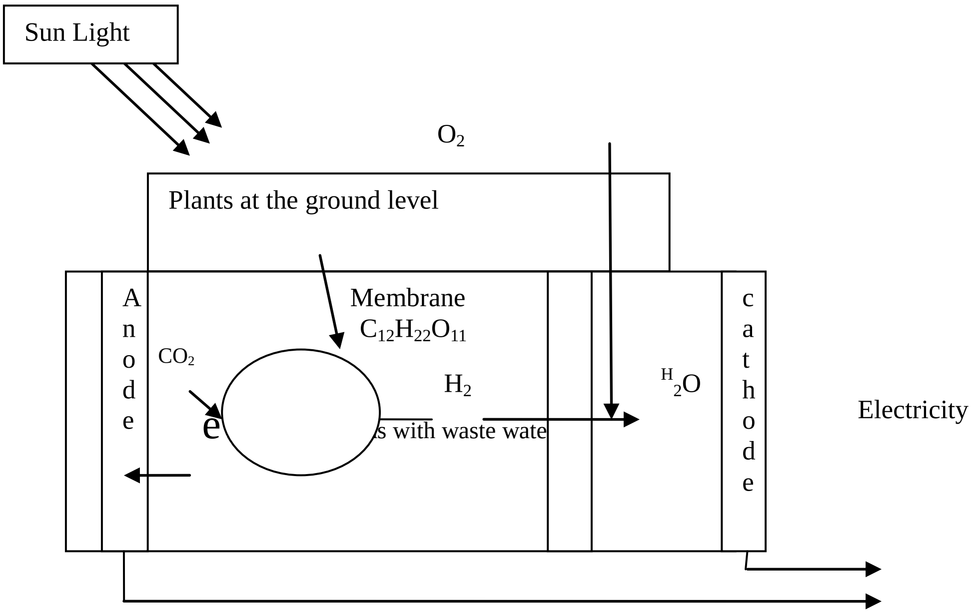

Figure 1: Plant Microbial Fuel Cell

4. Factors Affecting the Electricity Power Production:

The factors which affect the electricity production are

- ✓ Area of the sewage sludge
- ✓ Density of the sewage sludge used
- ✓ Amount of wastewater into the chamber
- ✓ Area of anode and cathode
- ✓ Nanoporous membrane like nylon, cellulose, poly carbonate.

Thus considering the above factors it is possible to suggest the plant produce the electricity from microbial fuel cell. The diagrammatic representation of the model is given in the figure 2:

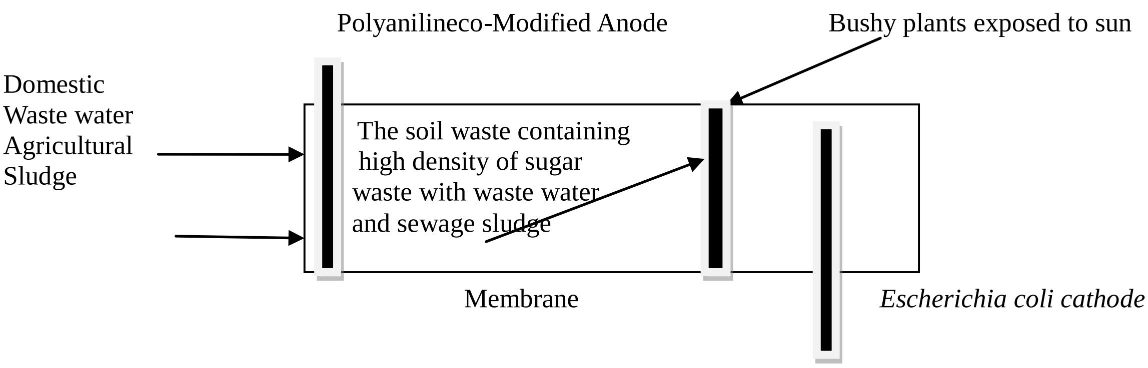

Figure 2: The Design of the Proposed Model

5. ABCD Listing:

ABCD analysis framework recently developed by Aithal et. al. (2015) [12- 22] has qualitative part of listing advantages, benefits, constraints, and disadvantages of a system or concept or a technique. The ABCD listing of Microbial Fuel Cell (MFC) for implementation in rural India are given below.

5.1 Advantages of this Method:

- ✓ Large amount of waste water and soil is available in rural villages, MFC can be designed
- ✓ The bio-degradable waste like sugar cane, paddy grass which can be used as manure for the agricultural land can also be used for generating electrical energy.
- ✓ Since the use of bacteria is essential for generating electrons the same bacteria can also be used to increase the fertility of the soil.
- ✓ The process uses CO_2 and releases H_2O, the environmental pollution will not be there.

5.2 Benefits of this Method:

- ✓ With the available materials, it is possible to get electrical energy.
- ✓ Separate setup is not required.
- ✓ It is an Eco-friendly setup
- ✓ The setup improves the water level inside which is useful for further agricultural activities.

5.3 Constraints of this Method:

- ✓ Knowledge in usage of electrodes
- ✓ Usage of chemical membranes
- ✓ The knowledge in MFC for the rural villagers

5.4 Disadvantages of this Method:

- ✓ The amount of electrical energy thus produced will be very less.
- ✓ It is not possible to generate the electrical energy to meet the domestic requirements.
- ✓ By using large amount of toxic chemicals sometimes the soil may not be useful for agricultural uses.
- ✓ This method can be thought of as an added technology in producing the electricity but not a method of production which can be dependable like solar or windmill etc.

6. Conclusion:

The MFC setup can be used for generating Electricity from the biowaste. Since the biowaste available in the rural area is in large quantity, this waste can be reused for power generation. However, this method of power generation is very low. Thus this method cannot be considered as an alternative to the other power production methods. The cost involved in identifying and using cathode and anode are costly and to that extent, the power production cannot be appreciably generated. However instead of wasting the soil sludge which is largely available in the rural area as well as there is a lot of wastewater from cattle hut as well as domestic use it is possible to generate the electrical energy. This energy can be used as an alternative energy along with other renewable energy resources.

7. References:

1. Badwal, S.P.S. (2014). Emerging electrochemical energy conversion and storage technologies. Frontiers in Chemistry. 2(79). DOI: 10.3389/ fchem. 2014.00079.
2. Min, B.; Cheng, S.; Logan, B. E. (2005). Electricity generation using membrane and salt bridge microbial fuel cells. Water Research. 39 (9), 1675–86. DOI: 10.1016/j. watres. 2005.02.002.
3. MFC Pilot plant at the Fosters Brewery. Retrieved 2013-03-09.
4. Allen, R. M.; Bennetto, H.P. (1993). Microbial fuel cells: Electricity production from carbohydrates. Applied Biochemistry and Biotechnology. 39–40, 27–40. DOI: 10.1007/bf02918975.
5. Pant, D.; Van Bogaert, G.; Diels, L.; Vanbroekhoven, K. (2010). A review of the substrates used in microbial fuel cells (MFCs) for sustainable energy production. Bioresource Technology. 101 (6): 1533–43. DOI: 10.1016/j.biortech.2009.10.017.
6. Delaney, G. M.; Bennetto, H. P.; Mason, J. R.; Roller, S. D.; Stirling, J. L.; Thurston, C. F. (2008). "Electron-transfer coupling in microbial fuel cells. 2. Performance of fuel cells containing selected microorganism-mediator-substrate combinations". Journal of Chemical Technology and Biotechnology. Biotechnology. 34, 13–27. DOI: 10.1002/jctb.280340104
7. Strik, David; H. V. M. Hamelers; Jan F. H. Snel; Cees J. N. Buisman (2008). Green electricity production with living plants and bacteria in a fuel cell. International Journal of Energy Research. 32 (9), 870–876. DOI:10.1002/er.1397.
8. Bombelli, Paolo; Bradley, Robert W.; Scott, Amanda M.; Philips, Alexander J.; McCormick, Alistair J.; Cruz, Sonia M.; Anderson, Alexander; Yunus, Kamran; Bendall, Derek S.; Cameron, Petra J.; Davies, Julia M.; Smith, Alison G.; Howe, Christopher J.; Fisher, Adrian C. (2011). Quantitative analysis of the factors limiting solar power transduction by Synechocystis sp. PCC 6803 in biological photovoltaic devices. Energy & Environmental Science, 4 (11), 4690–4698. DOI: 10.1039/c1ee02531g.
9. Biffinger, Justin C.; Ray, Ricky; Little, Brenda; Ringeisen, Bradley R. (2007). Diversifying Biological Fuel Cell Design by Use of Nanoporous Filters. Environmental Science and Technology. 41 (4), 1444–49. DOI: 10.1021/es061634u.
10. Bennetto, H. P. (1990). Electricity Generation by Micro-organisms. Biotechnology Education. 1 (4), 163–168.
11. Schröder, U., Nießen, J. & Scholz, F. (2003). A generation of microbial fuel cells with current outputs boosted by more than one order of magnitude Angew. Chem. Int. Edit., 42, 2880–2883.
12. Aithal, P. S., Shailashree V. T & Suresh Kumar P. M., (2016). Analysis of ABC Model of Annual Research Productivity using ABCD Framework. International Journal of Current Research and Modern Education (IJCRME), 1(1), 846-858. DOI: http://doi.org/10.5281/zenodo.62022.
13. Aithal P. S. & Suresh Kumar, P. M. (2016). Opportunities and Challenges for Private Universities in India. International Journal of Management, IT and Engineering (IJMIE), 6(1), 88-113.
14. Sridhar Acharya, P. & Aithal P. S., (2016). Concepts of Ideal Electric Energy System for production,

distribution and utilization. International Journal of Management, IT and Engineering (IJMIE), 6(1), 367-379.
15. Padmanabha Shenoy, & Aithal P. S. (2016). A Study on History of Paper and possible Paper Free World. International Journal of Management, IT and Engineering (IJMIE), 6(1), 337-355.
16. Aithal, P. S. (2015). Comparative Study on MBA Programmes in Private & Public Universities - A case study of MBA programme plan of Srinivas University, International Journal of Management Sciences and Business Research (IJMSBR), 4(12), 106-122.
17. Aithal P. S. & Shubhrajyotsna Aithal (2016). Impact of On-line Education on Higher Education System. International Journal of Engineering Research and Modern Education (IJERME), 1(1), 225-235.
18. Aithal, P. S., & Suresh Kumar P. M., (2016). Analysis of Choice Based Credit System in Higher Education. International Journal of Engineering Research and Modern Education (IJERME), 1(1), 278-284.
19. Varun Shenoy & Aithal, P. S., (2016). Changing Approaches in Campus Placements - A new futuristic Model, International Journal of Scientific Research and Modern Education (IJSRME), 1(1), 766 – 776.
20. Prithi Rao, & Aithal, P. S. (2016). Green Education Concepts & Strategies in Higher Education Model, International Journal of Scientific Research and Modern Education (IJSRME), 1(1), 793-802. DOI: http://doi.org/10.5281/zenodo.160877.
21. Aithal, P. S. & Shubhrajyotsna Aithal (2016). Ekalavya Model of Higher Education – an Innovation of IBM’s Big Data University. International Journal of Current Research and Modern Education (IJCRME), 1(2), 190-205. DOI: http://dx.doi.org/10.5281/ZENODO.198704.
22. Aithal, P. S. & Shubhrajyotsna Aithal, (2016). A New Model for Commercialization of Nanotechnology Products and Services. International Journal of Computational Research and Development, 1(1), 84-93, DOI: http://doi.org/10.5281/zenodo.163536.