# IMPACT OF AGAROSE CONCENTRATIONS ON ELECTRICITY GENERATION USING HOSTEL SLUDGE BASED DUEL CHAMBERED MICROBIAL FUEL CELL

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**ABSTRACT:** *The two major problems that have played havoc with our lives are; one is protection and perseverance of our environment and the other is energy crises. Microbial fuel cell (MFC) offers unambiguous advantages over other renewable energy conversion methods. Without any transitional conversion into mechanical power, fuel cells transmute chemical energy directly into electricity. In this context, present study deals with the utilization of sewage sludge, which contains high levels of organic compounds and one of the major sources of environmental pollution, as substrate in the MFC. Saccharomyces cerverciae sp. as a biocatalyst and methylene blue as mediator were used for the conversion of sewage sludge into electric current and power generation using MFC. MFC's efficiency was examined by the changing concentrations of agarose in the salt bridge of MFC. Concentration of agarose salt which range from 7% to 12% was utilized for analyzes of the best possible concentration was noticed being 10% because it exhibited maximum voltage generation of 0.97V.*

***Key words:*** *Agarose, Sat bridge, bio electricity, Microbial fuel cell*

## INTRODUCTION

Due to continuous destruction of fossil fuels as well as constant rise in values of fuels, the world is moving towards the energy catastrophe [1-3]. However consumption of fossils fuels cause an increase in pollution level which is a major cause of global warming. So requisition of an alternative source of energy is increasing day by day which should be economical, reusable and clean [4-6]. The microbial fuel cells provide a promising technology to handle the above two problems by decomposing organic waste to using it [7-9]. For constructing a realistic globe all of us need to reduce the usage of fossil fuels as well as pollutants produced. Both of these as a whole by means of the treatment of the particular wastewater or bio waste [10-12]. In 1911, M.C Potter observed that bacteria can be used produce electrical energy [13]. However not sufficient research was done to advance this technology during 1911-1967. But in 1967, John Davis patented the first microbial fuel cell technology & possible application and research on microbial fuel cell was began after 1990's [14-16]. Most of the patents were issued in 2000's. In Microbial Fuel Cells, electrons are generated from biomass by microorganisms [17]. MFC, mainly consists of two chambers, one of the chamber, where, oxidation takes place is call anodic chamber (anode) and the other chamber where reduction takes place is called cathodic chamber (cathode) [18]. At the bio-anode, microorganisms catalyze the oxidation of organic materials and produce $CO_2$, protons, and electrons [19]. The produced electrons flow from anode to cathode, where a reduction reaction takes place, usually the reduction of oxygen to water [20]. At the same time, positively charged ions, for example $K^+$ or $Na^+$, transferred by the salt bridge from anode to cathode to maintain electro neutrality in the solutions. On their way from anode to cathode, the electrons release their energy (for example at a light bulb) so that useful energy can be gained [22, 23]. An additional advantage is that this electron transfer takes place as a result of the breakdown of organic material at the anode, and when wastewater is used, this means that the wastewater is purified at the same time [24]. Industrial or domestic wastewaters are generally regarded as conducive substrates to the phenomenon of bioconversion in a bioreactor, whereby highly concentrated organic wastewaters contain higher chemical energy per unit volume as compared to that present in the wastewaters. Sewage sludge are deemed as a suitable fuel for MFC operation in terms of electricity generation. In addition, domestic or municipal wastewater (sewage), which contains multitude of organic compounds could be used as substrate. Considerable level of study need to be focused to determining the effects of various fuel cell components on voltage output like oxygen flow rate, substrate concentration and pH [23-25]. Towards this direction, the aim of this research paper is to use MFC for voltage generation by utilizing of sewage sludge as a substrate. The efficiency of MFC was investigated by utilizing different agarose concentrations of MFC for the fabrication of salt bridge and it was determined the impact of agarose concentrations on the voltage generation.

## MATERIALS AND METHODS

### Substrate collection – sewage sludge

Sewage sludge (1000ml), which served as the substrate of the MFC was collected from the hostel of MUET Jamshoro.

### Cathodic & anodic chamber

These chambers of the MFC was made up of plastic bottles. Two plastic bottles each of 1000 ml were used for this purpose. The bottle was washed with distilled water and then medium was filled in it. Methylene blue (10ml), sewage sludge (1000ml) as a sample and Saccharomyces cerverciae sp. (44g) added to it.

### Salt bridge

Salt bridge employed here was made with 5M NaCl and agar salt concentration from 7% to 12%. The salt bridge was cast in a PVC pipe (12 cm X 2cm). Proper precautions were taken to ensure complete sealing of anodic chamber by means of applying epoxy and wax to ensure anaerobic conditions. The external circuit was completed by connecting a resistor (10 Ω) between the two leads of the electrodes.

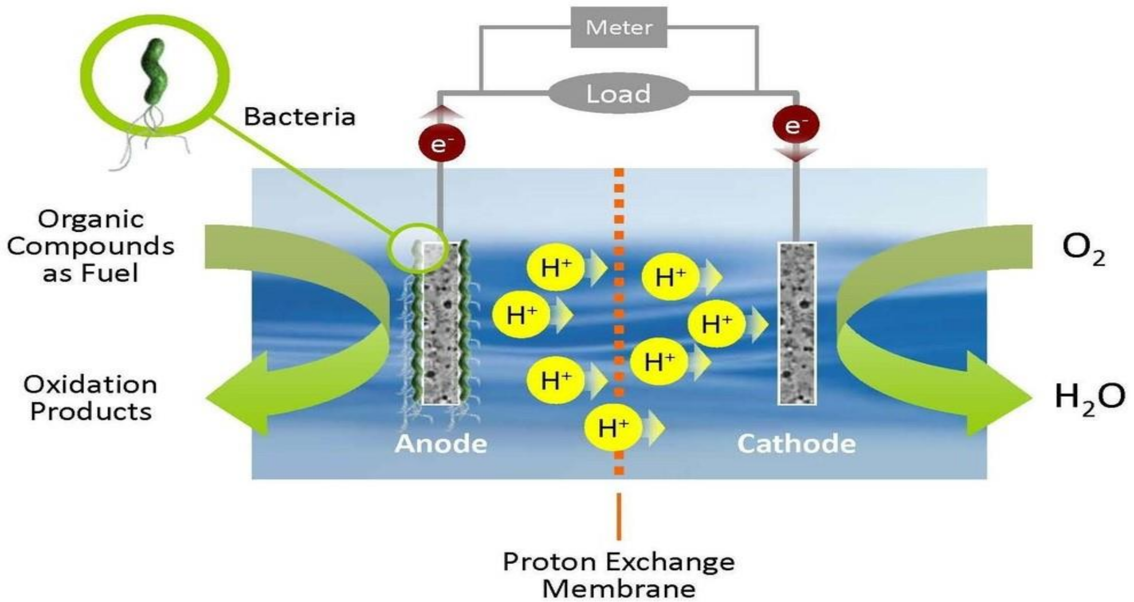


**Fig. 1: Double chambered MFC**

**Fabrication and Operation of double chamber MFC**

Salt Bridge-Immersed-Air Cathode MFC consisted of a plastic container of capacity 2 liters which served as the anodic chamber (Fig 1). The anodic compartment contained the substrate and the copper electrodes (6″ each). The salt bridge served as an electrolyte in transfer of protons. The cathode was immersed in the salt bridge when it was in molten stage to ensure complete surface contact. The 50% cathode surface was exposed to atmospheric air.

**MFC Operation**

Substrate (sewage sludge), was added in anaerobic chamber (anodic chamber) and then it is sealed completely for the creation of anaerobic conditions. The MFC was sparged with $CO_2$ before sealing completely to ensure complete removal of oxygen. A batch configuration was employed and readings were taken for a period of 6 days. The readings were taken on a daily basis.

## RESULT AND DISCUSSION

**Generation of voltages**

Created voltage seemed to be calculated for duration of 480 hours. Within this particular interval 10%agarose created the maximum voltage ((Table 1). The maximum voltage seemed to be created from 10 % agarose right at the end associated with 480 hours. The Fig.2 indicates the particular creation of highest voltage concerning the particular progress challenge involving microorganisms inside the anaerobic chamber depicting the initial enhance in the voltage through the experimental cycle connected with progress curve although goes in some sort of positioned voltage cycle in addition to minimize for the reason that the minimize because the startup goes into decline period because of the demise of microorganisms attributing towards the weariness of nutrition within the particular holding chamber. The generated voltage shows a hike from 7% to 10% concentration agarose, which could be for the reason that concentration of agarose boosts, the gel is extremely polymerized, suppressing the particular inter possibility of the segregated chamber liquids. Extremely polymerized gel in addition inhibits the particular admittance of indigenous as well as oxygen from the cathode chamber by the salt bridge penetration, keeping the anaerobic conditions of the anodic chamber. A decrease in creation of voltages was analyzed regarding 11% as well as 12% agarose concentration, for the reason that salt bridge extremely polymerized minimizing the sizing, limiting the movement of proton through the salt bridge.

**Generation of current and other parameters**

The current and other parameters like power, power density and current density generated in double chambered air cathode chamber MFC was recorded for a period of 480 hours. From Fig.2, 3, 4 and 5, it is clear highest values were produced at 10% concentration of agarose at the end of 480 hours and after this the maximum value gradually decrease due to the decreasing levels of organic matter's concentrations. There is an increase in values as concentration of agarose enhance from 7% to 10%, this is due to the effective transfer of protons and as the gels is highly polymerized, thus maintaining anaerobic conditions and increasing the growth of microorganisms. But there is reduction in values for 11% and 12% concentrations of agarose as the highly polymerized gel prevents the effective transfer of protons. The overall efficiency of the MFC was examined by considering various parameters like voltage, current, power, power density and current density.

**Table 1. Various parameters at different agarose concentrations**

| **Parameters** | **Agarose concentrations** | | | | | |
|---|---|---|---|---|---|---|
| | 7% | 8% | 9% | 10% | 11% | 12% |
| Voltage (V) | 0.77 | 0.86 | 0.95 | 0.97 | 0.59 | 0.34 |
| Current (mA) | 0.81 | 0.89 | 0.94 | 0.98 | 0.63 | 0.46 |
| Power (mW) | 0.6237 | 0.7654 | 0.8930 | 0.9114 | 0.3717 | 0.1564 |
| Power density ($mW/m^2$) | 50.43 | 61.53 | 71.98 | 78.42 | 30.21 | 10.92 |
| Current density ($mA/m^2$) | 67.29 | 73.98 | 78.97 | 82.48 | 52.74 | 37.47 |

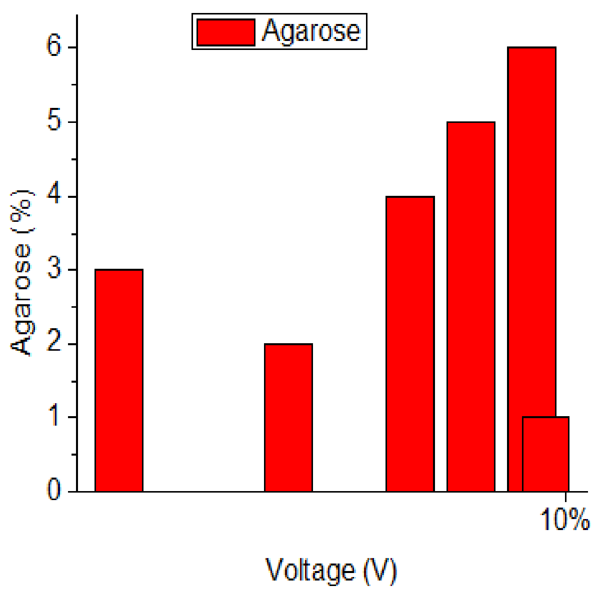


**Fig 2: Voltage generation versus time**

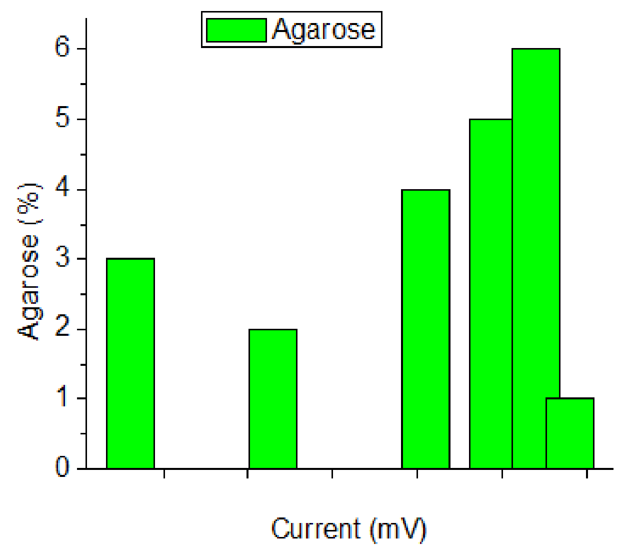


**Fig. 3: Current generation versus time**

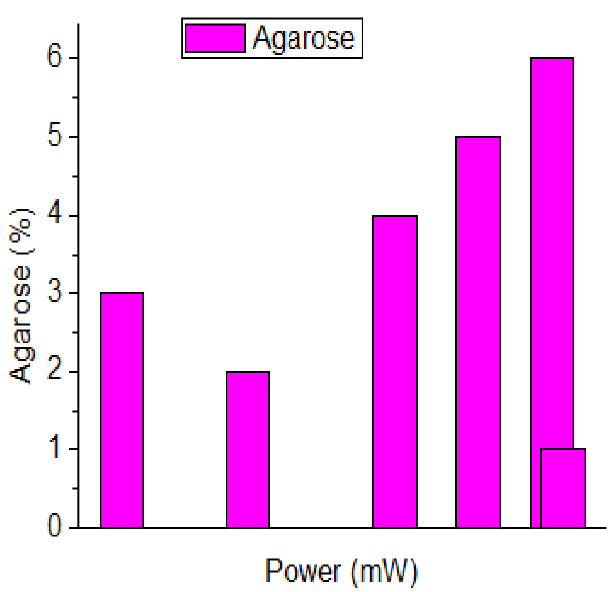


**Fig. 4: Power generation versus time**

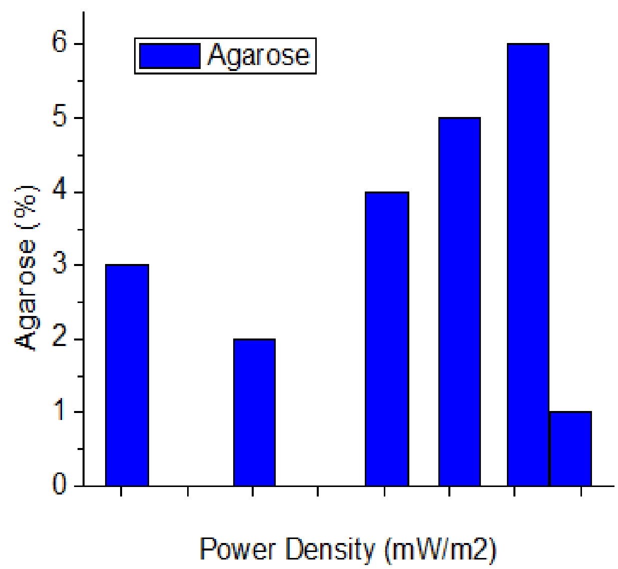


**Fig 5: Power density generation versus time**

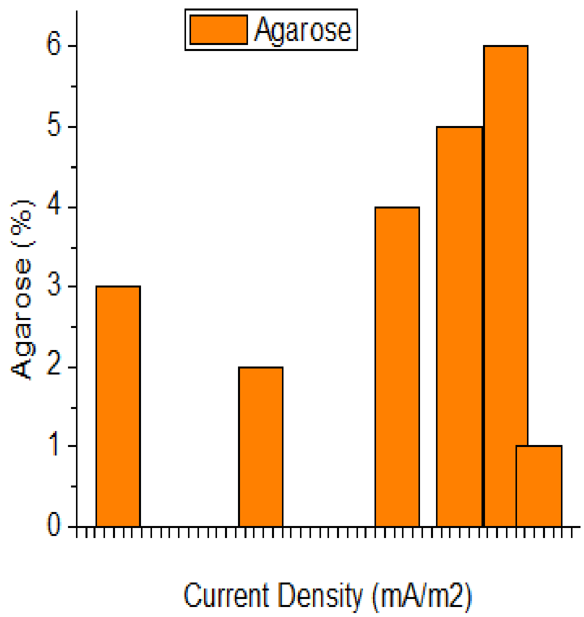


**Fig 6: Current density generation versus time**

## CONCLUSION

The double chamber MFC using Saccharomyces cerevisiae with various agarose concentrations based salt bridge was used for the performance and process optimized. The suitable agarose concentration or salt bridge of MFC was found to be 10% concentration as it showed maximum voltage 0.97V and maximum current 0.98 mA. Internal resistance resist the generation of voltages as a higher grade of polymerization of the gel, internal resistance build up inside the cell. Thus the optimal agarose concentration is preferred while fabricating a salt bridge as it increase the voltage generation.

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## REFERENCES

[1] Chang I. S., Kim B. H., Lovitt R. W. and J. S. Bang, Effect of CO partial pressure on cell-recycled continuous CO fermentation by *Eubacterium limosum* KIST612, *Process Biochemistry*, **37**: 411(2001).

[2] Chang I. S., Jang J. K., Gil G. C., Kim M., Kim H. J., Cho B. W. and B. H. Kim, Continuous determination of biochemical oxygen demand using microbial fuel cell type biosensor, *Biosensors and Bioelectronics*, **19**: 607–613(2004).

[3] Chang I. S, Moon H., Jang J. K. and B. H. Kim, Improvement of a microbial fuel cell performance as a BOD sensor using respiratory inhibitors, *Biosensors and Bioelectronics*, **20**: 1856-1859(2005).

[4] Cheng X., Shi Z., Glass N., Zhang L., Zhang J., Song D., Liu Z-S, Wang H. and J. Shen, A review of PEM hydrogen fuel cell contamination: impacts, mechanisms, and mitigation, *Journal of Power Sources*, **305**: 1280–1283(2004).

[5] Gong M., Liu X., Trembly J. and C. Johnson, Sulfur-tolerant anode materials for solid oxide fuel cell application, *Journal of Power Sources*, **168**: 289–298(2007).

[6] Kim I. S., Chae K-J, Choi M-J and W. Verstraete, Microbial fuel cells: recent advances, bacterial communities and application beyond electricity generation, *Environmental Engineering Research*, **13** (2): 51–65(2008).

[7] Kim J. R., Min B. and B. E. Logan, Evaluation of procedures to acclimate a microbial fuel cell for electricity generation, *Applied Microbiology Biotechnology*, **68**: 23–30(2005).

[8] Lee J., Phung N. T., Chang I. S., Kim B. H. and H. C. Sung, Use of acetate for enrichment of electrochemically active microorganisms and their 16S rDNA analyses, *FEMS Microbiology Letters*, **223**: 185–191(2003).

[9] Liu H., Cheng S. and B. E. Logan, Production of electricity from acetate or butyrate using a single-chamber microbial fuel cell, *Environment Science & Technology*, **39**: 658–662(2003).

[10] Pham T. H., Jang J. K., Chang I. S. and B. H. Kim, Improvement of cathode reaction of a mediatorless microbial fuel cell, *Journal of Microbiology Biotechnology*, **14**: 324–329(2008).

[11] Ragauskas A. J., Williams C. K., Davison B. H., Britovsek G., Cairney J., Eckert C. A., Frederick Jr. W. J., Hallett J. P., Leak D. J., Liotta C. L., Mielenz J. R., Murphy R., Templer R. and T. Tschaplinski, The path forward for biofuels and biomaterials, *Science*, **311**: 484–489(2008).

[12] Geun-Cheol G., In-Seop C., Byung H. K., Mia K., Jae-ung J., Hyung S. P., Hyung J. K., Operational parameters affecting the performance of a mediator-less microbial fuel cell, *Biosensors and Bioelectronics*, **18**: 327-334(2003).

[13] Song C., Fuel processing for low-temperature and high-temperature fuel cells: Challenges and opportunities for sustainable development in the 21st century, *Catalysis Today*, **77**: 17–49(2008).

[14] Aelterman P., Rabaey K., Pham H. T., Boon N. and W. Verstraete, Continuous electricity generation at high voltages and currents using stacked microbial fuel cells, *Environmental Science & Technology*, **40**(10): 3388–3394(2006).

[15] He Z., Minteer S. D. and L. T. Angenent, Electricity generation from artificial wastewater using an upflow microbial fuel cell, *Environmental Science & Technology*, **39**: 5262–5267(2006).

[16] Liu H. and B. E. Logan, Electricity generation using an air-cathode single chamber microbial fuel cell in the presence and absence of a proton exchange membrane, *Environmental Science & Technology*, **38**: 4040–4046(2004).

[17] Rabaey K., Clauwaert P. and P. Aelterman, Tubular microbial fuel cells for efficient electricity generation, *Environmental Science & Technology*, **39**: 8077–8082(2005).

[18] Schroder U., Niessen J. and F. Scholz, A generation of microbial fuel cells with current outputs boosted by more than one order of magnitude, *Angewandte Chemie*, **42**: 2880–2883(2005).

[19] You S., Zhao Q. and J. Zhang, A microbial fuel cell using permanganate as a cathodic electron acceptor, *Journal of Power Sources*, **162**: 1409–1415(2006).

[20] You S., Zhao Q. and J. Zhang, A graphite-granule membrane-less tubular air-cathode microbial fuel cell for power generation under continuously operational conditions, *Journal of Power Sources*, **173**: 172–177(2006).

[21] Jiansheng H., Ping Y., Yong G. and K. Zhang, Electricity generation during wastewater treatment: An approach using an AFB-MFC for alcohol distillery wastewater, Desalination, **276**: 373–378(2011).

[22] Sung T. O., Jung R. K., Giuliano C. P., Tae H. L., Changwon K. and W. T. Sloan, Sustainable wastewater treatment: How might microbial fuel cells contribute, *Biotechnology Advances*, **28**: 871–881(2010).

[23] Zhuwei D., Haoran L. and Tingyue G., A state of the art review on microbial fuel cells: A promising technology for wastewater treatment and bioenergy, *Biotechnology Advances*, **25**: 464–482(2007).

[24] Zhao F., Harnisch F. and U. Schroder, Application of pyrolyzed iron (II) phthalocyanine and CoTMPP based oxygen reduction catalysts as cathode materials in microbial fuel cells. *Biotechnology Letters*, **30**: 1771–1776(2006).

[25] You S. J., Identification of denitrifying bacteria diversity in an activated sludge system by using nitrite reductase genes, *Biotechnology Letters*, **27**: 1477–148(2005).