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RESEARCH ARTICLE

BIOELECTRICITY PRODUCTION BY MICROBIAL FUEL CELL (MFC) USING WASTEWATER AS SUBSTRATE

Vijay, K., Nagasinduja, V. and *Shahitha, S.

Department of Microbiogy, Muthayammal College of Arts and Science, Rasipurm – 637408, Namkkal (Dt), TamilNadu, India

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ABSTRACT

The microbial fuel cell (MFC) technology has captured the attention of the scientific community for the possibility of transforming organic waste directly into electricity though microbial catalyzed anodic and cathodic electro chemical reaction. The aim of the study is to determine the most efficient wastewater source that can generate the highest rate of electricity production by using MFCs and to determine the removal rate of carbon and nitrogen in wastewater by using MFCs. A two chamber MFCs process is developed for the treatment. The wastewater sample used was activated sludge. The highest rate of volts generation is achieved when the MFC was operated with in *Saccharomyces cerevicea*, (0.560v) and *staphaylococcus aureus* (0.450v) was produced in wastewater.

Key words: Current generation, sludge treatment, removal of sources, activated sludge, organic sludge, microbial fuel cell.

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INTRODUCTION

The non-renewable resources of energy is depleting at a faster rate in the current scenario. Hence, there is a search for high efficient energy transformations and ways to utilize the alternate renewable energy sources. Fuel cells are one of the most important topics in the research. The main aspect of fuel cell research is to reduce the cost and simplifying implementation conditions. In recent years, researchers are trying to find out the solution through biotechnology. In the current research, an attempt is being made to devise a way to transform biomass from wastelands to portable electricity generation. Fuel cells are the most burning area of research for quite a long time. Much of the current research is focused on the development of way to convert chemical energy stored in biomass to electricity. The biomass is used as major fuel in the rural India for the cooking. The energy transformation from burning of biomass (chemical energy to heat) and that utilization of heat for different purposes is very less energy efficient. Most of the rural country has to depend on the subsidized yet scarce electricity supply. A technology using microbial fuel cells (MFCs) that can convert the energy stored in chemical bonds in organic compounds to electrical energy achieved through the enzymatic reactions by microorganisms has generated considerable interests among academic researchers in the last decades.

Corresponding author: **Shahitha, S.**
Department of Microbiogy, Muthayammal College of Arts and Science, Rasipurm – 637408, Namkkal (Dt), TamilNadu, India.

The global energy demand is increasing with exponential growth of population. Unsustainable supply of fossil fuels and the environmental concerns like air pollution and global warming associated with the use of fossil fuels are acting as major impetus for research into alternative renewable energy technologies. The high energy requirement of conventional sewage treatment systems are demanding for the alternative treatment technology which will require less energy for its efficient operation and recover useful energy to make this operation sustainable. In past two decades, high rate anaerobic processes such as up-flow anaerobic sludge blanket (UASB) reactors are finding increasing application for the treatment of domestic as well as industrial wastewaters. Microbial fuel cell (MFC) is a promising technology for simultaneous treatment of organic wastewater and bio energy recovery in the form of direct electricity, which has gained much interest in recent years (Hou, 2011; Fatemi *et al*., 2012). Microbial fuel cells (MFCs) are devices that use bacteria as the catalysts to oxidize organic and inorganic matter and generate electricity (Wen, 2010; Tardast *et al.,* 2012). Earlier it was thought only few microorganisms can be used to produce electricity. Recently, it was observed that most of the microorganisms can be utilized in MFCs. MFC concept was demonstrated as early in 1910 where *Escherichia coli* and *Saccharomyces* sp. were used to generate electricity using platinum electrodes. Though not drawing much attention till early 1980s when the concept was boosted with advent of use of electron mediators to enhance the generation of electricity many folds. Except anodophiles, the microbes are incapable of transferring electrons directly to

the anode. The outer layers of the majority of microbial species are composed of non-conductive lipid membrane, peptididoglycans and lipopolysaccharides which stop the facilitation of electron transfer to the anode. The problem can be solved with mediators.

MATERIALS AND METHODS

Bacterial Identification

Collection of samples

- Soil sample - were collected near the tapioca industry
- Water sample - were collected from sewage areas.
- Yeast sample – baker's yeast were bought from the market.

Isolation and Identification of the isolated microorganisms

The serial dilutions methods, spread plate methods, and pour plate methods use for isolation organisms. The identified for organisms in use for morphological character- gram's staining, motility test, endospore test, LCB mount. Biochemical test - Imvic test, TSI test, Catalase test, Oxidase test, ONPG test and Coagulase test.

Maintenance of Bacterial Isolate

The isolated bacterial culture was maintained in Nutrient Agar slants and stored at 4^{o}C to 7ºC for future use. Sub culture was performed every 15 days interval

MFCs collection of specimen

The industrial effluent water was collected from cassava industry at vengayapalayam, Rasipuram (TK).

with the copper wire with a multimeter. 10 ml of 24 hours culture was incubated in the anode chamber. Cover and seal the MFCs plant with aluminium foil and cellophene tape. For every 3 hours OD value and multimeter was recorded. It is repeated for all the organisms.

RESULTS

Isolation and of Organism

Well isolated colonies were obtained. Mixed populations of organisms were separated by standard technique and discrete colonies were isolated. A total of 4 different isolates were obtained and these isolates were used for MFC. Totally 4 electric energy producing microbes (3 bacteria and 1 yeast) were isolated from soil, sewage water and baker's yeast samples using nutrient agar and SDA plates. The isolated electric energy producing organism was identified as *E.coli, S.aureus, Bacillus sp and S. cerevicea.* Based on their cultural characteristics, Morphological characteristics and biochemical characteristics.

Identification of isolates

Identification of these bacterial isolates such as cell morphology, motility, and spore production are given in table 1 and bio chemical characters of the isolates are shown in table 2. All the bacterial isolates were identified by performing the following tests.

Microscopic and culture characteristics

The staining and biochemical results are given in table 1 for all the 3 different isolates. Based on the obtained results they organisms isolated may be A1- *Escherichia coli*, A2- *Staphylococcus aureus,* A3 – *Bacillus sp*

Table 1. Microscopic observation of the isolate

S.No	Test	Grams reaction	Shape R/ (C)	Endospore	Motility
1	A1	(-)ve	R	Non Spore	Motile
2	A2	(+)ve	C	Non Spore	Non- Motile
3	A3	(+)ve	R	Spore	Motile

(+) Positive: (-) Negative: R – Rod Shape; C – Cocci

Biochemical characterstics of the isolates

S.NO	Organism	Bio-chemical test									
		I	MR	VP	CI	U	TSI	CA	OX	CO	ON
1	A1	+ve	+ve	–ve	–ve	–ve	A/A Gas +ve H2S –ve	+ve	-ve	–ve	–ve
2	A2	–ve	+ve	+ve	+ve	+ve	Alk/A Gas -ve H2S -ve	+ve	–ve	+ve	+ve
3	A3	–ve	-ve	+ve	+ve	–ve	Alk/A Gas -ve H2S +ve	+ve	+ve	–ve	–ve

I – indole; MR – methile red; VP- voges - proskauer test; U-urease; TSI- triple sugar iron; CA- catalase; OX-oxidase; CO- coagulase; ON- ONPG

MFCs plant construction(Bruce E Logan et al.,2006)

Take a rectangular chamber (Electrophoresis) for MFCs plant construction. Pour 500ml of effluent water. Place a membrane filter at the middle of the chamber to make two compartments for anode and cathode. Place a carbon electode for anode and platinum electrode for cathode. Connect both the electrodes

MFCs plant construction

The MFCs design for separate two chambers process. The MFCs plant mainly performed for the sludge treatment and utilized carbon source and nitrogen sources. The electric energy produced for isolated microbes. The microbes isolated for soil, sewage water and beaker's yeast. The electric


Sludge water


Treat in sludge water


Bacillus sp.,

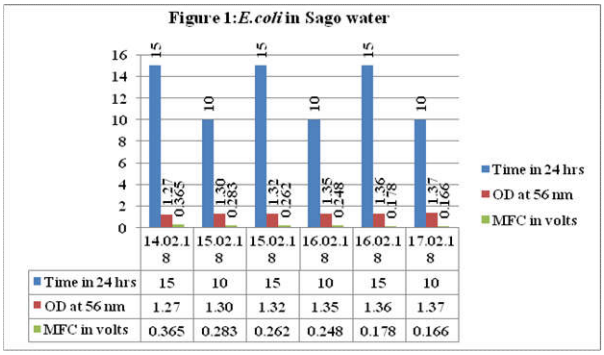

E. coli


S. aureus.,


Mixed Culture

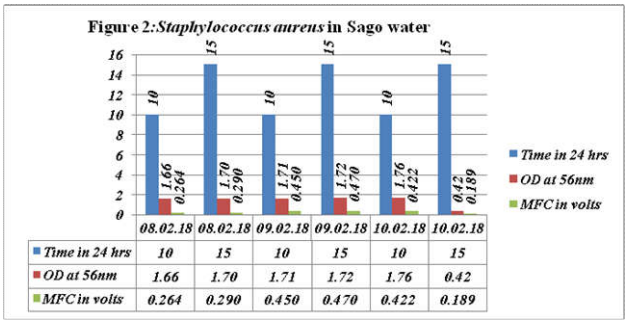
production of normal level of the sago effluent water. The sago wastewater OD value in 56 nm - 1.27 nm. The highest rate of voltage generation is achieved when the MFCs was operated with organisms (0.560 v) *Sacharomyces cerevicea.*, *Staphylococcus aureus*(0.465 v), and *E. coli* (0.366 v),*Bacillus sp*(*0.330 v*) in sludge effluent water. All the results are given in figures 1 to 5

Figure 1:*E.coli* in Sago water



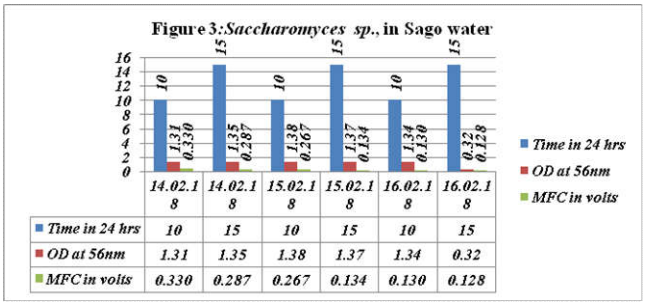
	14.02.18	15.02.18	15.02.18	16.02.18	16.02.18	17.02.18
Time in 24 hrs	15	10	15	10	15	10
OD at 56 nm	1.27	1.30	1.32	1.35	1.36	1.37
MFC in volts	0.365	0.283	0.262	0.248	0.178	0.166

Figure 2:*Staphylococcus aureus* in Sago water



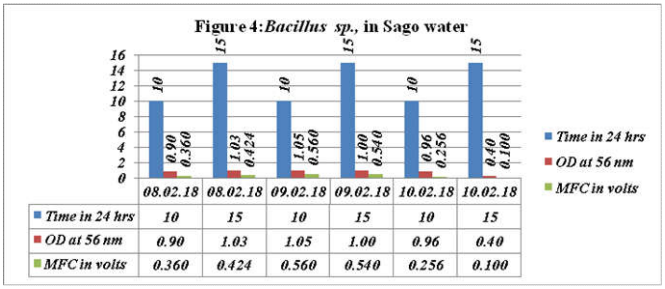
	08.02.18	08.02.18	09.02.18	09.02.18	10.02.18	10.02.18
Time in 24 hrs	10	15	10	15	10	15
OD at 56nm	1.66	1.70	1.71	1.72	1.76	0.42
MFC in volts	0.264	0.290	0.450	0.470	0.422	0.189

Figure 3:*Saccharomyces sp.*, in Sago water



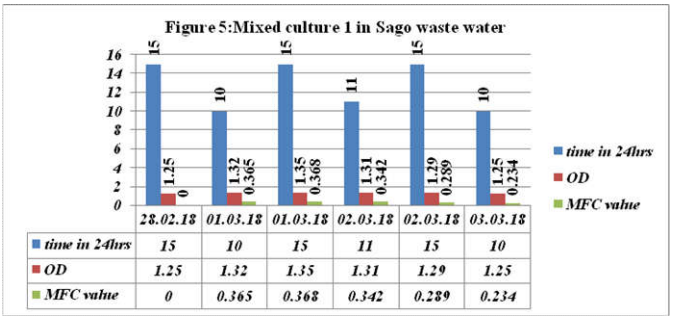
	14.02.18	14.02.18	15.02.18	15.02.18	16.02.18	16.02.18
Time in 24 hrs	10	15	10	15	10	15
OD at 56nm	1.31	1.35	1.38	1.37	1.34	0.32
MFC in volts	0.330	0.287	0.267	0.134	0.130	0.128

Figure 4:*Bacillus sp.*, in Sago water



	08.02.18	08.02.18	09.02.18	09.02.18	10.02.18	10.02.18
Time in 24 hrs	10	15	10	15	10	15
OD at 56 nm	0.90	1.03	1.05	1.00	0.96	0.40
MFC in volts	0.360	0.424	0.560	0.540	0.256	0.100

Figure 5:Mixed culture 1 in Sago waste water



	28.02.18	01.03.18	01.03.18	02.03.18	02.03.18	03.03.18
time in 24hrs	15	10	15	11	15	10
OD	1.25	1.32	1.35	1.31	1.29	1.25
MFC value	0	0.365	0.368	0.342	0.289	0.234

The MFCs in mixed culture used for the electricity production *Sacharomyces cerevicea.* And *Staphylococcus aureus.*, the highly voltage produce for (0.367 v) Korneal Rabeay *et al.*, stated that MFCs undoubtedly have potential in terms of energy recovery during wastewater treatment. They may occupy a market niche in terms of a stand-alone power source and also in the direct treatment of wastewater. They can also post-treat effluents from anaerobic digesters, even at ambient temperatures. Li He *et al., 2017* described MFC as an innovative technology based on the use of microbial fuel cells (MFCs) has been proved as a critical pathway for bioconversion processes towards electricity generation, then for addressing energy and environmental problems. Three special features including energy saving, less sludge production and less energy production make MFCs outstanding compared with the existing technologies. Multiform wastewaters could be efficiently degraded through advancing MFCs alone or integrating MFCs with other processing units. Mahendra *et al.*, 2013 used a single chamber (MFC-1) and double chambered (MFC-2) MFCs were

compared for domestic and dairy wastewater treatment and electricity generation. MFC-1 was proved to be more efficient and found to be producing maximum current of 0.84 mA and 1.02mA whereas MFC-2 produced maximum current of 0.56mA and 0.58mA from full strength (100%) domestic and dairy wastewater concentrations respectively. COD removal efficiency achieved in MFC-2 was 88.4% and 86.42% for 100% domestic and dairy wastewater concentrations respectively when compared with MFC-1 which attained 86.6% and 84.8% respectively for 100% domestic and dairy wastewater concentrations respectively. The performance of MFC-1 and MFC-2 decreased, when the wastewater concentration was decreased from 100% to 75% and 50% concentrations.

Conclusion

The treatment of effluent is a very important measure to be taken in every industry. Which make the environment pollution free and also living biota safe. This can be achieved by both chemical and biological process. The chemical process may release harmful gases and hazardous to the environment. Hence, microbial treatment is the alternative. In this study the microbial treatment of effluent is carried out in a novel method. In this method the microbes not only treated the effluent but also produce the electric energy. 4 organisms were selected viz;*E.coli, S.aureus,Bacillus sp* and *Saccharomyces sp.* Of the 4 species selected *Saccharomyces sp* and *S.aureus* showed the promising result of effective effluent treatment along with current production. For 500ml of the effluent taken both the stains gave a result of 0.560v and 0.465v respectively

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