Studies on Production of Electricity Using Paenibacillus Dendritiformis Isolated From The Coir Pith Waste Samples of Manavalakurichi And Muttom, Kanyakumari District, Tamil Nadu, South India

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Abstract- *It is very essential to find out a new way to produce electricity. Because this modern era is fully depends on electricity. The necessity of electricity production is going beyond the peak level. The world produces electricity through convenient methods such as burning coals and petroleum fuels, solar systems, wind mills, hydro power and nuclear power plan. But these production ways leads to the destruction of our valuable eco system by polluting water, air, land and radiation emission etc. The contribution of electricity production from nuclear resources is very high but in other hand, there are many disadvantages from nuclear way electricity production. A major problem is possible of radiation emission which leads to severe skin cancer and genetic mutations in humans as well as other organisms. Biologists were found a novel way to reduce the ecological problems and restore the electricity scarcity. This can be done through Bacteria. According to the Logan group of Pennsylvania state university (PSU), this way of electricity can be done by bacterial population have already present in waste water used as catalyst to catalyse the waste water for generation of electricity[10,11]. In this study, bacterial strains were isolated from various organic waste water samples from Muttom and Manavakurichi were subjected to electricity production by using Microbial Fuel cell. The produced electricity was measured with the help of Multi meter.*

Keywords- Microbial Fuel Cell (MFC), Proton Exchange Membrane (PEM), Green House Gases (GHS), World Nuclear Statistics (WNS), Mega volte (MW), International Nuclear Event Scale (INES), Deoxyribo nucleic acid (DNA), Polyvinyl chloride (PVC), Sample Flower (SMF),

I. INTRODUCTION

Nowadays, we are fully depending on the electricity for survival and doing day to day work. If no electricity, there is no world to live. Everything is functioned by only electricity so we are almost empty of electricity for our future generation. The necessity of electricity is going beyond the peak level. Generation of electricity was increased by producing it through petroleum fuel, burning of coal, solar system, wind mills, hydro and nuclear power plant etc. These ways of producing electricity leads to series of environmental problems such as water pollution, air pollution, land pollution, radiation emission etc. Water pollution causes the scarcity of water and contamination with lots chemicals and microbial discharges, atmospheric air gets polluted by many green house gases through coal burning and there are legislations and directives such as the Kyoto Protocol to drive this in order to reach the goal of reducing GHG emissions by at least 18% below the 1990 levels by the year 2020[7]. In worldwide, 30 countries were operating 449 nuclear reactors for the production of electricity and 60 new reactors are under construction in 15 countries. According to World Nuclear Statistics (WNS), 11% of world's electricity produced from nuclear power plants in 2014. In 2017, over 6,240MW electricity was produced from 22 nuclear reactors in India. Radiation emission is major serious problem of nation because it is unable to see and causes skin cancers or other types of cancers by cellular mutation. On 11th March 2011, horrible accident was happened due to earthquake and 15 metre of tsunami in Fukushima Daiichi, Japan.

This accident was rated 7 on the scale of INES due to high radioactive emission over 4 to 6 days. and the investment in these sectors seems to be very high resulting in less outcome as well as the release of toxic substances. In order to overcome these environmental and economic problems, a novel way of producing electricity without any environmental pollution is attracting the attention of the biologists, which is "Electricity through bacteria". The raw material in organic coir pith wastes is metabolised by bacteria in anaerobic respiration which results the release of electrons and hydrogen ions. This can be achieved through an instrument named MFC (Microbial fuel cell) technology represents a new form of renewable energy by generating electricity from what would otherwise be considered waste. Microbial degradation generally considered to be safe, effective and environmental friendly way to degrade coir pith wastes. Some free living prokaryotes are contributing the nitrogen fixation and give a fundamental of nitrogen homeostasis in the biosphere [1]. The microorganisms present in a marine environment has numerous activities such as biodegradation of dead sea animal & plants etc to increase the nutritive value of sea water, oil degradation in oil spilling areas, methanogenic bacteria are used to produce biogases. Many of them are used in recombinant DNA technology, and some of them are involved in the defence mechanism of marine animal like octopus. those microorganisms found in sea water has an antimicrobial and antibacterial activities against wide range of microorganisms, which also used to produce nutritional supplements like single cell protein and energy production (electric current) is a new vision of bacteriological applications. According to the Logan Group of Pennsylvania State University (PSU), this technology can use bacterium already present in wastewater as catalysts to generating electricity while simultaneously treating wastewater [10,11].

II. MICROBIAL FUEL CELL

Theory an MFC is capable of energy efficiency far beyond 50%. In fact, using the new microbial fuel cells, conversion of the energy to hydrogen is 8 times as high as conventional hydrogen production technologies [12]. This MFC helps the bacteria to convert the chemical energy into electrical energy. Substrates present in organic wastes can be utilised by bacterial population to generate electricity. Potter was the first worker in the production of electricity from *E.coli* in 1931 [5]. It is a combination of electricity production and waste water treatment for primary effluent waste water. The bacteria which have the capacity to produce electrochemical substances that may be either metabolic intermediates or final product of anaerobic respiration during which bacteria consume a substrate and produces carbon dioxide, protons and electrons[3].

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

This is the basic principle behind to generate a flow of electrons from microorganisms. In order to turn this into usable energy source of electricity, this process has to complete the circuit for electron flow. MFC consists of sealed anodic chamber, aerated cathode chamber, electrodes for absorb and transfer the electrons, and proton exchange membrane to transfer the proton ions from anode to cathode chamber for the oxidation reduction process. In certain way, MFC microbial population is used to degrade a wide range of environmental wastes which may be more important than electricity production especially this can also be used for environmental cleanup *in situ* [5].

Bacterial potential for electricity production from waste water

Waste water contains many pathogenic and non-pathogenic bacterial populations. Those microorganisms are widely used in the production of biogases and also researchers found that electricity can be produced by using a wide range of microorganisms. Since all of the microorganisms are metal reducing in nature, some of them could be the high source of electron production. *Geobacters*, *Shewella* and *Rhodoferox* behave similar to their natural condition as anode which acts and behaves as metal oxides [2,4,6].

Bacteria can extract energy from the cell by transferring electrons from reduced substrates like glucose, lactose and organic matters in waste water at a low reduction oxidation (redox) potential to an electron acceptor with high redox potential in oxygen [5]. The energy gained can be calculated as $\Delta G = -nxFx\Delta E$ (with n the number of electrons exchanged, F Faraday's constant (96485 Coulomb/mol) and ΔE the potential difference between electron donor and acceptor) If bacteria derive reducing equivalents from glucose in the form of NADH, and subsequently shuttle electrons from NADH (redox potential -320mV) to oxygen (redox potential +840mV), the potential difference is~1.2 V [ΔE= (0.840V)-(-0.320V)], and the energy gain would be ΔG=- 2x102 kJ/mol (2 electrons per molecule of NADH). If the electron acceptor is sulphate (redox potential -220mV), the potential difference decreases to ~100 mV, yielding a ΔG of ~2x101 kJ/mol. An iron reducing electrochemically active bacteria in sludge might be present in 3% of the bacteria. These ion reducing bacteria can be identified by microautoradiography (MAR) along with radiolabeled acetate, inhibition of sulphur reducer, methanogens and ferric iron as the sole of electron acceptor. This combination of MAR with fluorescent *in situ* hybridization probes shows that the MAR positive cells are identified 20% of these iron reducers as γ-proteobacteria, 10% as δ-proteobactria and 70% is not hybridize with proteobacteria targeted probes. This results that the diversity of iorn reducing bacteria which also have potential to generate the electricity apart from commonly studied *Shewanella* and *Geobacter* species [9].

In recent studies, an interesting inter relationship is found between exoelectrogenic bacteria and fungi which potentially increases the stability and also acts as a natural mediator in electron transfer. This would be significant twist for scaling up of MFC system [6].

III. MATERIALS AND METHODS

Description of study area

Muttom is a village in the Kanyakumari District of the Tamil Nadu State, India. The latitude of muttam fishing harbour is 8.0968 and the longitude is 77.5637. The major occupation of people in Muttom is fishing. Jeppiaar Fishing Harbour Muttom Private Limited is a Private Non-govt company involved in Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing.

Manavalakurichi is a panchayat town in Kanniyakumari district in the Indian state of Tamil Nadu. The latitude of manavalakurichi is 8̊ 08' 53.23'' N and longitude is 77̊ 18' 22.82'' E. Manavalakurichi is a private sea port and was built by educationalist and business man Jeppiaar.

IV. COLLECTION OF SAMPLES

In this work, sea water and coir pith waste water from **MUTTOM** and **MANAVALAKURICHI** is collected for further studies.

The capped sterile polythene bottles are dipped into the sea water and coir waste water then caps were opened and water samples were collected without any air bubbles, and the caps were closed inside the water. The bottles are marked and the samples were transferred to the refrigerator in the biotechnology laboratory at Noorul Islam College of Arts & Science for further work and physiochemical analysis.

Construction of Microbial Fuel Cell (MFC)

All experiments was conducted using a two chamber MFC consisting of two sterile plastic containers with capacity of 1000ml. These plastic bottles were connected by 20cm length and 1.5cm diameter of PVC pipe which is considered as proton exchange membrane. The proton exchange membrane made by mixing of 5g agar with 1g NaCl. This mixture is boiled in water bath and allowed to cool for the polymerization. The semi polymerized mixture was poured into the PVC pipe is known as proton exchange membrane or salt bridge. The two containers were sealed with epoxy sticky compound and without any leakage. Electrodes were placed in two respective chambers. Here copper wires and aluminium mesh was used as electrodes namely anode and cathode. The resistance of this electrode is about $1.68X10^{-8}$ m (ohm m). An anode acts as an absorber of electron from bacteria and cathode is present in second chamber were completes the electron flow in MFC system. Proton exchange membrane (PEM) functioned as a pump to transfer protons to cathode chamber where oxidation of proton ions takes place to produce water. In this experiment, we were using some mediator (potassium ferricyanide) to carry the electron produced from bacteria and transfer into anode. The mediator (Potassium ferricyanide) and mediator-less waste water or bacterial culture was prepared in 500-1000ml nutrient broth solution with various substrates such as glucose, sucrose and lactose broth media respectively and the isolated strain SMF (*P.dendritiformis*) was inoculated into an anode chamber and closed tightly with lid and cello tapped it to maintain anaerobic environment and allow the bacteria to perform anaerobic respiration. Another cathode chamber was filled with conductive solution (water) which was aerated by fish tank motor to ensure the process of oxidation to form H_2O. This whole set up was incubated for observe the electricity production.

Principle of Multimeter

A digital multimeter is the test equipment used for the measurement of resistance, voltage and current and other electrical parameters as per requirement. This multimeter displaying the results in the mathematical digits form on LCD or LED readout.

V. RESULTS, TABLES AND PLATES

Recovery of Electric current from MFC

During the incubation period, bacteria metabolise the substrate present in the nutrient broth medium and produce electric current those were read out by using Multimeter in the unit of micro ampere (µA) or millivolt (mV) and volte. These readings were recorded on the regular intervals of day 1 to 5.

Electricity Production from Microbial Fuel Cell (MFC)

An electric current were produced by SMF (*Paenibacillus dendritiformis*) with the help of lab made microbial fuel cell. An electric current were measured in micro ampere, milli ampere and voltage level regularly up to day 5. Different current productions were observed in raw waste water samples and isolated *P. dendritiformis* strain along with typical substrates and mediators. The actual readings are given below in **Table.1 and 2**. Visual proof was given in **Plate no.1, 2 and 3 Table.3** shows some other bacterial species were used in mediator-less MFC. **Table.4** contains commonly used PEMs, electrodes and Mediators.

Table.1 Electric current production from raw waste water of coir pith and sea water at Manavalakurichi

Incubation days	Coir pith waste			Sea water		
	µA	mA	V	µA	mA	V
1	30	0.03	-	10	0.01	-
2	13	0.01	-	-	-	-
3	006	-	-	-	-	-

Table no.1 shows the reading of electric current from coir pith waste water samples and sea water samples.

Table.2 Electric current produced from pure culture of SMF (P.dendritiformis) with various substrates

Incubation days	SMF (glucose)			SMF (sucrose)			SMF (lactose)		
	µA	mA	V	µA	mA	V	µA	mA	V
1	165	0.16	00.9	32	0.03	-	156	0.17	0.30
2	-	-	-	-	-	-	269	0.22	0.50
3	30	0.03	-	62	0.06	006	309	0.22	0.62
4	-	-	-	-	-	-	210	0.24	0.15
5	-	-	-	-	-	-	-	-	0.68

Note: The symbol – is represented as no readings or not measured.

Table no.2 shows the actual readings of electric current produced from various substrates by P.dendritiformis in MFC system.

Table.3 Microbes and substrates used in Mediator-less MFCs

Microbes	Substrate	Applications
Aeromonas hydrophilla	Acetate	Mediator-less MFC
Geobacter metallireducens	Acetate	Mediator-less MFC
Geobacter sulfurreducens	Acetate	Mediator-less MFC
Rhodoferax ferrireducens	Glucose, xylose	Mediator-less MFC
Shewanella putrfaciens	Lactose, pyruvate	Mediator-less MFC

Table.4 commonly used MFC parts

PEMs	ELECTRODES	MEDIATORS
Nafion	Graphite	Neutral red
Ultrex	Graphite felt	Potassium ferricyanide
Polyethylene/polystyrene	Carbon cloth	Methylene blue
Salt bridge	Carbon mesh	Thionine
Porcelain septum	Reticulated vitrified carbon	Fe-EDTA
Solely electrolyte	Copper	Humic acid
	Stainless steel	

Plates

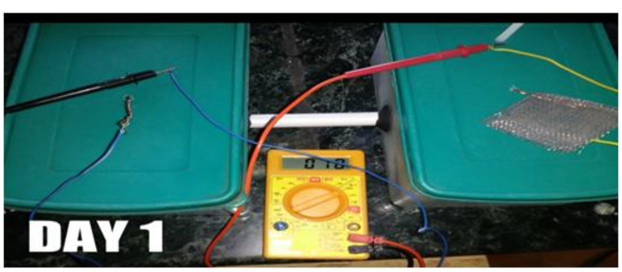

Plate.1 Electric current produced from sea water of Manavalakurichi

Plate.2 Electric current production from raw coir pith waste water of Manavalakurichi

Plate.3 LED light blinked by electric current produced from SMF (Paenbacillus dentritiformis) in Lactose broth medium with Potassium ferricyanide mediator

VI. CONCLUSION

MFC way of electricity production is more renewable than other methods and very eco-friendly. In this method, we are only using organic waste materials as a substrate to generate electric current. A biological mass product such as foods and biological wastes which contains carbohydrate has an energetic value. An average 1 kg of sugar contains 4.41 kWh of energy or potentially $13x10^6$ coulombs of charge. We can currently produce 0.5L of ethanol, 1.2 m^3 of hydrogen gas, 0.36 m^3 of methane gas or 0.5 m^3 of biogas and these can yield ~1 kWh of useful energy. Because of the high cost of sugar this cannot be much useful way for energy production. But some biological wastes can also yield sufficient amount of energy with very low-cost [5]. In this work we have achieved the bioelectric current production around 0.68-0.71V was enough to power the LED By using the isolated bacterial stain, *P.dendritiformis* with the help of mediator (potassium ferricyanide) MFC. Obviously it was low amount of electricity production but there will be possible to achieve more amount of bioelectricity production through MFC technology with little more modifications in future. According to this work, I concluded that the various bacterial strains are present in the Coir waste polluted sites at Kanyakumari district and biological wastes such as starch and lignocellulose wastes are potential source for the production of bioelectricity. However, in future work has to be standardized, optimaized and modified the MFC technology for the production bioelectricity in the industrial level.

Potential applications of MFC technology

This MFC technology has many prominent advantages over waste water management systems. Cleaning water and using electricity are very essential in day to day life. In deep vision there is a relationship between the generation of electricity and clean of waste water. Electricity can be generated from hydo-energy as same as that we need electricity for the purification or cleaning of water. Lots of advantages in this technology of energy production such as cost effective, no environmental problems like pollutions and radiation emission. In this method, we are only using organic waste materials as a substrate to generate electric current

These MFC can be used in electricity-consuming plants and waste water treatment plants in order to reduce the electricity cost for the operation of bioreactors. This makes the systems of reactors as good cost saving systems with the production of valuable products. The advancement MFC system will be a promising mobile renewable system for instant energy recovery and usage by using biomass-based resources. This MFC can also be used as bio-sensors by immobilizing the bacteria onto an electrode with the protection of membrane. When this sensor are dipped into polluted sites, rivers or waste water treatment plants if there is any toxicant bacteria shows lower metabolic activity due to the effects of toxicants.

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