



Generation of Electricity from Organic Waste through Microbial Fuel Cell

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Abstract: Microbial fuel cell (MFC), one of the best alternative sources of energy production is a bio-electrochemical device that directly generates electricity by harnessing the power of respiring microbes to decompose organic substrates. This paper is aimed at the study of a microbial fuel cell which uses yeast as micro-organism to decompose the organic waste for generation of electricity. This gives a detailed report of a microbial fuel cell which works with a low cost proton exchange membrane. To study the functioning of microbial fuel cell, a dual chambered microbial fuel cell was constructed using cathode and anode chambers. Later, the microbial fuel cell construction was modified into series for a detailed study. Moreover, a study of current density, power density, voltage, current, power was conducted in the case of both MFC constructions.

Key words: Microbial fuel cell, Cathode, Anode, Proton exchange membrane, Bio-electrochemical device.

Introduction:

Now a days electricity has become a basic need for most of the people along with food, water and shelter. However, the whole world still could not realize that the non renewable sources which are used in the production of electricity pollute the environment as well as the basic needs. Nearly, 40 crores people have zero access to electricity in India. One quarter of world's population i.e. 150 crores people out of 712.5 crores people are lacking electric supply [1].

The world needs to double or triple its current spending estimated at about \$400 billion a year to meet the United Nations' goal of bringing clean and modern electricity to all people by 2030. Many industries involved in the generation of electricity emit green house gases, out of which carbon dioxide is the prominent gas to raise the global temperatures. Under these circumstances, there is a need for an alternative source for energy production. Central Pollution Control Board (CPCB) studies depict that there are 269 sewage treatment plants (STPs) in India, of which only 231 are operational, thus, the existing treatment capacity is just 21 per cent of the present sewage generation [2]. The remaining untreated sewage is the main cause of pollution of rivers and lakes. Microbial fuel cell is one of the best alternative sources of energy production which is a bio-electrochemical device that harnesses the power of respiring microbes to convert organic substrates directly into electrical energy [3]. Currently, researchers are working to optimize electrode materials, types and combinations of bacteria, and electron transfer in microbial fuel cells. Even though the idea of harnessing the energy produced by bacteria has been around for almost 100 years, researchers have just begun to fully understand the MFC and how to bring out its true potential.

Construction of a microbial fuel cell:

Height of all containers	24.5 cm
Diameter of the containers	10.5 cm
Volume of the containers	2 liters
Height of pipes from the ground	11cm
Length of pipes	14 cm
Diameter of pipes	2.5 cm (1 inch)

Apparatus:

- Plastic containers
- Plastic Pipes
- Proton exchange membrane
- Zinc and Copper electrodes
- Copper wire
- Organic waste
- yeast
- Water
- Cutter/blade
- M seal/any epoxy material
- Digital multimeter

Procedure:

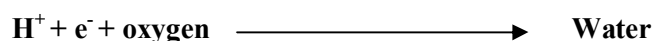
The dual chambered microbial fuel cell was constructed using four plastic containers of volume two liters. Initially, all the plastic containers were connected in series by attaching pipes using M seal, an epoxy material. The proton exchange membranes were placed in between the plastic pipes which connected the two chambers. The two anode chambers were filled with organic waste and water was poured into the cathode chambers up to the necessary height. Zinc electrodes (anode) and copper electrodes (cathode) were placed into their respective chambers. Copper wires were used to connect the chambers in series. Finally, the circuit was completed and the voltage was measured using a digital multimeter.

Chemical function of Microbial fuel cell:

Microbes need energy to survive, in the same way that humans need food to live. Microbes get this energy in a two-step process. The first step requires the removal of electrons from some source of organic matter (oxidation), and the second step consists of giving those electrons to something that will accept them (reduction), such as oxygen or nitrate. The following reactions took place when Yeast was added to the organic waste at anode [4].

Oxidation half- reaction (Anode chamber):

The organic waste at anode is decomposed by the microorganisms. This results in the formation of electrons, protons and carbon dioxide. The so formed protons reach the cathode through a proton exchange membrane and electrons travel along the external circuit and enable the occurrence reduction half reaction.

Reduction half-reaction (Cathode chamber):

The protons which leave the electrode at anode and enter the electrolyte at cathode react with electrons which flow into the cathode through an external circuit, along with atmospheric oxygen to form water at cathode. Finally the circuit gets completed when the cathode and anode are connected to a digital multimeter

with copper wires. The same reactions occur when two sets of dual chambered microbial fuel cells are connected in series [5].

Data Analysis and Interpretation:

The Microbial fuel cell which was connected in series was examined for 6 days and

- Voltage (V)
- Current (I)
- Power ($P = V \times I$)
- Current density ($C.D = I_{(max)} \div A$)
- Power density ($P.D = P_{(max)} \div A$) were calculated.

Voltage and Current was measured using digital multimeter.

The maximum power power (P) generated was calculated by using the formula

$$P_{(maximum)} = V_{(maximum)} \times I.$$

Where V is the maximum voltage obtained and I is the corresponding current produced in Amp against an external resistance of 0.9Ω .

Current density was calculated by the formula: Current density (C.D) = $I_{(max)} / A$ and

Power density was calculated by the formula: Power density (P.D) = $P_{(max)} / A$ and

Where A is the surface area of anode which is obtained by the following calculation

Surface area of the anode (A) = $2\pi r (r + h)$, where r is the radius of electrode and h = height of the electrode. Radius of the electrode was found using a Vernier calipers.

Area of anode:

Radius = 0.48 cm

Height = 15 cm

Therefore according to the formula: $A = 2\pi \times 0.48 (0.48 + 15) = 46.7 \text{ cm}^2$.

The electricity generation by a Microbial fuel cell was studied through the construction of a dual chambered microbial fuel cell using the materials which were mentioned in methodology. A maximum voltage of 1.08 V was obtained with this type of MFC. Expecting an increase in voltage, the dual chambered Microbial fuel cell was modified into two different types of MFCs. They are:



Fig. 1 Microbial fuel cell with two anodes and one cathode



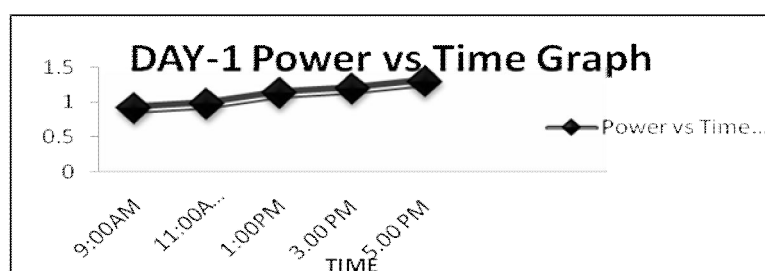
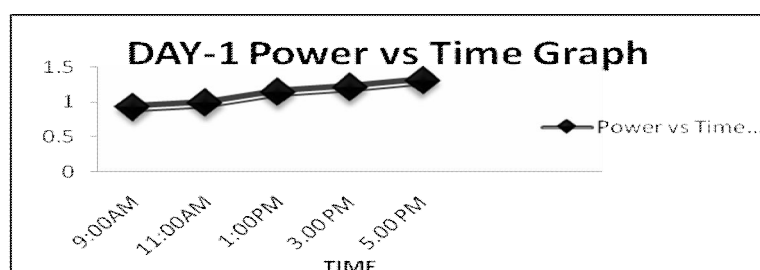
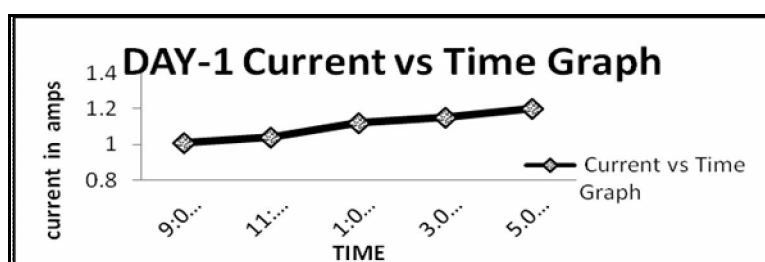
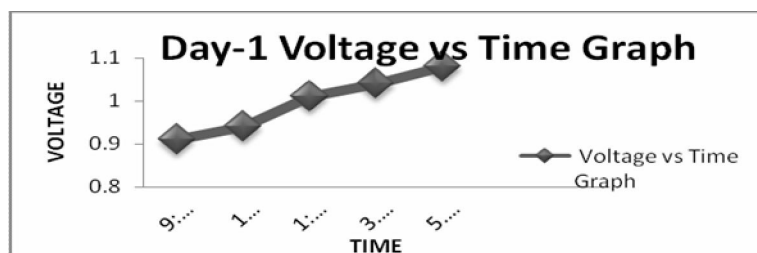
Fig. 2 Microbial fuel cell with two cathodes and one anode

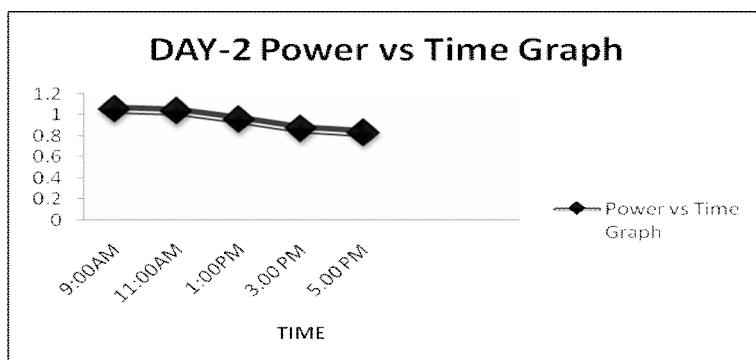
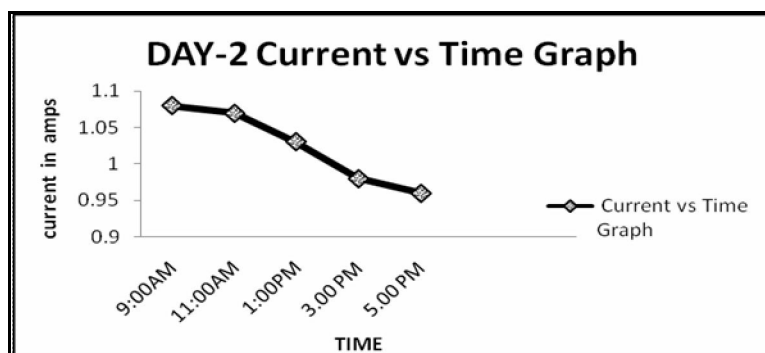
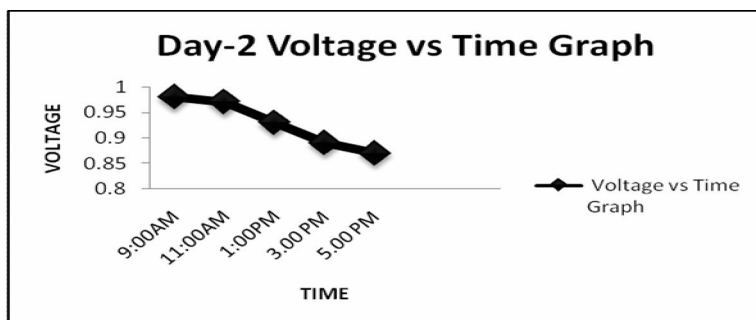
As the voltage remained the same in all three experiments, two sets of dual chambered microbial fuel cells were connected in series. Then, a maximum voltage of 2.09 V was obtained.

Results and discussion:

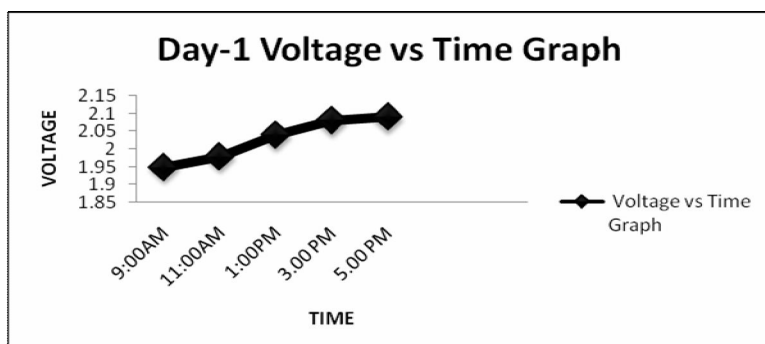
The two days report of the dual chambered microbial fuel cell are as follows:

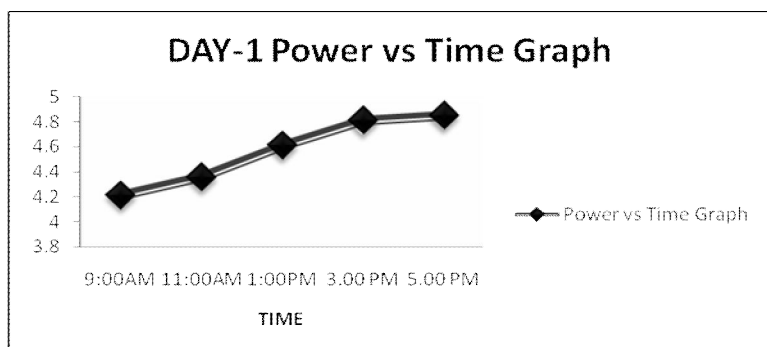
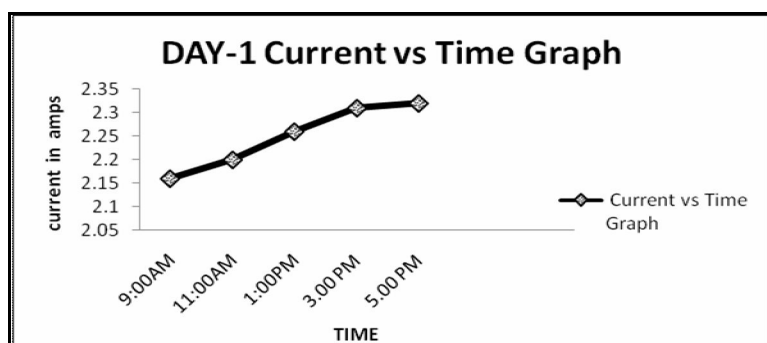
Day-1:



Day-2:

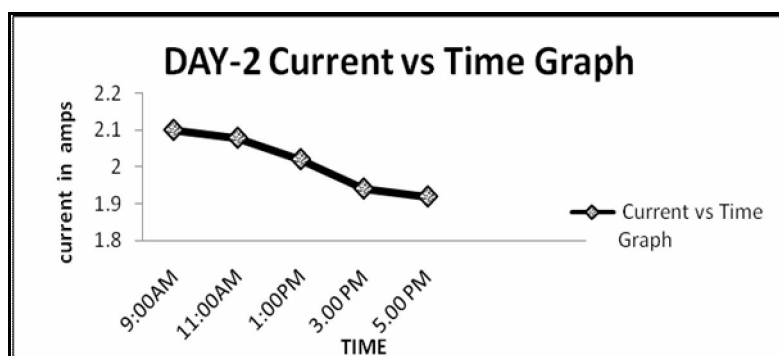
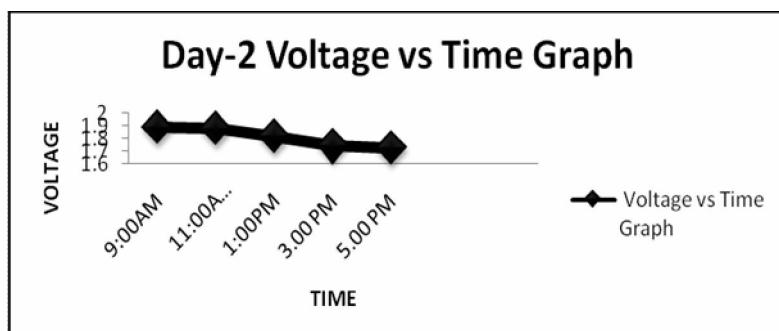
Voltage, power, current was measured for 6 days when the microbial fuel cell was connected in series and the graphs are as follows:

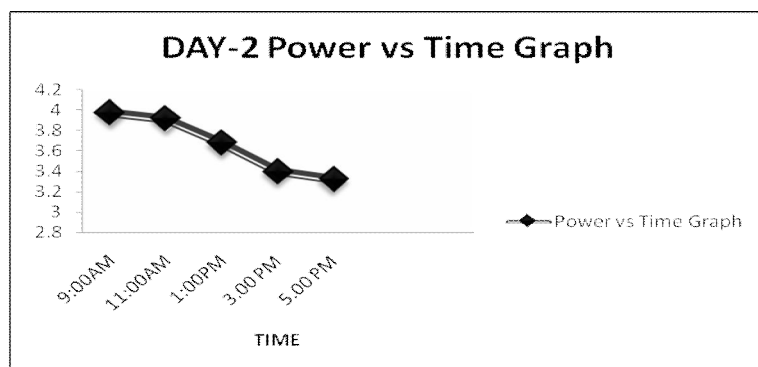
Day-1:



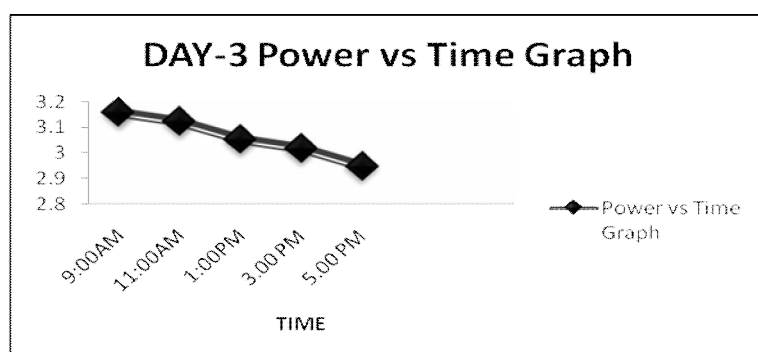
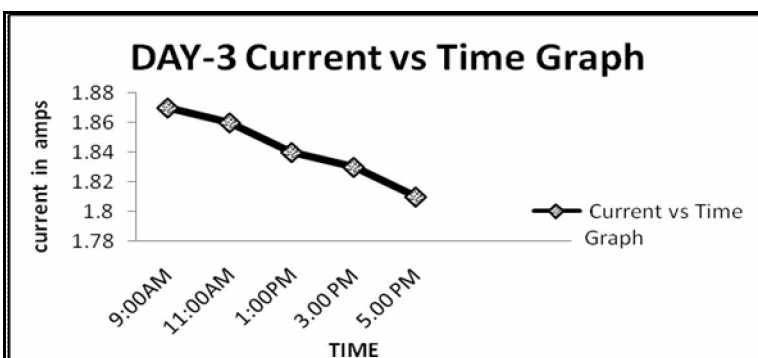
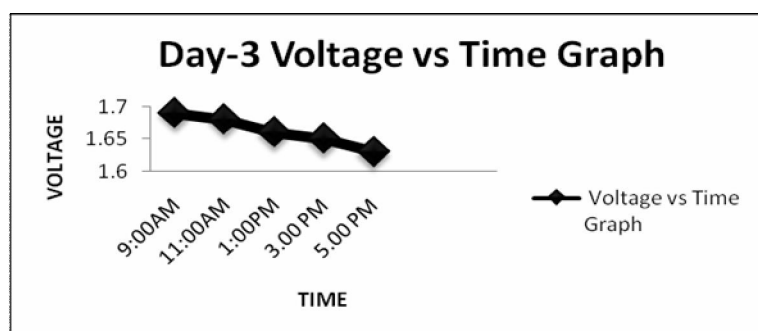
On the first day, the voltage could be obtained to a maximum of 2.09v and there was a change in Current and Power on the next day.

Day-2:

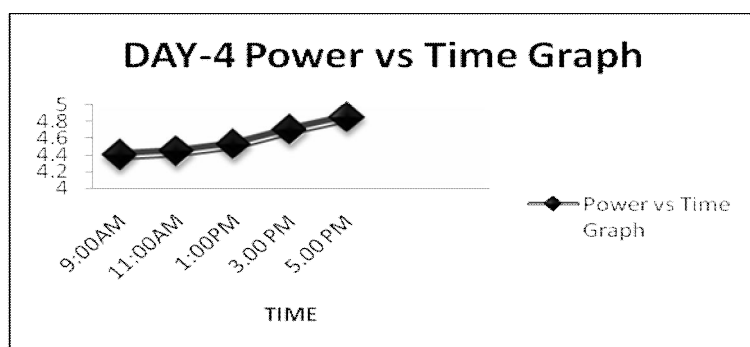
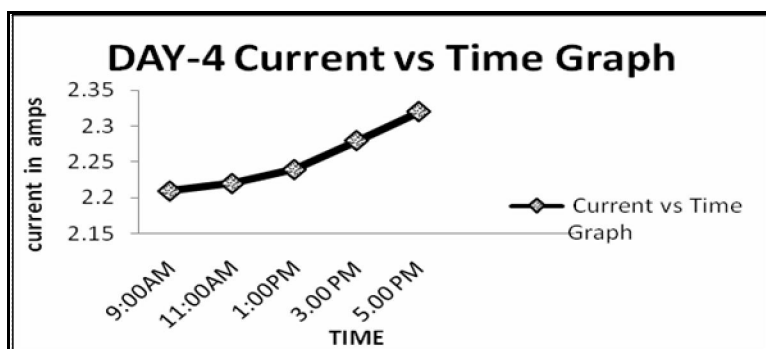
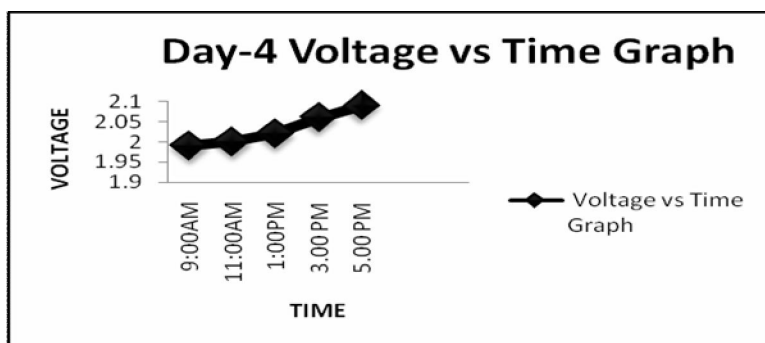
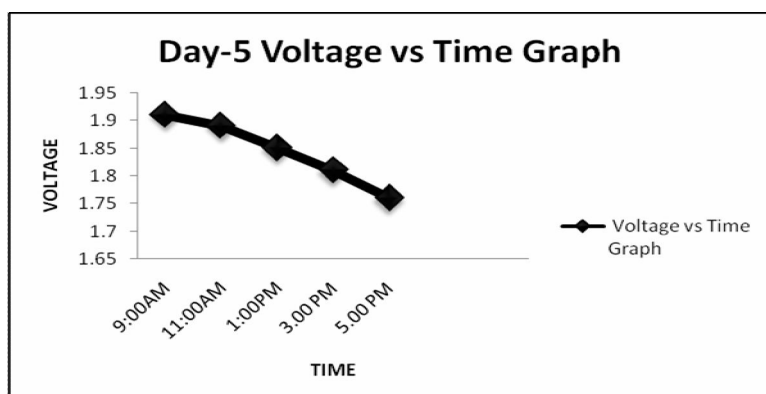


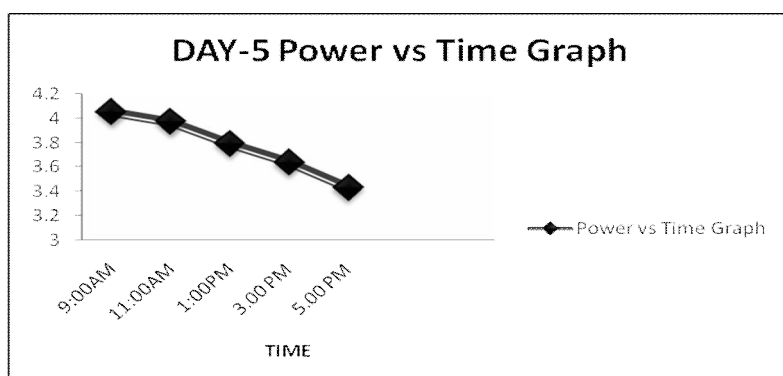
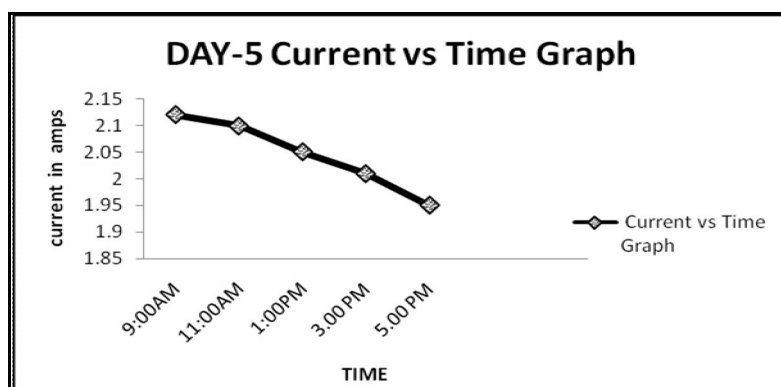


Day-3:

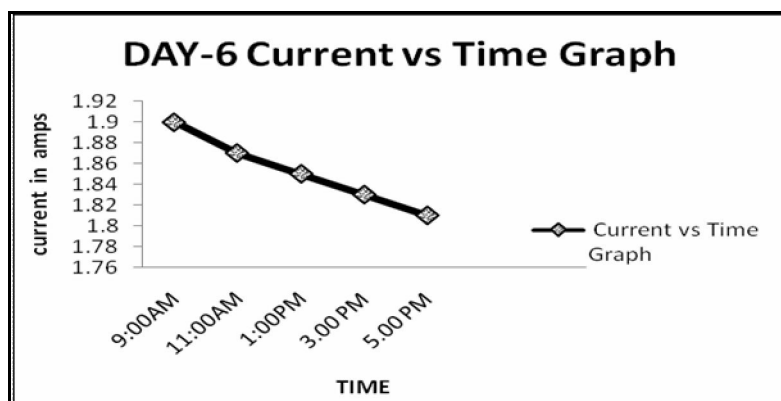
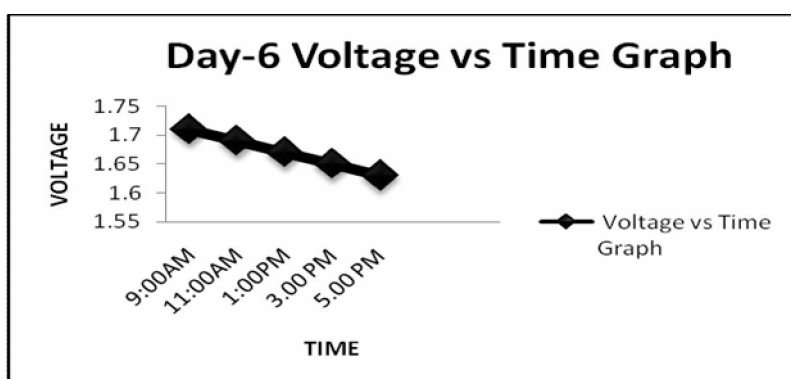


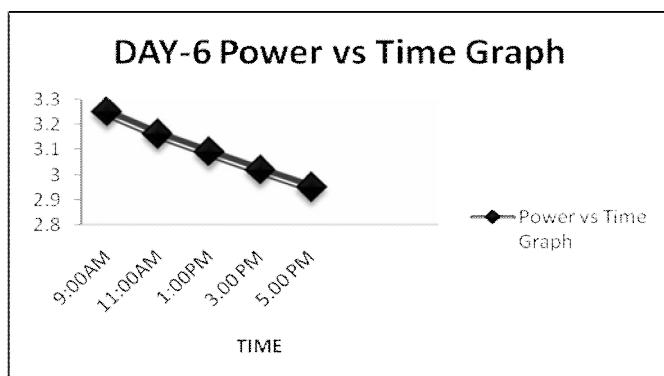
Organic waste was added on the 4th day due to the decrease in voltage on the 3rd day

Day-4:**Day-5:**



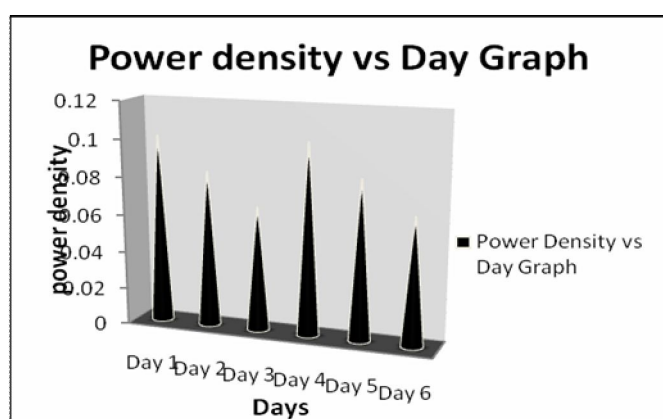
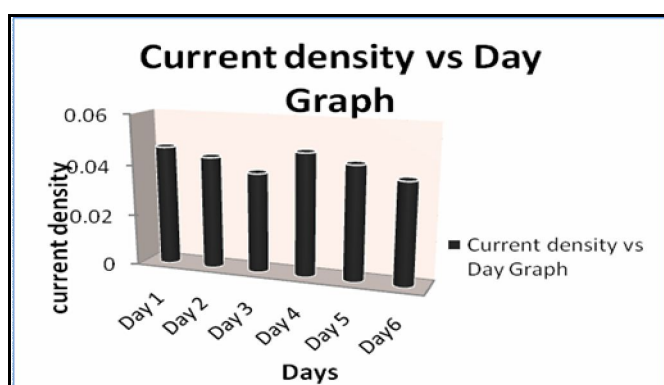
Day-6:





After obtaining a maximum voltage of 2.09 V on the first day, there was a voltage drop of 0.2 V after 20.5 hr. on the second day. By the end of third day the voltage was 1.63 V. Later, when the organic waste was added to the cell, the power generation continued.

The graphs of current density and Power density with respect to above data are as follows:



Conclusions:

The study performed here confirms that the increase in voltage can be obtained by connecting the MFCs in series. This Microbial fuel cell technology can be enhanced and it can be placed Sewage treatment plants to generate electricity. So, let's switch over to bio-energy for sustainable development.

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