

# STUDIES ON DESIGN AND FABRICATION OF DUAL CHAMBER MICROBIAL FUEL CELL FOR BIOELECTRICITY GENERATION FROM MICRO ORGANISMS

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**Abstract:** Legitimate treatment of wastewater is essential to human wellbeing and cultural turn of events, and the usually applied wastewater treatment innovations dependent on oxygen consuming treatment have a critical interest for energy. In this manner, new treatment innovations with low energy utilization and conceivable recuperation of important assets (e.g., energy and water) from wastewater happen to solid interest. Among the recently evolved ideas, microbial energy units (MFCs) incorporated with developed wetland give off an impression of being exceptionally appealing a result of direct power age from natural mixtures and treatment of wastewater. Developed microbial energy unit (MFC) is an arising innovation lately and has pulled in a great deal of consideration from analysts in the fields of wastewater treatment and bioenergy creation. MFC is a promising innovation in the fields of wastewater treatment and bioenergy. In any case, at ebb and flow power levels, the benefit of consolidating the two is predominantly a result of the upgrade of wastewater treatment in anaerobic zones inside the wetland. New operational systems should be investigated to increment and use power yield. Microbial energy units (MFCs) have been utilized to create power from various mixtures, including acetic acid derivation, lactate, and glucose. We show here that it is likewise conceivable to deliver power in a MFC from Automotive wastewater, while simultaneously achieving natural wastewater treatment (evacuation of COD, BOD, DO, pH, TDS, Total hardness and Chlorides).

**Keywords:** Automotive wastewater, powder density, pH, temperature

## 1. INTRODUCTION

Water is gotten from the Anglo-Saxon and Low German word, water which is a scentless, flavorless, and dull substance that is important to all living creatures that we as a whole know about. It is the primary constituent of earth's streams, lakes, seas, and the liquids of most living life forms [1]. Its substance equation is H<sub>2</sub>O, which implies that every one of its particles contains one iota oxygen and two iotas hydrogen that are associated by a bond known as "covalent bond". Water is found in three unique structures on earth, that is, strong, fluid, and gas [2]. These types of water rely upon the temperature. Water on our planet is available as a strong structure in the ice-caped territories at the North and South Poles, fluid in waterways, streams, and seas and is gas or fume structure in the climate [3]. In any case, the current situation says that all the water assets that are available in the globe are under a significant pressure. Today, in any case, extension of ventures, horticulture, damming, urbanization, populace, and contamination undermine these one-of-a-kind assets in numerous pieces of the earth [4]. A microbial power module is a device that believer's synthetic energy to electrical energy with the assistance of the synergist response of microorganisms. A microbial power device comprises of anode and cathode areas, which are isolated by a particular film [5]. Microorganisms are available in the anode segment and they oxidize fuel (electron giver) which at long last creates electrons and protons [6]. Electrons are moved to the cathode territory through the circuit and the protons through the particular layer. Electrons and protons are burned-through in the cathode compartment diminishing oxygen to water [7].

## 2. Experimental Procedure

Dual chambered MFC was constructed using air-tight plastic bottles of 1.0 liter volume each (anode and cathode chamber). A side opening of 1 cm radius was made at a height of 9 cm from the bottom of the bottle (approximately at the center) on each bottle and was connected with a PVC pipe. Agar of 100 gms along with 100 gms of sodium chloride (NaCl) salt was prepared by

heating it in a water-bath of 1000 ml and the molten agar was allowed to cool down and poured into the PVC pipe and sealed at one end using plastic cap and cello-tape. The agar was left undisturbed to solidify. The PVC pipe containing the salt-agar mixture was fixed between the two bottles using epoxy material and behaved like the salt-bridge assisting in the proton transfer mechanism during the MFC operation. Mild Steel (height= 10 cm; diameter = 0.5 cm) were used as electrodes. The distance between the two chambers was maintained at distance of 25, 20, 15, 10 and 5 cm in the MFC setup. Copper wires were used to connect the electrodes to the circuit. An external resistance (R) of 10, 47, 220, 500 and 1000  $\Omega$  were connected and the readings were measured using a digital multimeter. The collected sample was analyzed using standard methods in order to monitor the biodegradation process taking place inside the MFC. Many parameters are used to determine waste water characteristics. In this study the parameters analyzed were pH, TSS, TDS, BOD, COD, DO, Chlorides and Sulphates, etc to evaluate efficiency of the MFC. The waste water sample is analyzed for every 5 days and its various parameters are evaluated. During the operation, voltage and current is also checked by using a multimeter (Fig 2.1).

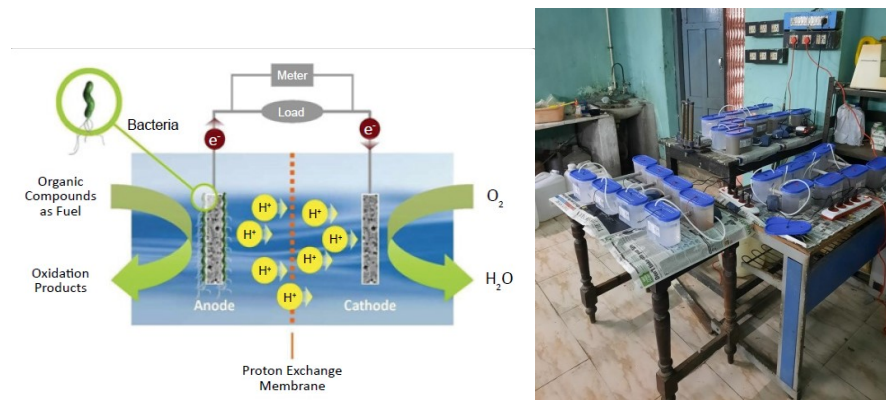


Fig. 2.1 Microbial Fuel Setup

### 3. RESULTS AND DISCUSSION

Effect of different variables and their impact were discussed as follows

#### 3.1. Effect of pH

pH of the waste example (Automotive waste water) was resolved utilizing pH meter. The variety of pH of the example taken at ordinary time frames Days is introduced in the Fig.3.1 Results show that pH of the Automotive waste water has diminished.

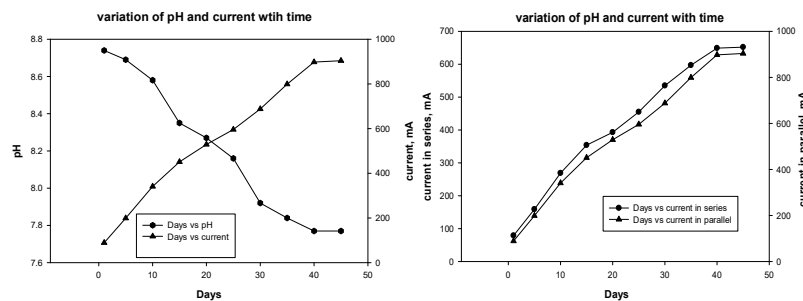


Fig. 3.1 Variation of pH with Time

The expansion of dextrose, which fills in as food to microorganisms, is answerable for the acidic idea of the Automotive waste water. pH was diminished from 8.74 to 7.77, which is in the reasonable degrees of BIS guidelines. The fundamental increment of pH is because of proton utilization by the cathodic responses [8]. In the meantime, digestion of living being continually delivers feeble corrosive mixtures and keeps up their intracellular pH [9].

### 3.2. Effect of Chemical oxygen demand (COD)

COD doesn't separate between organically accessible and idle natural matter, and it is a proportion of the all-out amount of oxygen needed to oxidize all-natural material into carbon dioxide and water. The waste is estimated as far as correspondence of oxygen needed for oxidation of natural make a difference to deliver CO<sub>2</sub> and water. For COD assurance, tests were saved utilizing H<sub>2</sub>SO<sub>4</sub> and handled for COD assurance after the whole examining activity was finished. During activity, MFC was consistently observed for squander (as COD) evacuation to list the capability of power module to go about as waste water treatment unit. COD of the Automotive burn through water at various time stretches are introduced in the Fig. 3.2. Results shown that COD of the Automotive waste water has diminished from an underlying of 1006.36 mg/L to 598.36 mg/L on the grounds that the creatures in the Automotive waste water have developed and corrupted the natural matter in squander test. The Automotive waste water showed its potential for COD expulsion demonstrating the capacity of microorganisms present in squander waters in using the carbon source as electron contributors[10]. Likewise eliminated COD substance of homegrown waste water from which it is apparent from test information that flow age and COD evacuation showed relative similarity. Persistent COD expulsion was seen during 30 days of activity.

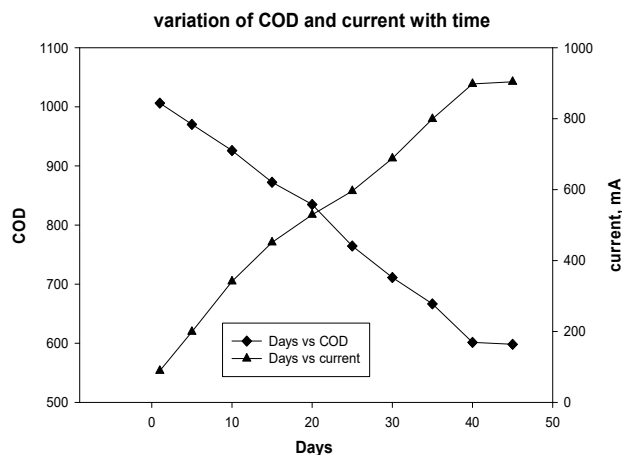


Fig. 3.2. Variation of COD with time

### 3.3. Effect of Biochemical oxygen demand (BOD)

BOD is a proportion of the measure of oxygen that creature will devour while breaking down natural matter under vigorous conditions. The impact of Microbial Fuel Cell on BOD of the Automotive waste water is outlined in the Fig. 3.3. Results show that BOD has diminished from an underlying worth of 620.39 mg/L to a last of 522.46 mg/L. The abatement in BOD is because of ceaseless air circulation and the activity of ooze. Comparable perceptions were made [11].

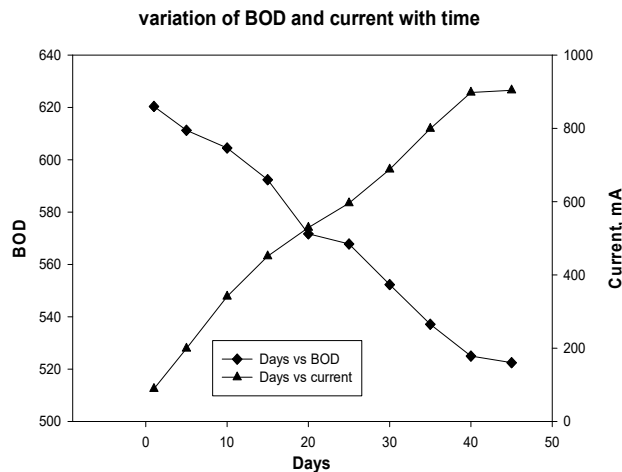


Fig. 3.3 Variation of BOD with Time

### 3.4. Effect of Dissolved Oxygen:

Fish and other sea-going creatures rely upon broke down oxygen (the oxygen present in water) to live. The measure of broke down oxygen in streams is subject to the water temperature, the number of dregs in the stream, the measure of oxygen removed from the framework by breathing and rotting life forms, and the measure of oxygen set back into the framework by photosynthesizing plants, stream, and air circulation. Broken up oxygen is estimated in milligrams per liter (mg/l) or parts per million (ppm).

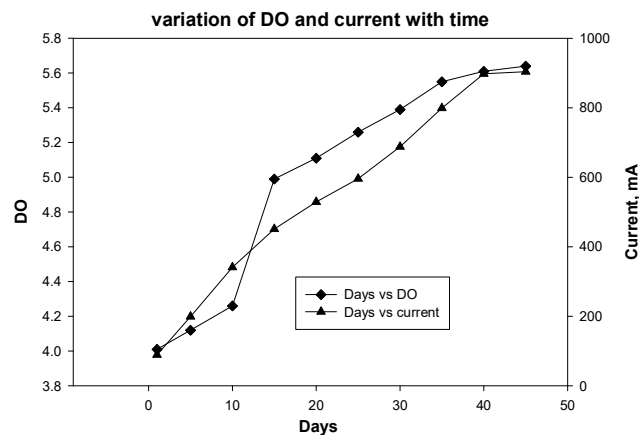


Fig. 3.4. Variation of Dissolved oxygen with time

The variety of Dissolved oxygen with time is portrayed in Fig.3.4. Results show that disintegrated oxygen expanded from 4.01 mg/L to 5.64 mg/L. The justification expansion in the Dissolved oxygen of Automotive waste water is because of diminishing in the degrees of BOD and COD in the Auto intention squander water test and air circulation. Comparable tests were performed [12].

### 3.5. Effect of Total Dissolved Solids:

All out broke up solids (TDS) involve inorganic salts (basically calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some limited quantities of natural matter that are disintegrated in water. TDS in drinking-water begin from common sources, sewage, metropolitan run-off, mechanical waste water and synthetic substances utilized in the water treatment measure, and the idea of the channeling or equipment used to pass on the water. All in all, the absolute broke down solids focus is the amount of the

cations (decidedly charged) and anions (adversely charged) particles in the water. Subsequently, the absolute disintegrated solids test gives a subjective proportion of the quantity of broke down particles yet doesn't disclose to us the nature or particle connections.

Present Microbial Fuel Cell (MFC) showed its potential for Total Dissolved Solids evacuation. The impact of MFC on complete broke down solids of the Automotive waste water at normal spans is introduced in the Fig.3.5. Exploratory information showed that broke up solids were diminished ceaselessly during the activity for 30 days. The TDS of the Automotive waste water test has diminished from 2914.31 mg/L to 2407.87 mg/L. The expulsion of disintegrated solids was perhaps because of accessibility of biodegradable substrate in wastewater test prompting cutthroat restraint in microorganisms. Indistinguishable trials have likewise been done and discovered to be adept [13-16].

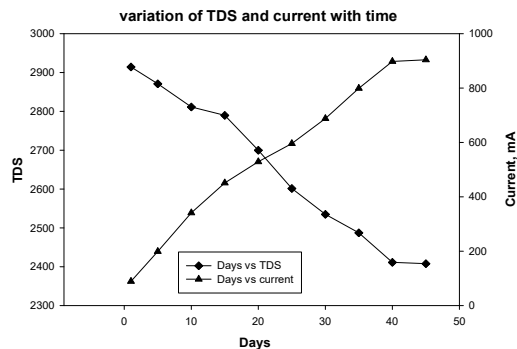


Fig. 3.5. Variation of TDS with Time

### 3.6. Effect of Total Suspended solids:

TSS are strong materials, including natural and inorganic, that are suspended in the water. These would incorporate sediment, tiny fish and mechanical squanders. High convergences of suspended solids can bring down water quality by retaining light. Waters at that point become hotter and reduce the capacity of the water to hold oxygen essential for sea-going life. Since oceanic plants additionally get less light, photosynthesis diminishes and less oxygen is delivered. The mix of hotter water, less light and less oxygen makes it unimaginable for certain types of life to exist. Suspended solids influence life otherly. They can obstruct fish gills, diminish development rates, decline protection from infection, and forestall egg and larval turn of events. Particles that settle out can cover fish eggs and those of amphibian creepy crawlies, just as suffocate recently brought forth hatchlings. The material that settles additionally occupies the spaces among rocks and makes these microhabitats unsatisfactory for different oceanic creepy crawlies, like mayfly fairies, stonefly sprites and caddisfly hatchling. Suspended solids can result from disintegration from metropolitan spillover and farming area, modern squanders, bank disintegration, bottom dwellers (like carp), green growth development or wastewater releases.

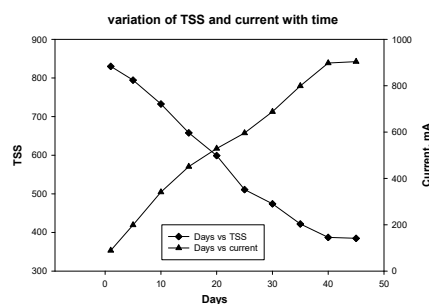


Fig. 3.6. Variation of TSS with Time

Impact of MFC on the expulsion of TSS of the Automotive waste water test is exhibited in Fig. 3.6. The Experimental information shows that the measure of TSS in the example has diminished with the slip by of time from 830.22 mg/L to 384.98 mg/L. The lessening of the suspended solids in example might be because of accessibility of biodegradable substrate in Automotive waste water test prompting cutthroat restraint in microorganisms. Related and Reliable exploratory runs were additionally completed and discovered to be precise coordinating [17-21].

### 3.7. Effect of Chlorides:

Chlorides are broadly conveyed as salts of calcium, sodium and potassium in water and Automotive waste water. In consumable water, the pungent taste delivered by chloride fixations is variable and ward on the substance arrangement of water. The significant taste delivering salts in water are sodium chloride and calcium chloride. The presence of chloride in the normal water can be credited to disintegration of salts stores released of gushing from synthetic enterprises, oil well activities, sewage release of profluent from compound ventures, and so on.

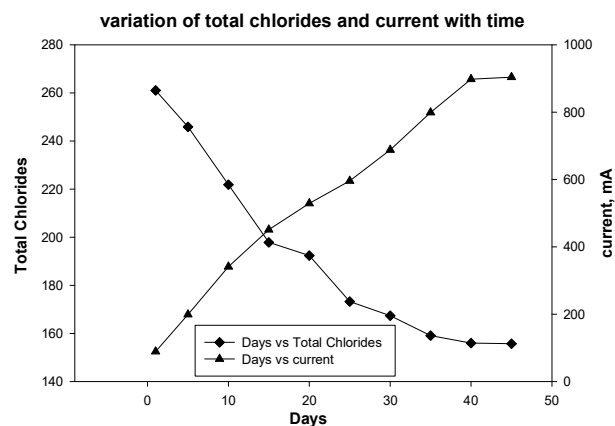
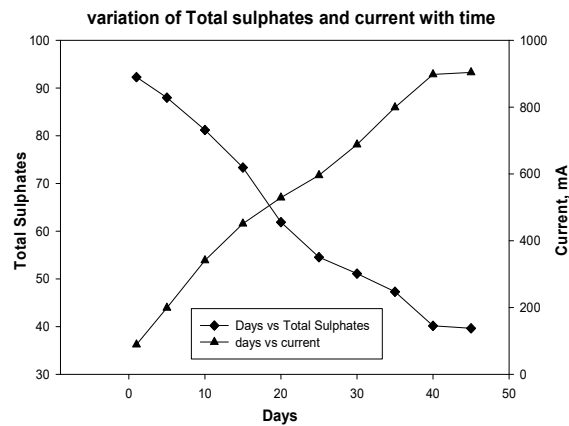


Fig. 3.7. Variation of Chlorides with Time

The impact of MFC on chlorides of the Auto rationale squander water test is introduced in Fig. 3.7. The test information shows that chlorides content has diminished from 261.05 mg/L to 155.76 mg/L. The evacuation of chlorides in the example might be ascribed to the accessibility of biodegradable substrate in wastewater test prompting cutthroat hindrance in microorganisms. Fortuitous trials were additionally inspected and comparative reports of results were found[22-26].

### 3.8. Effect of Sulphates:

Sulfate is a typical compound found in squander plants. It's likewise ordinarily found in drinking water. While it doesn't damagingly affect the body in low levels, it will go about as a purgative whenever devoured in high amounts. Regarding Auto intention squander water, it's imperative to wipe out sulfate because of the impact it can have on the climate. Sulfate is one of the significant cations happening in characteristic water. Sulfate being a stable, profoundly oxidized, solvent type of sulfur and which is for the most part present in regular surface and ground waters. Sulfate itself has never been a restricting variable in oceanic frameworks. The ordinary degrees of sulfate are an overabundance. At the point when water is over stacked with natural waste to point that oxygen is taken out then sulfate as an electron acceptor is regularly utilized for breakdown of natural make a difference to deliver H<sub>2</sub>S and produce spoiled egg smell.



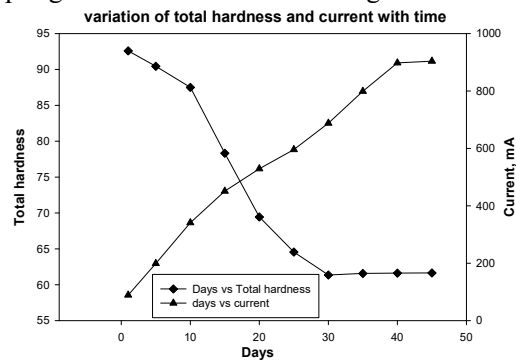
**Fig.3.8. Variation of Sulphates with Time**

The impact of MFC on Sulfates is appeared in Fig. 3.8. Results plainly show decline in sulfates from 92.30 mg/L to 39.66 mg/L. The evacuation of sulfates in the example may perhaps because of the accessibility of biodegradable substrate in wastewater test prompting serious restraint in microorganisms. Comparative interaction and results were likewise found by Feng Zhao et al [27-31].

The values of the sample after the treatment are shown in the Table.3.1. Here, the values of some of the parameters like pH, TSS, Dissolved Oxygen, TDS and Chlorides are well below the BIS standards. But, the values of some of the parameters like COD and BOD are slightly higher than the standard values.

### 3.9. Effect of Total Hardness:

The impact of MFC on complete hardness of the Automotive waste water test is introduced in Fig. 3.9. The test information shows that all out-hardness content has diminished from 92.60 mg/L to 61.65 mg/L. The expulsion of absolute hardness in the example might be ascribed to the accessibility of biodegradable substrate in Automotive waste water test prompting serious restraint in microorganisms.



**Fig. 3.9. Variation of total hardness with Time**

### 3.10. Effect of Treatment Efficiency:

The effect of MFC on Treatment Efficiency is shown in Fig. 3.10. Results clearly show increase in Treatment Efficiency from 5.12 mg/L to 43.59 mg/L.

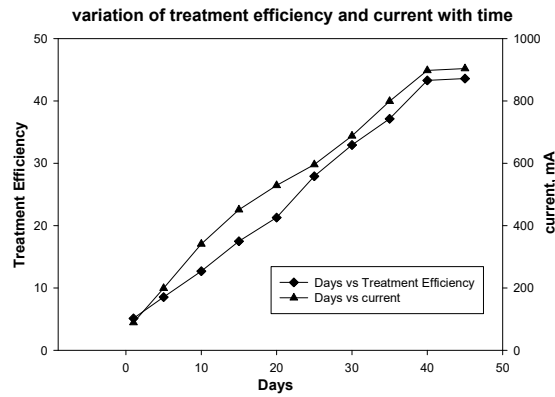


Fig. 3.10. Variation of Treatment Efficiency with Time

3.11. Effect of Power Density:

The effect of Microbial Fuel Cell on Power Density of the Automotive waste water is illustrated in the Fig. 3.11. Results show that Power Density has increased from an initial value of 194.60 mW/m<sup>2</sup> to a final of 592.20 mW/m<sup>2</sup>.

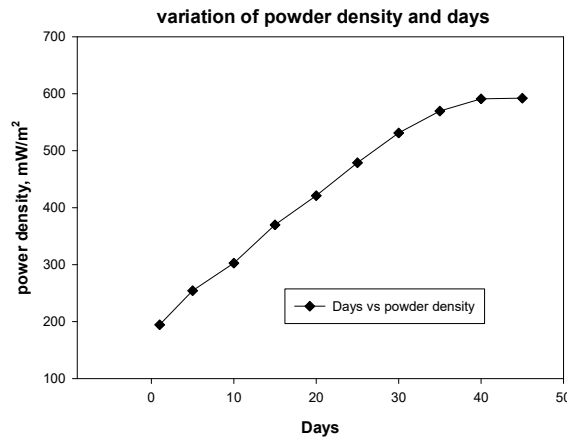


Fig. 3.11. Variation of Power Density with Time

Table 3.1: The Physico-chemical parameters of treated and untreated combination of household Engine oil waste and marine sea water

S. No	Parameter	Untreated	Treated	BIS standards
1.	Colour	Dark gray	Light Brown	--
2.	Temperature	32°C	30°C	--
3.	pH	8.74	7.77	6.5-9.0
4.	COD, mg/L	1006.36	598.36	250
5.	BOD, mg/L	620.39	522.46	50
6.	DO, mg/L	4.01	5.64	4-6
7.	TDS, mg/L	2914.31	2407.87	2100
8.	TSS, mg/L	830.22	384.98	600

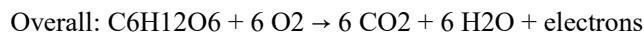
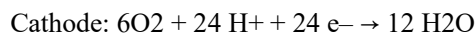


9.	Chlorides, mg/L	261.05	155.76	600
10.	Sulphates, mg/L	92.30	39.66	1000
11.	Total hardness	92.60	61.65	200

### 3.12. Power Calculations:

Microbial power devices have various expected employments. The most promptly obvious is collecting power delivered for use as a force source [32–33]. The utilization of MFCs is alluring for applications that require just low force yet where supplanting batteries might be tedious and costly, for example, remote sensor networks [34]. The boundaries differed, explored and determined incorporates Voltage, Current, Resistors, Power, Power Density. The tables beneath from 4.5 to 4.8 address the variety of resistors from 10, 47, 220, 500 and 1000.

Microbial power device depends on the essential standard where biochemical energy is changed over into electrical energy. Utilization of natural substrate (e.g., dextrose) by microorganism in oxygen consuming condition produce CO<sub>2</sub> and H<sub>2</sub>O. Assuming the terminal electron acceptor oxygen is supplanted by arbiter, the electrons will be caught by middle person, which will get decreased and transport electron to the cathode at anodic chamber. Be that as it may, when oxygen is absent, they produce carbon dioxide, protons and electrons as depicted beneath



It was first revealed by M.C.Potter in the year 1910 with E. coli. For present investigation 2L plastic container was utilized for making the anodic and Cathodic chamber. In Cathodic chamber Engine oil squander was utilized as the electrolyte arrangement and dextrose was utilized as carbon source individually [35]. It at that point starts to free electrons from the electron transport chain that would ordinarily be taken up by oxygen or different intermediates. The diminished middle person conveys electrons from the cell to the anode. Here the arbiter is oxidized as it stores the electrons. These at that point stream across the wire to the subsequent cathode, which goes about as an electron sink. Solid salt NaCl in 2M, 4M, 6M, 8 M and 10M focuses were utilized for creating salt scaffold. The most extreme voltage of 645 mV with Lacto Bacillus was acquired. Likewise, 300 mV voltage utilizing E. coli was gotten by M. C. Potter. NaCl was productive most in moving H<sup>+</sup> particles in the cathodic chamber[36]. Comparative and early papers by Rao et al. (1976) portrays a significant part of the underlying work focussed towards creating glucose-controlled power modules for use inside heart pacemakers. The favored living beings for MFC activities are metal lessening, anodophilic and lashed microorganisms. Geobacter species are of interest on account of their novel electron move capacities, the capacity to move electrons outside the cell and transport these electrons over significant distances through conductive fibers known as microbial nanowires[37]. A few creatures that are known to deliver aging items and have a place with the variety Clostridium, Alcaligenes, Enterococcus, have been utilized for MFCs activities [38]. Marine microbes create biofilms on the MFC anodes, permitting impressive change limit and openings for extracellular electron move (EET)[39]. There is less data about microorganisms have a place with sort. Penibacilus and its application in MFC which gave the most extreme

potential contrast for example voltage age of 1033 mV followed by *Pseudomonas* which create the voltage of 1010 mV. Salt scaffold was use for proton transportation into the cathode as it is modest contrasted with nafion films and similarly effective. The consortium of penibacillus and *Pseudomonas* created greatest voltage of 1039 mV.

The most extreme potential contrast announced by Cahyani and Gerard in the year 2008 for *Pseudomonas* is 0.2 V yet it is with nafion film which is extravagant and relatively the outcome acquired here is 1010 mV with basic salt scaffold. MFC have wide application in Biohydrogen creation by means of Bioelectrolysis, Wastewater Treatment and Cathodic Denitrification, Bioremediation, Biosensors, In-situ Power Source for Remote Areas[40–41].

### 3.13. Effect of Resistor

Power yield was additionally assessed as an element of outside obstruction even. The force yield was fluctuated and noticed for MFC worked under 10  $\Omega$ , 47  $\Omega$ , 220  $\Omega$ , 500  $\Omega$  and 1000  $\Omega$  separately. Indeed, even at higher current densities, the force yield was low, which showed that most of the substrate was not used for current age. This conduct was maybe because of rivalry for electron contributor between electrogenic life form and fermentative and anaerobically breathing organic entities for electron benefactor during the underlying time of anode colonization.

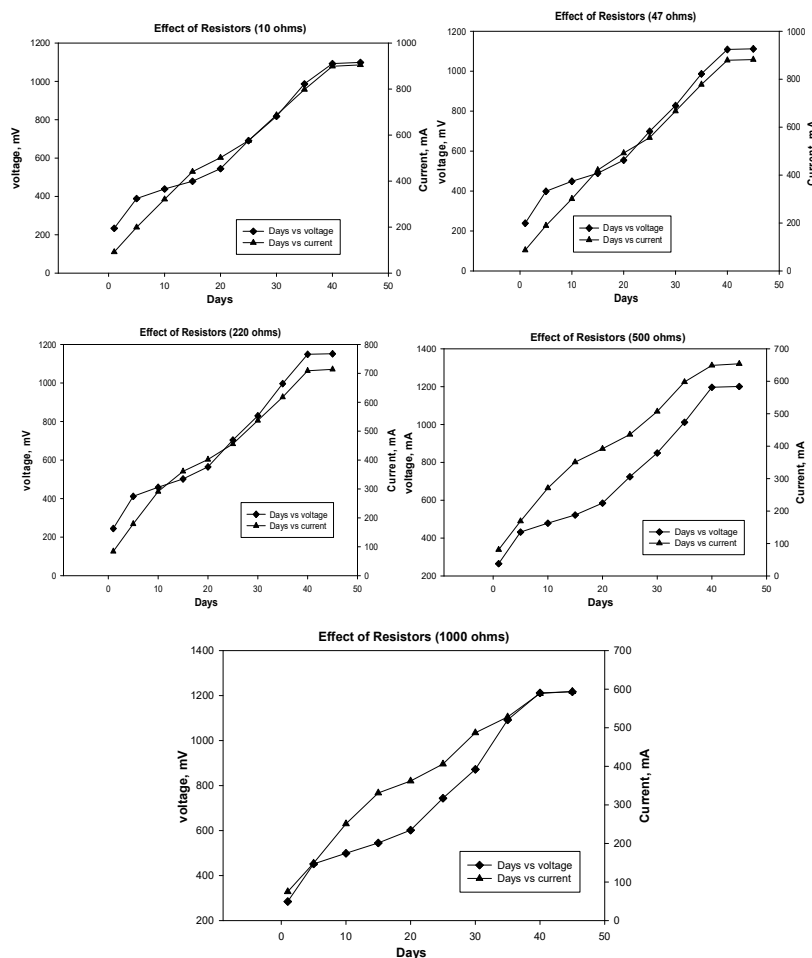


Fig. 3.12 (a) to (e) Plot for Number of Days vs Voltage

## Conclusions

It can be inferred from the above results that pH was decreased from 8.74 to 7.77 at room temperature. COD was decreased from 1006.36 mg/L to 598.36 mg/L at room temperature. BOD was decreased from 620.39 mg/L to 522.46 mg/L at room temperature. DO was increased from 4.01 mg/L to 5.64 mg/L at room temperature. TDS was decreased from 2914.31 mg/L to 2407.87 mg/L at room temperature. TSS was decreased from 830.22 mg/L to 384.98 mg/L at room temperature. chlorides was decreased from 261.05 mg/L to 155.76 mg/L at room temperature. Sulphates was decreased from 92.30 mg/L to 39.66 mg/L at room temperature. Total hardness was decreased from 92.60 mg/L to 61.65 mg/L at room temperature. Treatment efficiency was increased from 5.12 mg/L to 43.59 mg/L at room temperature. Power Density has increased from an initial value of 194.60 mW/m<sup>2</sup> to a final of 592.20 mW/m<sup>2</sup>. It can be concluded from the above results that Dual Chambered Microbial Fuel Cells are capable of treating waste waters using microorganisms along with power generation successfully.

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