

# Bioelectricity Generation from Living Plants Using Rhizosphere Microbial Activity

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**Abstract**—The aim of the project is to produce bioelectricity from living plants. The microbes present in the soil help to produce bioelectricity. Copper and zinc are used as the cathode and anode. This project mainly focuses on green, clean and sustainable energy production. It also encourages the energy security of our country. The main objective is to create a green and eco-friendly power source which should be available at all times. The electricity is generated from the ideal and left out microbes in rhizosphere layer of the soil. The plant prepares its own food by the photosynthesis process and stores its excess and left over energy in its rhizosphere layer. The source for this electricity is utilized from the rhizosphere region. This eco-innovative product aims at significant and demonstrable progress towards the goal of sustainable development through reducing impacts on the environment. The photosynthetic process helps plants to create their own food, which is then stored in their rhizosphere layer. The rhizosphere region serves as the source of this power. The cells were connected in series and parallel for 6 days and were observed. The series connection is said to provide high power output, and it is comparatively more efficient than the parallel connection. This environmentally friendly product attempts to prove energy at all times.

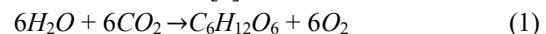
**Keywords** — Bio-electricity, Microbes, Rhizosphere, photosynthesis, and Sustainable development.

## I. INTRODUCTION

Energy conversion is defined as the transformation of energy from one form to another, such as light energy into heat, thermal energy into work, nuclear energy into heat energy, etc. The law of conservation of energy asserts that energy cannot be created nor destroyed, and energy conversion follows this rule. Energy transmits from one place to another. Energy can be transmitted from one object to another. There are several diverse types of energy all around us that can be changed from one form to another. In fact, plants can produce their food and release organic matter into the soil; bacteria decompose it and release electrons in the middle [1]. However, it is necessary

to establish the possibility of effectively implementing this mechanism in common day-to-day life and overcoming the difficulties of high costs. Also, it is imperative to determine what factors may affect this mechanism to take advantage of electrons in the middle. This research seeks to promote the possibility of using agricultural and even urban areas to produce electrical energy through microbial fuel cells to take advantage of electrons in the soil. For this, the selection of plants has focused on species of commercial interest applied in a fuel cell without including the separating membrane. A microbial fuel cell is a bio-electrochemical system that converts organic substrates directly into electrical energy using the power of respiring microbes. The microbial fuel cell, at its core, uses oxidation reduction processes to convert chemical energy into electricity. The microbial fuel cells use living biocatalysts to assist electron flow throughout their systems rather than chemically catalysed oxidation and reduction at the anode and cathode. A microbial fuel cell is a device that uses microorganisms to transform chemical energy into electrical energy.

A plant-microbial fuel cell (P-MFC) is a bioreactor whose operation is based on the use of microorganisms naturally present in the earth to convert a biodegradable substrate into electricity [2]. This fuel comes from the organic matter continuously released by a plant integrated into the system from the photosynthetic process through the following chemical reaction [3]:



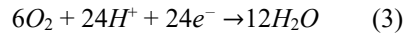
In general, P-MFCs consist of a pair of electrodes that serve as mediators with the electrons: the electrode closest to the plant (anode) where the oxidation half-reaction takes place and the electrode generally separated or away (cathode) from the plant where the reduction half-reaction is carried out [4]. Finally, an ion-exchange membrane or separator can be added to prevent oxygen or any other oxidizing agent from competing with the anode as the final electron

acceptor. In addition, ion-exchange membranes favour the diffusion of protons from the anode to the cathode, and they help to separate the cell into two different chambers. The P-MFCs are based on two processes: the rhizodeposition of organic compounds produced by photosynthesis carried out by plants and the generation of electricity from organic compounds within the cell. The root system produces and releases different organic compounds into the soil, including water-soluble exudates (sugars, organic acids and vitamins), water-insoluble materials (cell walls, sloughed-off materials and other root debris) and secretions such as polymeric carbohydrates and enzymes. All these release processes are called plant rhizodeposition and can represent as much as 40% of a plant's primary input of carbon. From this rhizodeposition, products are called rhizodeposits and are used in P-MFCs as a bioenergetic substrate. Then, the electrochemically active microorganisms naturally present in the soil use a part of the chemical energy of the substrate for their metabolism. In parallel, this process releases CO<sub>2</sub> in the medium, protons and electrons.

These electrons are delivered from one electrode (anode), which is coupled via an external charger to another electrode (cathode). Finally, the protons released at the anode travel to the cathode, where oxygen is reduced along with the protons and electrons, forming water [5]. In general, for any P-MFC system, the anodic oxidation due to the rhizodeposits present in the soil can be defined according to the following half-reaction [6]:

$$C_6H_{12}O_6 + 12H_2O \rightarrow 6HCO_3^- + 3H^+ + 24e^- \quad (2)$$

On the other hand, the cathodic reduction of oxygen to water can be represented according to the half-reaction shown below:



## II. MATERIALS AND METHODS

The stainless-steel outer frame was chosen a potting container. The soil mixture prepared for the project consists of one part of garden soil with half a part of coco peat and vermicompost. Process of constructing plant microbial fuel cell is shown in Figure 1. The major focus of the project is to use living plants for producing bioelectricity [7]. NJoy pothos, Swiss cheese plant, Moss rose, Philodendron plants were chosen as indoor plants that require indirect and bright light for its healthy growth. Indoor plants provide numerous benefits to humans, including improved physical health, cognition, and emotion, but the majority of these benefits have yet to be quantified and valued. Copper and zinc were used as the cathode and anode electrodes (4 × 4 cm and 3 mm thick) to keep the material as simple as possible for a daily scenario. The copper electrode was placed 7.5–8.5 cm tipped in the surface of the soil, while the second electrode zinc was placed 7 cm away from the cathode. The plants were initially grown in separate pots before constructing the P-MFCs, were purchased from a local nursery. The plants are planted in the potting container using the prepared soil mix. The plants are placed in indirect sunlight. The plant is watered regularly. The anode strip and cathode strip are connected using connecting wires and clips (Figure 2). To enhance the power density, connecting the plants in series or parallel can be effective [8]. The ends are connected to the external load and the electricity is used. The electricity can also be stored using a dischargeable battery and used later.

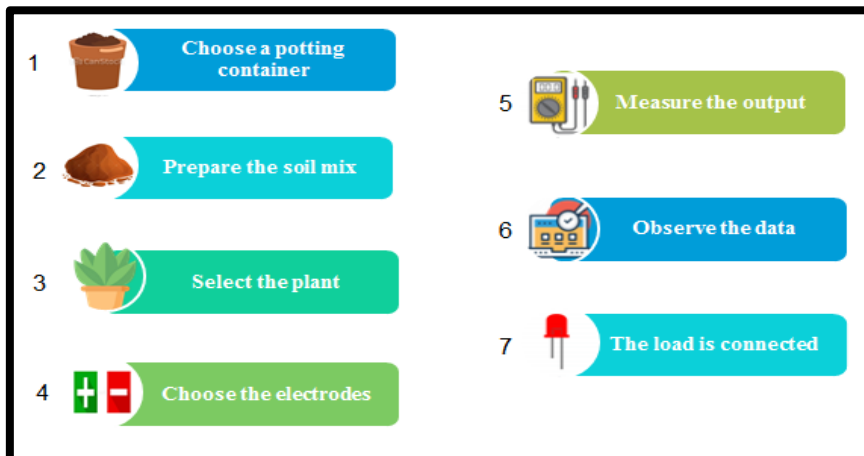


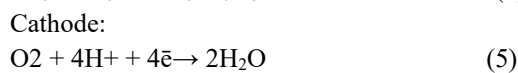
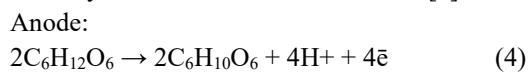
Figure 1: Process for constructing the project of P-MFC



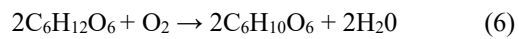
Figure 2: Pictorial representation of plant microbial fuel cell (P-MFC)

### III. WORKING OF PMFC

Plant MFC generally operate by exploiting microorganisms in the sub soil region. They provide exudates to these microorganisms which in turn break down the exudate into protons, electrons and carbon dioxide. Thus, they act as natural carbon fixing medium maintaining carbon balance in the atmosphere. Protons are attracted towards the anode which transfers them through a power harvester in an external circuit returning to the cathode. Water is produced at the cathode combining the protons with electrons in presence of oxygen from the atmosphere. The following are the various reactions taking place in the system at the anode and cathode [9].



Net Reaction:



The systems performance is determined by measuring the open circuit voltage and the short circuit current. The plant system was setup exposed to the atmosphere at Alwarpet Chennai, where the temperature ranged from 34-25°C, and the humidity was not controlled.

### IV. RESULT AND DISCUSSION

#### 4.1 Series connection readings

Location: Alwarpet, Chennai.

Latitude of the location: 13.03° Longitude of the location: 80.25°

Amount of water provided to the plants: Monday – 25ml per plant

Connection type: 8cells connected in series with one pair of electrodes.

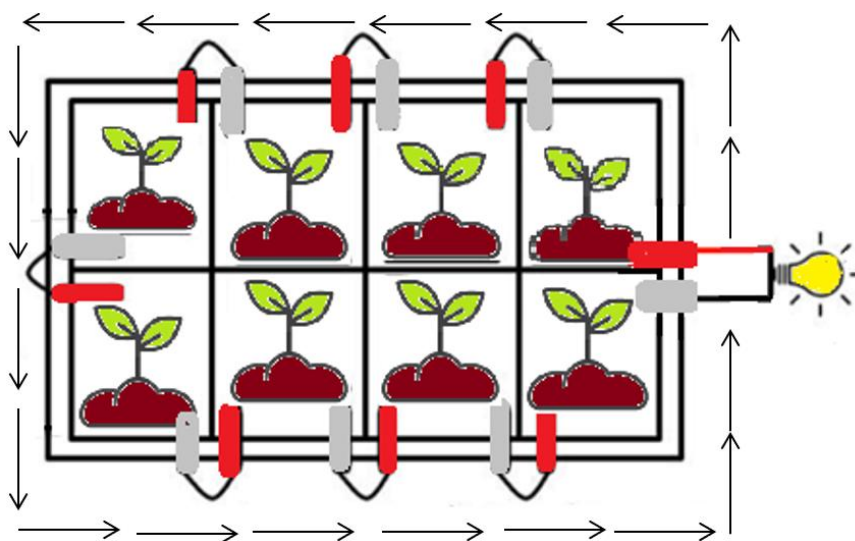


Figure 3: Direction of flow of electricity in P-MFC series connection



Figure 4: Pictorial representation of Series connection of P-MFC

Table 1: 18hrs format - Day 1 – 07/03/2022

| S.No                        | Time     | Voltage in V | Current in mA |
|-----------------------------|----------|--------------|---------------|
| 1                           | 6:00 AM  | 5.7          | 1.43          |
| 2                           | 7:00 AM  | 5.48         | 1.45          |
| 3                           | 8:00 AM  | 5.5          | 1.13          |
| 4                           | 9:00 AM  | 6.06         | 1.12          |
| 5                           | 10:00 AM | 6.14         | 1.92          |
| 6                           | 11:00 AM | 6.1          | 1.7           |
| 7                           | 12:00 PM | 7.54         | 1.52          |
| 8                           | 1:00 PM  | 7.54         | 1.52          |
| 9                           | 2:00 PM  | 7.02         | 1.62          |
| 10                          | 3:00 PM  | 6.08         | 1.5           |
| 11                          | 4:00 PM  | 6.12         | 1.48          |
| 12                          | 5:00 PM  | 6.11         | 1.37          |
| 13                          | 6:00 PM  | 6.51         | 1.33          |
| 14                          | 7:00 PM  | 5.92         | 1.35          |
| 15                          | 8:00 PM  | 5.6          | 1.6           |
| 16                          | 9:00 PM  | 6            | 1.62          |
| 17                          | 10:00 PM | 5.04         | 1.98          |
| 18                          | 11:00 PM | 5.56         | 1.46          |
| Maximum Voltage and Current |          | 7.54         | 1.98          |

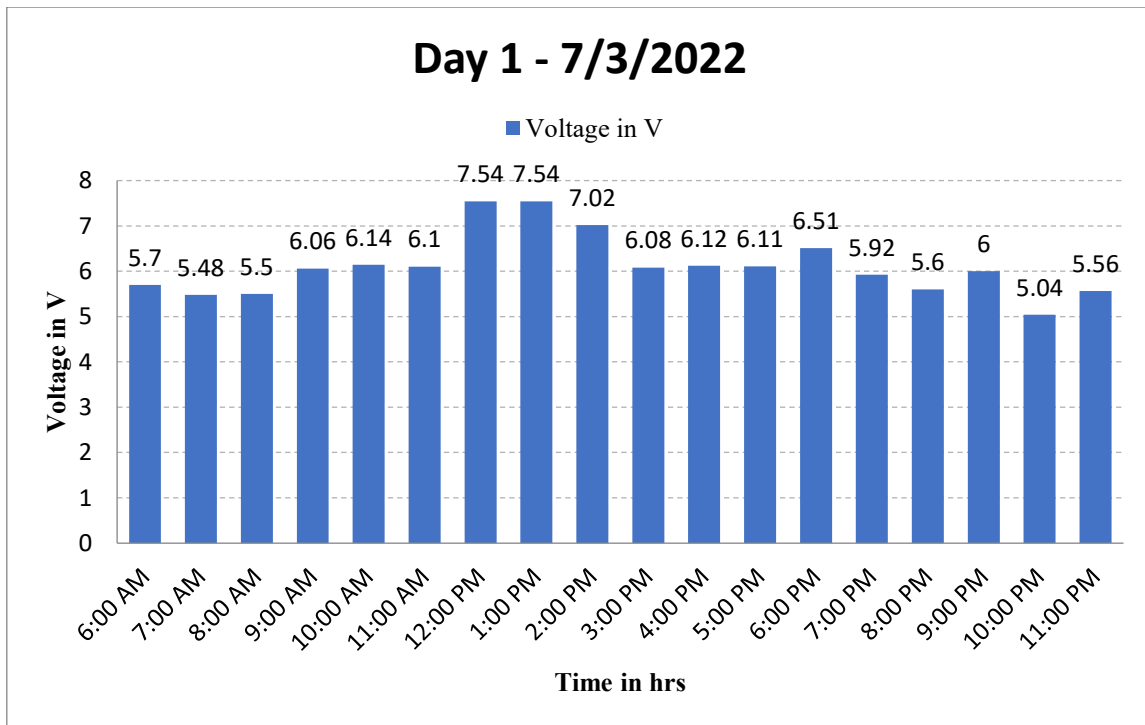


Figure 5: Day 1 Time vs Voltage graph in series connection

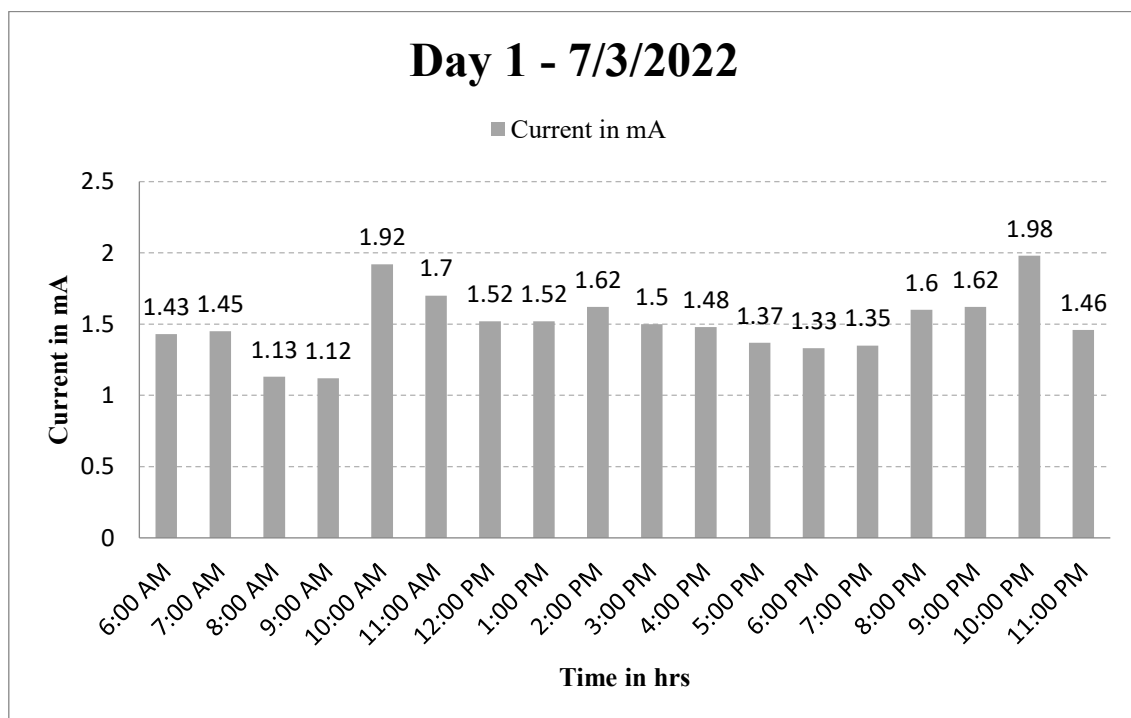


Figure 6: Day 1 Time vs Current graph in series connection

Table 2: 18hrs format - Day 2 - 08/03/2022

| S.No | Time    | Voltage in V | Current in mA |
|------|---------|--------------|---------------|
| 1    | 6:00 AM | 5.47         | 1.8           |
| 2    | 7:00 AM | 5.45         | 1.36          |
| 3    | 8:00 AM | 5.42         | 1.37          |
| 4    | 9:00 AM | 5.38         | 1.58          |

|                             |          |      |      |
|-----------------------------|----------|------|------|
| 5                           | 10:00 AM | 5.23 | 1.37 |
| 6                           | 11:00 AM | 5.2  | 1.2  |
| 7                           | 12:00 PM | 5.7  | 1.67 |
| 8                           | 1:00 PM  | 5.99 | 2.8  |
| 9                           | 2:00 PM  | 5.95 | 2.3  |
| 10                          | 3:00 PM  | 5.57 | 2.92 |
| 11                          | 4:00 PM  | 5.32 | 2.73 |
| 12                          | 5:00 PM  | 6.02 | 2.47 |
| 13                          | 6:00 PM  | 6.68 | 2.55 |
| 14                          | 7:00 PM  | 5.38 | 2.24 |
| 15                          | 8:00 PM  | 6.05 | 2.59 |
| 16                          | 9:00 PM  | 5.21 | 2.75 |
| 17                          | 10:00 PM | 5.85 | 2.65 |
| 18                          | 11:00 PM | 5.65 | 2.21 |
| Maximum Voltage and Current |          | 6.68 | 2.92 |

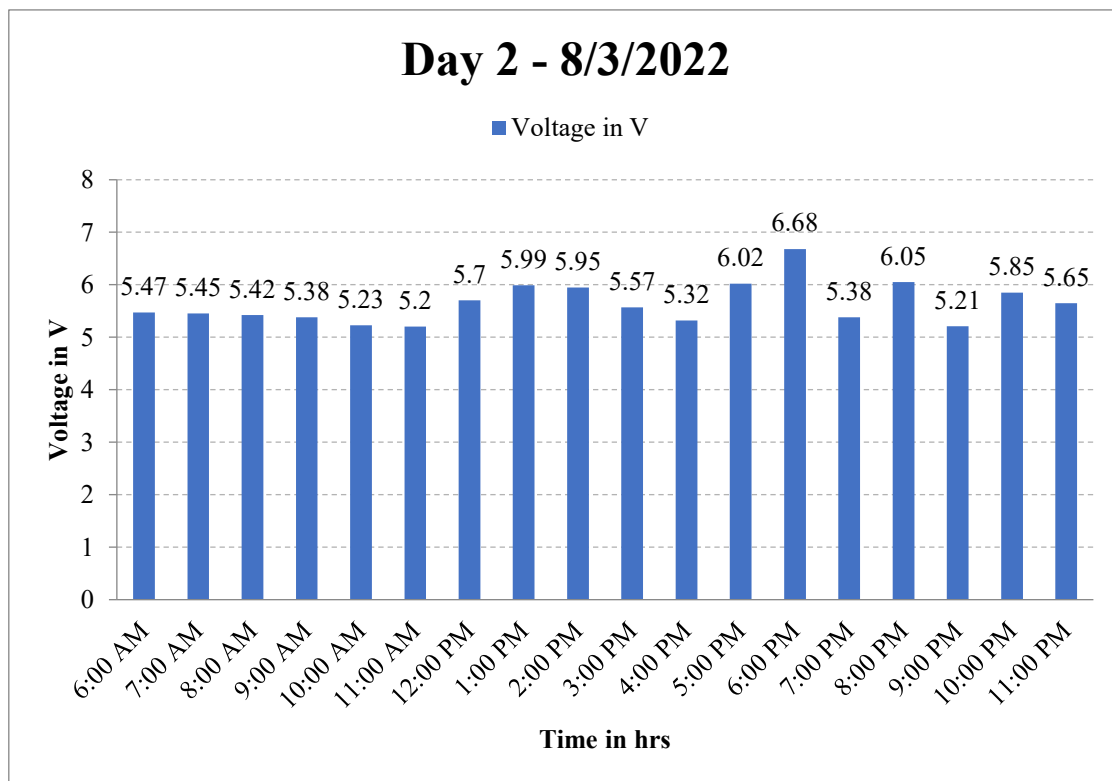


Figure 7: Day 2 Time vs Voltage graph in series connection

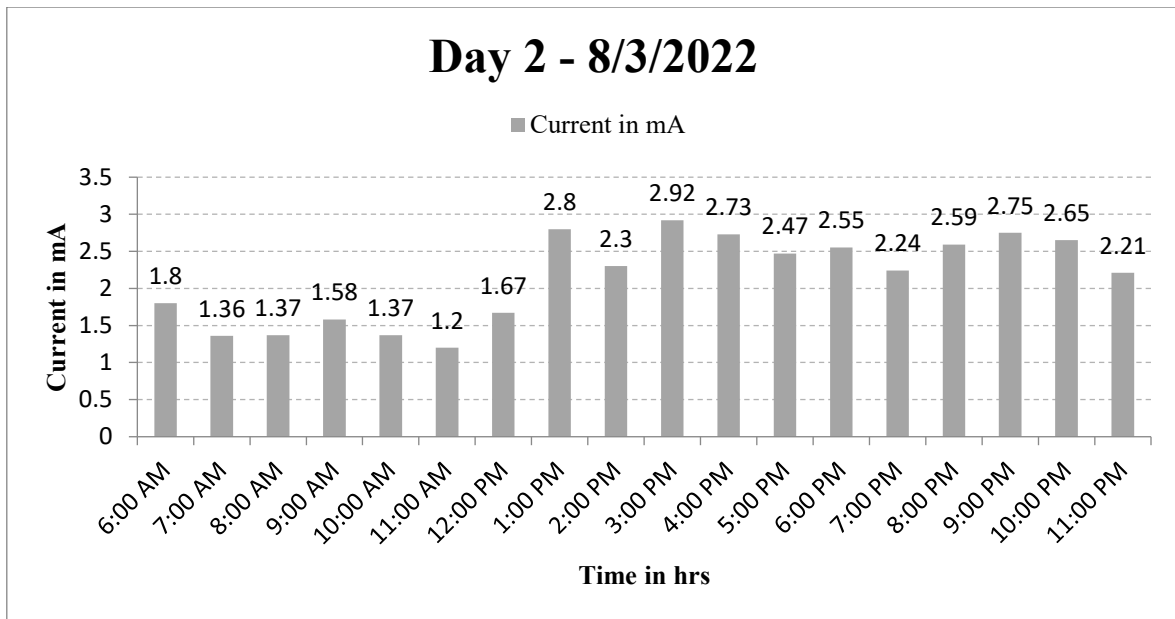


Figure 8: Day 2 Time vs Current graph in series connection

Table 3: 18hrs format - Day 3 – 9/3/2022

| S.No                        | Time     | Voltage in V | Current in mA |
|-----------------------------|----------|--------------|---------------|
| 1                           | 6:00 AM  | 5.33         | 2.16          |
| 2                           | 7:00 AM  | 5.67         | 1.89          |
| 3                           | 8:00 AM  | 5.97         | 1.57          |
| 4                           | 9:00 AM  | 6.02         | 1.34          |
| 5                           | 10:00 AM | 6.37         | 1.09          |
| 6                           | 11:00 AM | 6.43         | 1.27          |
| 7                           | 12:00 PM | 6.52         | 1.47          |
| 8                           | 1:00 PM  | 6.37         | 1.32          |
| 9                           | 2:00 PM  | 6.12         | 1.24          |
| 10                          | 3:00 PM  | 6.96         | 1.59          |
| 11                          | 4:00 PM  | 6.82         | 1.61          |
| 12                          | 5:00 PM  | 6.05         | 1.05          |
| 13                          | 6:00 PM  | 6.18         | 1.03          |
| 14                          | 7:00 PM  | 6.14         | 1.02          |
| 15                          | 8:00 PM  | 6.23         | 1             |
| 16                          | 9:00 PM  | 6.25         | 1.25          |
| 17                          | 10:00 PM | 6.32         | 1.03          |
| 18                          | 11:00 PM | 6.24         | 1.34          |
| Maximum Voltage and Current |          | 6.96         | 2.16          |

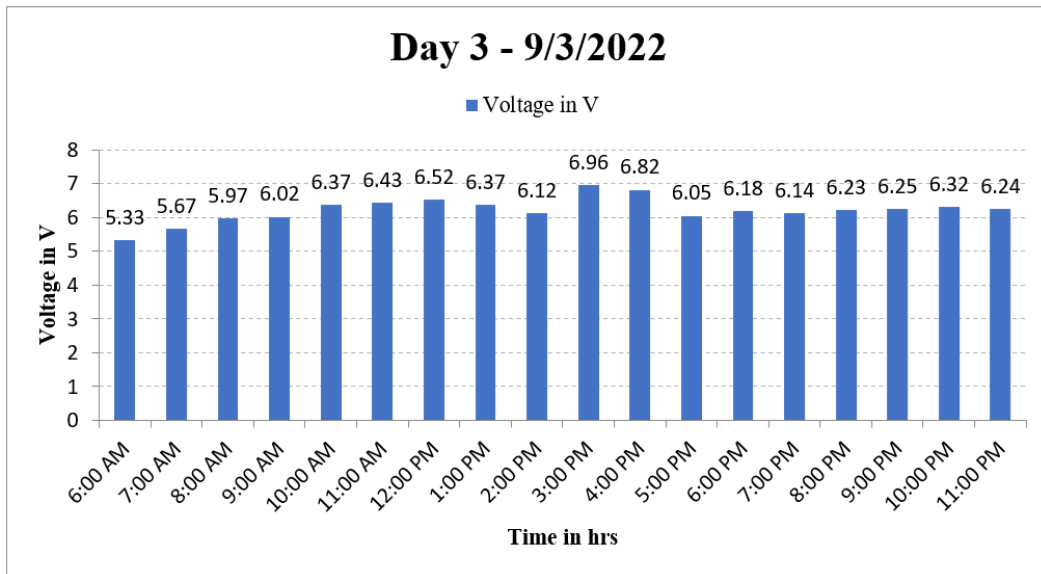


Figure 9: Day 3 Time vs Voltage graph in series connection

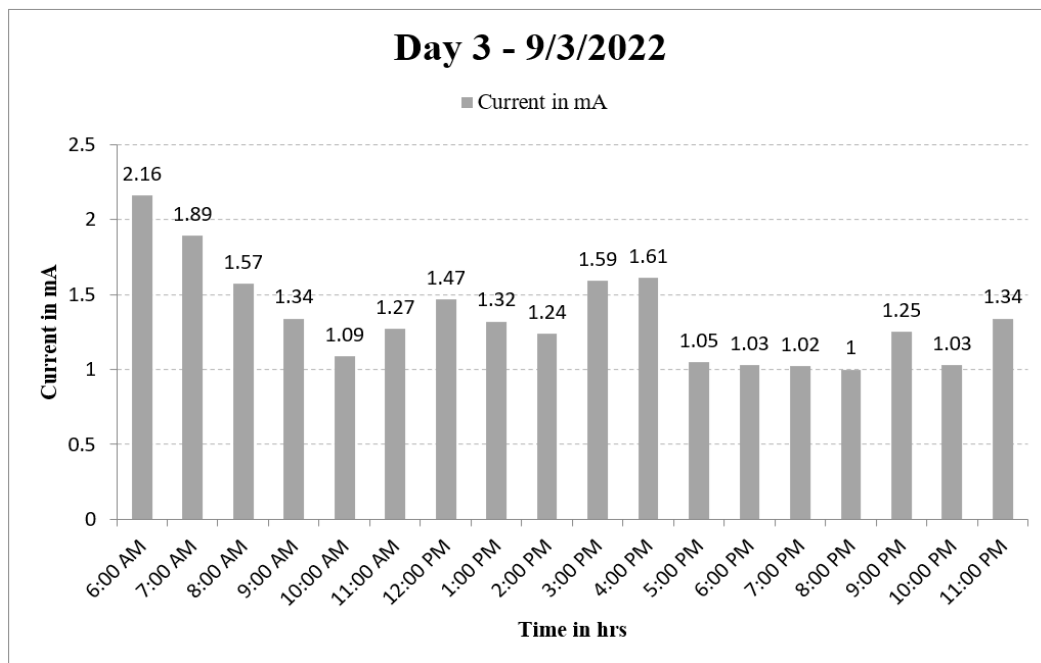


Figure 10: Day 3 Time vs Current graph in series connection

Table 4: 18hrs format - Day 4 – 10/3/2022

| S.No | Time     | Voltage in V | Current in mA |
|------|----------|--------------|---------------|
| 1    | 6:00 AM  | 6.15         | 1.5           |
| 2    | 7:00 AM  | 5.75         | 2.01          |
| 3    | 8:00 AM  | 6.01         | 2.26          |
| 4    | 9:00 AM  | 5.84         | 2.24          |
| 5    | 10:00 AM | 6.21         | 2.38          |
| 6    | 11:00 AM | 6.39         | 2             |
| 7    | 12:00 PM | 6.47         | 1.78          |
| 8    | 1:00 PM  | 6.58         | 1.73          |
| 9    | 2:00 PM  | 5.92         | 1.26          |

|                             |          |      |      |
|-----------------------------|----------|------|------|
| 10                          | 3:00 PM  | 6.8  | 1.56 |
| 11                          | 4:00 PM  | 6.47 | 1.53 |
| 12                          | 5:00 PM  | 6.38 | 1.87 |
| 13                          | 6:00 PM  | 6.4  | 2.92 |
| 14                          | 7:00 PM  | 6.29 | 1.47 |
| 15                          | 8:00 PM  | 5.57 | 1.84 |
| 16                          | 9:00 PM  | 5.76 | 2.03 |
| 17                          | 10:00 PM | 5.7  | 2.06 |
| 18                          | 11:00 PM | 6    | 1.92 |
| Maximum Voltage and Current |          | 6.8  | 2.92 |

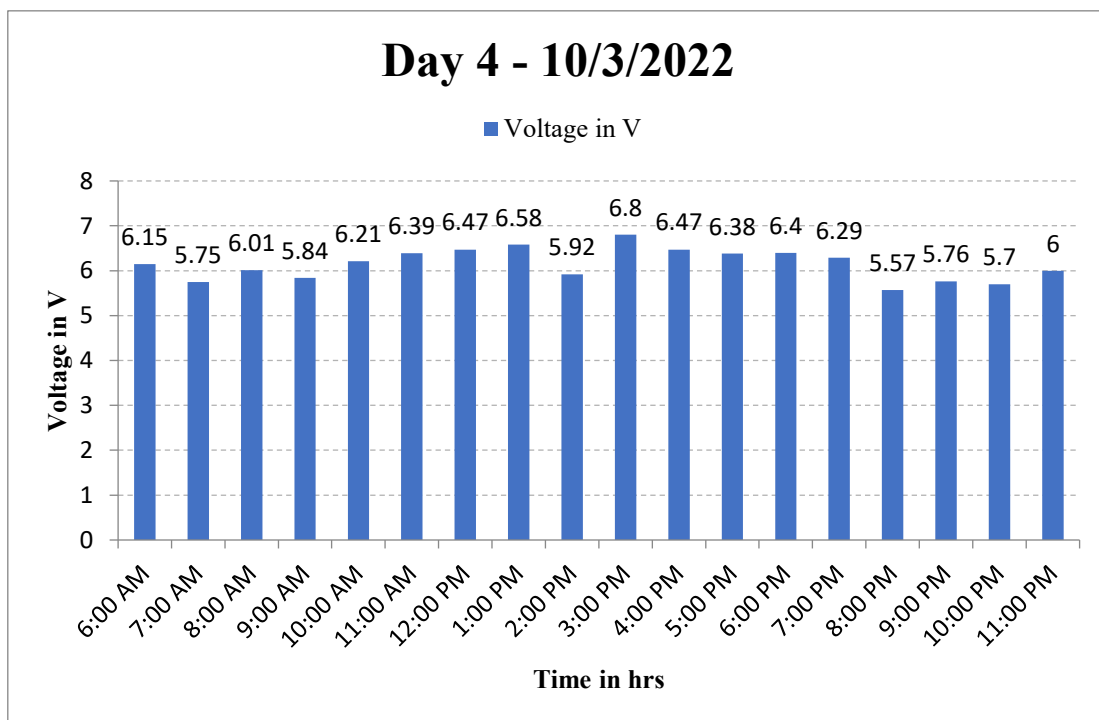


Figure 11: Day 4 Time vs Voltage graph in series connection

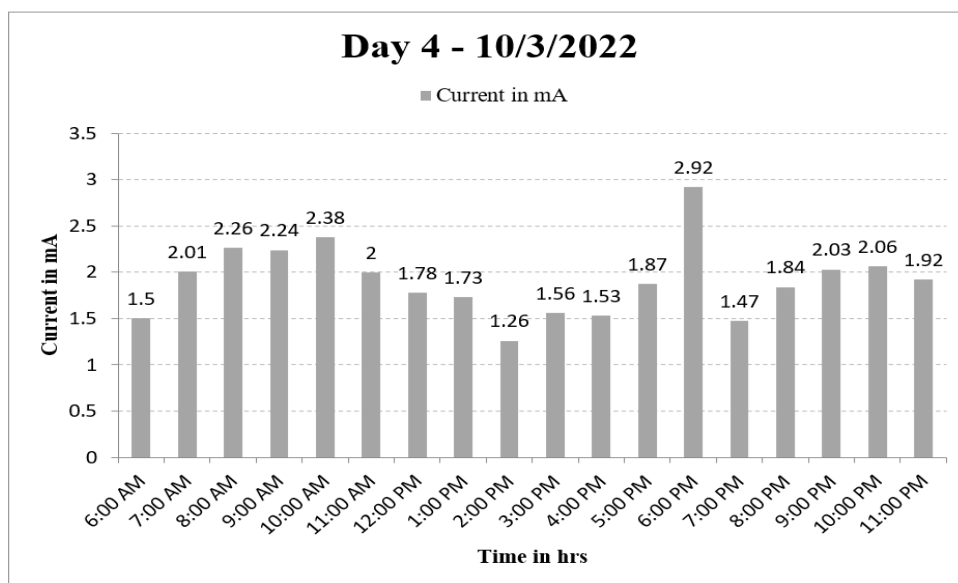


Figure 12: Day 4 Time vs Current graph in series connection

Table 5: 18hrs format - Day 5 – 11/3/2022

| S.No                        | Time     | Voltage in V | Current in mA |
|-----------------------------|----------|--------------|---------------|
| 1                           | 6:00 AM  | 5.33         | 2.16          |
| 2                           | 7:00 AM  | 5.67         | 1.89          |
| 3                           | 8:00 AM  | 5.97         | 1.57          |
| 4                           | 9:00 AM  | 6.02         | 1.34          |
| 5                           | 10:00 AM | 6.37         | 1.09          |
| 6                           | 11:00 AM | 6.43         | 1.27          |
| 7                           | 12:00 PM | 6.52         | 1.47          |
| 8                           | 1:00 PM  | 6.37         | 1.32          |
| 9                           | 2:00 PM  | 6.12         | 1.24          |
| 10                          | 3:00 PM  | 6.96         | 1.59          |
| 11                          | 4:00 PM  | 6.82         | 1.61          |
| 12                          | 5:00 PM  | 6.05         | 1.05          |
| 13                          | 6:00 PM  | 6.18         | 1.03          |
| 14                          | 7:00 PM  | 6.14         | 1.02          |
| 15                          | 8:00 PM  | 6.23         | 1             |
| 16                          | 9:00 PM  | 6.25         | 1.25          |
| 17                          | 10:00 PM | 6.32         | 1.03          |
| 18                          | 11:00 PM | 6.24         | 1.34          |
| Maximum Voltage and Current |          | 6.96         | 2.16          |

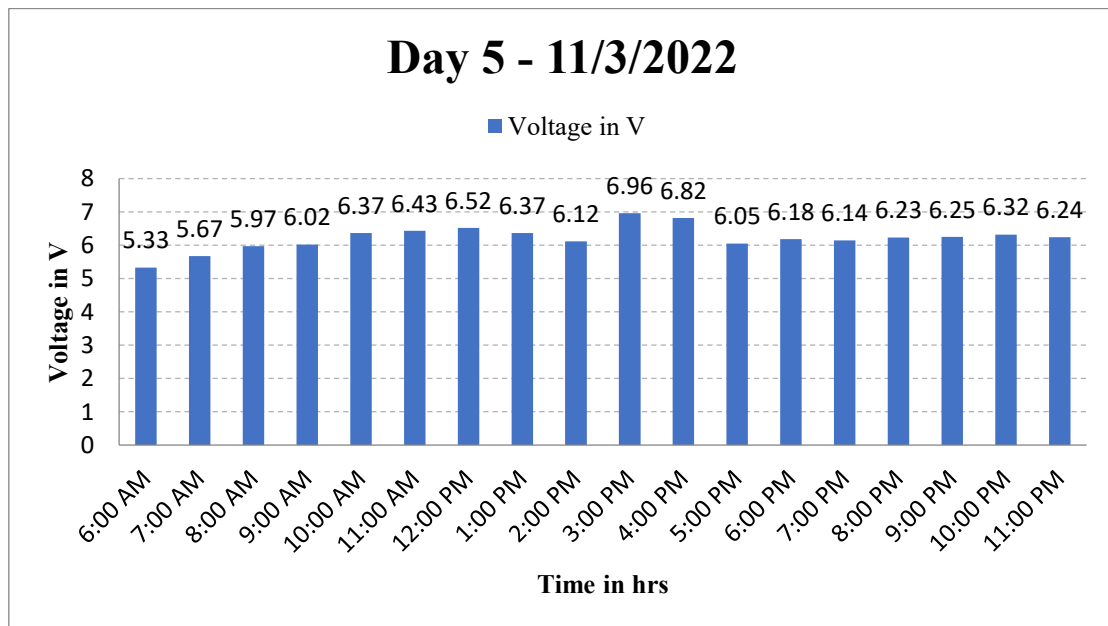


Figure 13: Day 5 Time vs Voltage graph in series connection

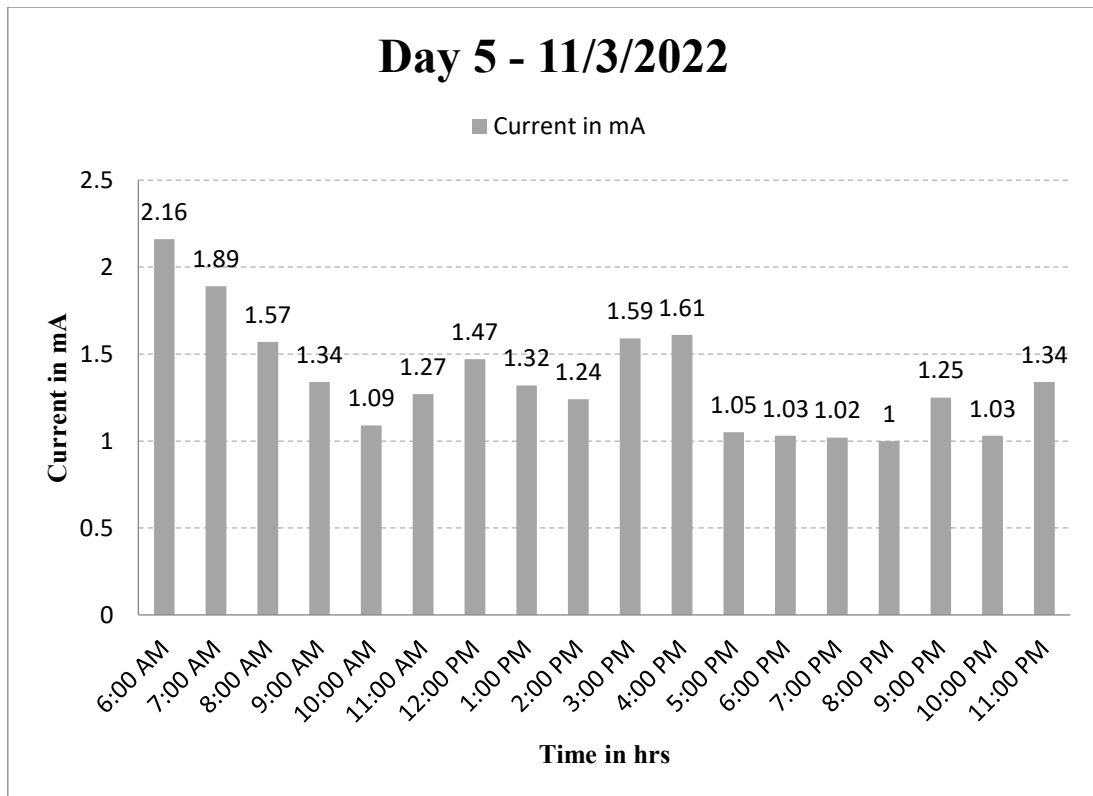


Figure 14: Day 5 Time vs Current graph in series connection

Table 6: 24hrs format - Day 6: 12/3/2022 (24hrs reading)

| S.No | Time     | Voltage in V | Current in mA |
|------|----------|--------------|---------------|
| 1    | 6:00 AM  | 6.26         | 1.01          |
| 2    | 7:00 AM  | 5.87         | 1.07          |
| 3    | 8:00 AM  | 5.99         | 1.05          |
| 4    | 9:00 AM  | 6.02         | 1.02          |
| 5    | 10:00 AM | 6.04         | 1             |
| 6    | 11:00 AM | 6.22         | 1.12          |
| 7    | 12:00 PM | 6.25         | 1.13          |
| 8    | 1:00 PM  | 6.32         | 1.11          |
| 9    | 2:00 PM  | 6.35         | 1.07          |
| 10   | 3:00 PM  | 6.57         | 0.92          |
| 11   | 4:00 PM  | 6.02         | 1.5           |
| 12   | 5:00 PM  | 6.13         | 1.95          |
| 13   | 6:00 PM  | 5.68         | 2.64          |
| 14   | 7:00 PM  | 5.5          | 2.16          |
| 15   | 8:00 PM  | 5.48         | 2.22          |
| 16   | 9:00 PM  | 5.52         | 1.96          |
| 17   | 10:00 PM | 5.12         | 1.9           |
| 18   | 11:00 PM | 5.4          | 2.02          |
| 19   | 12:00 AM | 5.43         | 1.64          |
| 20   | 01.00 AM | 5.46         | 1.97          |
| 21   | 02.00 AM | 5.63         | 2.09          |
| 22   | 03.00 AM | 5.54         | 1.95          |

|                             |          |      |      |
|-----------------------------|----------|------|------|
| 23                          | 04.00 AM | 5.85 | 1.21 |
| 24                          | 05.00 AM | 6.09 | 1.1  |
| Maximum Voltage and Current |          | 6.57 | 2.64 |

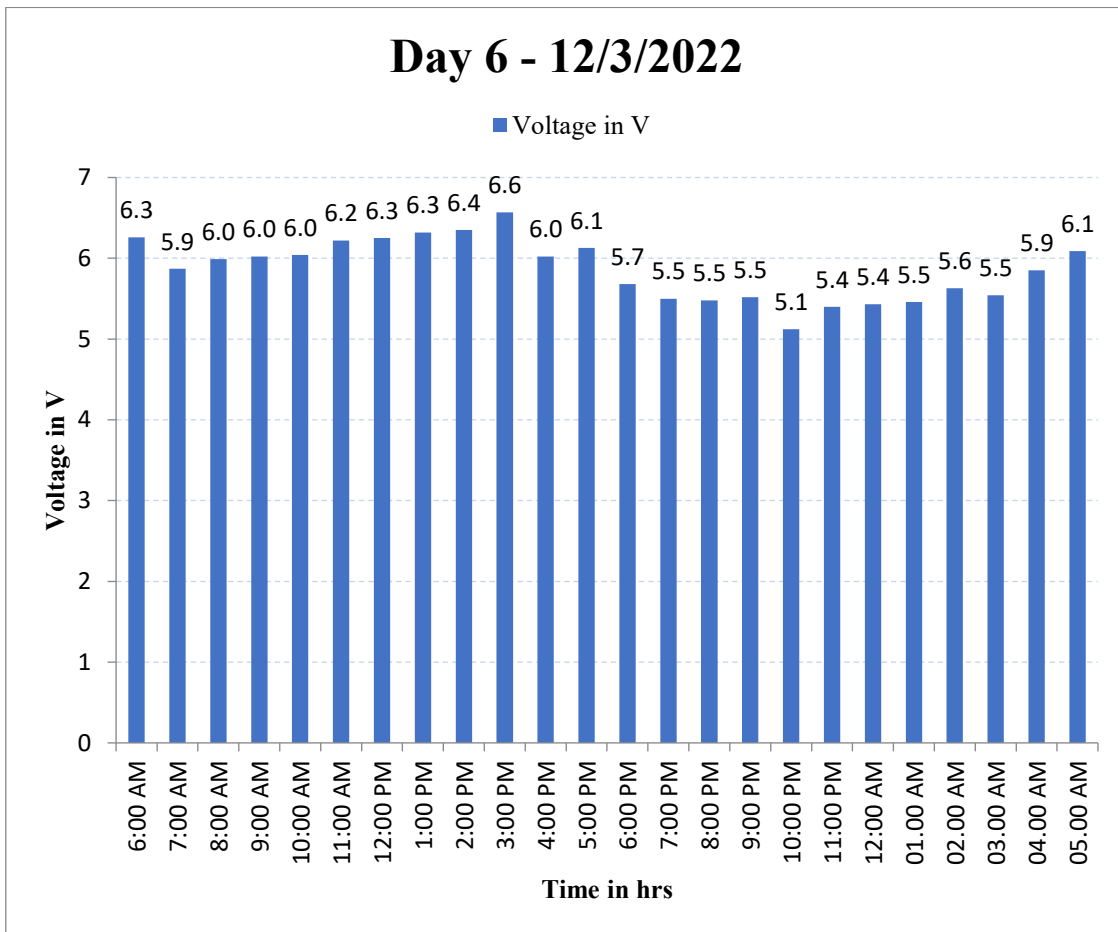


Figure 15: Day 6 Time vs Voltage graph in series connection

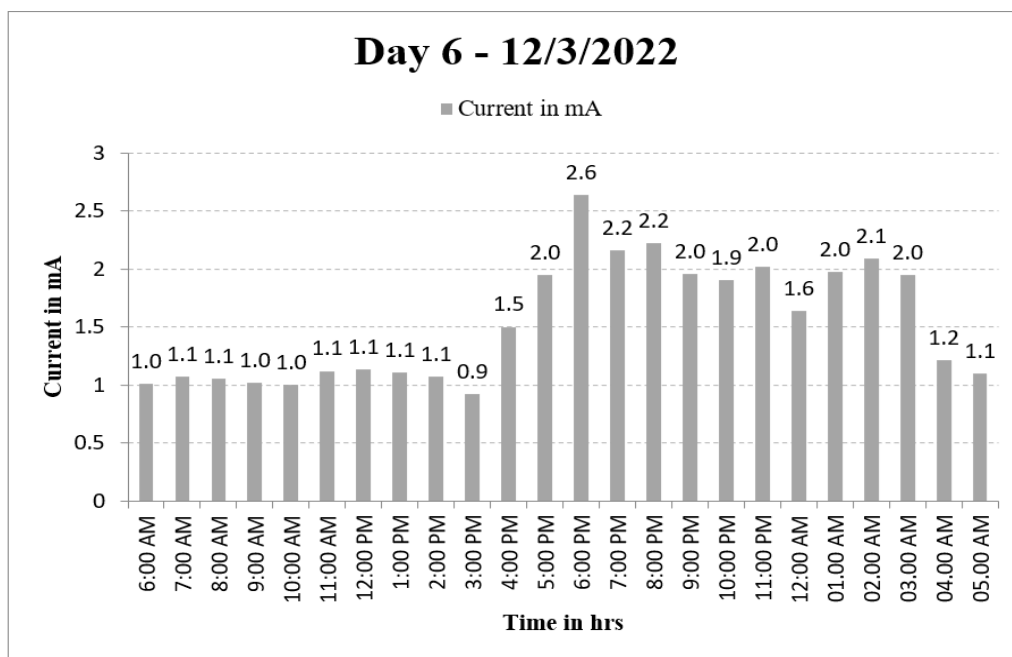


Figure 16: Day 6 Time vs Current graph in series connection

4.2. Parallel connection readings

Date: 14/03/2022 to 19/03/2022

Location: Alwarpet, Chennai.

Latitude of the location: 13.03° Longitude of the location: 80.25°

Amount of water provided to the plants: Monday – 25ml per plant

Connection type: 8cells connected in parallel with one pair of electrodes

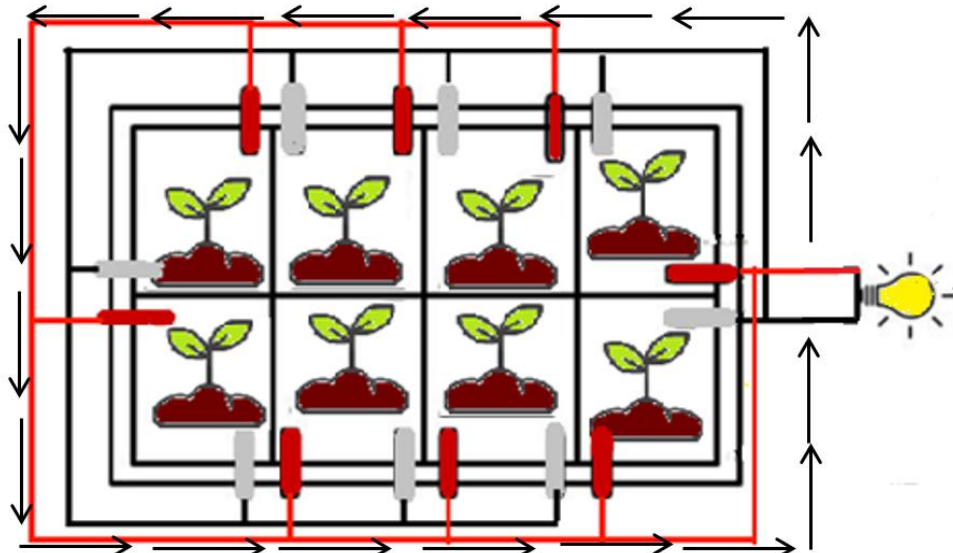


Figure 17: Direction of flow of electricity in P-MFC parallel connection



Figure 18: Pictorial representation of Series connection of P-MFC

Table 7: 18hrs format - Day 1: 14/03/2022

| S.No | Time     | Voltage in V | Current in mA |
|------|----------|--------------|---------------|
| 1    | 6:00 AM  | 0.8          | 10.95         |
| 2    | 7:00 AM  | 0.82         | 10.98         |
| 3    | 8:00 AM  | 0.78         | 11.08         |
| 4    | 9:00 AM  | 0.79         | 11.02         |
| 5    | 10:00 AM | 0.81         | 11.04         |
| 6    | 11:00 AM | 0.83         | 11.01         |

|                             |          |      |       |
|-----------------------------|----------|------|-------|
| 7                           | 12:00 PM | 0.85 | 10.99 |
| 8                           | 1:00 PM  | 0.86 | 10.96 |
| 9                           | 2:00 PM  | 0.84 | 10.94 |
| 10                          | 3:00 PM  | 0.83 | 11.08 |
| 11                          | 4:00 PM  | 0.81 | 11.1  |
| 12                          | 5:00 PM  | 0.84 | 11.12 |
| 13                          | 6:00 PM  | 0.85 | 11.15 |
| 14                          | 7:00 PM  | 0.84 | 11.11 |
| 15                          | 8:00 PM  | 0.84 | 11    |
| 16                          | 9:00 PM  | 0.83 | 10.93 |
| 17                          | 10:00 PM | 0.79 | 10.88 |
| 18                          | 11:00 PM | 0.82 | 10.97 |
| Maximum Voltage and Current |          | 0.86 | 11.15 |

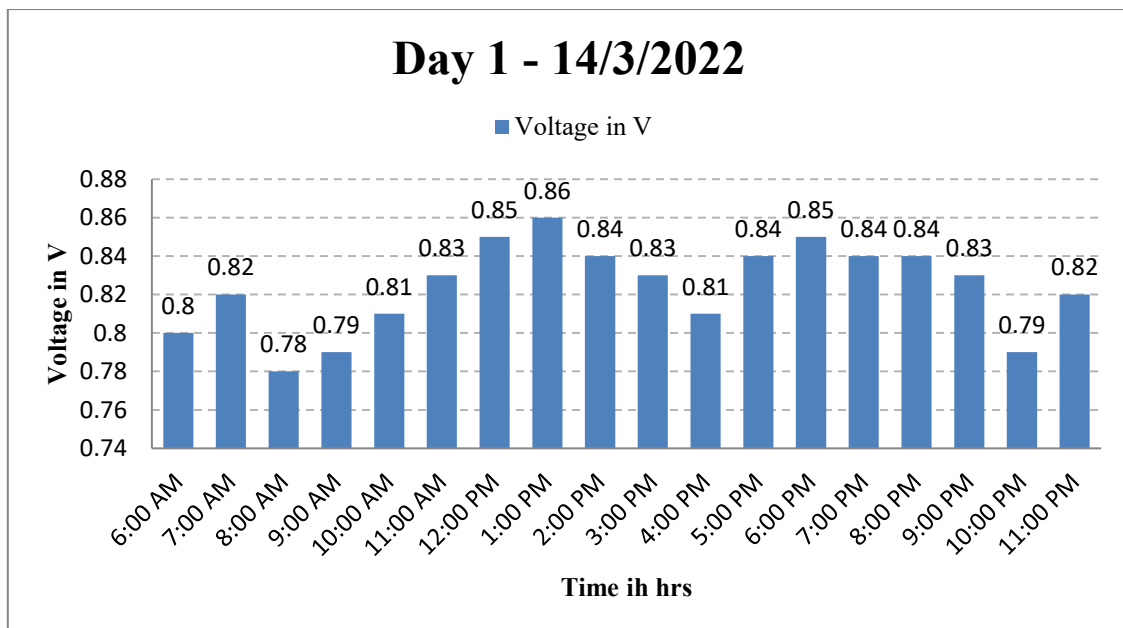


Figure 19: Day 1 Time vs Voltage graph in parallel connection

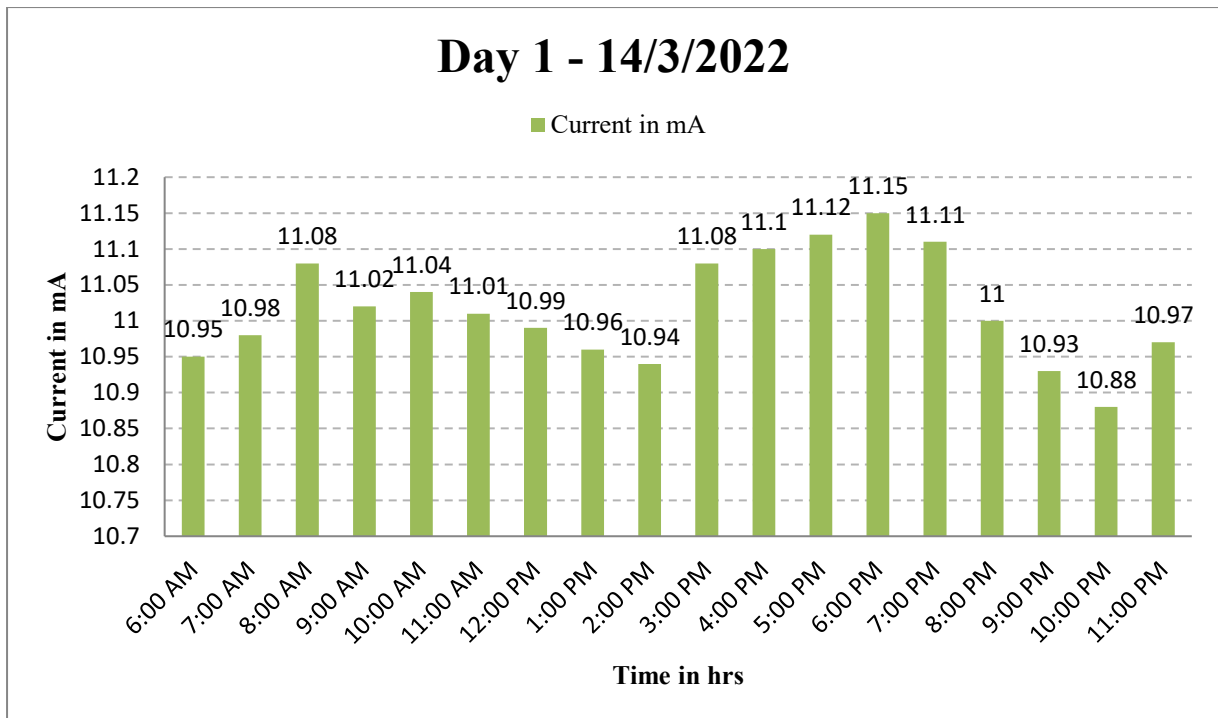


Figure 20: Day 1 Time vs Current graph in parallel connection

Table 8: 18hrs format - Day 2 – 15/3/2022

| S.No                        | Time     | Voltage in V | Current in mA |
|-----------------------------|----------|--------------|---------------|
| 1                           | 6:00 AM  | 0.78         | 10.83         |
| 2                           | 7:00 AM  | 0.78         | 10.95         |
| 3                           | 8:00 AM  | 0.78         | 11.09         |
| 4                           | 9:00 AM  | 0.78         | 10.87         |
| 5                           | 10:00 AM | 0.78         | 11.21         |
| 6                           | 11:00 AM | 0.78         | 11.38         |
| 7                           | 12:00 PM | 0.78         | 11.43         |
| 8                           | 1:00 PM  | 0.78         | 11.56         |
| 9                           | 2:00 PM  | 0.78         | 11.22         |
| 10                          | 3:00 PM  | 0.78         | 11.05         |
| 11                          | 4:00 PM  | 0.78         | 10.02         |
| 12                          | 5:00 PM  | 0.78         | 10            |
| 13                          | 6:00 PM  | 0.78         | 10.08         |
| 14                          | 7:00 PM  | 0.78         | 9.49          |
| 15                          | 8:00 PM  | 0.78         | 9.37          |
| 16                          | 9:00 PM  | 0.78         | 8.74          |
| 17                          | 10:00 PM | 0.78         | 9.68          |
| 18                          | 11:00 PM | 0.78         | 9.87          |
| Maximum Voltage and Current |          | 0.78         | 11.56         |

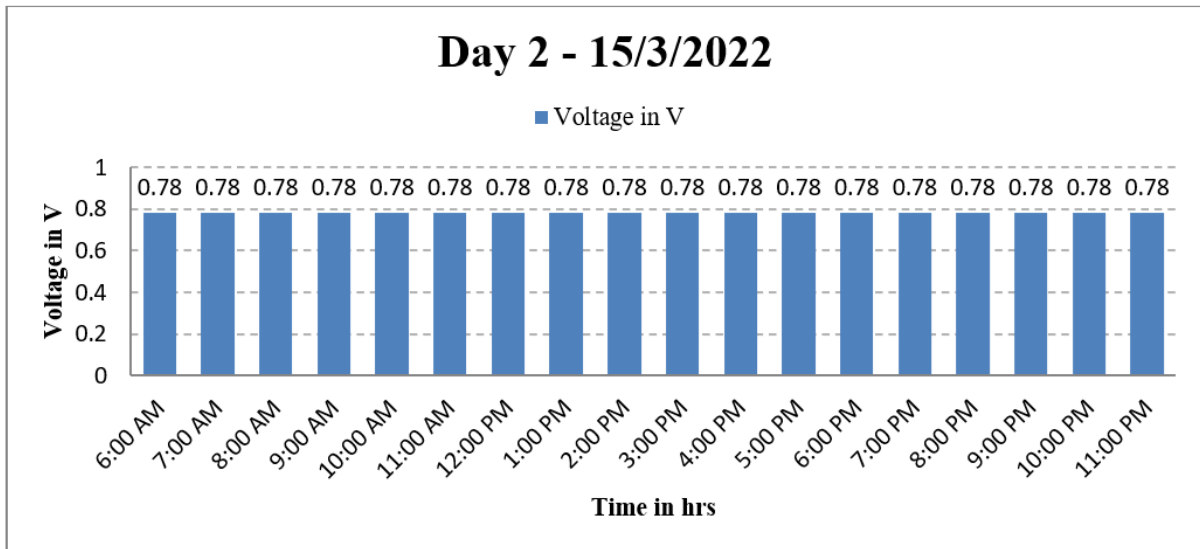


Figure 21: Day 2 Time vs Voltage graph in parallel connection

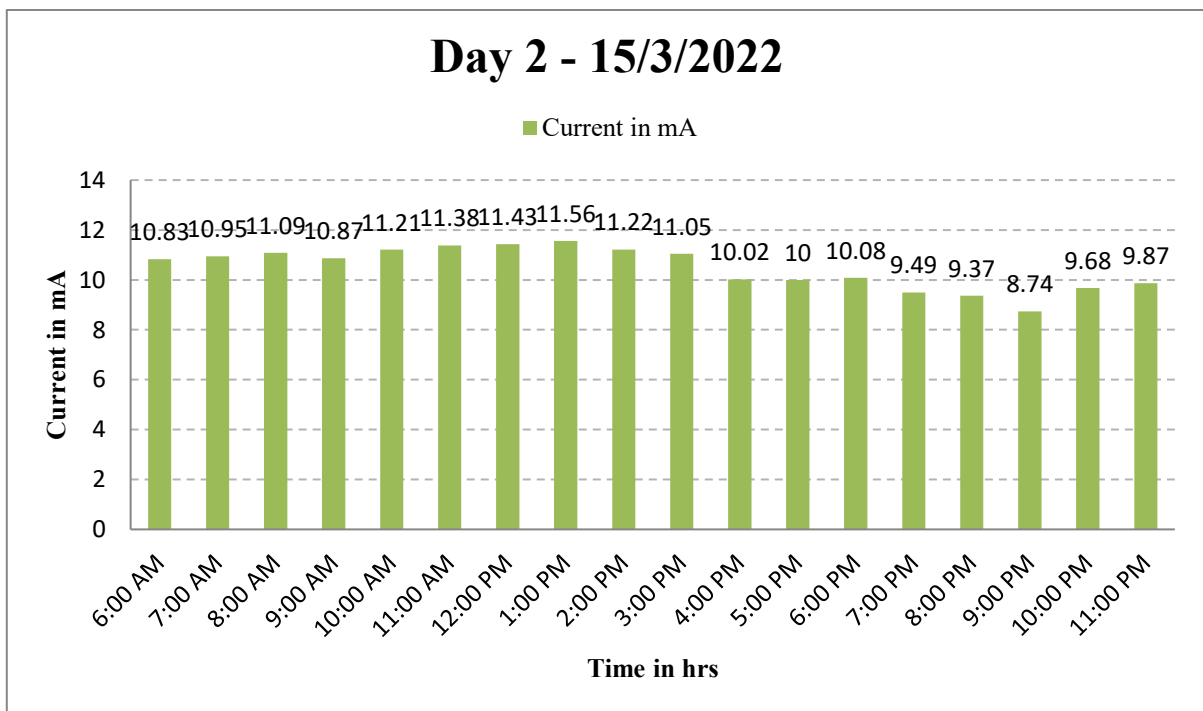


Figure 22: Day 2 Time vs Current graph in parallel connection

Table 9: 18hrs format - Day 3 – 16/3/2022

| S.No | Time     | Voltage in V | Current in mA |
|------|----------|--------------|---------------|
| 1    | 6:00 AM  | 0.78         | 8.53          |
| 2    | 7:00 AM  | 0.78         | 8.73          |
| 3    | 8:00 AM  | 0.79         | 8.21          |
| 4    | 9:00 AM  | 0.79         | 7.98          |
| 5    | 10:00 AM | 0.79         | 7.85          |
| 6    | 11:00 AM | 0.78         | 7.43          |
| 7    | 12:00 PM | 0.78         | 7.27          |

|                             |          |      |      |
|-----------------------------|----------|------|------|
| 8                           | 1:00 PM  | 0.78 | 6.9  |
| 9                           | 2:00 PM  | 0.78 | 6.73 |
| 10                          | 3:00 PM  | 0.75 | 6.52 |
| 11                          | 4:00 PM  | 0.75 | 6.14 |
| 12                          | 5:00 PM  | 0.75 | 5.57 |
| 13                          | 6:00 PM  | 0.78 | 4.5  |
| 14                          | 7:00 PM  | 0.78 | 4.88 |
| 15                          | 8:00 PM  | 0.75 | 6.24 |
| 16                          | 9:00 PM  | 0.75 | 6.36 |
| 17                          | 10:00 PM | 0.75 | 6.41 |
| 18                          | 11:00 PM | 0.75 | 6.29 |
| Maximum Voltage and Current |          | 0.79 | 8.73 |

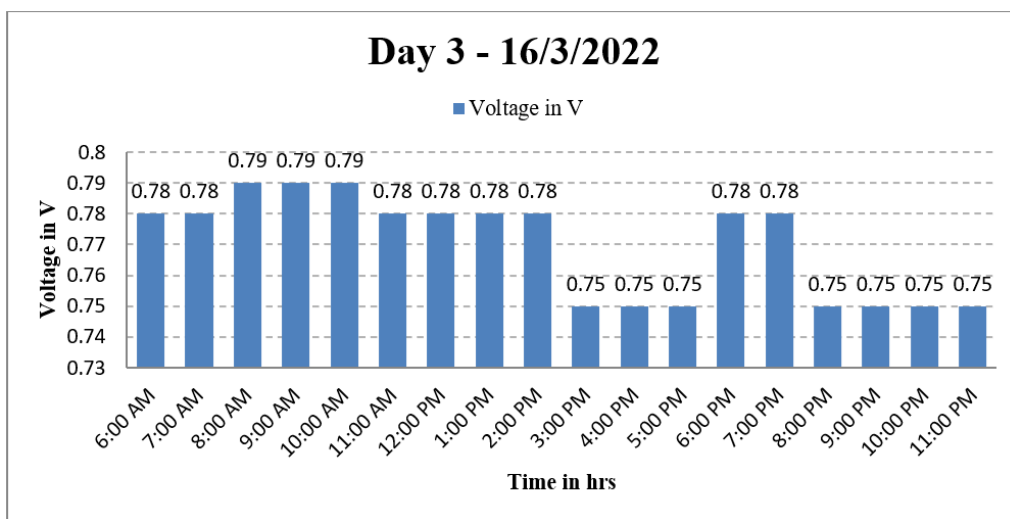


Figure 23: Day 3 Time vs Voltage graph in parallel connection

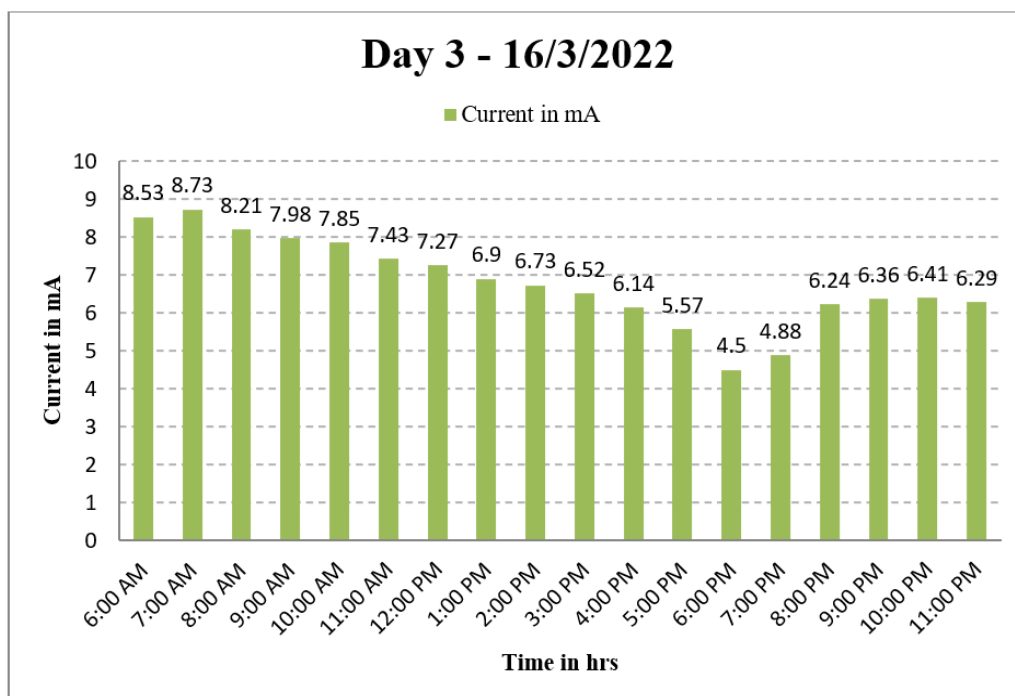


Figure 24: Day 3 Time vs Current graph in parallel connection

Table 10: 18hrs format - Day 4 – 17/3/2022

| S.No                        | Time     | Voltage in V | Current in mA |
|-----------------------------|----------|--------------|---------------|
| 1                           | 6:00 AM  | 0.73         | 6.21          |
| 2                           | 7:00 AM  | 0.73         | 6.34          |
| 3                           | 8:00 AM  | 0.73         | 6.29          |
| 4                           | 9:00 AM  | 0.75         | 6.48          |
| 5                           | 10:00 AM | 0.75         | 6.52          |
| 6                           | 11:00 AM | 0.75         | 6.27          |
| 7                           | 12:00 PM | 0.75         | 6.15          |
| 8                           | 1:00 PM  | 0.73         | 6.08          |
| 9                           | 2:00 PM  | 0.73         | 6.43          |
| 10                          | 3:00 PM  | 0.73         | 6.86          |
| 11                          | 4:00 PM  | 0.73         | 7.59          |
| 12                          | 5:00 PM  | 0.75         | 7.83          |
| 13                          | 6:00 PM  | 0.75         | 7.38          |
| 14                          | 7:00 PM  | 0.75         | 7.26          |
| 15                          | 8:00 PM  | 0.73         | 7.13          |
| 16                          | 9:00 PM  | 0.73         | 6.73          |
| 17                          | 10:00 PM | 0.73         | 6.51          |
| 18                          | 11:00 PM | 0.73         | 6.43          |
| Maximum Voltage and Current |          | 0.75         | 7.83          |

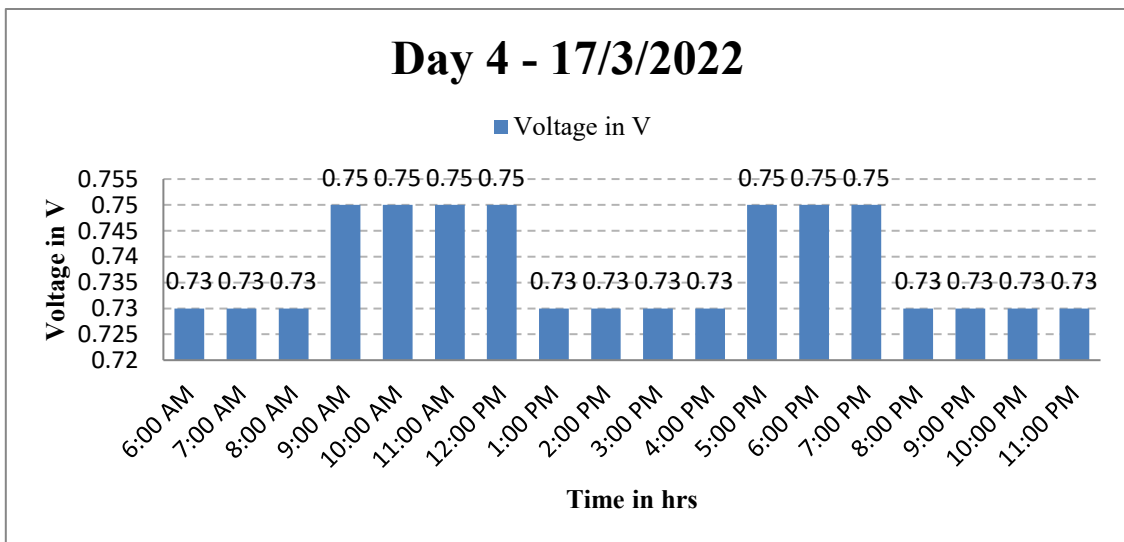


Figure 25: Day 4 Time vs Voltage graph in parallel connection

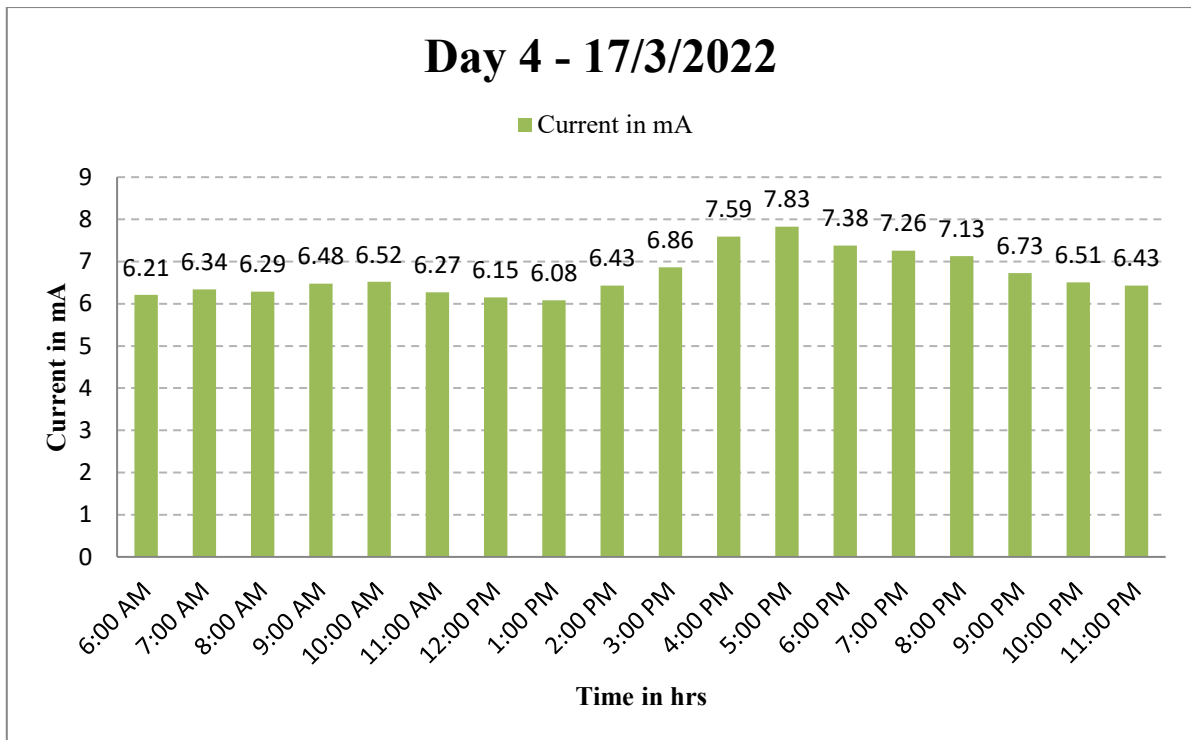


Figure 26: Day 4 Time vs Current graph in parallel connection

Table 11: 18hrs format - Day 5 – 18/3/2022

| S.No                        | Time     | Voltage in V | Current in mA |
|-----------------------------|----------|--------------|---------------|
| 1                           | 6:00 AM  | 0.7          | 6.21          |
| 2                           | 7:00 AM  | 0.7          | 6.3           |
| 3                           | 8:00 AM  | 0.71         | 6.29          |
| 4                           | 9:00 AM  | 0.71         | 6.18          |
| 5                           | 10:00 AM | 0.71         | 6.04          |
| 6                           | 11:00 AM | 0.71         | 6.17          |
| 7                           | 12:00 PM | 0.7          | 6.22          |
| 8                           | 1:00 PM  | 0.7          | 6.33          |
| 9                           | 2:00 PM  | 0.7          | 6.24          |
| 10                          | 3:00 PM  | 0.7          | 6.09          |
| 11                          | 4:00 PM  | 0.71         | 6.16          |
| 12                          | 5:00 PM  | 0.71         | 6.31          |
| 13                          | 6:00 PM  | 0.71         | 6.35          |
| 14                          | 7:00 PM  | 0.71         | 6.28          |
| 15                          | 8:00 PM  | 0.7          | 6.15          |
| 16                          | 9:00 PM  | 0.7          | 6.02          |
| 17                          | 10:00 PM | 0.7          | 5.9           |
| 18                          | 11:00 PM | 0.7          | 6.27          |
| Maximum Voltage and Current |          | 0.71         | 6.35          |

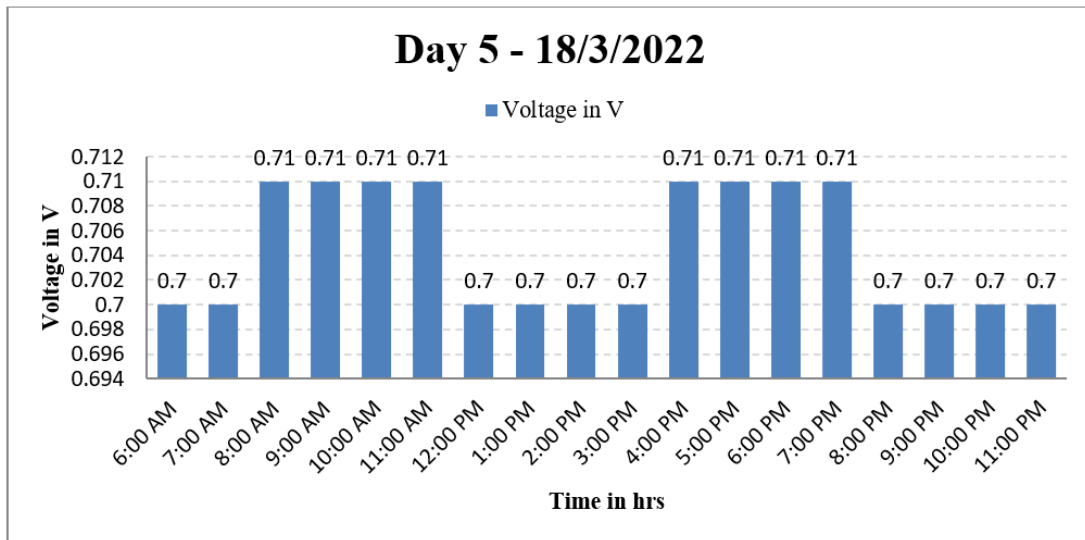


Figure 27: Day 5 Time vs Voltage graph in parallel connection

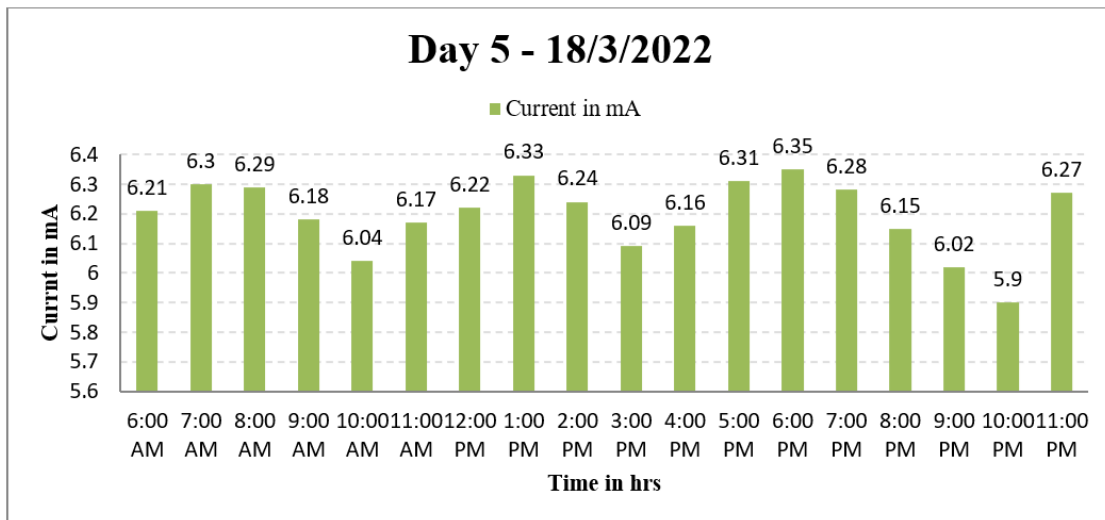


Figure 28: Day 5 Time vs Current graph in parallel connection

Table 12: 24hrs format - Date: 19/3/2022

| S.No | Time     | Voltage in V | Current in mA |
|------|----------|--------------|---------------|
| 1    | 6:00 AM  | 0.77         | 5.52          |
| 2    | 7:00 AM  | 0.77         | 5.43          |
| 3    | 8:00 AM  | 0.77         | 5.38          |
| 4    | 9:00 AM  | 0.77         | 5.34          |
| 5    | 10:00 AM | 0.77         | 5.26          |
| 6    | 11:00 AM | 0.78         | 5.17          |
| 7    | 12:00 PM | 0.78         | 5.09          |
| 8    | 1:00 PM  | 0.78         | 5.31          |
| 9    | 2:00 PM  | 0.77         | 5.45          |
| 10   | 3:00 PM  | 0.77         | 5.8           |
| 11   | 4:00 PM  | 0.77         | 5.74          |

|                             |          |      |      |
|-----------------------------|----------|------|------|
| 12                          | 5:00 PM  | 0.77 | 5.96 |
| 13                          | 6:00 PM  | 0.77 | 6.05 |
| 14                          | 7:00 PM  | 0.77 | 6.22 |
| 15                          | 8:00 PM  | 0.77 | 6.18 |
| 16                          | 9:00 PM  | 0.77 | 6.37 |
| 17                          | 10:00 PM | 0.77 | 6.45 |
| 18                          | 11:00 PM | 0.78 | 6.28 |
| 19                          | 12:00 AM | 0.78 | 6.13 |
| 20                          | 01:00 AM | 0.78 | 6.06 |
| 21                          | 02:00 AM | 0.78 | 5.21 |
| 22                          | 03:00 AM | 0.77 | 5.33 |
| 23                          | 04:00 AM | 0.77 | 5.62 |
| 24                          | 05:00 AM | 0.77 | 5.85 |
| Maximum Voltage and Current |          | 0.78 | 6.45 |

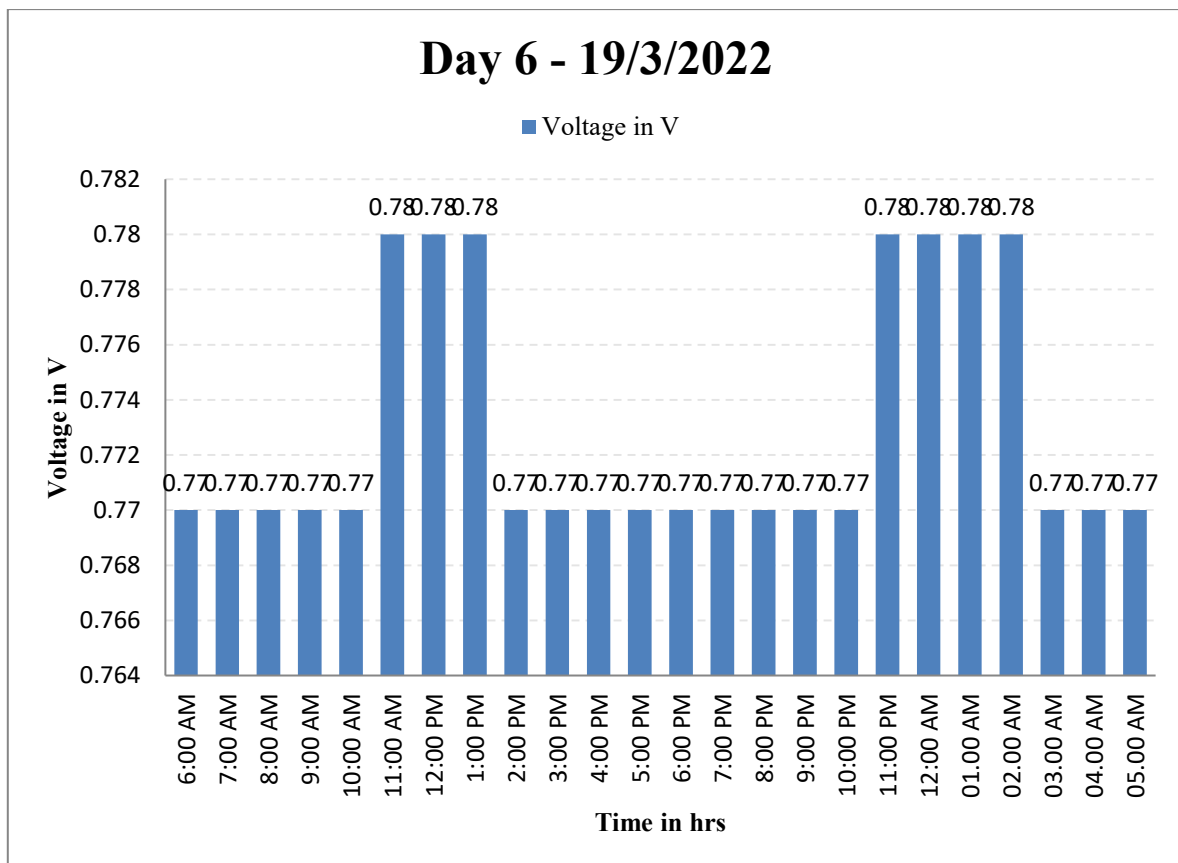


Figure 29: Day 6 Time vs Voltage graph in parallel connection

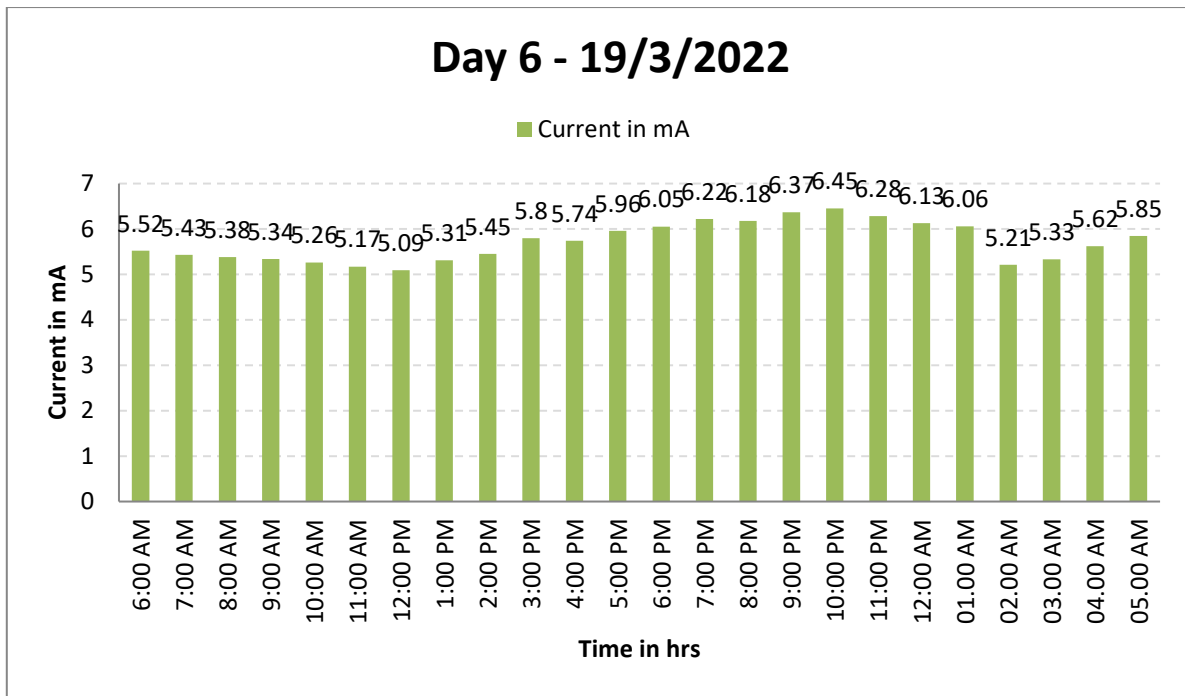


Figure 30: Day 6 Time vs Current graph in parallel connection

#### 4.3. Suggestions for Future work

This project can be improvised by implementing the following steps:

- The anode and cathode can be doubled which helps to double the efficiency
- The source can be changed to bio slurry, waste water treatment and pond water can be used.
- It can be connected with solar panels as a hybrid system.
- Plants having higher photosynthetic activity can be used
- The soil medium can only be used as cocopeat as the planting medium
- This can also be done in hydroponics method

#### V. CONCLUSION

The project's goal of producing bioelectricity from living plants was achieved by utilising the excess energy and the plant growth was not damaged at any point. The soil bacteria play a crucial role in assisting the production of bioelectricity. The cathode and anode were made of copper and zinc. This initiative is primarily concerned with the creation of eco innovative product and green source of energy. It helps to be a part of saving energy which can help to promote our country's energy security. This initiative can help to develop a green and environmentally beneficial power source that is always available. The left-out bacteria in the soil's rhizosphere layer helps in producing the power. The

photosynthetic process helps plants to create its own food, which then stores in its rhizosphere layer. The rhizosphere region serves as the source of this power. The cells were connected in series and parallel for 6 days each, and were observed. The series connection is said to provide high power output and it is comparatively more efficient than parallel connection. This environmentally friendly product attempts to prove energy at all times.

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