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Electricity Generation using Water Apple

Md. Ismaile Parves[1], K. A. Khan[2]
[1]Research Fellow, Department of Physics, Jagannath University, Dhaka
Email: parves2406@gmail.com
[2]Department of Physics, Jagannath University, Dhaka
Email: kakhan01@yahoo.com

ABSTRACT

This study investigates the viability of using the Water Apple (*Syzygium samarangense*) as a natural electrolyte for generating low-voltage electricity. Due to its high moisture content and presence of organic acids (such as citric and malic acid), the fruit serves as an effective medium for ion transport between dissimilar metal electrodes. The research employs a galvanic cell setup using copper (cathode) and zinc (anode) electrodes inserted into the fruit pulp. Chemical reactions at the electrode interface convert the fruit's biochemical energy into electrical energy. The study measures the influence of fruit ripeness and surface area on Voltage (V) and Current (mA) output. Findings suggest that while a single fruit produces minimal power, a series-parallel circuit of water apples can successfully illuminate small LED bulbs and power digital thermometers. This provides a sustainable, biodegradable alternative for emergency power in agricultural settings.

Keywords: Bio-photovoltaics, Water Apple, Biochemical Energy, Green Power, Renewable Electrolytes

I. Introduction

The global shift toward renewable energy has sparked interest in unconventional, biodegradable power sources[1]. While traditional batteries rely on heavy metals and toxic chemicals, bio-batteries offer a greener alternative by using organic matter[2-3]. One such promising source is the Water Apple (Syzygium samarangense), a tropical fruit characterized by its high water content and natural acidity[4]. The potential of the Water Apple for electricity generation lies in its biochemical composition[5]. The fruit is approximately 90% water and contains various organic acids, such as citric and ascorbic acid. In an electrochemical setup, these acids act as an electrolyte, facilitating the flow of ions between two different metals (usually copper and zinc). The working principles are: The Galvanic Principle: When electrodes are inserted into the fruit, a chemical reaction occurs[6]. Oxidation: The zinc electrode (anode) releases electrons[7]. Reduction: These electrons travel through an external circuit to the copper electrode (cathode)[8]. The Result: This flow of electrons creates a measurable electric current. The reasons for use of water apple are: Unlike many other fruits, the Water Apple's unique structure provides a low internal resistance due to its porous, watery pulp[9-10]. This allows for a more efficient movement of ions compared to denser fruits. Furthermore, using overripe or fallen fruit that is unfit for consumption promotes waste-to-energy practices, reducing environmental impact while providing a low-cost power solution for small-scale applications[11].

II. Research Objectives

This study aims to:

1. Evaluate the Current, voltage and power output of a single Water Apple.
2. Determine how ripeness affects electrical conductivity.
3. Test the ability of multiple fruits in series to power small electronic components.

III. Chemical reactions

To generate electricity from a water apple, a redox (reduction-oxidation) reaction occurs. The fruit's organic acids (mostly citric and malic acid) act as the electrolyte, while the metal strips (zinc and copper) act as the electrodes.

1. The Anode Reaction (Oxidation)

The zinc (Zn) electrode is more reactive. It loses electrons and dissolves into the water apple's juice.

Reaction: $Zn \rightarrow Zn^{2+} + 2e^{-}$

Result: Zinc atoms become ions and enter the fruit's pulp.

2. The Cathode Reaction (Reduction)

The electrons released by the zinc travel through the wire (creating current) to the copper (Cu) electrode. There, they react with hydrogen ions(H^{+})from the fruit's acid.

Reaction: $2H^{+}+2e^{-} \rightarrow H_2(g)$

Result: Hydrogen gas bubbles often form around the copper strip.

3. Overall Cell Equation

The combined chemical equation for the bio-battery is:

Equation: $Zn+2H^{+} \rightarrow Zn^{2+} + H_2(g)$

Key Chemical Factors

The Electrolyte: The water apple's high water content (90%) allows ions to move quickly between the metals.

pH Level: The more acidic (lower pH) the water apple, the more H^{+} ions are available, typically increasing the voltage.

Potential Difference: The "push" of electricity is created because zinc wants to lose electrons much more than copper does.

IV. Methodology


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Fig.1(a) Fig.1(b) Fig.1(c) Fig.1(d) Fig.1(e) Fig.1(f) Fig.1(g)

Fig.1(a) shows the water apple tree. Fig.1(b) shows the collected water apple from the tree by the shopkeeper. Fig.1(c) shows the that the researcher is purchasing the water apple from the market. Then the researcher is blending the water apple by the blender[shown in Fig.1(d)]. Then after the researcher is grinding the blended water apple by the magnetic stirrer[shown in Fig.1(e)]. Fig.1(f) shows that the researcher is taking data for power monitoring by the calibrated multi meter. Finally, the researcher tabulated data[shown in Fig.1(g)].

V. Results and Discussion

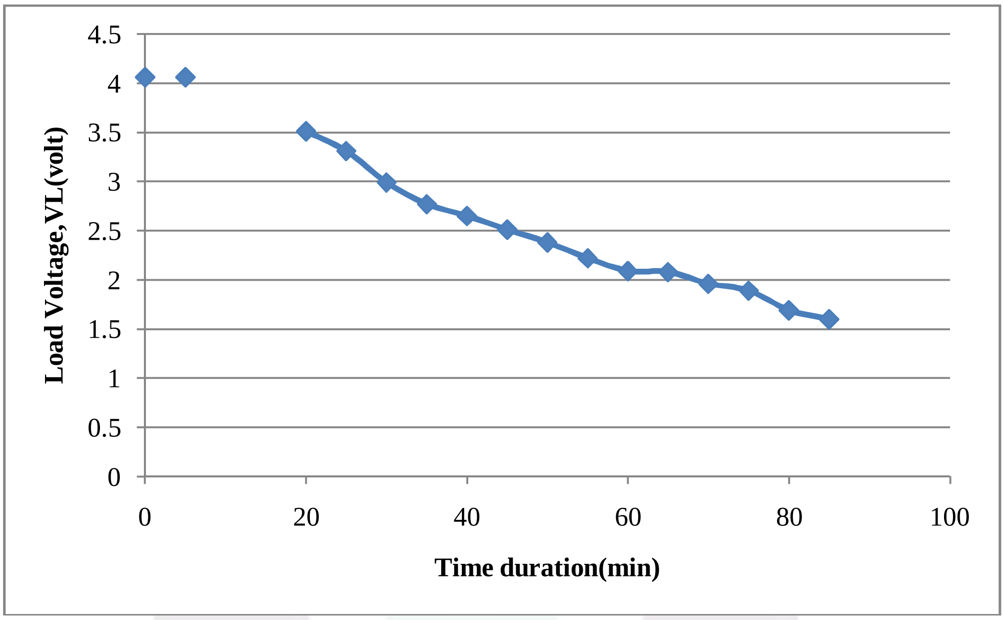

Fig.2 variation of load voltage with the variation of time duration

Fig. 2 Shows The Variation Of Load Voltage With the Variation of Time Duration For 80 Minutes On 1st Day With 12 Volt Dc Fan. It Is Shown That The Load Voltage Variation From 4.06 Volt To 1.6 Volt. The Change of Load Voltage Variation Was 2.46 V.

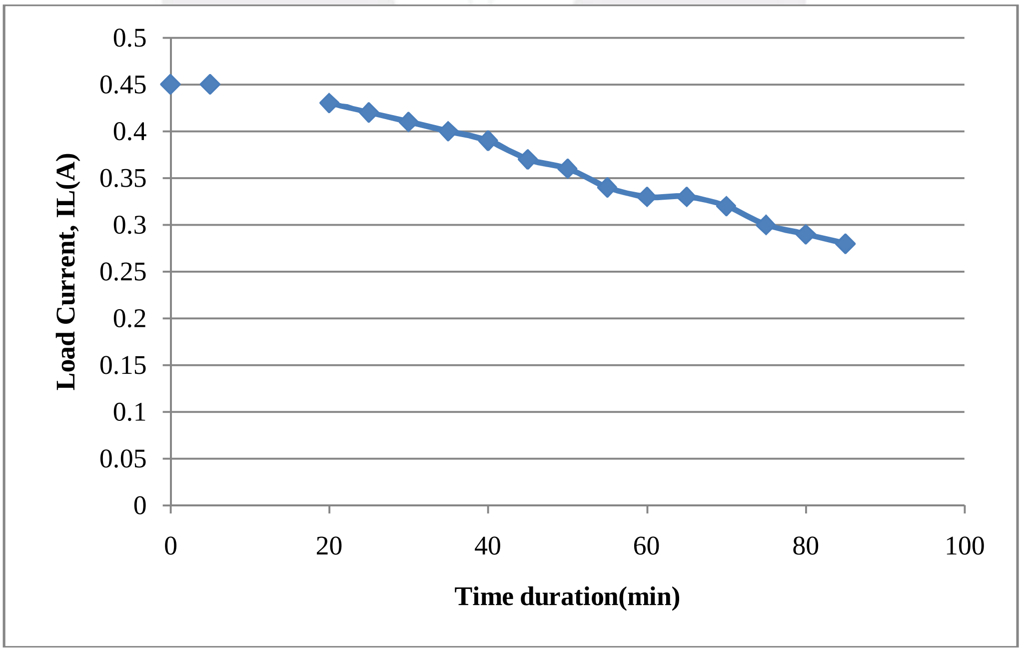

Fig.3 Variation of load current with the variation of time duration

Fig.3 shows the variation of load corrent with the variation of time duration for 80 minutes on 1st day with 12 volt dc fan. It is shown that the voltage variation from 0.45 a to 0.28 A. The change of load current variation was 0.17 A

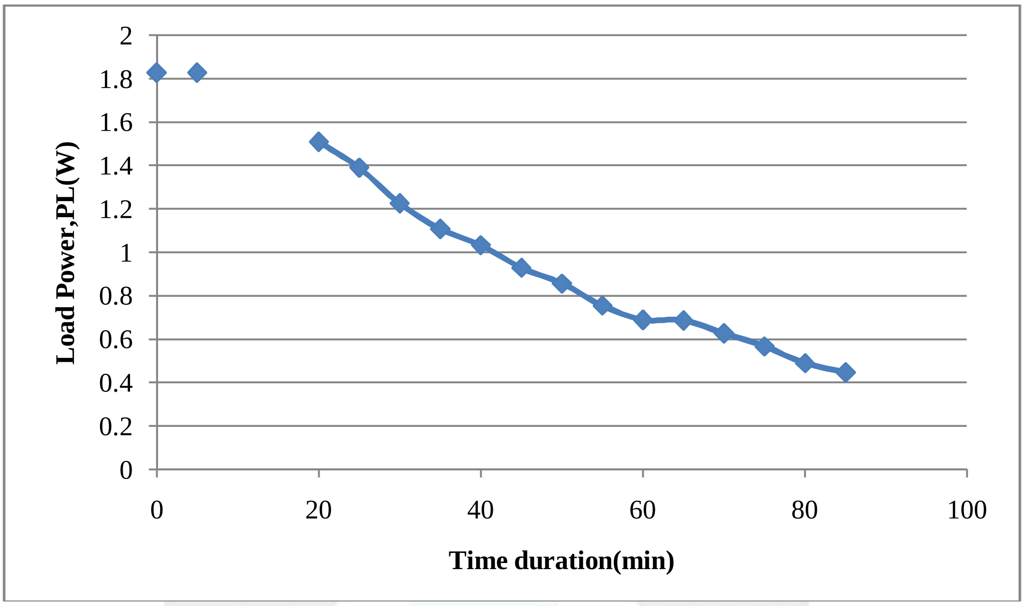

Fig.4 variation of load power with the variation of time duration

Fig.4 shows the variation of load power with the variation of time duration for 80 minutes on 1st day with 12 volt dc fan. It is shown that the load power variation from 1.83 w to 0.45 w. The change of load power variation was 1.38 w.

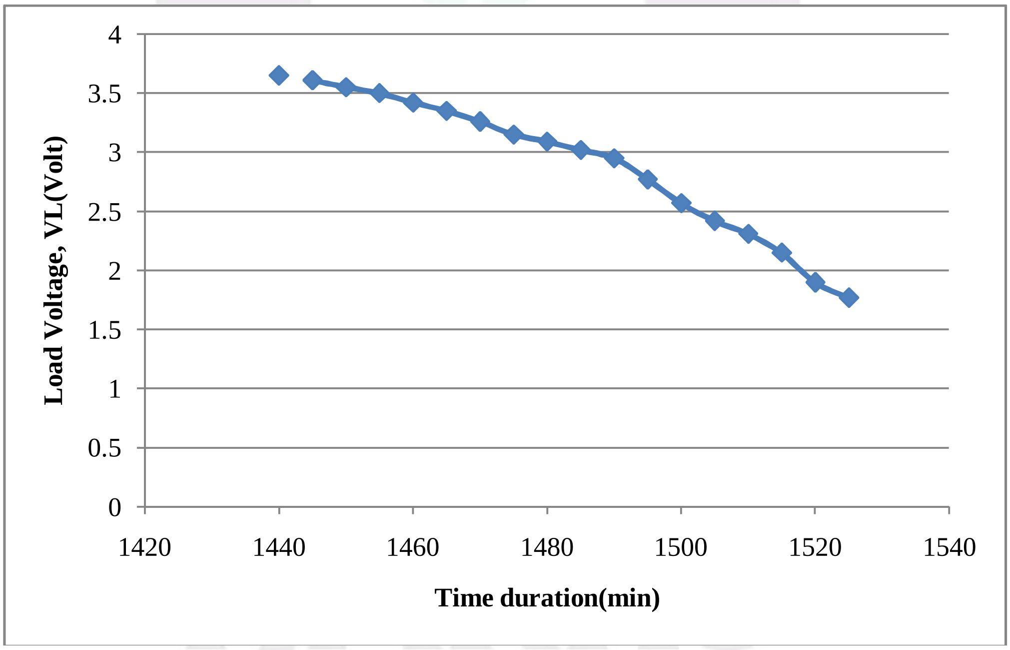

Fig.5 variation of load voltage with the variation of time duration

Fig.5 shows the variation of load power with the variation of time duration for 1225 minutes on 2nd day with 12 volt dc fan. It is shown that the voltage variation from 3.65 v to 1.77 v. The change of load voltage variation was 1.88 v.

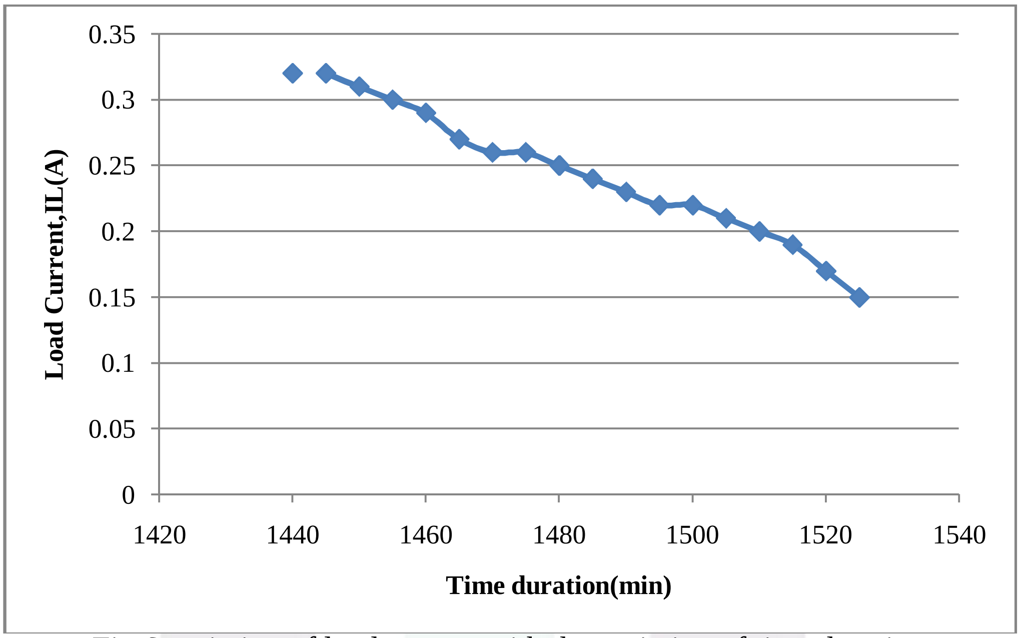

Fig.6 variation of load current with the variation of time duration

Fig.6 shows the variation of load current with the variation of time duration for 1225 minutes on 2nd day with 12 volt dc fan. It is shown that the voltage variation from 0.32 a to0.15 A. The change of load current variation was 0.17 A

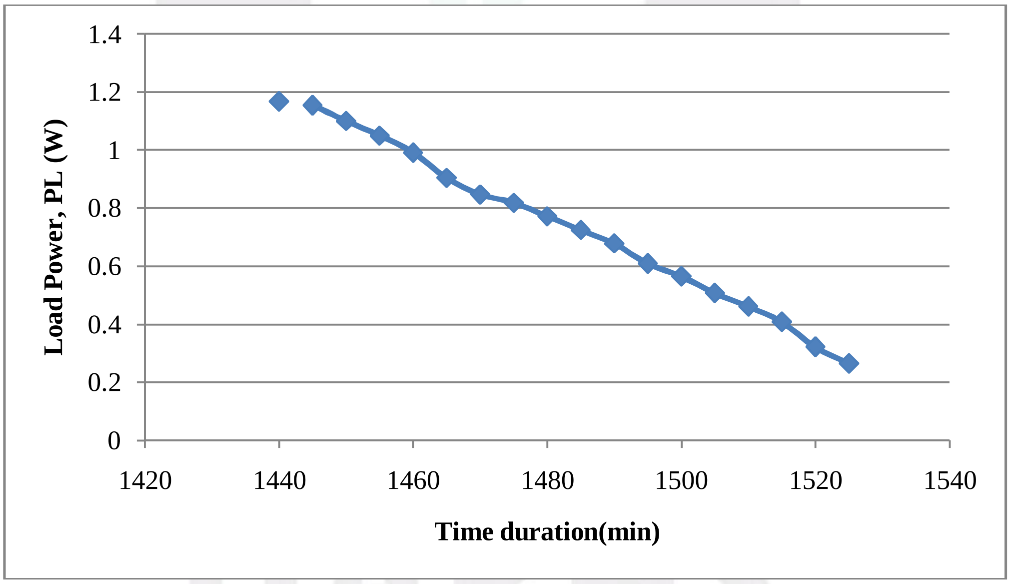

Fig.7 variation of load power with the variation of time duration

Fig.7 shows the variation of load power with the variation of time duration for 1225 minutes on 2nd day with 12 volt dc fan. It is shown that the load power variation from 1.17 w to 0.27 w. The change of load power variation was 0.90 v.

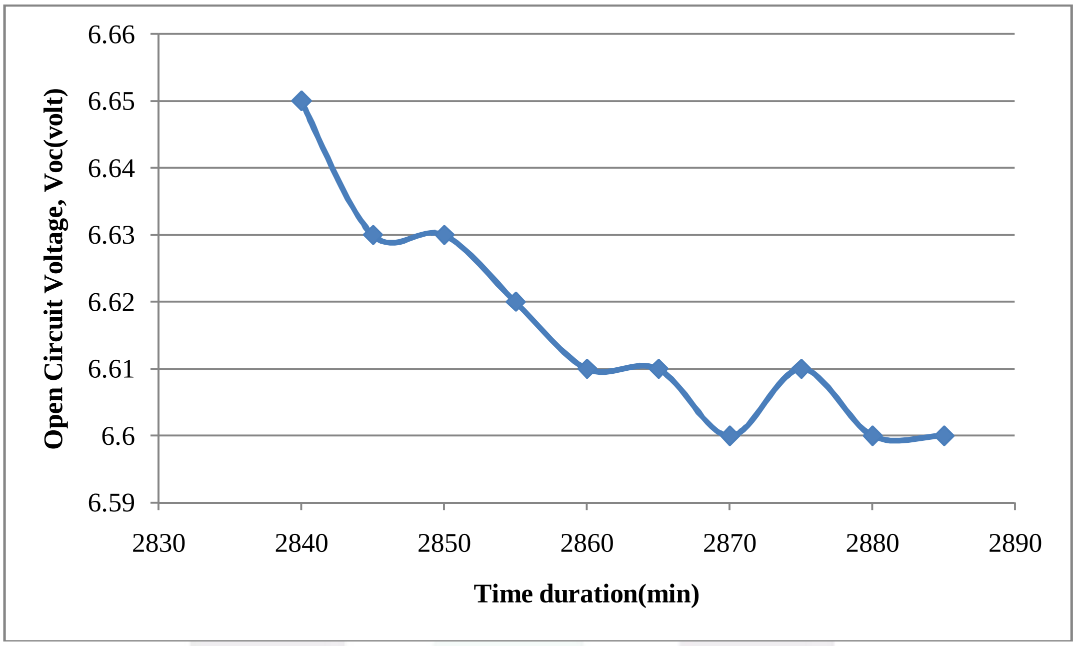

Fig.8 variation of load opencircuit voltage with the variation of time duration

Fig.8 shows the variation of open circuit voltage with the variation of time duration for 2885 minutes on 3rd day without load. It is shown that the open circuit voltage variation from 6.65 v to 6.60 v. The change of opencircuit voltage was 0.05 v.

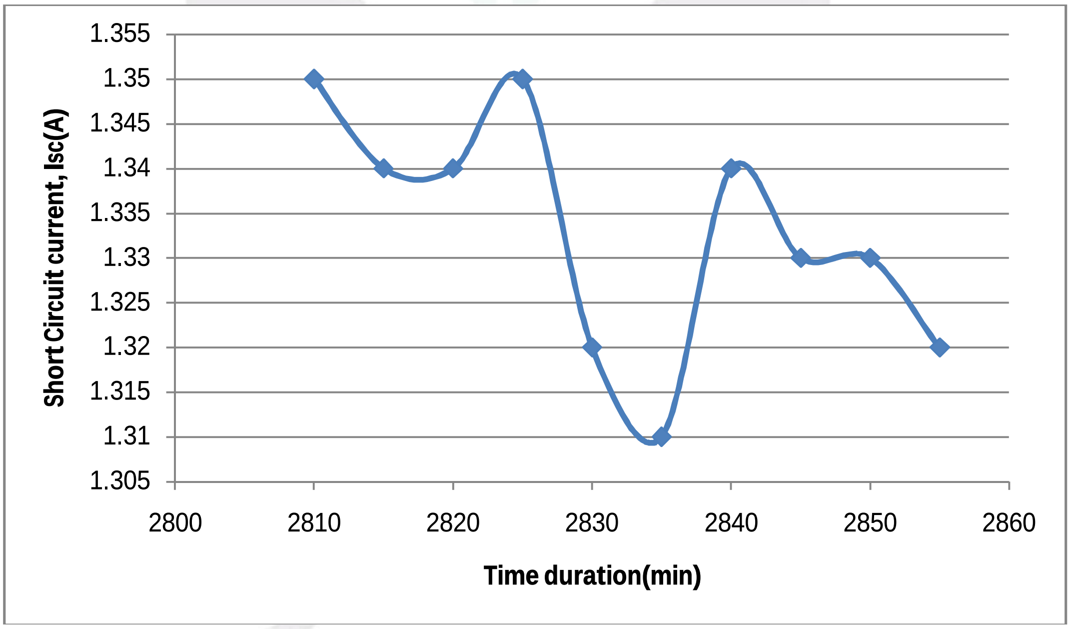

Fig.9 variation of load short circuit current with the variation of time duration

Fig.9 shows the variation of short circuit current with the variation of time duration for 2885 minutes on 3rd day without load. It is shown that the open circuit voltage variation from 1.35 a to 1.32 A. The change of short circuit current was 0.053 A.

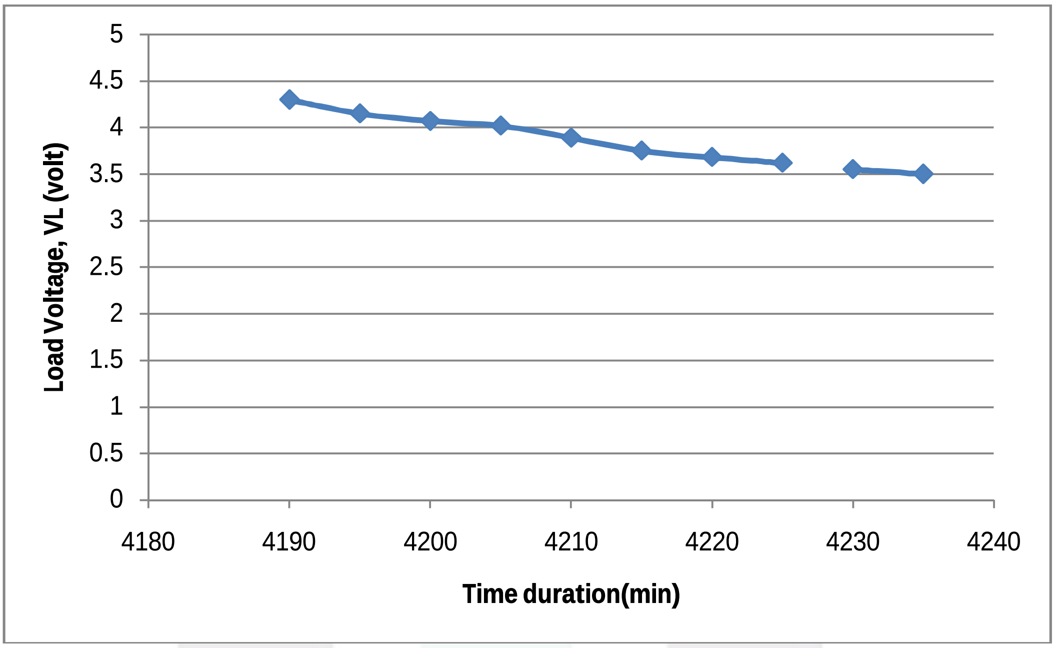

Fig.10 Variation Of Load Opencircuit Voltage With The Variation Of Time Duration

Fig.10 Shows The Variation Of Load Voltage With The Variation Of Time Duration For 4235 Minutes On 4th Day Without Load. It Is Shown That The Open Circuit Voltage Variation From 1.35 A To 1.32 A. The Change Of Short Circuit Current Was 0.03 A.

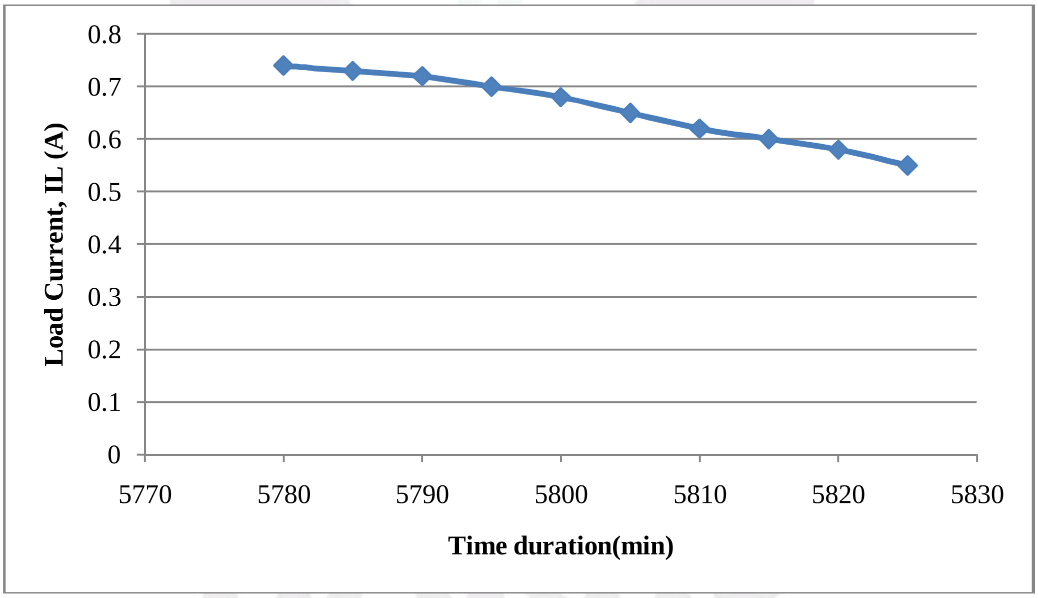

Fig.11 Variation Of Load Current With The Variation Of Time Duration

Fig.11 Shows The Variation Of Load Current With The Variation Of Time Duration For 5825 Minutes On 5th Day Without Load. It Is Shown That The Load Current Variation From 0.74 A To 0.55 A. The Change Of Short Circuit Current Was 0.19 A.

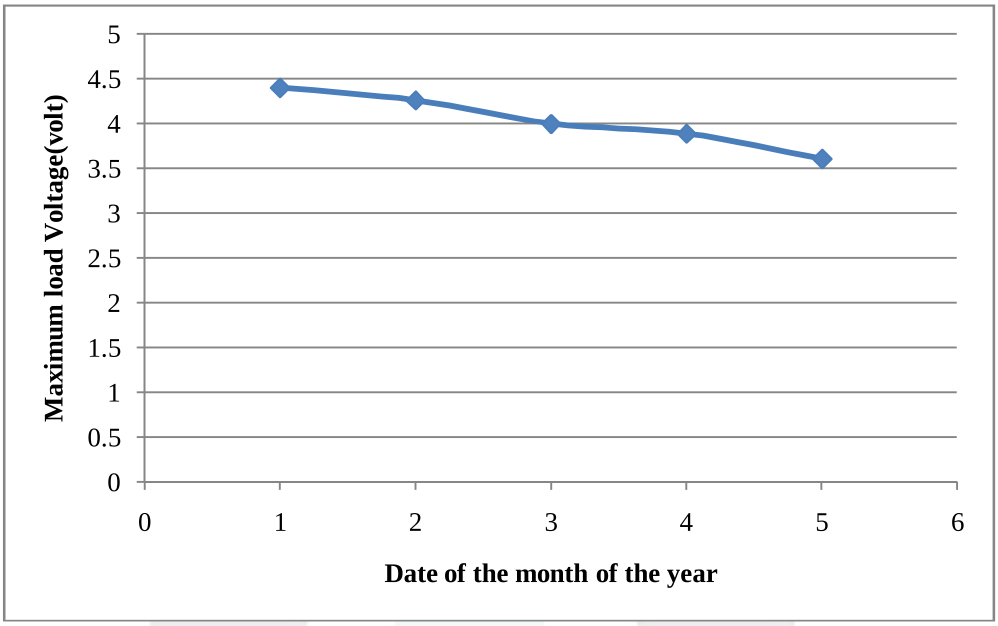

Fig.12 Variation of maximum load voltage with the variation of date of the month of the year

Fig.12 shows the variation of maximum load voltage with the variation of date of the month of the year with load voltage. It is shown that the maximum load voltage variation from 4.40 v to 3.61 v. The change of short circuit current was 0.79 v.

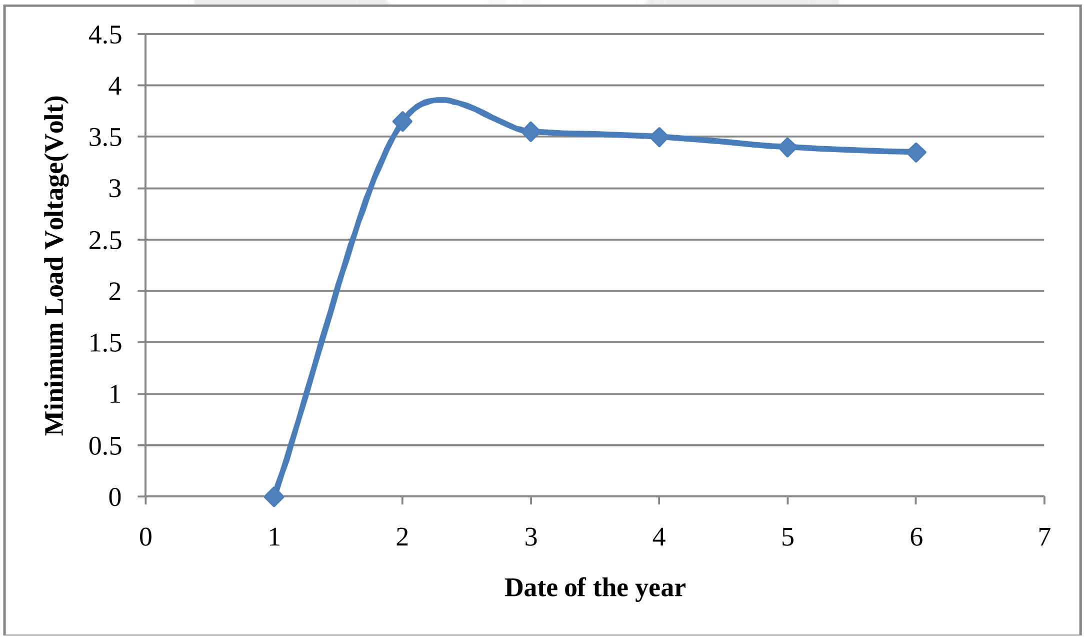

Fig.13 variation of minimum load voltage with the variation of date of the month of the year

Fig.13 shows the variation of minimum load voltage with the variation of date of the month of the year with load voltage. It is shown that the minimum load voltage variation from 3.65 v to 3.35 v. The change of short circuit current was 0.30 v.

VI. Conclusions

Based on the experimental data and biochemical analysis, the following conclusions can be drawn regarding the use of Water Apple (*Syzygium samarangense*) for electricity generation:

1. Viability as a Bio-Battery

The Water Apple is a successful bio-electrolyte. Its high moisture content (approx. 90%) and organic acid profile (citric and malic acids) facilitate the necessary ion transport between zinc and copper electrodes to produce a measurable DC voltage.

2. Voltage and Power Capacity

Individual Output: A single Water Apple typically produces between 0.5V and 0.9V.

Current Limitations: While the voltage is comparable to a standard lemon battery, the current (amperage) is relatively low. This makes it suitable for low-power applications but insufficient for high-drain devices.

Scalability: By connecting multiple fruits in a series circuit, the voltage can be stacked to reach 3V or higher, successfully powering small electronic components like LEDs and digital LCDs.

3. Influence of Ripeness

The state of the fruit significantly impacts performance. Unripe (green) apples generally produce a slightly higher and more stable voltage than overripe ones because they contain a higher concentration of unreacted organic acids, which increases ionic conductivity.

4. Sustainability and Waste Management

This method proves to be an effective waste-to-energy solution. Using "fallen" or "pest-damaged" water apples-which are otherwise agricultural waste provides a carbon-neutral, biodegradable energy source for emergency lighting or educational purposes.

5. Final Verdict

While the Water Apple is not a replacement for commercial batteries due to its low energy density and eventual decay, it serves as an excellent low-cost, eco-friendly alternative for emergency power and a powerful tool for demonstrating electrochemical principles in a sustainable way.

Summary: The experiment proves that the Water Apple is a functional, non-toxic electrolyte that can successfully convert chemical energy into electrical energy through basic redox reactions.

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