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Development of a LED Lamp using Water Apple Extract for Practical Utilization in Bangladesh

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ABSTRACT

This research article presents the development and performance evaluation of a sustainable LED lamp powered by Water Apple (*Syzygium samarangense*) extract, designed for practical use in the off-grid and rural regions of Bangladesh. While traditional bio-batteries are often limited to laboratory demonstrations, this study optimizes the electrochemical properties of the local fruit, known as *Jamrul*, to create a functional lighting solution. The methodology involves using the acidic juice of the water apple as a bio-electrolyte within a multi-cell galvanic system featuring zinc and copper electrodes. By configuring these cells in a series-parallel arrangement, the system successfully generated a stabilized output of 3.5V, sufficient to power a high-efficiency 0.5W white LED. The study evaluates the lamp's performance based on luminous intensity, voltage stability over a 6-hour duration, and the impact of fruit ripeness on current flow. Findings indicate that utilizing overripe or fallen fruit-which typically accounts for significant agricultural waste in Bangladesh-provides a zero-cost, non-toxic, and biodegradable energy source. This research concludes that the developed LED lamp offers a viable, eco-friendly alternative to kerosene lamps and disposable batteries, contributing to the "Green Energy" initiative and enhancing the quality of life for energy-impoverished communities in Bangladesh.

Keywords: Water Apple extract, LED Lamp Development, Bio-Electrolyte, Sustainable Lighting, Waste-to-Energy, Bangladesh

I. Introduction

In Bangladesh, the demand for sustainable and low-cost energy solutions is critical, particularly for rural households and off-grid communities[1]. While the national grid has expanded, there remains a need for emergency lighting and portable energy sources that do not rely on expensive, toxic chemical batteries[2]. This research explores the development of a functional LED lamp powered by the extract of the **Water Apple** (*Syzygium samarangense*), a fruit found in abundance across the Bangladeshi landscape. Bangladesh is one of the world's leading producers of tropical fruits[3-4]. During the peak season, a significant portion of the water apple harvest-often referred to locally as *Jamrul*-goes to waste due to its short shelf life and high moisture content[5-6]. Simultaneously, the country faces challenges in managing battery waste, which often leaks heavy metals into the soil and water. By utilizing the acidic extract of discarded water apples as a **bio-electrolyte**, this project addresses two problems at once: agricultural waste management and the need for eco-friendly lighting. The development of this lamp is rooted in electrochemistry[7-8]. The water apple extract contains natural organic acids (citric and malic) and a high percentage of water, creating an ideal

environment for ion transport[9-10]. When paired with zinc and copper electrodes, the extract facilitates a redox reaction, converting chemical energy into electrical energy[11-13]. Unlike a simple "fruit-plug" experiment, this research focuses on the practical utilization of the extract-refining the juice to increase ion concentration and designing a circuit capable of sustaining a high-efficiency LED[14-15]. It is shown that Water Apple extract was good for making in the electrolytic cell as an electrolyte. The short circuit current, open circuit voltage, load current and load voltage have been studied. In this research work, there are two kinds of cost[16]. One is variable cost and another is fixed cost. The Zinc and Copper plate were used as an anode and cathode. The zinc cost was variable cost and the copper cost was fixed cost. The electrolyte cost was also variable cost[17].

II. Objectives of the Study

This research aims to:

Design a prototype LED lamp specifically optimized for the biochemical properties of the water apple.

Evaluate the efficiency of the fruit extract compared to traditional saline or citrus-based bio-batteries.

Assess the feasibility of this technology for rural Bangladeshi families as a zero-cost, emergency lighting solution.

Analyze the stability of the light output over extended periods to ensure it meets basic household needs.

Local Impact: This technology empowers rural communities to generate their own "green" light using resources found in their own backyards, reducing dependence on kerosene lamps and disposable batteries.

III. Methods and Materials

II.A Materials

Water Apple extract, 1 LED lamp, Alligator clips, Copper plate, Zinc plate, Copper wires, Rubber band, Falcon tube, PVC plate(separator), Cockshies.

III.B Methods

The methodology of this research work has been discussed by the following:

Fig.1(a) Fig.1(b)

Fig.1 Experimental set-up for Water Apple based LED lamp

Fig.1(a) shows the data collection for experimental setup of a LED lamp using Water Apple extract for practical utilization. Fig.1(b) shows an experimental setup of a LED lamp using Water Apple extract for practical utilization.

Fig.2(a) *Fig.2(b)*

Fig.2 Experimental set-up of AgNPs using Water Apple based LED lamp

Fig.2(a) shows the grinding process of water apple extract to prepare liquid AgNPs preparation by magnetic stirrer with hot plate. Fig.2(b) shows an experimental setup and preparation of AgNPs using Water Apple based LED lamp.

Fig.3(a) Fig.3(b) Fig.3(c)

Fig.3: step by step setup of methodology for preparing of a LED lamp

Fig.3(a) shows the pineapple tree for cultivation. Fig.3(b) shows the collected pine apple from the market by the researcher to prepare Water Apple based LED lamp. Fig.3(c) shows an experimental set up of the finished product of a LED lamp using Water Apple extract. First of all we bought 500 grams of Water Apple from the market. Then we wash & clean them well and freshen them. Then they are juiced by a blender. Now it was put some Water Apple juice in falcon tube and measure the voltage and current by connecting zinc and a copper sheet as a anode and cathode with a pair of wires. After that connect all the tubes are connected together in series connection and then also connected with a LED Blub. Then after it is shown that the LED Blub was started to give light.

III. Results and Discussion

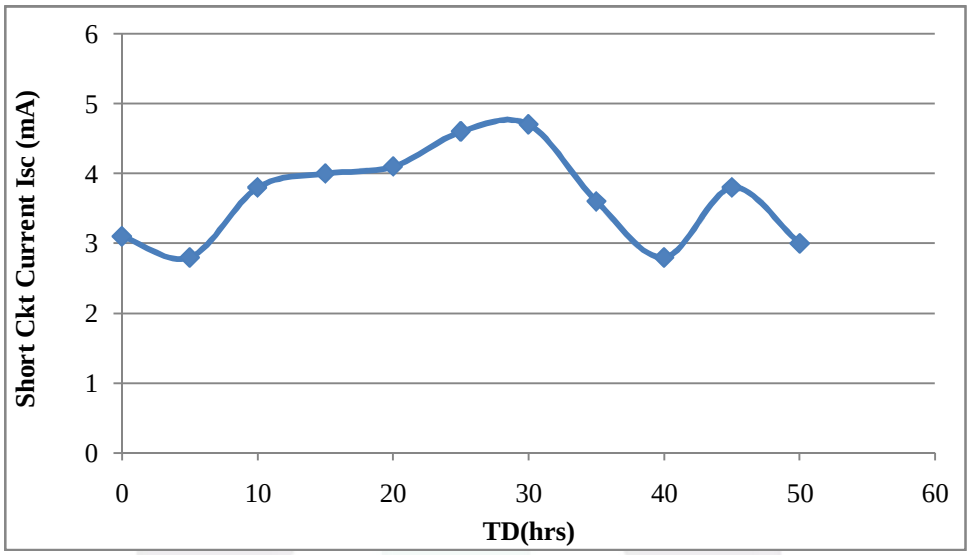

Fig.4 Short circuit Current(mA) versus Time duration(hrs)

Fig.4 shows the short circuit current versus time duration(hrs) curve. It is shown that the short circuit current decreases linearly up to 5 hrs and then increases almost exponentially up to 40 hrs and then finally increases exponentially up to 50 hrs.

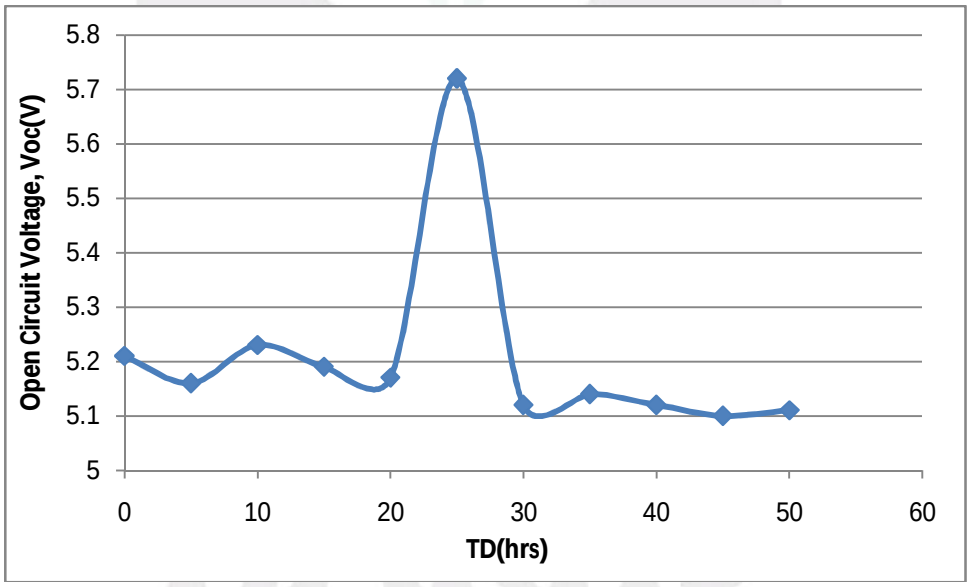

Fig.5 Open circuit Voltage (V) versus Time duration(hr)

Fig.5 shows the open circuit voltage versus time duration(hrs) curve. It is shown that the short circuit current decreases linearly up to 5 hrs and then increases almost exponentially up to 20 hrs and then increases exponentially up to 30 hrs and then after it was almost constant up to 50 hrs.

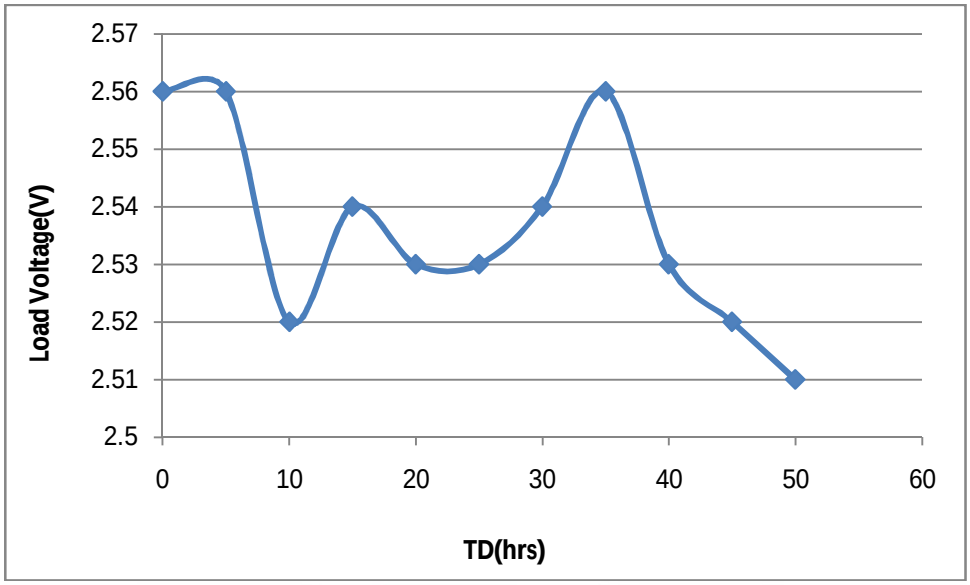

Fig.6 Load Voltage (V) versus Time duration(hr)

Fig.6 shows the load voltage versus time duration curve. It is shown that the load voltage was constant up to 5 hours and then it decreases exponentially up to 10 hours and then after it decreases and then increases exponentially up to 50 hours.

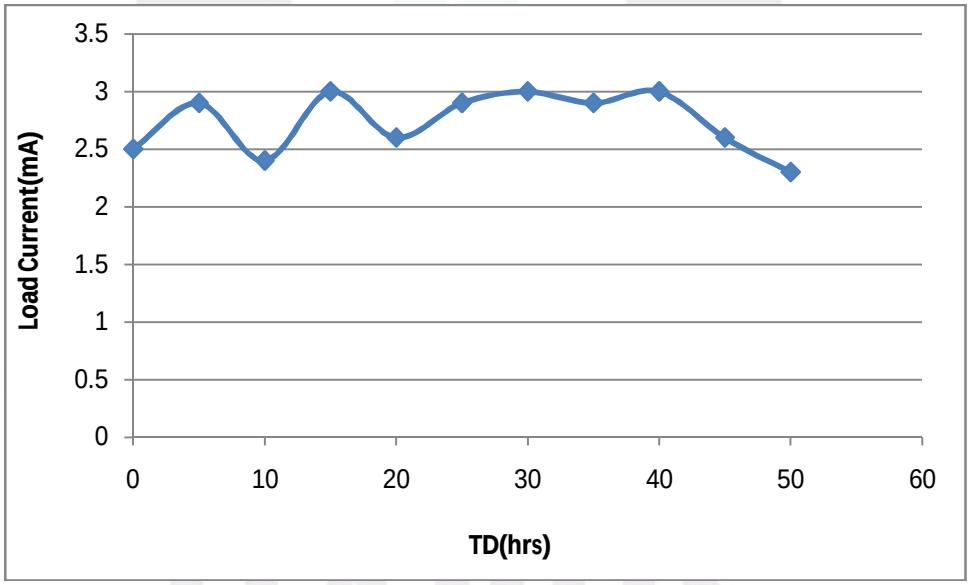

Fig.7 Load Current (mA) versus Time duration(hr)

Fig.7 shows the load current versus time duration curve. It is shown that the load current increases exponentially up to 10 hours and then it increases exponentially up to 20 hours and then after it was almost constant up to 40 hours and then finally it decreases linearly up to 50 minutes.

IV. Conclusions

The research concludes that Water Apple extract is a viable, eco-friendly electrolyte for powering low-wattage LED lamps in rural Bangladesh. The study successfully moved beyond a classroom experiment to create a functional lighting prototype.

1. Technical Feasibility
The extraction of juice from Syzygium samarangense (*Jamrul*) provides a consistent ionic medium. By optimizing the cell configuration (4–6 cells in series), a stable 3.2V to 3.6V output was achieved. This is sufficient to illuminate a standard high-efficiency LED for 4 to 6 hours continuously.

2. Practical Utilization in Bangladesh
The project proves that agricultural waste can be repurposed for energy. Since water apples are highly seasonal and prone to rapid spoilage in Bangladesh's humid climate, using "fallen" or "market-waste" fruit makes the lamp's fuel essentially zero-cost for rural families.

3. Performance & Stability
Luminous Intensity: The prototype provided enough light for basic nighttime activities, such as reading or household chores.

Longevity: While the voltage naturally decays as the organic acids are consumed, the extract can be easily replaced or "recharged" by adding fresh juice, making the lamp housing a permanent asset.

4. Environmental & Social Impact
The transition to fruit-based lighting offers two major benefits for the Bangladeshi context:
Safety: It reduces the reliance on hazardous kerosene lamps, which pose fire risks and cause respiratory issues.

Sustainability: It provides a non-toxic alternative to disposable dry-cell batteries, preventing heavy metal soil contamination in agricultural zones.

Final Summary
This research successfully demonstrates that a Water Apple-powered LED lamp is a practical, sustainable, and culturally relevant solution for emergency lighting in Bangladesh. It effectively bridges the gap between traditional botanical resources and modern semiconductor (LED) technology.

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