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# CONSTRUCTION OF BIO-BATTERY FROM VEGETABLE WASTE

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***Abstract:*** This project is focused on energy harvesting and energy storage through renewable sources. In many cases, vegetables may either get rotted or the market gets full due to imbalance in supply, price and demand. The waste vegetables and wild plants contain electrochemically active compounds, which can be used for preparation of rechargeable bio-battery cells. In this project, a set of battery cells was constructed by coupling the electroactive compounds of Onion-Radish, Onion-Bitter Orange, Onion-Cactus, Turnip-Radish, Turnip-bitter orange and Turnip-cactus. The fresh juices of these vegetable combinations were used and the reaction conditions were optimized to maximize the output voltage. The output voltage was measured before and after charging of cells for different charging times, juice volume and charging voltage. Among the investigated batteries, turnip-cactus single cell battery produced an open circuit voltage of 2.13 V while the onion-radish battery produced an open circuit voltage.

***Index Terms*** – Bio-Battery, Waste Management.

## I. Introduction

In recent years, there has been a notable shift towards embracing green, sustainable, and renewable energy sources due to concerns over fossil fuel depletion and environmental impact. While renewable sources like wind and solar energy show promise, their intermittent nature poses a challenge. Innovative solutions are needed, and rechargeable batteries emerge as a compelling option. They are essential for storing energy across various applications, from small devices to vehicles and heavy machinery. The effectiveness of batteries depends on factors such as energy storage capacity, recharging time, safety, biodegradability, and environmental impact. Biofuel cells, unlike bio-batteries, utilize electrodes separated by a liquid electrolyte and a membrane to regulate ion transport, facilitating electricity production. Surplus vegetables often face the risk of rotting or oversupply, leading to market saturation and unsuitability for consumption. Interestingly, these discarded vegetables, along with wild plants, contain electrochemically active compounds capable of generating electricity when paired with appropriate electrodes. This presents an opportunity to utilize these vegetables in creating rechargeable bio-batteries.

The future of battery technology holds significant promise as researchers and engineers push the boundaries of energy storage. As the world shifts towards sustainable energy, batteries play a crucial role in mitigating the intermittency of renewable energy sources and powering various electronic devices. Solid-state batteries, in particular, are anticipated to revolutionize the field. Unlike traditional lithium-ion batteries with liquid electrolytes, solid-state batteries employ solid electrolytes, offering advantages such as enhanced safety and higher energy density. They have the potential to store more energy in smaller, lighter forms, potentially transforming the efficiency and range of electric vehicles. Exciting advancements in battery technology include solid-state designs, graphene enhancements, and the evolution of flow batteries. These innovations not only promise to revolutionize energy storage for devices and vehicles but also contribute to a cleaner, more sustainable future. Ongoing research efforts hold the potential for breakthroughs that will redefine the energy storage landscape, promoting heightened efficiency, safety, and environmental friendliness. This trajectory suggests a future where energy storage is not only technologically advanced but also aligned with the imperative of a greener world.

## II. Literature Review

A review of the research papers connected to this research work is presented in this chapter. Latest developments happening in the areas related to this research work are also presented here.

1: Ajayi, F.F., Weigele, P.R., conducted a study on “A terracotta bio-battery” pot bio-batteries show promise for off-grid lighting! Though simple in design, they generate a decent, stable voltage and can even survive drying out for days. While their power output is currently limited, it's enough for LED lighting, making them a potential boon for rural communities. Further development could improve efficiency and pave the way for sustainable, local power generation.

2: This review highlights the key strengths of this technology: simplicity, decent performance, and resilience. It points towards the exciting potential for providing clean, accessible light in areas lacking infrastructure.

3: Azam, A., Khan, I., Mahmood, A., Hameed, A. conducted a study on “Chemical composition and nutritional quality responses of carrot, radish and turnip to elevated atmospheric carbon dioxide” Elevated atmospheric CO2 dramatically boosted the yield of carrots, radishes, and turnips by 69-139%. However, this came at a cost – nutritional quality suffered. Protein, vitamin C, and fat levels significantly decreased, while sugar and fibre saw significant increases. Minerals were also hit hard, with many showing substantial reductions. Fatty acids and amino acids followed suit, decreasing in quantity under elevated CO2 conditions. In essence, rising CO2 levels may offer tempting yields, but the nutritional punch of our root vegetables could take a significant hit.

4: Burgos, G., Amoros, W. et al conducted a study on “Total phenolic, total anthocyanin and phenolic acid concentrations and antioxidant activity of purple-fleshed potatoes as affected by boiling” Boiling purple-fleshed potatoes (Solanum andigenum) boosted their total phenolics and antioxidant activity while not significantly impacting anthocyanin and chlorogenic acid content in most varieties. This suggests boiled purple potatoes retain their health benefits and may even enhance some aspects. The deep purple variety Guincho stood out with the highest anthocyanin and antioxidant activity. Overall, boiled purple potatoes are a good source of health-promoting phenolic compounds.

## III. Bio Battery

### 3.1 What is a Bio-Battery

A bio-battery is an energy storing device that is powered by organic compounds. Although the batteries have never been commercially sold, they are still being tested, and several research teams and engineers are working to further advance the development of these batteries. Bio-batteries may be classified as; batteries using enzymes for the redox reactions, batteries using microbes for the generation of electrical power and batteries formed by coupling the easily oxidisable and reducible biomolecules or other organic compounds.

Here the bio-battery is strictly confined to the rechargeable batteries using biomass for the storage and generation of the electrical power.

### 3.2 Application

Although bio-batteries are not ready for commercial sale, several research teams and engineers are working to further advance the development of these batteries. Sony has created a bio battery that gives an output power of 50 mW (milliwatts). This output is enough to power approximately one MP3 player. In the coming years, Sony plans to take bio batteries to market, starting with toys and devices that require a small amount of energy. Several other research facilities, such as Stanford and North-eastern, are also in the process of researching and experimenting with bio batteries as an alternative source of energy. Since there is glucose in human blood, some research facilities are also looking towards the medical benefits of bio-batteries and their possible functions in human bodies. Although this has yet to be further tested, research continues on the subject surrounding both the material/device and medical usage of bio-batteries.

## IV. WORKING OF BIO-BATTERY

### 4.1 Basic Construction

Like any battery, bio-batteries consist of an anode, cathode, separator and electrolyte with each component layered on top of another. Anodes and cathodes are the positive and negative areas on a battery that allow electrons to flow in and out. The anode is located at the top of the battery and the cathode is located at the bottom of the battery. Anodes allow current to flow in from outside the battery, whereas cathodes allow current to flow out from the battery.

Between the anode and the cathode lies the electrolyte which contains a separator. The main function of the separator is to keep the cathode and anode separated, to avoid electrical short circuits. This system as a whole, allows for a flow of protons and electrons which ultimately generates electricity.

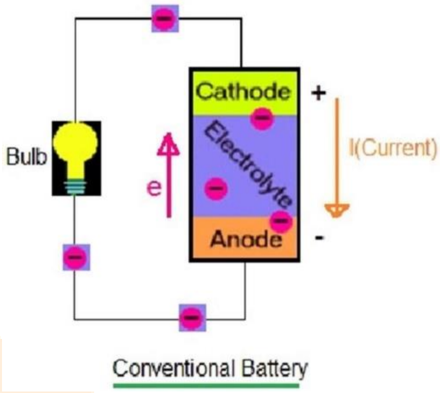


**Fig 1: Conventional Battery**

### 4.2 Working

Working of a bio-battery can be demonstrated by taking sugar battery as an example. Sugar battery generates electric current by the oxidation of the glucose unit of maltodextrin. The oxidation of the organic compound produces carbon dioxide and electrical current. 13 types of enzymes are planted in the battery so that the reaction goes to completion and converts most chemical energy into electrical energy.

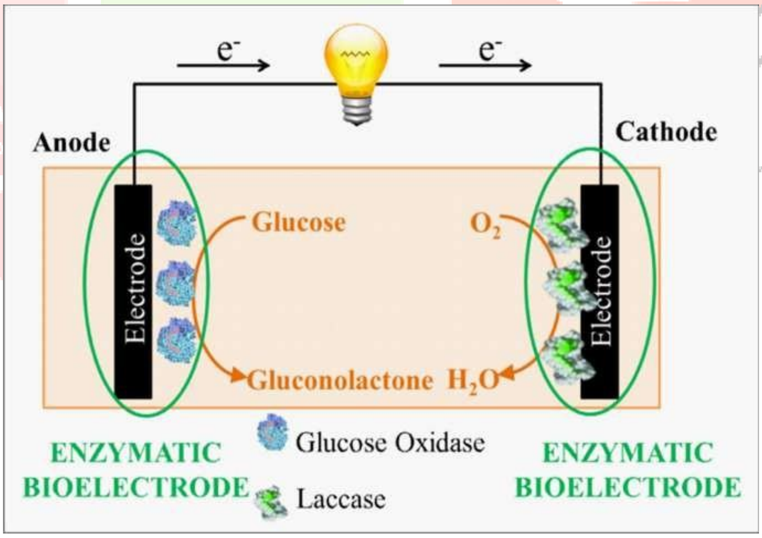


**Fig 2: Working of Bio-Battery**

## V. MATERIALS AND METHOD USED IN BIO BATTERY

Radish, onion, turnip and bitter orange were purchased from a local vegetable market. The cactus and the vegetables were used after proper washing and cleaning with distilled water. Except orange, each material was chopped into small pieces using a chopper. This was followed by grinding and crushing to obtain the juice. The juice of orange was obtained by pressing the peeled-out fruit in a custom-made presser.

The obtained juice was filtered using Whatman filter paper. The filtered solution of radish, onion, turnip and bitter orange were used for the preparation of bio-battery.

## VI. Construction of Bio Battery

The bio-battery consisted of a single cell containing cathodic half and anodic half. Each half of the cell was filled with 50 ml of the freshly prepared juice. The batteries of onion series were prepared by using onion juice as anodic half cells while the other solution was filled into cathodic half. The anodic half for the turnip series was loaded with turnip juice.

The container for bio-battery was made of high-density polyethylene. Each cell had two compartments for the formation of half cells. The salt bridge for these cells is made of a wick which is placed between cut between two compartments. This wick was a cotton cloth of 2 mm thickness, 1 cm width and 6 cm length. Each half cell compartment has a volume of 3.2 cm'. The graphite electrodes were mounted in a strip of cardboard and were connected to each other in series through copper connecting wires.

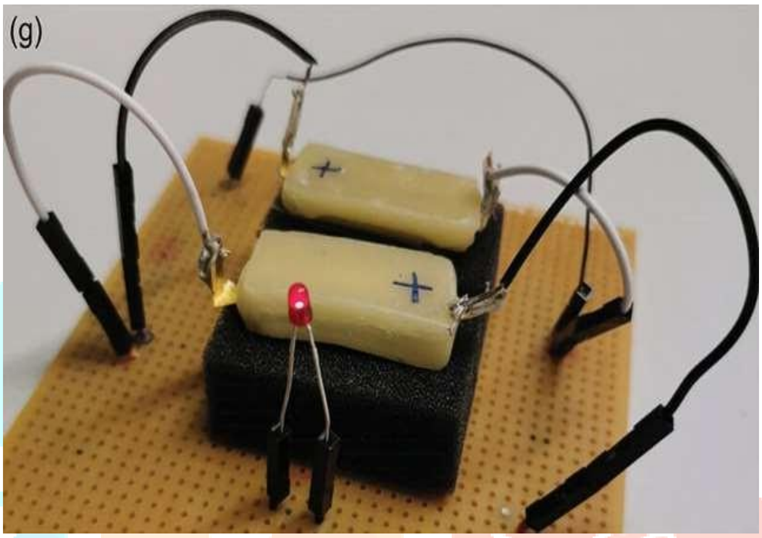


**Fig 3: Bio-battery with 2 cells**

However, the power of each battery was investigated using batteries consisted of two cells. The optimization experiments were conducted in triplicate and the average of these results was reported. The voltage was measured both before and after charging by using Fluke 115 Multimeter.

## VII. Optimization of Charging Time

The charging time is one of the important parameters for characterization of rechargeable batteries. These batteries store electricity through electro-generation of redox species. The present work is focused on the use of onion, turnip, bitter orange, cactus and radish juices as source of electro-active materials for the preparation of bio-batteries. The battery was prepared by coupling anodic and cathodic half solutions through salt bridge. The resulting cell gives voltage before and after charging. Variations in charging time are responsible for the variation of active concentration of redox species. Based on Nernst equation, a probable change in the active concentration of redox species is the cause of changes in cell potential. The concentration of electro-active species for each of this solution depends upon the voltage and time of charging. The effect of charging time on the voltage of rechargeable battery was investigated in the range of 5-30 min by using a 24 V transformer.

An increase in charging time also increases the voltage for almost all the redox pairs due to electro generation of redox species with the passage of time. However, in some pairs like cells of onion and turnip and radish experienced a decrease in voltage after a certain time period. The reduction in voltage is attributed to initiation of side reaction after certain time and the formation of chemical species having low voltage. It can be seen from the results the voltage of the rechargeable battery increases as the charging time increases unless a constant voltage is reached. This is because an increase in charging time results in an increase in concentration of the active substances which result in an increase in the voltage till the electrochemical equilibrium is established. However, long charging time may lead to decomposition of the electroactive species. By passing through another type of reaction, the formation of polymeric species takes places and in response the voltage decreases.

## VIII. Reference

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