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EXTRACTION OF ELECTRICAL ENERGY FROM *Aloe barbadensis Miller* AND *Musa acuminate* PLANTS

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Abstract. Electricity can be generated through various means, and extraction of electricity from green plants is a developing trend in technology. In this work, electrical energy was extracted from *Aloe barbadensis Miller* (Aloe Vera) and *Musa acuminate* (Banana) plants. This was achieved by inserting pairs of electrodes (copper and zinc) into the plants to facilitate ion flow, thereby generating voltage at the electrode terminals. Results of the experiment performed showed that Aloe Vera produced higher voltage 0.83V compared to the Banana plants, which produced a voltage of 0.74V. Furthermore, it was observed that the incorporation of a second and third pair of electrodes within the same leaf branch resulted in voltage of 1.37V and 1.59V respectively for the *Aloe barbadensis Miller* plant, and 0.86V and 1.11V respectively for the Musa plant, while inserting the second and third electrode pairs in separate leaf branches produced output voltages of 1.4V and 2.01V for the *Aloe barbadensis Miller* plant and 0.92V and 1.15V for the *Musa acuminate* plant respectively. Finally, it was proven experimentally that sunlight had very little effect on the output voltage.

Keywords: *Aloe barbadensis Miller, Musa acuminate, Electrical energy, Electrode, Voltage*

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INTRODUCTION

Electricity being one of the most widely used form of energy has over the years become one of the basic and most essentials for human survival owing to the technological advancement in the world since the beginning of the 21st century [1- 4]. Electricity can be generated through various means.

Over the years, Non-renewable system of electricity generation employed systems which depend on petroleum materials to provide adequate and readily available electric power for both private and industrial use but are faced with high cost of maintenance as well as scarcity of resources upon which their operation depend. Also they release harmful gases into the atmosphere (environment) which pollute the environment and thus pose great threat to human lives, [5, 6].

In other to efficiently and effectively provide energy while maintaining ecological balance, advancement in science, technology and engineering ushered in renewable energy generation systems such as Biogas, Wind Turbine and Solar powered systems etc, and according to [7], which depend on naturally and widely available resources to run such as wind, sun and bio-degradable waste [2,8-11]. The renewable systems, despite their numerous advantages require huge setup cost and in most cases, are difficult to maintain. This makes them hardly accessible to individuals and households.

Electricity generation from green plants is a developing trend of technology, aimed at developing a renewable method of generating electricity from plants without altering their growth and life performance [12]. Through photosynthesis, plants produce organic matter. The excess part of this production is excreted via their roots. During this electrons are released that can be harvested as electricity with the help of electrodes. Hence, in principle sustainable electricity can be generated at any location where plants can grow [13]. It is a self-sufficient system; nothing else is needed. This system of electricity production does not emit any form of toxic gases to the atmosphere and the plants may even serve as ornamentals thereby creating further aesthetics as well as serving their primary functions [14]. Although plants are classified among the weak energy sources (very faint source of electricity), a voltage boost converter have been developed by a team of electrical engineers from University of Washington for harvesting energy from trees. This study is therefore aimed at generating electricity capable of powering simple domestic appliances from green plants.

MATERIALS AND METHODS

The plants used in this study are Aloe Vera (*Aloe barbadensis Miller*) and Banana (*Musa acuminate*). Aloe Vera was chosen because it contains some chemical compounds like zinc, copper, magnesium which are capable of generating electricity in chemical process like electrolysis. Also, the Banana plant has a lot of water and this water contains various ions like Potassium, Sodium, Calcium, Chlorine etc. when electrodes are inserted into the plant, the electrodes react with these ions to produce electricity. Generally, Aloe Vera and Banana plants were selected because they grow in abundance throughout the year, have good moisture content and their trunk or leaf structure allows for easy electrode embedding.

Other materials used include: Buckets inside which the plants are planted (nursery), Electrodes (Copper and Zinc) to serve as positive and negative terminals, connecting wires, Multi-meter (for voltage testing) and Harvester circuit for boosting the generated voltage.

Electrodes Selection

Electrodes were selected based on their availability and electrical conduction properties.

This selection was based on experiments conducted by [15,16], to determine the best combination of electrodes for harvesting electricity from plants. According to [15], four materials including copper, iron, zinc and aluminum were obtained and tested in pairs (Cu-Fe, Cu-Zn, Al-Zn, Cu-Al)as positive and negative electrodes respectively, and the best pair that produced the satisfactory result (in terms of voltage output) was selected. From the experiment, Cu-Zn electrodes produced the highest voltage approximately 0.95V, followed by Cu-Fe (0.60V), Cu-Al (0.58V) and Al-Zn producing the lowest voltage of 0.46V on the Aloe vera plant, while for the banana plant, Cu-Zn gave 0.91V, followed by Cu-Fe (0.57V), Cu-Al (0.48V) and Al-Zn again produced the lowest voltage of 0.30V [15]. In this regard, the electrode materials used as positive and negative terminals were determined by their electrochemical potential, E and the electrode with higher electrode potential was selected as the anode while the electrode with lower electrode potential was selected as the cathode. The electrodes selected as positive and negative electrodes are Copper (Cu) and Zinc (Zn).

Procedure for Harvesting Electricity from Plants

The steps taken in the actualization of this project are outlined below:

1. The selected plants Aloe vera and Banana were obtained and placed in nursery buckets and left outside for a few days to ensure continuous survival.
2. The selected Electrodes were carefully cleaned to eradicate impurities and kept under sun for some hours (3 hours) to get rid of moisture from their respective surfaces.
3. Each of the electrode terminals were connected to electric wires (by means of a clip). The wires were then connected to a multi-meter with respect to their polarities.
4. The electrode terminals were then inserted into the plants in order to harness the energy stored within the plant for electricity production. For the Aloe vera plant, the electrodes were inserted into the leaves while those for the Banana were inserted into the stem.
5. The entire setup was then taken outside and left for some hours (about 4 hours) to allow adequate sunlight absorption and enable photosynthesis to occur.
6. The multi meter was then switched on to read the quantity of voltage generated.
7. Once the meter reads a stable voltage, the multi meter can then be disconnected and replaced with a harvester circuit to boost the generated voltage.

Performance Test Procedure

The voltage produced when several electrodes connected in series were inserted into one leaf branch of the plant was measured for both the Aloe Vera and Banana and compared with the voltage produced when the same number of electrodes (also connected in series) were inserted one electrode pair per leaf branch into the Aloe Vera and Banana plants respectively. The procedure is described below.

All Electrodes in One Leaf Branch

1. One pair of electrode terminals (anode and cathode) was inserted into one leaf branch of the Aloe Vera and the multi meter reading was recorded. The procedure was repeated for the Banana plant and the reading was also recorded.
2. An additional pair of electrode was inserted into the same leaf branch used in (i) above of both the Aloe Vera and Banana plants respectively. The two pairs of electrodes were joined in series and connected to a multi meter. The resulting voltages were read and recorded.
3. A third pair of electrode was inserted into the same leaf branch used in (i) and (ii) above. Again, the three terminals were joined in series and connected to a multi meter. The resulting voltage was read and recorded.

One Electrode Pair per Leaf Branch

1. One pair of electrode terminals (anode and cathode) was inserted into one leaf branch of the Aloe Vera and the multi meter reading was recorded. The procedure was repeated for the Banana plant and the reading was also recorded.
2. An additional pair of electrode (i.e. another negative and positive) terminals were inserted into a different leaf branch to make it two electrode pairs in two separate leaf branches of both the Aloe Vera and Banana plants. The two pairs of electrodes were connected in series and connected to a multi meter with which the voltage was read and recorded.
3. A third pair of electrode was connected to yet another leaf branch in the two plants respectively, separate from the ones used in (i) and (ii) above to make it three electrode pairs in three separate leaf branches. The electrode pairs were again joined in series and connected to a multi meter. The resulting voltage was read and recorded.

The entire processes described in all electrodes in one leaf branch and One Electrode Pair per Leaf Branch, where firstly performed indoors where the plants do not have direct contact with the sun and then repeated outside, with the plants placed directly under the sun. Both results were compared.

RESULTS AND DISCUSION

The results of the experimental investigation as per each experimental procedure described in Performance Test Procedure, are presented and discussed in this section.

Determination of Output Voltages of the Aloe Vera and Banana Plants

Results of the experiment for the determination of the different output voltages of the Aloe Vera and Banana plants when three electrode pairs are intermittently inserted in one leaf branch of the plants is shown in Table 1 while Table 2 shows different output voltages produced by the plants when the electrodes are inserted one electrode pair per leaf branch of the respective plants.

Table 1. All Electrode Pairs in One Leaf Branch without direct access to sunlight

S/n	Electrode connections	Number of leaf branches	Voltage (V) Aloe Vera	Voltage (V) Banana
1	one electrode pair	1	0.83	0.74
2	two electrode pairs	1	1.37	0.86
3	three electrode pairs	1	1.59	1.11

Table 2. One Electrode Pair per Leaf Branch without direct access to sunlight

S/n	Electrode connections	Number of leaf branches	Voltage (V) Aloe Vera	Voltage (V) Banana
1	one electrode pair	1	0.83	0.74
2	two electrode pairs	1	1.40	0.92
3	three electrode pairs	1	2.01	1.15

From tables 1 and 2, it can be seen that output voltage increases as the number of electrodes increases for both Aloe Vera and Banana plants respectively. i.e., Increase in Voltage varies directly as increase in the number of electrode pairs (Voltage and Number of electrode pairs). We can therefore achieve a set voltage by varying the number of electrode pairs. In Table 1, inserting the second and third electrode pairs in the same leaf branch produced an output voltage of 1.37V and 1.59V respectively for the Aloe Vera plant and produced 0.86V and 1.11V respectively for the Banana plant. In Tables 2inserting the second and third electrode pairs in separate leaf branches produced output voltages of 1.4V and 2.01 V for the Aloe Vera plant and 0.92V and 1.15V for the Banana plant respectively. Hence, more voltage can be achieved by connecting each pair of electrode on a separate leaf branch for both plants.

Effect of Sunlight on the Voltage Produced

The entire experiments performed in determination of output voltages of the Aloe vera and Banana plants were repeated, this time with the plants placed directly under sunlight and the corresponding voltage readings were taken. This is shown in Tables 3 and 4.

Table 3. All Electrode Pairs in One Leaf Branch with the plants having direct access to sunlight

S/n	Electrode connections	Number of leaf branches	Voltage (V) Aloe Vera	Voltage (V) Banana
1	One electrode pair	1	0.83	0.74
2	Two electrode pairs	1	1.38	0.86
3	Three electrode pairs	1	1.59	1.12

Table 4: One Electrode Pair per Leaf Branch with the plants having direct access to Sunlight

S/n	Electrode connections	Number of leaf branches	Voltage (V) Aloe Vera	Voltage (V) Banana
1	one electrode pair	1	0.83	0.74
2	two electrode pairs	2	1.40	0.92
3	three electrode pairs	3	2.02	1.15

Tables 3 and 4, show that direct access to sunlight has very little effect on the output voltage. Hence the plants can be kept in any convenient place. Also, Tables 1, 2, 3 and 4 clearly show that the Aloe Vera plant, under similar conditions produce higher voltages than the Banana plant hence, making Aloe Vera plant a better choice for electricity production.

Obviously, the voltages produced from the experiments are very low and may not be able to power basic household devices. To solve this problem, the output voltage should be made to pass through a harvester circuit to boost the voltage before use.

CONCLUSION

The potential to develop electrical energy for powering simple household devices from Aloe Vera and Banana plants was demonstrated in this work. This electrical energy was harvested using copper and zinc electrode pairs embedded into the plants. Results of the experiments performed showed that Aloe vera produced higher voltage than banana. Although the voltage output from the plants is weak, higher voltage was obtained by inserting more electrode pairs in the plants and connecting them in series. Also connecting the electrodes terminals to a voltage harvester circuit further increased the output voltage.

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IZDVAJANJE ELEKTRIČNE ENERGIJE IZ BILJKA *Aloe barbadensis Miller* I *Musa acuminate*

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Abstract. Električna energija se može proizvesti na različite načine, a prikupljanje (izdvajanje) električne energije iz zelenih biljaka je trend razvoja ove tehnologije. U ovom radu, električna energija je izdvojena iz biljaka *Aloe barbadensis Miller* (Aloe Vera) i *Musa acuminate* (Banana).

Ovo je postignuto umetanjem parova elektroda (bakar i cink) u sistem da se olakša protok elekrona, čime se generiše napon na krajevima elektroda.

Rezultati obavljenog eksperimenta pokazali su da je Aloe Vera proizvodila veći napon od 0,83V u odnosu na biljke Banana koje su proizvodile napon vrednosti od 0,74V.

U toku eksperimenta primećeno je da ugradnja drugog i trećeg para elektroda unutar iste grane lista biljaka rezultira pojavom napona od 1,37V i 1,59V respektivno za biljku *Aloe barbadensis Miller*, odnosno 0,86V i 1,11V za *Musa acuminate* (Banana).

Ugradnja drugog i trećeg para elektroda u odvojene grane listova proizvelo je izlazne napone od 1,4V i 2,01V za biljku Aloa vera (*Aloe barbadensis Miller*) i 0,92V i 1,15V za biljku Banana (*Musa acuminate*) respektivno.

Konačno, eksperimentalno je dokazano da sunčeva svetlost ima veoma mali uticaj na vrednosti izlaznog napona kod ispitivanih biljaka.

Ključne reči: *Aloe barbadensis Miller (Aloa vera), Musa acuminate (Banana), električna energija, elektroda, napon*

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