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Design and Development of Soil Battery System for Sustainable Energy Storage

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Abstract: Every day, the renewable energy and alternative power industries are growing, resulting in reduced global warming, enhanced public health, abundant electricity, and affordable energy prices. One of alternative power source is the soil-battery, which can be utilized without relying on external power for charging. It naturally charges itself when in contact with water. This work aims to demonstrate the process of electricity generation from soil and its application in operating small-scale devices. Initially, different soil samples, influential reactors, and electrodes were analyzed to determine the complete potential difference and electron flow. The soil battery represents a recent development in clean energy. The soil battery system was developed using components setup such as copper spikes, galvanized nails and copper wire as cathodes, anodes and conductors, respectively for the generation of electricity from the moist soil. By four fundamental materials such as copper cathodes, zinc anodes, copper conductors and moist soil, a battery system can generate enough power to operate low-consumption loads offering a sustainable solution for generating electricity. For example, the 100% of moisture level of clay soil managed to generate maximum voltage and power which are around 5.7 V and 0.057µ W, respectively. Besides, the prototype of soil-battery system can power-up loads such as an LED (0.033µ W) and a calculator (0.033µ W) without the need for conventional batteries.

Keywords: Soil Battery, Zinc Anode, Copper Cathode, Power

1. Introduction

Over the years, engineers and scientists have made significant advancements in battery technology, with many commercially available [1]. In 1841, the earth energy was introduced by Alexander Bain, who proposed the soil as the main component in an earth battery prototype for low-power generation

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[1]. An earth battery is a relatively straightforward concept for an affordable and practical way to produce electricity from the soil. Research on earth soil chemical reactions and earth battery based on electron affinity has been conducted in order to understand the process of generating an electrical current using soil as the electrolyte and two disparate metals as electrodes. Electricity is created by the presence and flow of electrons from positive to negative points. In this case, zinc gives up electrons more easily than copper and the damp soil contains free electrons. The reaction of the zinc with the copper and the presence of the free electrons, results in a current [2].

The work intends to generate increasing amounts of electricity. Therefore, the primary goal was to create an alternative and immediate electrical solution to meet the increasing technological and energy demand in the industrial revolution, particularly in the context of internet of things (IoT) sensors, as well as addressing the needs of rural and underdeveloped areas. The simplicity of the soil-battery system makes it highly eco-friendly, and, in the event of any accidents, it would not incur costs. As a result, it represents the simplest method for producing electricity from natural resources [3].

2. Materials and Methods

In this project, the main objective is to design and develop a prototype of power-generating unit cell configuration using soils as a primary component. For the first step for this prototype, 4-set cups of soil which each set consists of 16-cells of cups connected in series with zinc and copper materials immersed in soil. Then, analyze the output parameters generated by a set of soil-based unit cell series configuration. The moisture level also takes an important role to generate output parameters. Figure 1 shows the flowchart of the whole process to make a prototype.

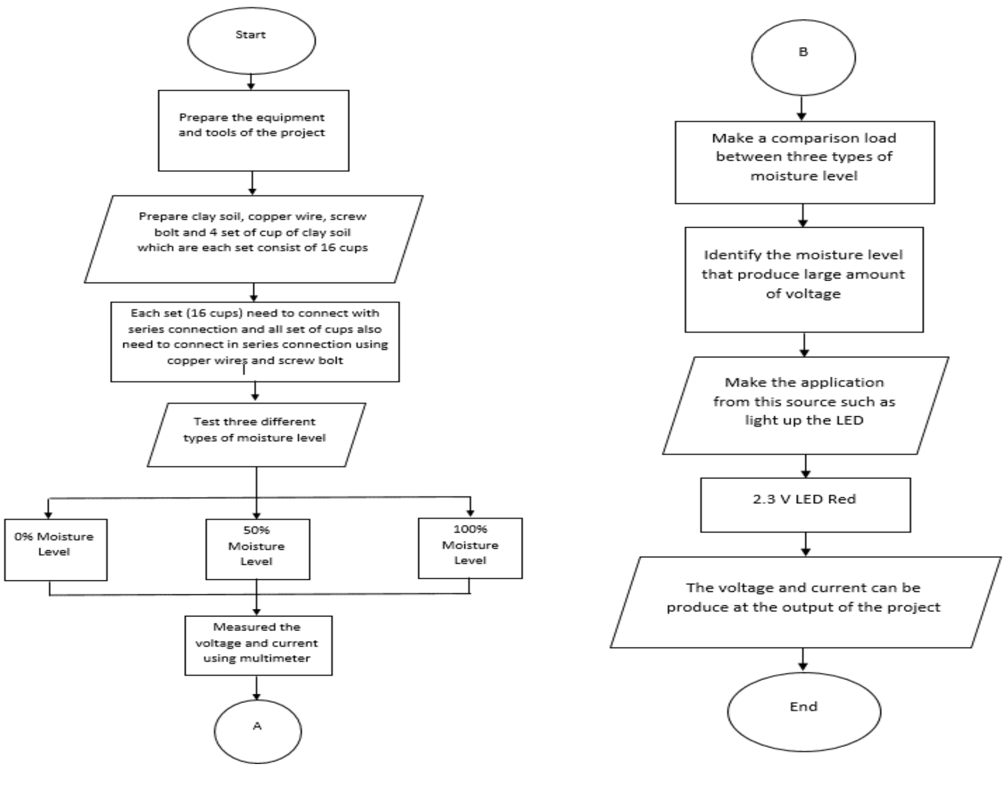

Figure 1: Flowchart of prototype

2.1 Sketch diagram of the project

Figure 2 shows the 4 set cups of clay soil which are each set consists of 16 cups and all the sets are connected in series connection with copper wire as copper and screw bolt as zinc immersed with clay soil.

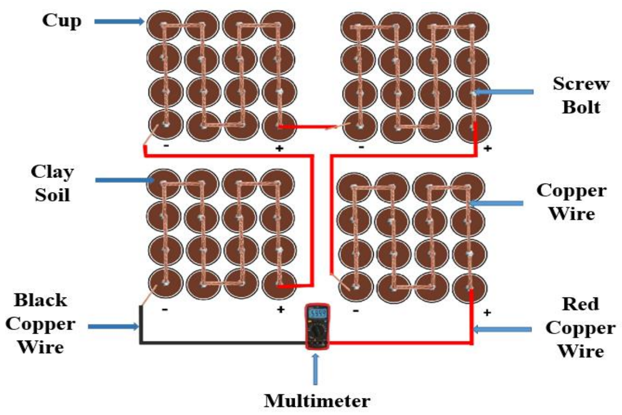

Figure 2: Sketch diagram of prototype

2.2 One set of clay soil diagram in series connection

Figure 3 shows the diagram of 1-set of clay soil in series connection and measured using multimeter,

Figure 3: 1-Set of clay soil

2.3 Diagram of the prototype

Figure 4 shows the diagram of the prototype which had 4-set cups of clay soil that connected in series connection and each set consists of 16 cups of clay soil.

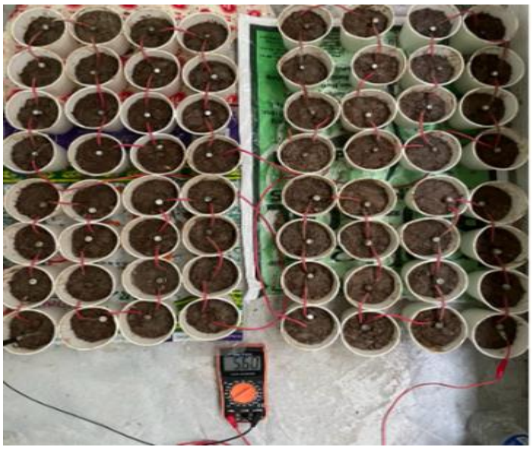

Figure 4: Diagram of the prototype

2.4 Formula of method

Table 1 shows the list of formula that used to calculate all parameter in prototype [4].

Table 1: Table of Formula

Calculation of the power in Watt (W)	$P = I \times V$
Calculation of the Resistance in Ohm (Ω)	$R = \rho \frac{l}{A}$
Calculation of the Current Density in Ampere per Square Meter ($\frac{A}{m^2}$)	$J = \frac{I}{A}$
Calculation of the Conductance in Siemens (S)	$G = \frac{1}{R}$
Calculation of the Conductivity in Siemens per Meter ($\frac{S}{m}$)	$\sigma = \frac{l}{R \times A}$
Calculation using Ohm's Law	$V = I \times R$

3. Results and Discussion

This section explains the results of the project. It covered the result of measurement, simulation and calculation of Design and Development of Soil Battery System for Sustainable Energy Storage.

3.1 Voltage and current output from different moisture level of clay soil

Figure 5 shows the result output from soils battery with soil 0% of moisture level.

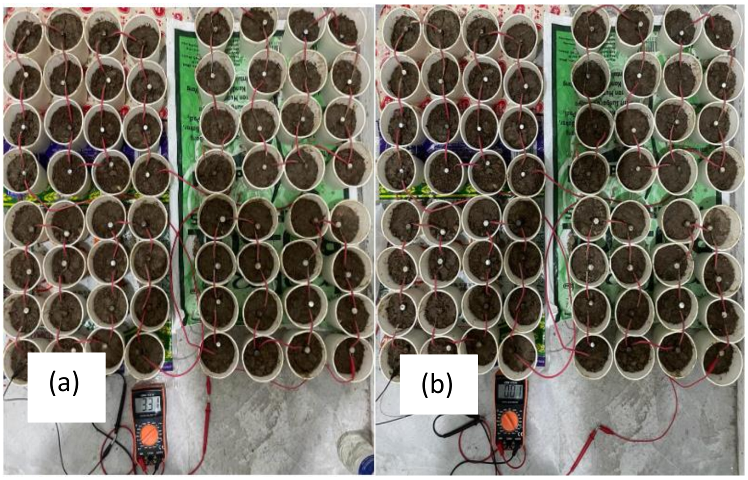

Figure 5: (a) V = 3.33 V, (b) I = 0.01μ A

Figure 6 shows the result output from soils battery with soil 50% of moisture level.

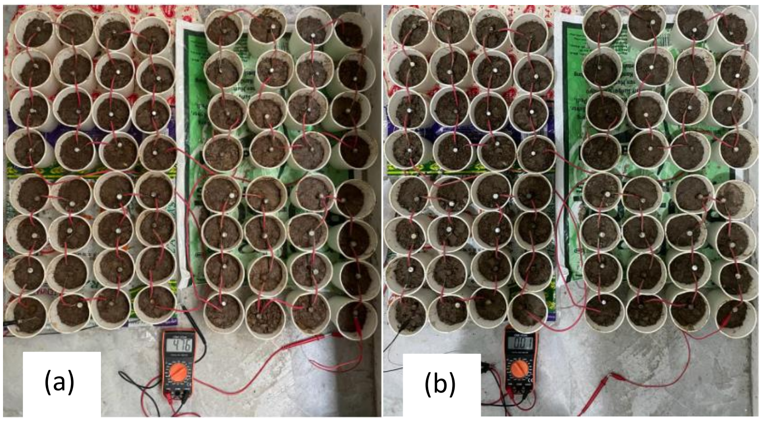

Figure 6: (a) V = 4.25 V, (b) I = 0.01μ A

Figure 7 shows the result output from soils battery with soil 100% of moisture level.

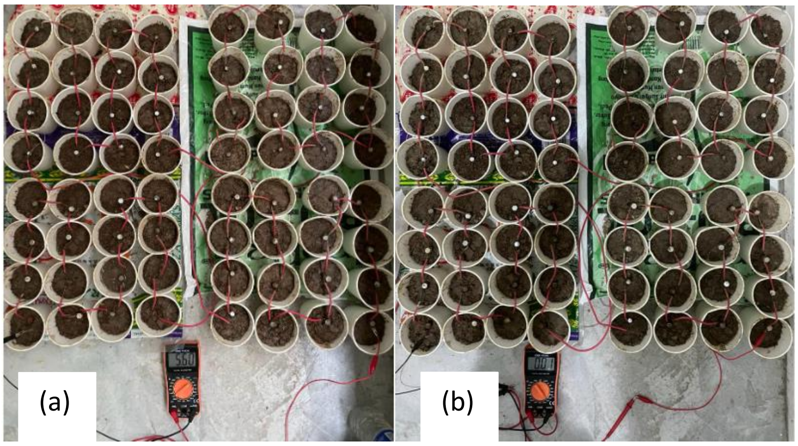

Figure 7: (a) V = 5.6 V, (b) I = 0.01μ A

From the result obtained, there are three types of moisture level which affects the output parameters. The higher percentage of moisture level, the higher voltage output generates. The results measured using multimeter.

Table 2 shows the result output parameter that obtained from measurement.

Table 2: Table of result output

Moisture Level (%)	Voltage. V	Current, A	Power, W
0	3.3	0.01μ	0.033μ
50	4.25	0.01μ	0.0425μ
100	5.6	0.01μ	0.056μ

3.2 Graph result

Figure 8 shows the result graph result of voltage and current in different moisture level.

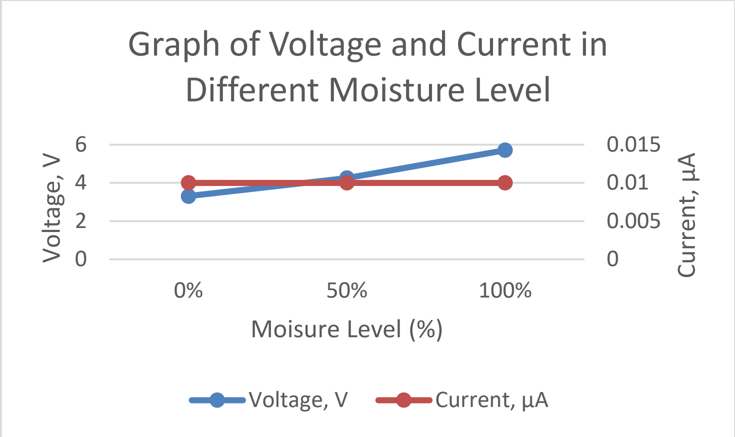

Figure 8: Graph of voltage and current in different moisture level

From the graph shown in Figure 8, it can be observed that the voltage and current values at different moisture levels. The values indicate that the higher the percentage of soil moisture level, the higher value of voltage and current produced. In addition, if the voltage increases, the current will also increase.

Figure 9 shows the result graph of power in watt (µW) in different moisture level of clay soil (%).

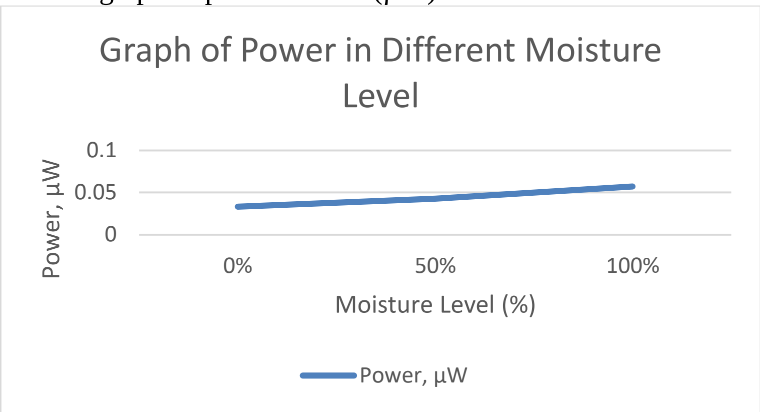

Figure 9: Graph of power in different moisture level

From the graph in Figure 9**,** it shown the output powers at different moisture levels. It was found that the higher the percentage of soil moisture level, the higher value of power produced.

3.3 Soil battery system with load

i. LED (0.033µ W) as a load

Figure 10 shows that the LED is on after being connected by soil as a source.

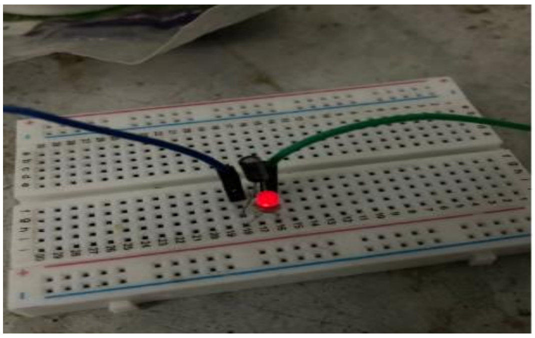

Figure 10: Turn on LED (0.033µ W)

ii. Calculator (0.033µ W) as a load
Figure 11 shows the calculator was turn on after connected by soil as a voltage source without using any conventional battery.

Figure 11: Calculator turn on after connected by soil as voltage source without using any conventional battery

From the result and voltage obtained from the clay soils, this project can be continued by making the clay as a source to turn on the application. Among the applications that have been successfully made are turning on 2.3 V LED lights (0.033µ W) as a load and can turn on the calculator (0.033µ W) as a load without any conventional battery. It proves that clay soil has a load that useful to people in emergency situation and also proves that soil is one of the sustainable sources that can act as battery or energy storage.

4. Conclusion

Through the project all the objectives have been achieved. The project, or prototype, had been developed to generate power from soil. The soil chosen for this prototype is clay soil. The unit cell of clay soil managed to generate power as a primary component. From the results, the prototype is able to analyse the output parameter using a set of soil-based unit cell series configurations. Therefore, the materials of this prototype, which are zinc anode, copper cathode, series connection of copper wire, and soil-based unit cell series configuration, are suitable to generate electricity in terms of voltage, current, and power. Then, the analysis of the output parameters generated from the prototype was measured by a multimeter, and the characteristic materials such as copper and clay soil were able to be analysed using calculations. Besides, the moisture level also plays an important role in this project because the higher the soil moisture, the higher the value of voltage, current, and power produced. In addition, from the load that obtained from output of clay soil, this prototype was able to make the small application. From the application results, this prototype managed to turn on the 2.3 V LED light without any supply voltage and also turn on the calculator without any battery. This proves that the design and development of soil battery systems using clay soil can provide sustainable energy storage.

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References

[1] S. Islam, M. Sayeduzzaman, K. M. Elme, M. H. Islam, and A. Rahman, “An empirical analysis of Sustainable Earth-Battery,” vol. 7, pp. 144–151, Sep. 2021, .https://www.sciencedirect.com/science/article/pii/S2352484721003917

[2] M. Spiske, “What is an Earth Battery, and How Does It Work? Aspiration,” Make Change - Where Money and Mission Meet, Feb. 18, 2021. https://makechange.aspiration.com/earth-battery/.

[3] N. Khan, Z. Saleem, and N. Abas, “Experimental study of earth batteries,” ResearchGate, Apr. 25,2008.https://www.researchgate.net/publication/4347039_Experimental_study_of_earth_batteries.

[4] Vedantu, “Current Density,” May 20, 2020. https://www.vedantu.com/physics/current-density.