

Sustainable Earth Battery for Power Generation

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Abstract

Nowadays, the gaps to meet the rapid growth of technology are by approaching a clean energy source according to the sustainable development goals that offer access to affordable and reliable energy for all. Accordingly, battery energy storage is a concern today because, although readily available and easy to use, the hazardous chemicals it contains can harm the environment and human life over time if improperly disposed of. This study proposes to identify an eco-friendly battery that is initiated using a natural compound which is soil by focusing on the ability of several soil types, including clay soil, barren soil, and peat soil to generate voltage. The voltage values were achieved by placing electrodes in the battery cell prototype and utilizing two types of electrolytes, distilled water and tamarind water. These soils' surface morphology and elemental compositions were characterized using Scanning Electron Microscopy with Energy Dispersive X-ray (SEM-EDX). The average voltage values gained for clay soil, barren soil, and peat soil with distilled water are 11.73 V, 13.44 V, and 7.30 V while for tamarind water are 8.554 V, 7.190 V, and 9.70 V respectively. Subsequently, elemental analysis by EDX shows that clay soils main elemental consists of Al (7.01%), followed by Fe (1.55%) and K (0.77%), then for barren soil, led by Al (11.25%), which plays a major role in increasing voltage for barren soils and Cu (0.54%), and peat soil consists of Al (5.36%) and K (0.88%). The existence of these elemental ions demonstrates the soil's ability to conduct electron flow for electrical Generation properties thereby, among these three types of soil, barren soil with distilled water produces the highest voltage value, an average of 13.44 V.

1. Introduction

Power generations nowadays are getting advanced as decades pass by and along the way, the demands of it also getting higher by users and providers. Correspondingly, power generation has emerged as a global concern in recent years due to the recent population increase, advancements in technology, and most recently, the advent of the fourth wave of industrialization, which has had a particularly destructive impact on poor and undeveloped nations [1]. Given Malaysia ranks as one of the world's leading oil and gas suppliers (O&G), ranking 26th and 13th, respectfully, it is already making a statement that coal or fossil is considered a treasure to our nation [2]. A few main issues that are worrisome are, the depletion of fossil fuels which the supplies already exhausted to this day which also questions the stability of energy for tomorrow. Coal being vital among the other sources is very

common as it is used to produce fossil fuel other than its ability to produce heat and light energy. A million years ago, coal already formed even before dinosaur existence which resulted from the dead plants that were buried under water and dirt, and as time passed by all the heat and pressure naturally turned the dead plants into coal [3]. This research shows how electricity may be generated from soil and utilized to power small powered gadgets. Consequently, it qualifies as a clean energy source well. Utilizing raw materials was a top priority in terms of price and availability.

The design, functionality, traits, and ideal method for a soil-powered electricity generation system are all explained in this study [4]. For a normal daily battery that has been commonly used in human daily life, it has come to understand if its disadvantages had been disregarded or they had not been acknowledged. The types of batteries consist of heavy metals such as cadmium, copper, lead, mercury, nickel, and zinc, all of which are harmful to humans as well as the environment. The careless disposal of old batteries into landfills eventually results in the percolation of heavy metals and other hazardous substances into soil and water, polluting food and water supplies and rendering them unsafe for human and wildlife consumption [5].

The urge of this study is to gain more enlightenment and explore alternative ways to preserve energy also known as battery storage. In a matter of time, the dependence on electricity in everyday routines became a basic necessity for consumers and energy storage became handy mainly in industries and the economy. According to these matters, it is also known that the usage of lithium batteries is also in demand and high [6]. Automotive electric vehicles (EVs) exhibit extraordinary growth, with approximately 24 percent annually increasing sales and predicted global sales of 21.5 million through 2030. Also, lithium-ion batteries (LIBs) are the ideal electrochemical energy storage option for EVs due to their high energy density, long cycling life, low memory effects, and wide working temperature range yet these benefits also come with effects where all these batteries have excellent recycling, restoration, and remanufacturing activities, massive numbers of batteries will unavoidably be abandoned [7].

The need to explore possibilities of electrochemical energy storage systems also known as Battery Energy Storage Systems (BESSs) getting wider as soon as previous researchers prove that electricity can be generated with better and more reliable sources which is the soil, not only it justifies the greener option but it is also low in cost [8]. Therefore, by considering all of these issues as a main concern, this study became more purposeful where the cleaner energy sources also became more approachable and meaningful to consumers without any harmful effect to them and the environment. This study carries the main objective to be able to set up the electrode arrangement for the earth battery prototype on several soil samples. The next agenda is to generate and measure the voltage produced by the earth battery using distilled water and tamarind water solution as electrolytes. Accordingly, this study is purposely to be able to provide benefits to consumers, which is it can improve the study types of power generation along with the growth of modern technologies and its importance to users. In addition, this study also creates an opportunity and new chances for eco-friendly energy storage to be introduced to these day generations.

For the principle of earth batteries, its reaction to generate electricity is quite simple and direct. Firstly, when the soil is distributed evenly on the particular cells, the electrolytes are poured according to the specific amount then the soil is considered activated as it gains moisture. Next, the electrodes are arranged and connected with the copper wires, then the activated soil starts to react with it. The moisture soil technically contained the elemental ion that increased the chances of electron flows and then allowed it to cooperate with components which resulted in electricity generation.

2. Materials and Methods

2.1 Sample Preparation

The sample soils for clay soil and peat soil were taken at Parit Botak, Batu Pahat, Johor while barren soil at Pagoh, Muar, Johor as shown in Fig. 1. Each sample soil undergoes heat treatment at 110°C for barren and clay soil 60°C for peat soil for 24 hours to remove the moisture and unwanted residue with the sieving process. Then, the sample soils were stored and labelled in plastic containers. Afterward, the sample soils were ground using the planetary ball mills to transform them into powder form in the range of 60-100µ. All of these procedures are significant in ensuring the optimum results as the finer soil structures allow the electron flow and incorporation with other components better.

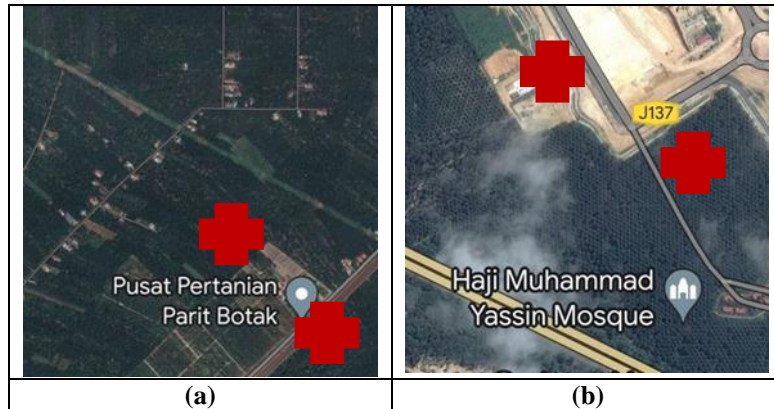


Fig. 1 The location of sample soils a) Parit Botak, Batu Pahat; b) Pagoh, Muar, Johor.

2.2 Sample Characterization

The sample soils undergo characterization to observe their morphology structure and elemental composition consists in it with Scanning Electron Microscopy and Energy Dispersive X-ray (SEM-EDX). This analytical technique allows this study to examine the morphology of the sample soils with a high spatial resolution where it is capable of detailed imaging of surfaces at the nanoscale view. Then, the EDX is also capable of identifying the distribution of elemental compositions within the sample soils.

2.3 Voltage Measurement

The voltage generated is measured by using a digital multimeter. Positive and negative wires are connected respectively to the copper wires and electrodes. To ensure stability and improve reading accuracy, crocodile clips are used as connecting wires from the digital multimeter to the earth battery. Voltage gained is taken up to five times as the fluctuation remains hence repetitive reading is needed for average measurement.

2.4 Fundamentals of the Earth Battery

For the earth battery prototype, it is constructed by using dissimilar electrodes which used in this study are copper and iron. Then, the medium used is a few types of soils consisting of clay soil, barren soil, and peat soil resulting in three types of earth batteries. Next, the electrodes are arranged into the battery cells connected in series. This study used two types of electrolytes, distilled water, and tamarind water that act as vital parts of the earth battery, which enable electron flow by the reaction of electrodes and the elemental ion presence in the soils. Moreover, the battery can sustain almost more than 6 hours, as long as the soil is moist, the electricity still can be generated. Then, the quantity of soil is distributed evenly by using a particular spatula to ensure the same amount according to the size of battery cells where one earth battery prototype contains up to 14 cells.

3. Results and Discussion

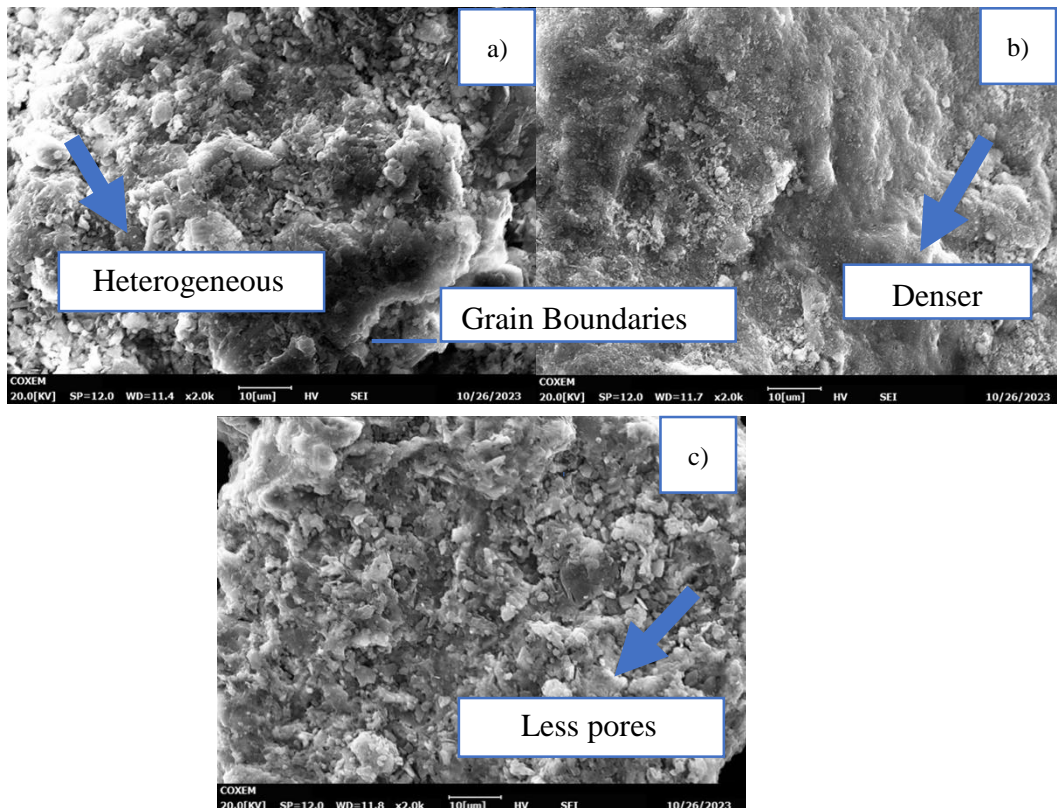


Fig. 2 Scanning Electron Microscopy (SEM) image of a) Clay soil; b) Barren soil; c) Peat soil

3.1 Soil elemental composition analysis using EDX

The EDX spectrum of clay soil is shown in Fig. 3 a) and it can be seen that the main peak forms are C, O, and Si. Fig. 3 b) illustrates the EDX spectrum for barren soil, which can be seen in a few types of elemental peaks that are present in the barren soil. Element Al and Cu are identified as the highest percentage that contains the ions to interact which is believed to have the ability to support generating electricity that carrying percentage amounts of $(14.59 \pm 11.25\%)$ and $(1.64 \pm 0.54\%)$ respectively. The spectrum for peat soil is shown in Fig. 3 c) where the most intense peak indicates the most present elemental in the soil.

For clay soil, mostly several ion elements are Aluminum, Al with a percentage amount of $(10.15 \pm 7.01\%)$, K $(1.62 \pm 0.77\%)$, and Cu $(0.96 \pm 0.28\%)$. Also, other elements that consist in the clay soil are mainly from O with a percentage of $(50.10 \pm 58.40\%)$, second by C $(11.82 \pm 18.35\%)$, and the least is Ti $(0.45 \pm 18.35\%)$. While, from the analysis conducted for barren soil, there are other major elements present in the soil that led to the highest atomic percentage $(42.84 \pm 55.45\%)$, followed by Si $(13.54 \pm 10.03\%)$ and the least Ti with percentage $(0.62 \pm 0.27\%)$. It can be identified that the highest elemental in the peat soil is Al with a percentage of $(8.05 \pm 5.36\%)$ and K (1.93 ± 0.88) as the ion elementals that enable the electron movement within the soils and electrode, there are also present in peat soil are mainly from O with $(40.48 \pm 45.1\%)$, followed by C $(24.36 \pm 36.40\%)$ and the lowest are K (1.93 ± 0.88) .

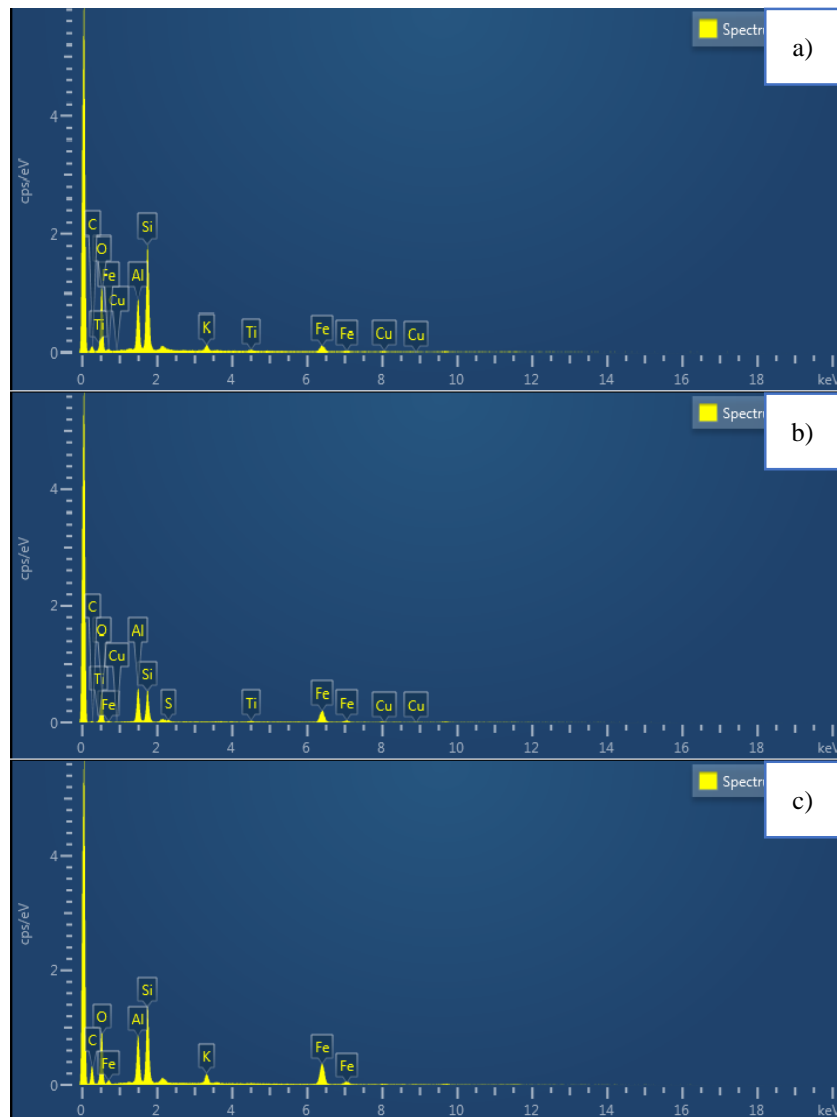


Fig. 3 EDX-Spectrum of a) Clay soil b) Barren soil c) Peat soil

3.2 The Best Battery Soil

Overall, all the battery soils are working and able to generate electricity with different kinds of soils and different types of electrolytes. In this study, it is shown that between clay soil, barren soil, and peat soil, the highest voltage value gained is battery soil with barren soil and distilled water as electrolytes. Hence, the barren soil gives the highest brightness of LED compared to clay and peat soil. As discussed above, it is identified that barren soil consists of the highest elemental ion which is Al with 11.25%. Based on the elemental ions for clay soil and peat soil, conclusions can be made in terms of elemental ion value, clay soil is the second-best battery soil, followed by peat soil. Fig. 4 a) and Fig. 4 b) show the brightness differences between these two types of soils.

Barren soil is most likely to generate the highest voltage measurement compared to the other two soil types, as seen in Table 1 and Table 2. For distilled water, the average voltage gained is 13.44 V for 10 ml and 13.46 V for 20 ml. Next, for tamarind water, the average for 10 ml is 7.190 V and 3.183 V for 20 ml. The drastic changes in voltage gained might be due to factors such as unstable multimeter readings, corroded material, and a few other possible factors. Both distilled and tamarind water can act as electrolytes to enable the function of earth batteries. These two types of electrolytes had different characteristics and the pH values of distilled water were 6.8 nearly neutral and tamarind water had a pH value of 2 which is very acidic. In addition, the surface morphology and it is chemical composition contribute to voltage generation as the surface morphology reveals the texture of the soil, the rate of electrolyte absorption to the soil can be expected while the chemical composition consists of the soil acting as the main character especially Aluminium, Al to generate the electricity.

Based on another study, it is proven that soil can generate electricity. The previous study conducted the earth battery with different kinds of connection and the standard series-parallel connection outperforms all other connections in terms of voltage loss, current, and power ratings. Carbon (C6) and Aluminium (Al13) are the ideal

electrodes for standard connections [9,10]. Hence, both kinds of earth batteries are capable of generating electricity with different parameters and results.

Table 1 Barren soil voltage reading with distilled water.

Distilled water	Volume (concentration)	1	2	3	4	5	Average
Voltage (V)	10 ml	13.45	13.44	13.44	13.44	13.43	13.44
	15 ml	13.48	13.47	13.47	13.47	13.46	13.47
	20 ml	13.46	13.46	13.46	13.46	13.46	13.46

Table 2 Barren soil voltage with tamarind water.

Tamarind water	Volume (concentration)	1	2	3	4	5	Average
Voltage (V)	10 ml	7.180	7.190	7.110	7.230	7.240	7.190
	15 ml	6.000	6.003	6.010	6.002	6.001	6.003
	20 ml	3.815	3.812	3.813	3.812	3.815	3.813

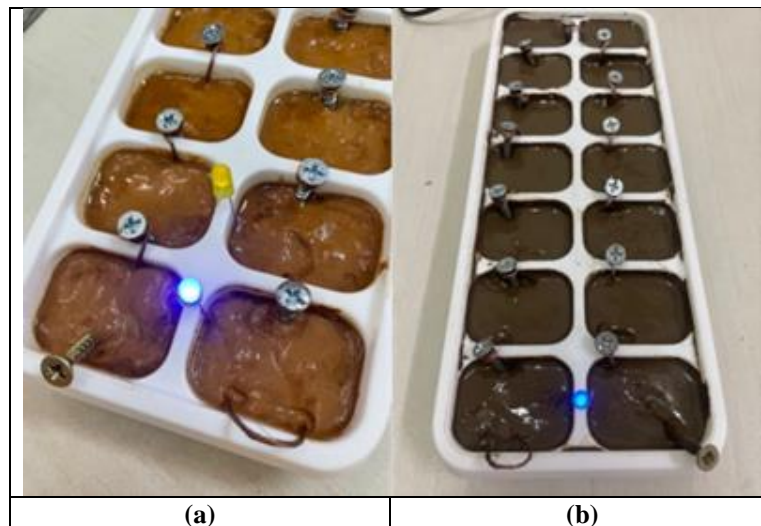


Fig. 4 LED light up with a) Barren soil b) Clay soil

4. Conclusion

As a conclusion, it can be summarized that all of the soil samples worked with in the earth battery can generate electricity. Scanning Electron Microscopy (SEM) investigated the surface morphology of the sample soils, such as denser, homogeneous, and porous, while Energy Dispersive X-ray (EDX) detected the elemental content of the sample soils, such as oxygen, O, iron, Fe, and carbon, C. The elemental ion content of the sample soils is primarily aluminium (Al), copper (Cu), and potassium (K). The statistics show that earth batteries with barren soil and distilled water as electrolytes produce the most electricity, with a voltage of 13.47 V.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design, data collection, methodology, analysis and interpretation of results:** Siti Rawiah Zulkipli, Mudzaffar Syah and Zaidi Embong. All authors reviewed the results and approved the final version of the manuscript.

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