ISSN: 1118-5872

FOS

MULTI-DISCIPLINARY JOURNAL

(Alvan Ikoku Federal University of Education)

GENERATING ENERGY FROM EARTH BATTERY: AN ALTERNATIVE SOURCE FOR ECO-FRIENDLINESS

Ngozi-Olehi L.C (PhD), Achinihu I.O & Mgbemene M.C
Department of Chemistry, Alvan Ikoku Federal University of Technology Owerri
Corresponding Author E mail: mrs.ngoziolehi@gmail.com,
Orcid: 0000-0001-6559-4055

Abstract

Technological advancement and man's discovery have been an effective development in the knowledge of chemistry. Although, fossil fuels are continually being formed via natural resources they are generally considered non-renewable resources. The practice of green chemistry supports generating energy from earth battery as an alternative energy considered to be eco-friendly. The threat of depletion of conventional energy which is rarely replaced at equal rate of consumption as well as its negative environmental hazards prompted this study, and has given more enlightenment on the awareness and importance of green chemistry especially in the industrial energy sector. Multiple cells were connected in series by connecting the negative electrodes to the positive electrodes while parallel connection was done by connecting negative to negative and positive to positive using a copper wire. The ground was also salted to help with the conductivity. It was observed that the total voltage of the cells increased in series connection above ground but decreased when connected in parallel. Results of the pilot experimental study on generating energy from earth batteries using copper cathode and zinc anode electrodes showed that energy from earth batteries has a reasonable potential use in remote locations for signaling as well as charging cell phone and white light applications. Increased number of cells led to increase in number of volts. This paper reports a detailed experimental design of an earth battery system which is cost effective and accessible. A total of 6.56 volts were obtained from the experiment and white light LEDs were powered on site.
Keywords: Earth battery, fuel cells, fossil fuels, alternative energy, electrodes.

Introduction

Over the decades, technological advancement and man's discovery has been an effective development with the knowledge of chemistry, which has increased man to a more advanced technical level. Teller (1908) in BrainyQuote (2003) stated that the "Science of today is the technology of tomorrow". brainyquote.com (2003).

Fossil fuel which is fuel formed by natural processes contain high percentages of carbon which includes coal, natural gas and petroleum. The theory that fossil fuels formed from the fossilized remains of dead plants, by exposure to heat and pressure in the Earth's Crust over millions of years, was first introduced by Andreas Libavius "in his 1597 Alchemia (Alchymia)" and later by Mikhail Lomonosov "as early as 1757 and Certainly by 1763". The first use of the term "fossil (https://en.wikipedia.org/wiki/Alternative_fuel). Although sustainable alternatives to fuel are currently being researched, the worldwide economy depends on fuel as a source of energy and

ensures that petrol will be in extremely high demand in years to come. For these reasons, many alternative sources of energy are currently being explored as replacement for petrol fuel as a source of energy.

According to Martel, Davies, Olson, Abraham, (2003), green chemistry also called sustainable chemistry, deals with the design of chemical products and processes that reduce or eliminate the use or generation of substances hazardous to humans, animals, plants and the entire environment. The limitations of a command-and-control system for environmental protection have become more obvious even as the system has become more successful.

In 1990, the pollution prevention act passed in the United States helped to create a modus operandi for dealing with pollution in an original and innovative way (www.epa.gov.com). It aims to avoid or curb problems before they happen. Anastas and Warner (1998), published twelve principles of green chemistry that explained a range of ways to reduce the environmental and health impacts of chemical production, and also indicate research priorities for the development of green chemistry technologies. The identified negative environmental impact of conventional fuel leads to investigation into alternative energy sources that are also eco-friendly. Energy from earth battery is an alternative energy considered to be eco-friendly.

Renewable Energy

Renewable energy refers to energy obtained from sources whose utilization do not result in the depletion of the earth's resources but replaced as used. According to Emem (2015), it is becoming increasingly acknowledged that the absence of access to modern energy services is detrimental to development. Modern energy services include household access to minimum level of electricity; household access to safer and more sustainable energy; access to modern energy that enables productive economic activities, and access to modern energy for public services. All these elements are crucial to social and economic development.

The major conventional sources of energy like coal, crude oil and natural gas remain critical components of Nigeria's energy mix and given the current reserves and rate of exploitation, its sustainability is a concern. Conventional energies will continue to be used in pursuance of socio-economic activities; however, it is not certain the role it would play in the increasing access to

energy. Energy is consumed by both rural and urban dwellers and connecting the rural communities to the existing electricity grid which is usually more accessible to the urban dwellers is expensive and uneconomical for the average developing country. This makes it imperative to diversify energy sources to include renewable energy which are alternatives to the conventional source.

Types of Renewable Energy or Alternative Fuel includes;

1. Solar energy - energy from the sun
2. Wind energy - energy from the wind
3. Geothermal energy - power from the earth derived from the heat of the earth
4. Hydroelectricity - kinetic energy of flowing rivers
5. Tidal power - power from motion of tides and waves from the ocean
6. Bioenergy – energy from biomass.
7. Refuse-derived fuel, chemically stored electricity (batteries and fuels cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil propane and other biomass sources.

This study focused on the chemically stored electricity type of renewable energy, one which is known as Earth Battery.

Earth Battery

Earth battery is one of the alternative energies that can be used to produce electricity. Earth battery is produced by the combination of soil and electrodes such as Copper electrode (Cu) with Zinc electrode (Zn) or other metals that can produce potential difference (V) and current (A). Earth batteries can be buried in the soil or immersed in the sea. They can act as water activated batteries and if the plates are sufficiently far apart, they can tap telluric current which are natural electrical current that flow through the earth crust. Earth batteries are sometimes referred to as telluric power sources and telluric generators. Earth batteries are not to be confused with soil-

based microbial fuel cells, which rely on electrogenic micro-organisms present in soil to generate electricity, as opposed to the galvanic reaction of two different metals.

This study generally sets out to generate energy of about 6volts from earth battery. It was piloted at the Chemistry laboratory of Alvan Ikoku Federal University of Education, Owerri Imo State.

Materials and Method

Materials used to set up a 6vdc system

- Copper Piping (1" thick, 2.4" long)
- Copper wire (2mm)
- Masking Tape
- 2.4" Insulator (Batten wood and thin plastic material)
- Galvanized pipe (Zinc pipe, 1" thick, 2.4" long)
- Multi-meter
- Plastic containers (20 litres each)
- Measuring tape
- Saw blade

Procedure for system assembly

Copper pipe, Zinc pipe and Insulator (wooden material) were cut to 2.4 inches long each. The insulator was placed in-between the two electrodes and tied together using masking tape. The electrodes were buried in a plastic container filled with soil (red mud) for effective monitoring. The set- up was a closed system and the soil was also salted before and after burying the metals to increase its conductivity as well as reduce the soil resistivity. About 10 litres of water was added to the soil to make it moist and ensure free flow of ions as water is a good electrolyte. The set-up was connected in series to obtain 6 volts. Copper wire was used to connect the negative electrodes to the positive electrodes. The voltage was measured daily using a Multimeter for seven (7) days, the positive and negative terminals of the metals were connected to the corresponding positive and negative terminals of the voltmeter for voltage level readings. Meter readings were allowed to be stable before recording

Results and Discussion

Table 1: Representation of data and observations in Day 1

Day 1	Single voltage readings in volts (v)
Cell 1	0.80
Cell 2	0.79
Cell 3	0.82
Total v in series	**2.41v**

Multiple cells were connected in series by connecting the negative electrodes to the positive electrodes while parallel connection was done by connecting negative to negative and positive to positive using a copper wire. Negative values were obtained when positive terminal of the meter was connected to the anode and negative terminal connected to the cathode.

Fluctuating values were observed and readings were taken at a stable meter value. The reading are as shown in Table 1 above giving a total voltage of 2.41v

Table 2: Presentation of data and observations in Day 2

Day 2	Single voltage readings in volts (v)
Cell 1	0.67
Cell 2	0.64
Cell 3	0.77
Cell 4	0.47
Cell 5	0.44
Cell 6	0.42
Total v	**3.41v**

The total voltage of the cells increased in the series connection which was maintained, however, the readings for cells 1-3 reduced by 0.13, 0.15, and 0.05 respectively. Total voltage was observed to be 3.41volts.

Table 3: Presentation of data and observations in Day 3

Day 3	Single voltage readings in volts (v)
Cell 1	0.72
Cell 2	0.64
Cell 3	0.77
Cell 4	0.50
Cell 5	0.45
Cell 6	0.39
Cell 7	0.74
Cell 8	0.45
Cell 9	0.37

Total v	**5.03v**

The total voltage of the cells increased in the series connection as more cells were added. It was observed that individual cells showed irregular pattern in voltage generation each day. The total voltage obtained with the 9 series connected cells is 5.03volts.

Table 4: Presentation of data and observations in Day 4

Day 4	Single voltage readings in volts (v)
Cell 1	0.49
Cell 2	0.61
Cell 3	0.53
Cell 4	0.55
Cell 5	0.54
Cell 6	0.48
Cell 7	0.74
Cell 8	0.51
Cell 9	0.35
Total v	**4.80 v**

Irregular generation of voltage from each individual cell was still observed. The total voltage decreased to 4.80v while maintaining the 9 cells on day 4 as seen on Table 4. Series connection was maintained.

Table 5: Presentation of data and observations in Day 5

Day 5	Single voltage readings in volts (v)
Cell 1	0.52
Cell 2	0.52
Cell 3	0.55
Cell 4	0.63
Cell 5	0.21
Cell 6	0.69
Cell 7	0.77
Cell 8	0.64
Cell 9	0.58
Cell 10	0.68
Cell 11	0.49
Cell 12	0.58
Total v	**6.86v**

From Table 5 above, the total voltage reading was observed to increase markedly yielding a value of 6.86 v with more cells added to make them up to 12.

Table 6: Presentation of data and observations in Day 6

Day 6	Single voltage readings in volts (v)
Cell 1	0.67
Cell 2	0.69
Cell 3	0.60
Cell 4	0.42
Cell 5	0.55
Cell 6	0.52
Cell 7	0.53
Cell 8	0.54
Cell 9	0.55
Cell 10	0.54
Cell 11	0.50
Cell 12	0.54
Total v	**6.65v**

Six extra cells were added in order to obtain higher voltage. Series connection was maintained. Total voltage was observed to be 6.65v, showing an increase in total voltage from day 5.

Table 7: Presentation of data and observations in Day 7

Day 7	Single voltage readings in volts (v)
Cell 1	0.68
Cell 2	0.69
Cell 3	0.62
Cell 4	0.45
Cell 5	0.56
Cell 6	0.53
Cell 7	0.68
Cell 8	0.53
Cell 9	0.59
Cell 10	0.58
Cell 11	0.56
Cell 12	0.60
Total v	**7.07 v**

As previously done in day 6, the single voltage reading of the 12 cells were taken. Cells 1, 3, 4, 5, 6, 7, 9, 10, 11, and 12 increased by 0.01, 0.02, 0.03, 0.01, 0.01, 0.15, 0.04, 0.04, 0.06, 0.06

respectively. While cell 2 remained constant and cell 8 reduced by 0.01. The total voltage as observed was recorded as 6.65v on day 6 to 7.07v on day 7 which was used to power white LEDs and rechargeable lamp. *(See Appendix)*.

Table 8: Showing the merged readings from days 1-7

Days/ Cells	1(v)	2(v)	3(v)	4 (v)	5(v)	6(v)	7(v)
1	0.80	0.67	0.72	0.49	0.52	0.67	0.68
2	0.79	0.64	0.64	0.61	0.52	0.69	0.69
3	0.82	0.77	0.77	0.53	0.55	0.60	0.62
4		0.47	0.50	0.55	0.63	0.42	0.45
5		0.44	0.45	0.54	0.21	0.55	0.56
6		0.42	0.39	0.48	0.69	0.52	0.53
7			0.74	0.74	0.77	0.53	0.68
8			0.45	0.51	0.64	0.54	0.53
9			0.37	0.35	0.58	0.55	0.59
10					0.68	0.54	0.58
11					0.49	0.50	0.56
12					0.58	0.54	0.60
Total (v) (series)	2.41v	3.41v	5.03 v	4.80 v	6.86 v	6.65v	7.07 v

It is observed that the voltage of the cells did not follow a regular pattern. The voltages increased at some days and decreased at other days. However, with additional cells connected to the series, more voltage was generated. Accurate measurements were maintained throughout the experiment. Readings were calculated from the voltmeter for both single and cumulative readings.

Discussion

Results of the study show a relationship between power generated from the cells and reaction time. The results reveal substantial evidences of power generation and this was consistent with all the cells studied. The power generation is as a result of exchange of ions owing to the potential difference created by the two electrodes with the soil as the transport medium of electrolytic ions. Across the entire cells, there were strong indications of voltage fluctuations and sags. This is clearly shown in the inconsistent rise and fall patterns of the graphs of the different cells as shown in Figures 1,2,3 and 4. Voltage sag is a phenomenon where the generated voltage from a cell keeps fluctuating as a result of the apparent values between the phase generated and the earth (Borno et al., 2021).

Direct and indirect observations were made when alternating the positive and negative terminals to control possible effects of changes made on energy generated. Connections were varied by testing both series and parallel connection to ascertain which is suitable for the experiment. Connection by series showed viability and was used. Earthing factor which is assumed to affect the voltage generation was considered and controlled by employing a closed system of having the soil enclosed in a container to avoid passage of energy should it be left in an open earth system. It was observed that the voltage level increased by connecting multiple earth battery cells in series, as shown in Figure 5. It is known that when cells are connected in series, the overall voltage of the combination (battery) is the sum of the individual voltages of each cell in the combination. However, this is typically not the case in practice owing to the afore mentioned issues of voltage fluctuations and sags (Mendes et al., 2008).

Alteration of the negative and positive terminals (negative terminal of meter to positive electrode and vice versa) was tested on day 1 and resulted to negative value. Voltage readings were found unstable on the digital meter, fluctuating values occurred for unstable wires and hands when readings were taken, however, readings were taken when stability was maintained. The observations made from the readings led to changing the experimental conditions by addition of more cells progressively to determine if the changes can affect the energy generation. This was however achieved. There is observed energy transfer as the total voltage of the cells was measured when connected in series.

Furthermore, there is transfer of energy only by measuring the voltage, but there is no transfer of mass/material from one container to another. This therefore showed that the system operated as a closed system. If the earth can produce charge, it means it can absorb the charge as well, (Khan et al., 2008). Due to the fact that earth consumes charges, precautionary measures were taken to control the experiment by enclosing the electrodes in plastic containers to avoid discharge of electrons to the earth.

Figure 1: Plot of Voltage (v) Generated against Reaction Time (days) for Cells 1, 2 and 3

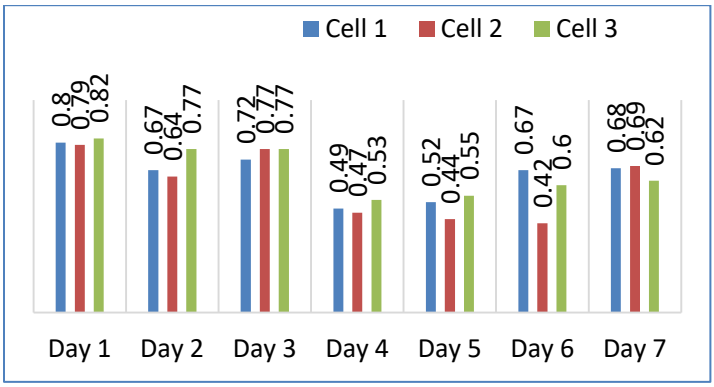

Figure 2: Plot of Voltage (v) Generated against Reaction Time (days) for Cells 4, 5 and 6

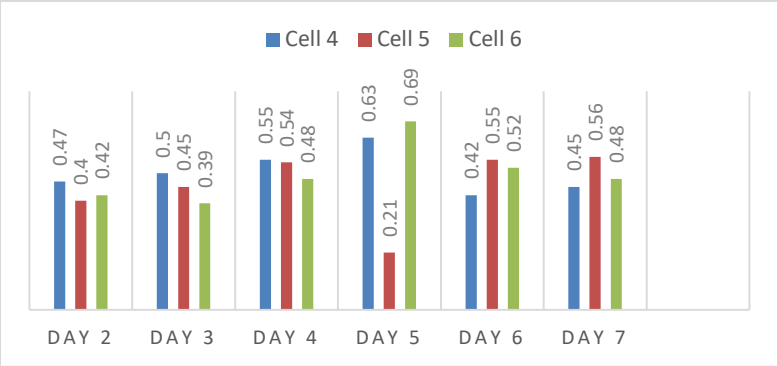

Figure 3: Plot of Voltage (v) Generated against Reaction Time (days) for Cells 7, 8 and 9

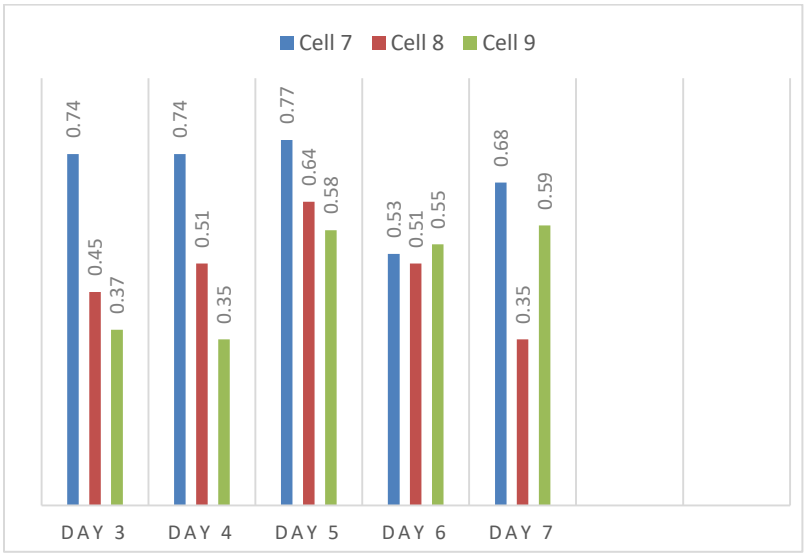

Figure 4: Plot of Voltage (v) Generated against Reaction Time (days) for Cells 10, 11 and 12

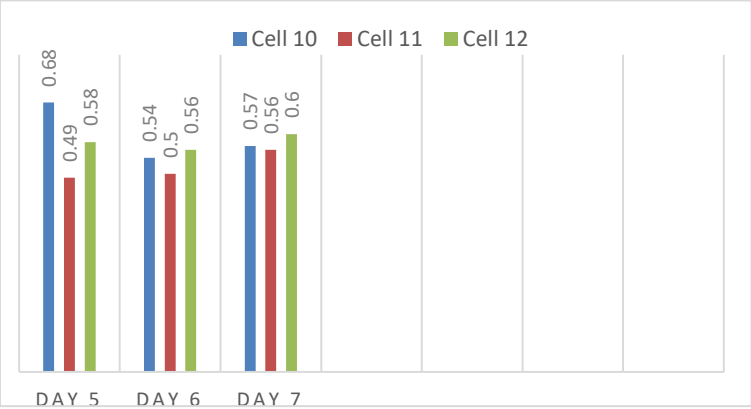

Figure 5: Plot of Voltage (v) Generated against Number of Cells Connected in Series

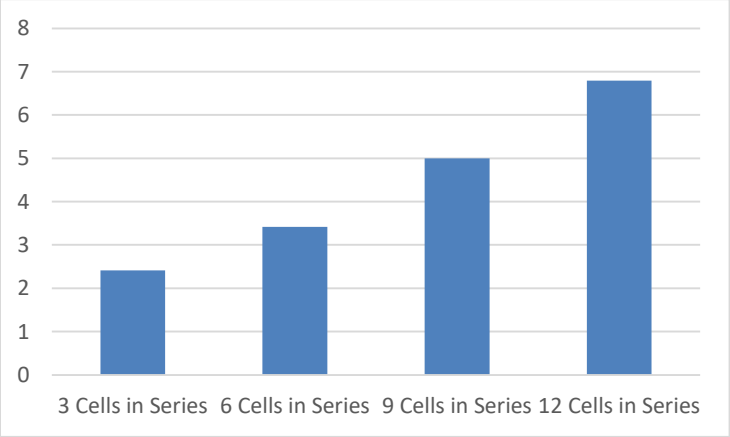

Fig. 6: Pictures of experimental process and output.

References

Anastas, P. T., Warner, J. C., (1998). *Green chemistry: theory and practice*.

Borno, Md. S. I., Sayeduzzaman, Md., Elme, K. Md., Islam, Md. H., & Rahman, Md. A. (2021). An empirical analysis of Sustainable Earth-Battery. *Energy Reports*, *7*, 144–151. https://doi.org/10.1016/j.egyr.2021.06.026

BP. (2018). Statistical review of World Energy. https://www.bp.cpm/content/dam/bp/business sitesen/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review

Edward Teller quotes (2019). Brainyquote.com.https://www.brainyquote.com/quotes /edward/teller.

Energy Commission of Nig 2013. *National Energy policy (draft revised edition). 12 World Alliance for Decentralized Energy (WADE),* August 2009. The potential or decentralized Energy in Nig. 4.

https://en.m.wikipedia.org retrieved April 18, 2019.

https://en.wikipedia.org/wiki/fossilfuel.

https://en.wikipedia.org/wiki/Alternative_fuel.

Khan, N., Saleem, Z., & Abas, N. (2008). Experimental study of earth batteries. *2008 Second International Conference on Electrical Engineering*, 1–4. https://doi.org/10.1109/ICEE.2008.4553917

Martel, J., Davies, W., Olson M & Abraham M. A. (2003). *Green Chemistry and Engineering*: Drivers, Metrics, and Reduction to practice".

Mendes, W., Samesima, M. I., & Moura, F. (2008). *Influence of power transformer winding connections on the propagation of voltage sags through electric system* (p. 6). https://doi.org/10.1109/EEM.2008.4579012

NasrullaK,. Zahid S., & Naeem A. (2008). Experimental study of earth batteries. *Second International Conference on Electrical Engineering,* University of Engineering and Technology, Lahore (Pakistan). 25-26 March 2008.

Onyejelam Emem (October 11, 2015), *The Energy crisis in Nig. & the role of law in promoting renewable energy development*.https://papers.ssrn.com

www.books.google.com ("The chemical works of Caspar Neumann".).

www.clipper.com.

www.epa.gov.com.

12 Principles of Green Chemistry - American Chemical Society. American Chemical Society. https://www.acs.org/greenchemistry/principles/12-principles-of-green-chemistry.html