“I hereby declare that I have read through this report entitle “Experimental Analysis of Earth Battery Using Different Combination of Metallic and Non-Metallic Solid” and found that it has complied the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power).

Signature : ....

Supervisor’s Name : PUAN ANIS NIZA BINTI RAMANI

Date : 25/6/2015

EXPERIMENTAL ANALYSIS OF EARTH BATTERY USING DIFFERENT COMBINATION OF METALLIC AND NON-METALLIC SOLID

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITY TEKNIKAL MALAYSIA MELAKA

2015

“I declare that this report entitle Experimental Analysis of Earth Battery Using Different Combination of Metallic and Non-Metallic Solid” is the result of my own result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : MUHAMMAD SYAHMI BIN ZAINUDDIN`

Date : 25/06/2015 .

DEDICATION

Specially dedicated to my beloved mother and father, friends and also my supervisor Puan Anis Niza Binti Ramani who always give me strength, guidance, and encouraged throughout my journey of education

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I, Muhammad Syahmi Bin Zainuddin have taken efforts in this project "Experimental Analysis of Earth Battery Using Different Combination of Metallic and Non-Metallic Solid". However, it would not have been possible without then kind support and help of many individuals and organizations. I would like to extend my sincere thanks to all of them.

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ABSTRACT

Soil has been proven it is capable to generate electricity. Numerous studies have been made regarding its capability of doing so. This is possible through the earth battery concept. Different research successfully applied it making LED's work. In this project, condition of soil, combination of electrode, and type of connection had been conclude. Diverse mixes of metallic and non-metallic solid were examined for most extreme potential energy. Material that will be used are copper, zinc, carbon and lead. Result show the best combination of electrode are zinc and copper. The voltage level was found to increment directly by change the combination of material. Other than that, voltage and current were found to increase by the wet condition of the soil. The humidity also give effect of measurement as the higher humidity, the increment of voltage and current will occur. Operation of earth battery as a free power source was exhibited effectively. Additionally, it is important to find way on the most proficient method to build the ability to be created by an earth battery.

ABSTRAK

Telah dibuktikan bahawa tanah mampu mengalirkan arus elektrik. Pelbagai kajian telah dilakukan untuk membuktikan kemampuan tersebut. Ini dapat dibuktikan dengan konsep bateri tanah. Pelbagai kajian telah berjaya dibuktikan dalam menyalakan LED. Di dalam projek ini, keadaan tanah, kombinasi elektrod dan jenis sambungan telah disimpulkan. Pelbagai gabungan logam dan bukan logam telah dikaji untuk tenaga keupayaan ekstrem. Bahan yang akan digunakan adalah kuprum, zink, karbon dan plumbum. Keputusan kajian menunjukkan kombinasi electrod yang terbaik adalah zink dan kuprum. Peningkatan voltan telah dikenalpasti dengan mengubah kombinasi bahan. Selain daripada itu, kondisi tanah lembab telah dikesan dapat meningkatkan voltan dan arus. Kelembapan juga memberi kesan terhadap bacaan dimana tinggi darjah kelembapan, peningkatan arus dan voltan berlaku.Operasi menentukan bateri tanah sebagai sumber tenaga asli telah berjaya dibuktikan. Tambahan pula, ianya penting untuk mencari langkah terbaik dalam membina keupayaan bateri tanah.

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LIST OF SYMBOLS

Cu	-	Copper
Pb	-	Lead
Zn	-	Zinc
C	-	Carbon
G	-	Gravel
S	-	Sand
W	-	Well graded
P	-	Poorly graded
Pu	-	Uniform
Pg	-	Gap graded
F	-	Fines soil
M	-	Silt (M-soil)
C	-	Clay
L	-	Of low plasticity
I	-	Of intermediate plasticity
H	-	Of high plasticity
V	-	Of very high plasticity
E	-	Of extremely high plasticity
U	-	Of upper plasticity range
Ca	-	Calcium
Mg	-	Magnesium
K	-	Potassium
Na	-	Sodium
NH4	-	Ammonium
H	-	Hydrogen

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Earth battery was construct by Scottish inventor Alexander Bain in 1841. This invention was first used to power his electric clock. The combination the plates that he used is zinc and copper. An earth battery is the simple homemade cell. Almost any liquid or moist object that has enough ions to be electrically conductive can serve as the electrolyte can serve as the electrolyte for a cell [1]. Production of small amount of electricity can be demonstrate by insert two electrodes into a lemon, potato and glass of soft drink. These homemade cells are of no real practical use because it just can produce small current and cost far more per unit energy generated than commercial cells. Earth batteries were used around the end of the 19th and beginning of the 20th century to power telegraph lines. They were buried in convenient locations along the power lines and supplied free for that infrastructure. The technology was discarded and replaced with hydroelectric because hydro was a measurable, finite source that industry could use to make money.

The earth battery bears resemblance to the common chemical or acid battery. Basically, the battery consist of two metal sheets or rods; one copper or carbon and the other zinc or aluminium. These metals are present as positive and negative terminal of the battery. An earth battery acts as the electrolyte system in voltaic cell because the conductive plates from different location are buried in the ground. This cell operating just like operating devices, these devices were not continuously reliable owing to drought condition. To obtain natural electricity, experiment would thrust two metal plates into the ground at a certain distance from each other in the direction of a magnetic meridian or astronomical meridian [2].

Notwithstanding, earth soil compound responses and electron partiality based earth batteries may be investigated for low to high voltage DC potential. Besides that, it also can considered to supplant high voltage low current charging force supplies or ionization power supplies. Like earth batteries the sea batteries likewise may be considered for comparable applications. Nonetheless, air batteries can be utilized for mass force creation and matrix framework operation. It has turn out to be essential to search for option vitality sources to keep down mankind from engagement to an awesome vitality war

1.2 Problem Statement

Nowadays, many type of generation were used to generate electricity in daily life. The generation can be generating by renewable source and non-renewable source. Example of renewable generation are wind generation, solar generation and hydro generation while non-renewable generation are comes from fossil fuel and nuclear fuel. The generation from the renewable source is very expensive and make a lot of cost to construct it. There has an alternative way to reduce the cost and generate electricity by using soil. It is very easy to construct and also pollution free. Other than that, relationship between combinations of material utilized as a part of the setup and the measure of voltage produce need to consider wisely. Besides that, it is important to know the relationship between the types of connection to generate lots of energy.

1.3 Objective

This objectives of this project are:

i. To determine the best type of electrode that will give better generation of the electricity.
ii. To investigate the effect of metal and non-metal electrode when connect with the load in different types of connection
iii. To explore the effect of moisture in different condition of soil.
iv. To analyse the performance electricity of earth battery.

1.4 Scope of work

This research project will focus primarily toward zinc and copper as the combination of the electrode that will be used in Earth battery. This is because the, copper and zinc have tendency that will produce high voltage, current and power. Besides that, zinc, graphite and lead also were used to find the best combination of electrode. This project will be attempt in five days and the reading will be measure five times.

Furthermore, the soil that will be used in this research is organic soil. Due to this, organic soil is the best type of soil because of the moisture of organic soil is very moist and can stand the moist condition in several day and also it is very easy to find. The selection of soil also will affect the production of voltage, current and power. Moreover, the effect of soil in temperature and humidity also will done. Additionally, the test will be done in ice cube and the distance between two materials have been fix. The distance would be use is 40mm.

1.5 Thesis outline

Chapter 1 of this report are discussed about the introduction of the research. This includes the abstract, project background, problem statement, objectives and scope of the study. Chapter 2 of this report is discussed about the literature review. This chapter present an overview of the research from introduction of earth battery, material of electrode, type of soil and galvanic cells. Furthermore, Chapter 3 discuss about the research methodology. This including the technique used, the procedures need to be complied and also describe the flow of the research and analysis parts are proceeding. Chapter 4 is discussed on the result and discussion. Chapter 5 will discuss about conclusion. It also includes the recommendation of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory and Basic Principle

A simple explanation of earth battery is that it is a water activated battery. When the distances of the two plates are far from each other, it can tap an electric current that moves underground or through the sea. An Earth battery is a pair of electrodes made of two dissimilar metals, such as iron and copper. It consists of conductive plates from different locations in the electro potential series, buried in the ground so that the soil acts as the electrolyte in a voltaic cell. As such, the device acts as a rechargeable battery [2].

At the point when sample of two plates, for example, zinc and copper are joined together through a substance that permit electrical current to stream and an electrochemical reaction procedure is started. When the procedure of plates are connect together with the right condition of soil, the electrochemical reaction occur to ensues production zinc ions from the zinc metal which travel through the ground toward the copper terminal. The chemical reaction of zinc will affect the plant and topsoil but it also affect groundwater, so it is important to limit the amount of zinc [3].

The soil is an unutilized chamber of natural energy. The chemical reaction in the soil produce independent ions which are left unresolved. The soil take actions as an electrolyte with two dissimilar electrodes buried in the soil and thus produce a potential difference. This process is called an 'earth cell'. To increase the voltage, connection in series is needed whereas to increase the current, connection in parallel should be done. Earth battery consists of electrodes buried in the earth, as therefore constructed, have not been capable of giving an electromotive force greater than that obtainable from a single couple.

2.2 Soil Groups

Soils consist of one or more distinct layers called horizons. These layers are alluded to as O, A, E, B, C and R relying upon their position and nature [2]. Figure 2.1 show the layer of the soil.

- O: Layers overwhelmed by natural material. Generally not introduce under warm-dry conditions.
- A: The mineral soil horizon that is as a rule at the surface or beneath an O horizon. It more often than not has more natural carbon than hidden layers. In some cases this layer is missing or truncated because of disintegration or evacuation. Likewise, all surfaces coming about because of furrowing, feeding, or comparable aggravations are alluded to as A horizon.
- E: Horizon characterized by eluviation (removal of materials such as silicate clay, iron, aluminium, or organic matter), if distinct from the A horizon. Frequently not present. Usually more pale coloured than the A horizon.
- B: A skyline, framed underneath An, E, or O skyline, which is ruled by demolition of all or quite a bit of the first shake structure and which shows proof of soil development, for example, alluvial (moved down from an above skyline) amassing of silicate dirt, iron, aluminium, humus, carbonates, gypsum, or silica; improvement of soil shading or structure; or weakness, and so on.

- C: Horizons or layers, barring hard bedrock, that are minimal influenced by pedogenic (soil framing) procedures what's more, that need properties of O, A, E or B skylines.
- R: Hard bedrock

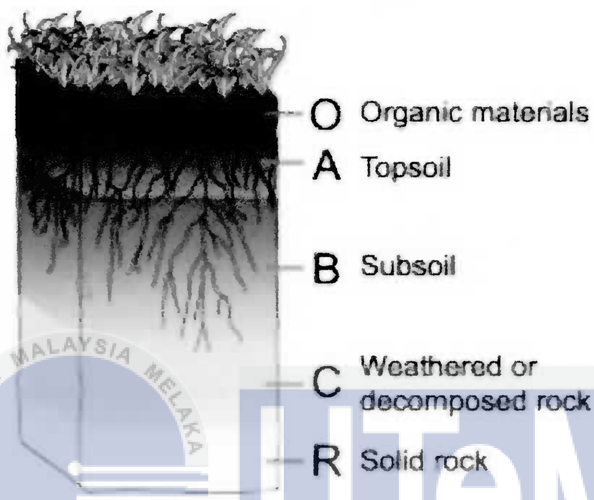


Figure 2.1 Layer of soil [4]

Table 2.1 shows the soil groups which is coarse soils, fine soils and other soil. In the coarse soils, it consist of gravel and sand while the fine soils consist of silt and clay whereas the other soil is organic soil [5].

Table 2.1: Soil Group [6]

Coarse Soils		Fine Soil		Other Soil
Gravel	Sand	Silt	Clay	Organic Soils

2.2.1 Gravel and Sand

Gravel and sand contain of rock fragment of different sizes and shape that can be either rock fragment or single mineral. The term uniform was describe as the narrow range of particle sizes present while the broad range of particle sizes is describe as well graded [6].

2.2.2 Silt

Silt is the intermediate among fined sand and clay. Silt is less plastic and more permeable than clay. Quick behaviour in silt is the impulse of silt to liquefy when shaken or vibrate. Dilatancy is refer to the tendency to sustain volume increase when deformed [6].

2.2.3 Clay

Clay consist of particles with a grain size of less than 4 micrometre and present in properties of cohesion and plasticity. That properties are not present in gravel or sand. Cohesion is the fact that material will stick together whereas plasticity is the property that grant substance to be deformed without volume change or rebound and without cracking or crumbling [6].

2.2.4 Organic Soil

Organic soil is different category from coarse or fine soils and it does not behave like silt or clay if the organic content is high. When the content of the organic is small to moderate, it still contain the properties of silt or clays [6]. Organic matter comprises of dead plant parts and creature and microbial waste items in different phases of disintegration. In the long run, these things separate into humus, which is generally steady in the dirt.

2.2.5 Soil Conductivity

Soil conductivity is a measure of the amount of salt in the soil. Soil conductivity is an important material in an earth battery. Soil conductivity determines the output power of the cell. The conduction in dirt occur through the moisture-filled pores that happen between individual soils particles. Naturally excess salt in soils containing in arid and semiarid climates. Salts level in the soil can increase as a result of cropping, irrigation and land management [7]. Although soil conductivity does not give a direct measurement of specific ions or salt compounds, it has been correlated to the concentrations of nitrates, potassium, sodium chloride, sulphate and ammonia. Therefore, the electrical conductivity of soil is determined by the following soil properties [8].

a. Porosity: The higher soil porosity, the more efficiently electricity is conducted. Soil with lot clay content has bigger porosity than sandier soil.
b. Water content: Dry soil is much lessened in conductivity than moist soil.
c. Salinity level: Increasing absorption of electrolytes (salts) in soil water will dramatically increase soil electrical conductivity. The salinity level in most soils is very low.
d. Cation exchange capacity (CEC): Mineral soil containing high levels of organic matter (humus) and/or 2:1 clay minerals such as Montmorillonite , illite , or vermiculite have a much higher ability to retain positively charged ions (such as Ca, Mg, K, Na, NH4, or H) than soil lacking these constituents. The presence of these

ions in the moisture-filled soil pores will enhance soil electrical conductivity in the same way that salinity does.

e. Temperature: As temperature decreases toward the freezing point of water, soil electrical conductivity decreases slightly. Below freezing, soil pores become increasingly insulated from each other and overall soil EC declines rapidly.

When managing for salinity on irrigated land, irrigation water salinity must be measured. If the quantity of the irrigation is too small, it will difficult to leach salts but when the water that high with amount of salts, it will be allows salts to accumulate in the root zone and increasing electric conductor in the soil. Good soil management measures to maintain soil organic matter and overall soil health and must be utilized to maintain the desired soil electric conductor level [8].

2.2.6 British Soil Classification System (BSCS)

From the Table 2.2, soil can be classify into group symbols of main terms and qualifying term in type of soil component. In BSCS, the soil consider as fine soil when it contains more than 35% fines while less than 35%, it is regarded as coarse soil. The boundary in fine soil is 65% fines whereas the boundary subgroup in coarse soil, between gravel and sand is 50% of 20mm coarse size as shown in Table 2.3. Figure 2.2 shows the British standard range of particle size

Table 2.2: Name and descriptive letter for grading and plasticity characteristic [9].

Components	Terms	Descriptive name	Letter
Coarse	Main	GRAVEL	G
		SAND	S
	Qualifying	Well graded	W
		Poorly graded	P
		Uniform	Pu
		Gap graded	Pg
Fine	Main	FINE SOIL, FINES	F
		may be differentiated into M or C	
		SILT (M-SOIL)	M
		Plots below A-line of plasticity chart	
		(of restricted plastic range)	
		CLAY	C
		Plots above A-line (fully plastic)	
	Qualifying	Of low plasticity	L
		Of intermediate plasticity	I
		Of high plasticity	H
		Of very high plasticity	V
		Of extremely high plasticity	E
		Of upper plasticity range	U
		Incorporating groups I, H, V and E	
Organic	Main	PEAT	Pt
	Qualifying	Organic	O
		May be suffixed to any group	

Table 2.3 British Soil Classification System for Engineering Purpose [9].

Soil groups			Subgroup and laboratory identification			
GRAVEL, and SAND may be qualified sandy GRAVEL and gravelly SAND, etc where appropriate			Group symbol	Subgroup symbol	Fines (%less than 0.06mm)	Liquid limit
COARSE Less than 35% of the material Is the finer than 0.06mm	GRVELS More than 50% of coarse material is of gravel size (coarser than 2mm)	Slightly silty or clayey GRAVEL	GW G GP	GW GPu GPg	0 to 5	
		Silty GRAVEL Clayey GRAVEL	G-M G-F G-C	GWM GPM GWC GPC	5 to 15	
		Very silty GRAVEL Very clayey GRAVEL	GM GF GC	GML, etc GCL GCI GCH GCV GCE	15 to 35	
	SANDS More than 50% of coarse material is of sand size (finer than 2mm)	Slightly silty or clayey SAND	SW S SP	SW SPu SPg	0 to 5	
		Silty SAND clayey SAND	S-M S-F S-C	SWM SPM SWC SPC	5 to 15	
		Very silty SAND Very clayey SAND	SM SF SC	SML, etc SCL SCI SCH SCV SCE	15 to 35	
FINE SOILS More than 35% of the material is finer than 0.06mm	Gravelly or sandy SILTS and CLAYS 35% TO 65% fines	Gravelly SILT Gravelly CLAY	MG FG CG	MLG, etc CLG CIG CHG CVG CEG		<35 35 to 50 50 to 70 70 to 90 >90
		Sandy SILT Sandy CLAY	MS FS CS	MLS, etc CLS, etc		
	SILTS AND CLAYS 65A5 to 100% fines	SILT (M-SOIL) CLAY	M F C	ML, etc CL CI CH CV CE		<35 35 to 50 50 to 70 70 to 90 >90
ORGANIC SOILS		Descriptive letter 'O' suffixed to any group or subgroup symbol				
PEAT		Pt				

In BSCS, the soil can be categorized into various group according to particle size:

i. Size more than 200mm : Boulder
ii. Size range 60 to 200mm : Cobble
iii. Size range 2 to 60mm : Gravel
iv. Size range 0.06 to 2mm : Sand
v. Size range 0.002 to 0.06mm : Silt
vi. Size range less than 0.002mm : Clay

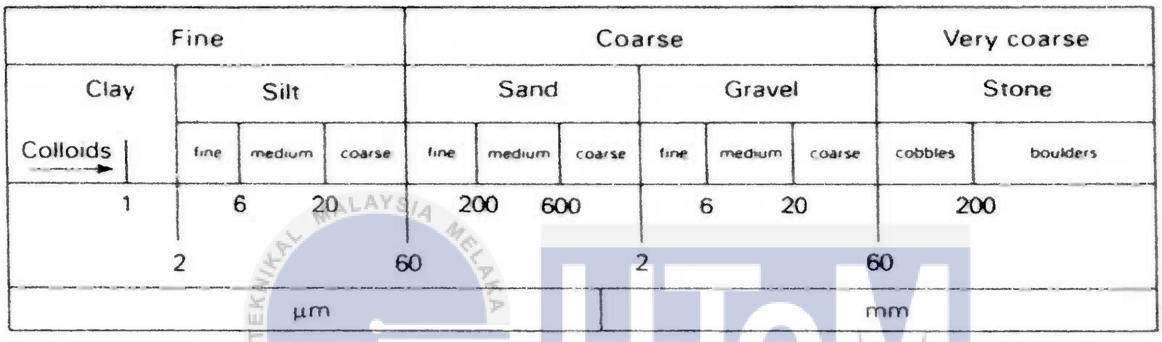


Figure 2.2: British standard range of particle sizes [7].

2.3 Metal Electrodes

An electrode is an electrical conductor used to make contact with a non-metallic part of a circuit and it refer either an anode or a cathode [2]. The anode is defined as the electrode at which electrons leave the cell and oxidation occurs. Anodes are positively charged electrode used in a variety of electrochemical processes such as corrosion protection and electroplating as well as components in batteries fuel cells and electrochemical devices. The cathode as the electrode at which electrons enter the cell and reduction occurs and cathode is negatively charged electrodes that been used in batteries, electrolysis system, fuel cells, electro winning, plating, and electron emission and other specialized processes [2].

Direction of current through the cell will determine the anode and cathode. The electrode step as way to tap the energy from the ground. Each electrodes will have different potential in the soil if different metal were used. This electrode have different strengths to oxidize or get reduced. The potential difference value is depend on potential of electrodes used as cathode and anode. From the table 2.4, the combination of electrode is very important to achieve a higher voltage, current and power from the previous work. The combination of copper and zinc is the best because of the value of power and current is higher than the other. The type of connection is very important to get maximum value of voltage and current. The voltage will increase while in parallel, the voltage in increase. For earth battery, connection in series was choosing to get maximum voltage and current.

Table 2.4: Potential Different in each type of material [8]

Metal	Potential (V)
Magnesium (Pure)	-1.75
Magnesium (Alloy)	-1.60
Zinc	-1.10
Aluminium (Alloy)	-1.05
Aluminium (Pure)	-0.8
Steel (clean)	-0.50 to -0.80
Steel (Rusted)	-0.20 to -0.50
Cast Iron	-0.50
Lead	-0.50
Steel (Concrete)	-0.20
Copper	-0.20
Brass	-0.20
Bronze	-0.20
Steel (Mill Scale)	-0.20
Cast Iron (High Silicon)	-0.20
Carbon	+0.30
Graphite	+0.30
Coke	+0.30

2.4 Galvanic Cells

In the electrochemical reaction, galvanic cell is the one way that can provide electricity. The process is the electron transfer in redox reaction to perform useful electrical work. The salt bridge is method in the galvanic cell and it is the same chemical reaction happen to the earth battery [10].

The salt bridge or porous disk is necessary to maintain the charge neutrality of each half-cell by allowing the flow of ions with minimal mixing of the half-cell solutions. As electrons are transferred from the oxidation half-cell to the reduction half-cell, a negative charge builds in the reduction half-cell and a positive charge in the oxidation half-cell. That charge build-up would serve to oppose the current from anode to cathode-- effectively stopping the electron flow if the cell lacked a path for ions to flow between the two solutions [10].

Theoretically, oxidation occur at anode while the reduction process is at cathode. Figure show the process of galvanic cell. From the cell, the negative charged electron flow through the wire not the direction of current.1

The oxidation takes place at the anode while the reduction is occurring at the cathode. The anode, as the source of the negatively charged electrons is usually marked with a minus sign (-) and the cathode is marked with a plus sign (+). Physicists define the direction of current flow as the flow of positive charge based on an 18th century understanding of electricity. As we now know, negatively charged electrons flow in a wire. Therefore, chemists indicate the direction of electron flow on cell diagrams and not the direction of current. To make that point clear, the direction of electron flow is indicated on with an arrow and the symbol for an electron, e^- [10].

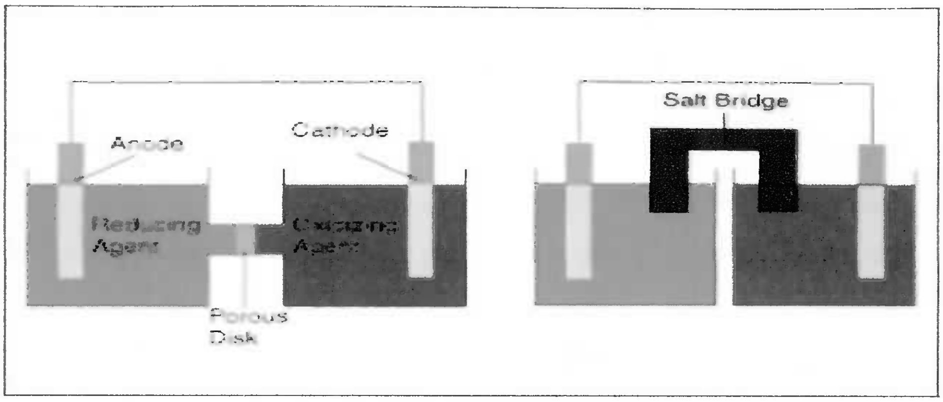


Figure 2.3: Galvanic cells [10]

For the reaction between zinc and copper, the two electrons is being transfer from both side oxidation and reduction. From the Figure 2.3, it shows that the galvanic cells reaction take place. At the anode, the reducing agent take place while the oxidizing agent take place at cathode. The reaction of negative electron will been flow to the anode. The reaction can be shown in equation (1),(2) and (3) below. Theoretically, copper strip will get heavier as the copper ion are reduced and deposited while zinc strip will getting lighter [11].

$$Cu^{2+} (aq) + 2e^- = Cu^0(s) \quad (1)$$

$$Zn^0(s) = Zn^{2+} (aq) + 2e^- \quad (2)$$

$$Cu^{2+} (aq) + Zn0 (s) = Cu0(s) + Zn2+ (aq) \quad (3)$$

2.5 Zinc

In the periodic table, zinc was in period number 4, group number 12 and element of classification is metal. Zinc metal is produce by heating the mineral calamine. Nowadays, zinc are usually used in the galvanization process and electroplating process. Moreover, the metallic zinc also used in making of battery.At present, zinc electrodes are analysed for zinc oxide, zinc chloride, zinc fluoride, zinc carbonate as the metal and trace metal. The quantity of zinc in the compound is determined by the ration of the molecular weight of zinc. Zinc metal is the charged state on the anode. In the earth battery, zinc particles from the zinc electrode are falling off the copper electrode. The electrochemical reaction occurs [12].

2.6 Copper

In the periodic table, copper was in period number 4, group number 11 and element of classification is metal. In electrical industry, copper were used in large of amount because copper is the good conductor and easily to mine and refine it. Copper also widely used in coin and the element were also used in electroplating.

In the experiment of determining the electrode, copper is been chosen because of the ionization energy and the condition in conducting electricity. Copper metal is the charged state on the cathode. The copper is usually being coated because the cost of pure copper is expensive [12].

2.7 Summary and Discussion

From the previous work it can see that the comparison between coarse, fine and organic soil in Table 2.5. It can be shown that fine soil between three types of the soil, fine and organic soil would be the best to use in this project. However, in this project organic soil would be choose because of it is easy to find than clay. Organic soil also have high compressibility than other types of soil and this characteristic need to be concern because it have high tendency to produce high energy. Organic soil also have variable permeability. Permeability is important because it need to give soil can absorb water easily and extend the time the soil will dry.

Table 2.6 show the British standard range of particle size for the soil. Clay have size range about 0.002 and less than the value. In this project, organic soil will be fixed medium. Table 2.7 show the properties of organic soil. The narrow size range is needed in this research. Table 2.8 show the differences between metallic and electrolytic conductance.

Table 2.5: Comparison between coarse, fine and organic soil

	Coarse	Fine	Organic
Inclusive soil type	Stone Gravel Sand	Silt Clay	Peat
Particle shape	Rounded to angular	Flaky	Fibrous
Particle or Grain size	Coarse	Fine	-
Porosity or Void Ratio	Low	High	High
Permeability	High	Low to very low	Variable
Apparent cohesion	None to very low	High	Low
Inter particle friction	High	Low	None to low
Plasticity	None	Low to high	Low to moderate
Compressibility	Very low	Moderate to very high	Usually very high
Rate of compression	Immediate	Moderate to slow	Moderate to rapid

Table 2.6: British standard range of particle size [7]

TYPE	COARSE								FINE		ORGANIC
	Boulders	Cobbles	Gravel			Sand			Silt	Clay	Organic Soil
			coarse	medium	fine	coarse	medium	fine			
Size Range (mm)	200	60	20	6	2	0.6	0.2	0.06	0.002		Refer to Section 2.3.5
Graphic Symbol											

Table 2.7: Organic soil properties

Term	Description
Topsoil	Surficial organic soil layer that may contain living matter. However topsoil may occur at greater depth, having been buried by geological processes or man-made fill, and should then be termed a buried topsoil
Organic clay, silt or sand	Contains finely divided organic matter; may have distinctive smell; may stain; may oxidise rapidly. Describe as for inorganic soils.
Peat	Consists predominantly of plant remains. Can be further described according to its degree of decomposition and strength. Firm: Fibres already compressed together Spongy: Very compressible and open structure Plastic: Can be moulded in hand and smears in fingers Fibrous: Plant remains recognisable and retain some strength Amorphous: No recognisable plant remains

Table 2.8: Different between metallic and electrolytic conductance

Metallic Conductance	Electrolytic conductance
Conductance is due to migration of electrons	Migration of ions to another electrode
It does not result in any chemical change	It involves the decomposition of the conductor
It decrease with increase in temperature	It increase with increase in temperature
It does not involve the transfer of any matter	Involve the transfer of matter

CHAPTER 3

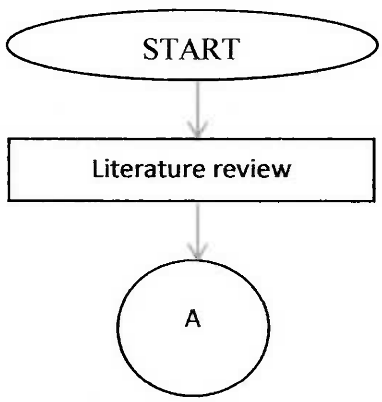
RESEARCH METHODOLOGY

3.1 Introduction

The aim of the earth battery project is to determine the suitable combination of electrode by analyse the measurement of the voltage and current and earth battery cells. The electrodes arrangement on earth's surface in open air environment consists of simple pricking of pointed electrodes on earth's surface [10].

3.2 Flow chart of the methodology

Figure 3.1 below show the flow chart of the methodology.



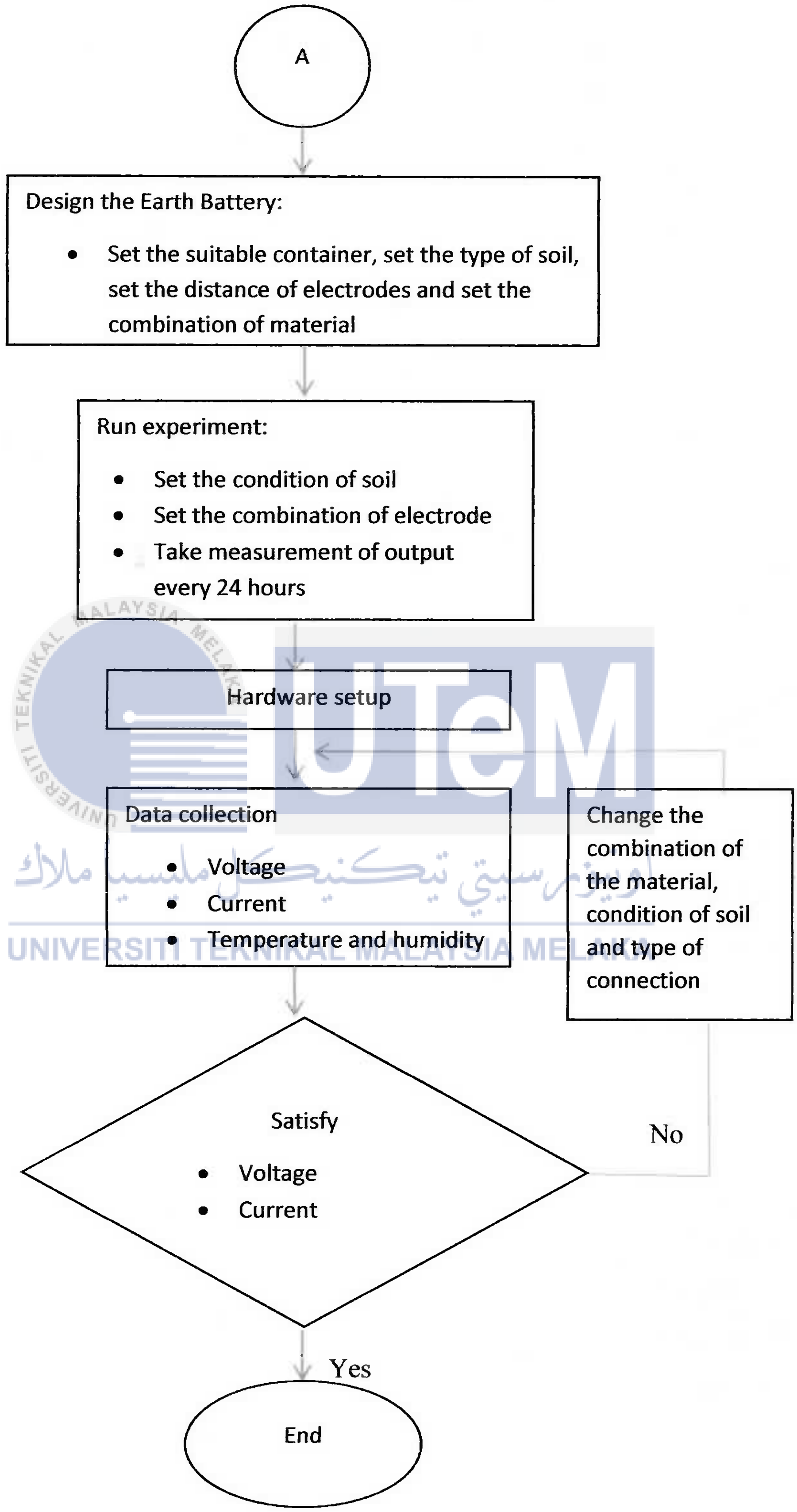


Figure 3.1: Flow chart of the Methodology

3.3 Setup the project

In this project, the arrangement in this project focus on the combination of the material for anode and cathode. The length for each material were be fixed at 20mm. Organic soil was used as electrolyte for earth battery. Table 3.2 show the other equipment or material that will be use in this project.

Table 3.2: The parameter and the value

Parameter	Value
Ice cube	4 pieces
Organic cell	$22.5cm^3$
Cable	1 meters
Crocodile clip	60 units
Zinc (10mm width, 20mm length)	40 pieces
Copper (10mm width, 20mm length)	40 pieces
Lead (10mm width, 20mm length)	40 pieces
Carbon (20mm length)	40 pieces
Multimeter	1 unit
Fluke 971 (Temperature Humidity meter)	1 unit
LED	1 unit

3.4 Combination of electrode

The materials that were used in this experiment are copper for anode electrode, zinc for cathode electrode and organic soil. Figure 3.1 shows the connection of the earth battery. The connections of electrode are made from bunch of pair of anode and cathode to give a high measurement of current and voltage. The type of connection to be test in this experiment are series-parallel connection and series. This is to investigate what is the best connection to be use that will get a suitable current and voltage.

The distance of anode and cathode also are important because the larger the distance, the current and voltages were found lower as the distance of anode and cathode are in smaller range. The distance between anode and cathode have been fixed in this test. The distance that will be used is 30mm. Repetition of measurement is also important because it found that the reading were unstable by using digital multi-meter and also the interchange of electrodes from north to south resulted in relatively increased voltages and currents. The earth battery potential is depends on the type of material were used for anode and cathode and also the condition of the soil. For the combination of electrode, five pair of electrode were take place in this research. The pair combination of electrode are:

i. Zinc – copper
ii. Zinc – carbon
iii. Zinc – lead
iv. Copper – carbon
v. Copper – lead
vi. Lead - carbon

Figure 3.2, Figure 3.3 and Figure 3.4 show the connection of material that will be use. The output of the research will measure by using multimeter and lamp to test the brightness of lamp. Crocodile clip are used to connect the combination of material

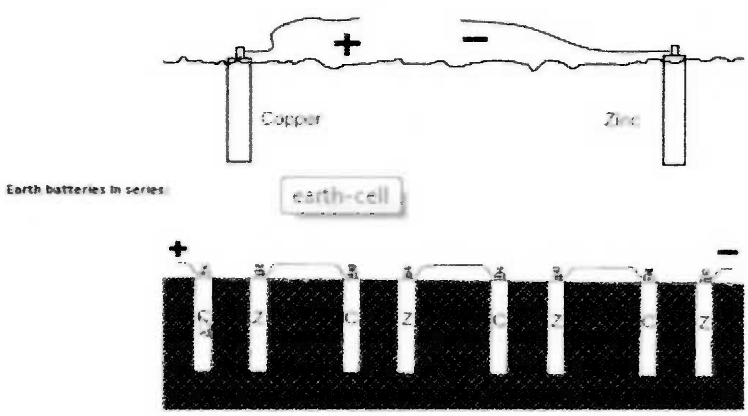
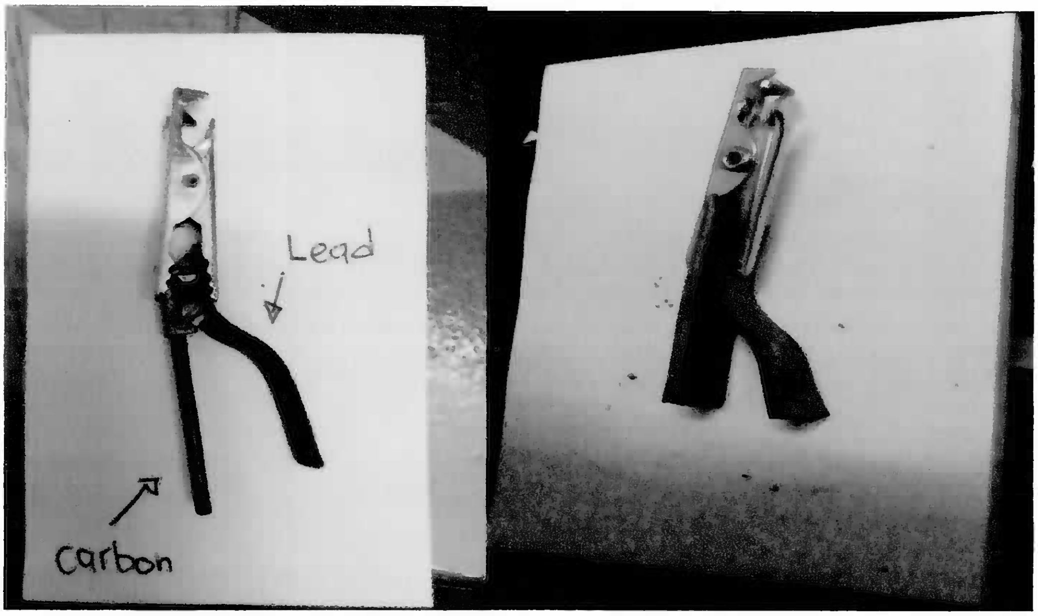
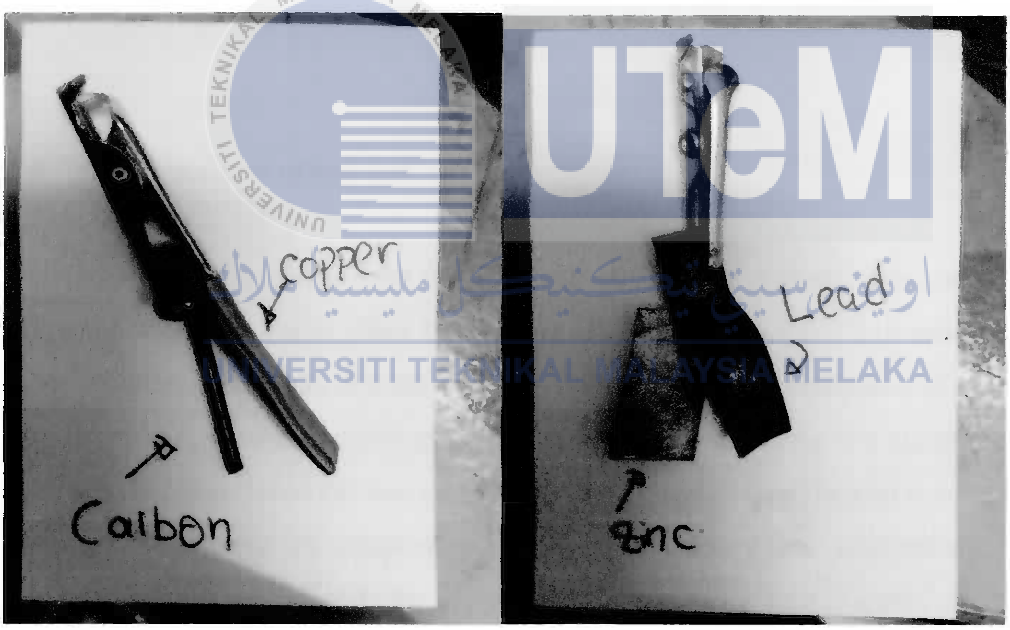


Figure 3.1: The connection of earth battery [12]



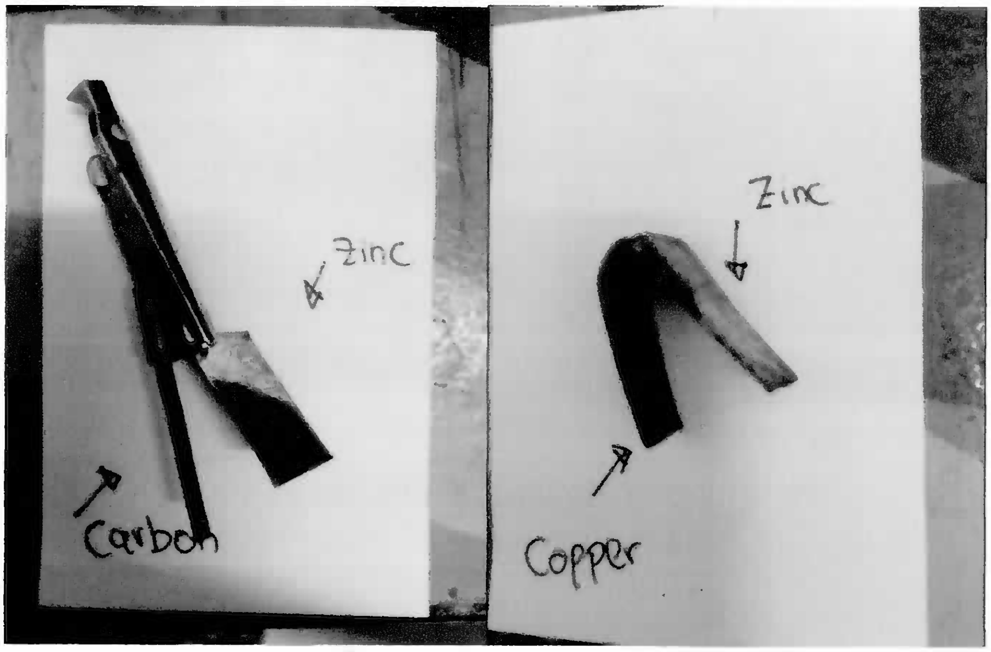
(i) (ii)

Figure 3.2 Combination of material; (i) lead-carbon; (ii) copper-lead



(i) (ii)

Figure 3.3 Combination of material; (i) Copper-Carbon; (ii) Lead-Zinc

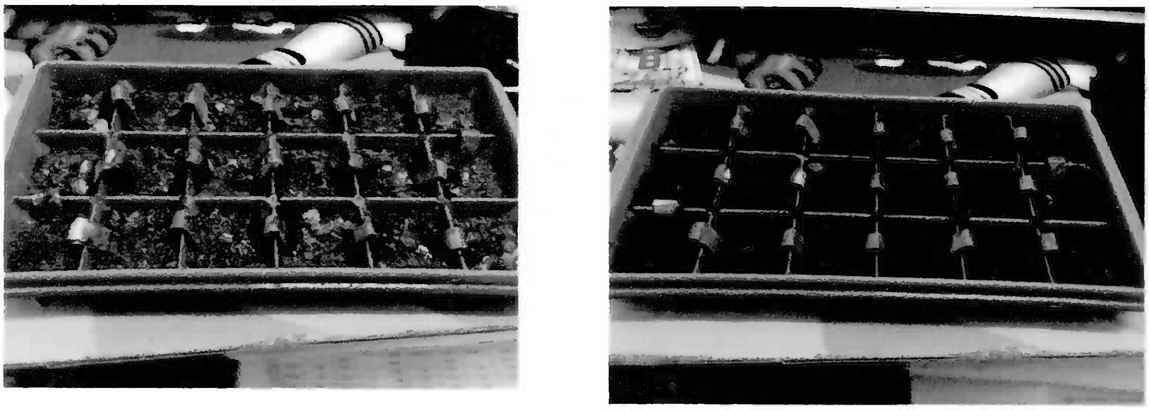


(i) (ii)

Figure 3.4 Combination of material; (i) Zinc-Carbon; (ii) Copper-Zinc

3.5 Condition of soil test

The condition of the soil and the type soil will used for the research is organic soil and this is important to know effect to the measurement. The organic soil contains large value of mineral salt than dry soil and it is will increase the conduction of electricity. Ensure the soil always in moist and repeated five times in taking the measurement of the earth battery because the energy that produces is not stable. The soil need to be mix with water because of the composition of organic soil is very low. This test also will be measure in dry soil to identify the measurement in two condition. Figure 3.5 (i) shows the dry organic soil while the wet organic soil is shown in Figure 3.5 (ii). Both have the same amount of soil in each cube.



(i) (ii)

Figure 3.5 Condition of soil; (i) Dry; (ii) Wet

3.6 Type of connection

The type of connection in needed to measure several way to get the best measurement. The Earth Battery project will be test in series connection and series-parallel connection. Figure 3.6 shows the connection in series while Figure 3.7 shows the connection in series-parallel. This observation will be test in ice cube with the same amount soil and the same amount of water in each cube. Series and series-parallel connection also will be test in dry soil and wet soil condition. Figure 3.6 show the connection of earth battery in series for copper-zinc combination while Figure 3.7 shows the connection in series-parallel. For the series-parallel connection, the major part of connection is in series because to give a greater value of voltage. Both of the soil will be test in series and series-parallel connection with different type of material.

Figure 3.6 Connection in series

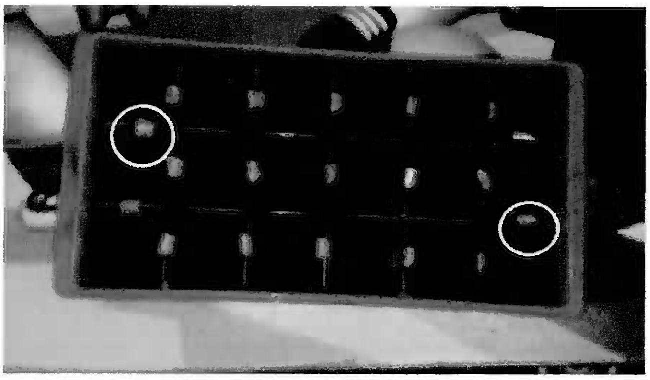


Figure 3.7 Connection in series parallel

3.7 Effect Moisture

This experiment will be test 5 times to observe the moisture of the soil for both condition of soil. Temperature of soil and humidity of soil can be measure by using humidity meter as shown in figure. The reading will take once for a day. The measurement will be taken by using Fluke 971 Temperature Humidity meter. This is need to be measure because the humidity of soil are not stable.

Figure 3.8: Fluke 971 Temperature Humidity meter

3.8 Project milestone

Table 3.2.: Table of Project milestone

Project task	Date
Project Title and SV Approval	25 August 2014
Literature Review	18 October 2014
Material Selection	5 December 2014
Setup Project	10 January 2014
Collect Data	15 February – 27 March 2015
Report Writing	29 April 2015

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter will discuss the result of the experimental analysis of earth battery using different combinations of metallic and non-metallic solid. This chapter will consist of the result and analysis of the research.

4.2 Combination of electrode

The main purpose of the earth battery is to find the ideal type of combination for electrode. Table 4.1 show the combination of the electrode between metallic with non-metallic and metallic with metallic. This test will be analyse in two condition which is dry soil and wet soil. Table 4.1 and Table 4.2 shows the difference measurement between voltage and current for different condition of soil. Figure 4.1 and Figure 4.2 show the state the differences voltage and current among the combination of material. The wet organic soil do much higher voltage and current than the dry soil. It is because dry are very apart in composition of soil and it can see that the data for current in the Table 4.1 is very low in measurement while the current on wet organic soil is higher. Table 4.1 and Table 4.2 also shows that the combination of zinc and copper are the best among the other material. It can be conclude that condition of soil should be wet to get maximum amount of current and voltage. Figure 4.1 and Figure 4.2 shows that the graph for combination in dry and wet soil.

Table 4.1: Combination of electrode in dry soil

Day		Combination					
		Zinc-Copper	Zinc-Carbon	Zinc-Lead	Copper-Carbon	Copper-Lead	Lead-Carbon
Day 1	Voltage (V)	12.42	1.23	3.66	0.25	2.55	0.93
	Current (mA)	0.01	0.00	0.00001	0.00	0.00001	0.00
Day 2	Voltage (V)	11.03	0.98	2.53	0.23	1.15	0.48
	Current (mA)	0.01	0.00	0.00	0.00	0.00	0.00
Day 3	Voltage (V)	9.68	0.58	2.53	0.16	1.15	0.13
	Current (mA)	0.01	0.00	0.00	0.00	0.00	0.00
Day 4	Voltage (V)	7.56	0.58	1.40	0.05	1.03	0.00
	Current (mA)	0.00	0.00	0.00	0.00	0.00	0.00
Day 5	Voltage (V)	7.46	0.58	1.4	0.05	0.98	0.00
	Current (mA)	0.00	0.00	0.00	0.00	0.00	0.00

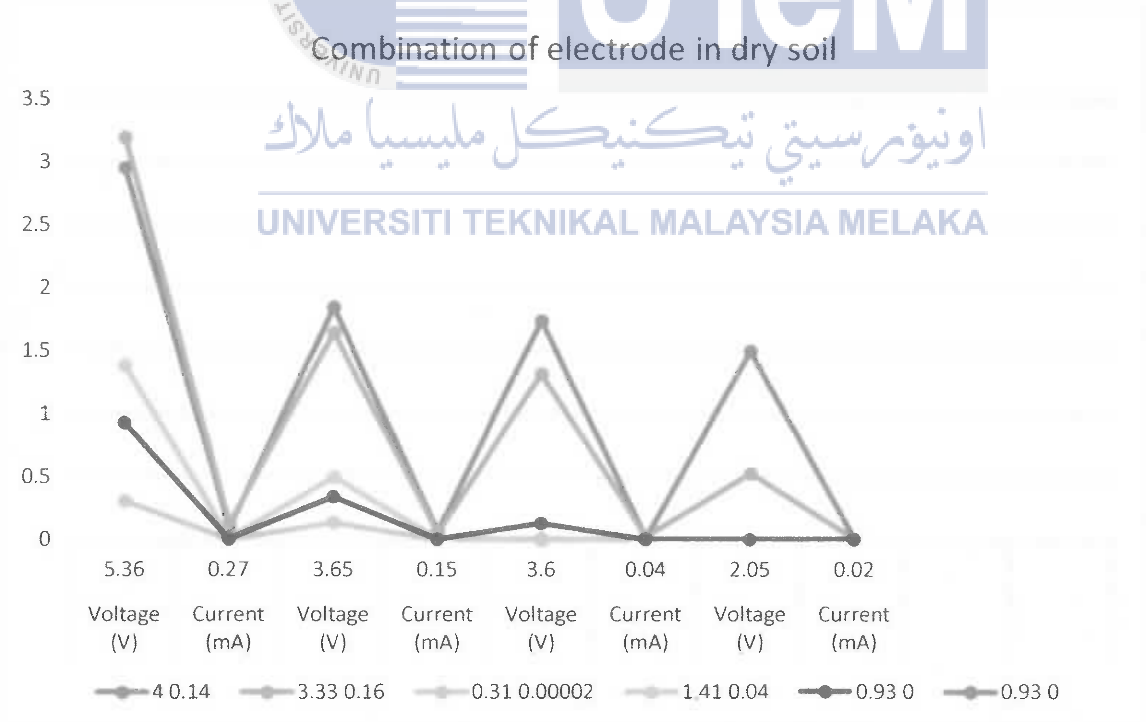


Figure 4.1: Combination of electrode in dry soil

Table 4.2: Combination of electrode in wet soil

Day		Combination					
		Zinc-Copper	Zinc-Carbon	Zinc-Lead	Copper-Carbon	Copper-Lead	Lead-Carbon
Day 1	Voltage (V)	7.30	4.00	3.33	0.31	1.41	0.93
	Current (mA)	0.46	0.14	0.16	0.00002	0.04	0.00
Day 2	Voltage (V)	5.36	2.96	3.20	0.31	1.39	0.93
	Current (mA)	0.27	0.10	0.13	0.00002	0.01	0.00
Day 3	Voltage (V)	3.65	1.85	1.65	0.14	0.50	0.34
	Current (mA)	0.15	0.07	0.06	0.00	0.01	0.00
Day 4	Voltage (V)	3.60	1.74	1.32	0.01	0.00	0.13
	Current (mA)	0.04	0.02	0.03	0.00	0.00	0.00
Day 5	Voltage (V)	2.05	1.50	0.53	0.00	0.00	0.00
	Current (mA)	0.02	0.01	0.01	0.00	0.00	0.00

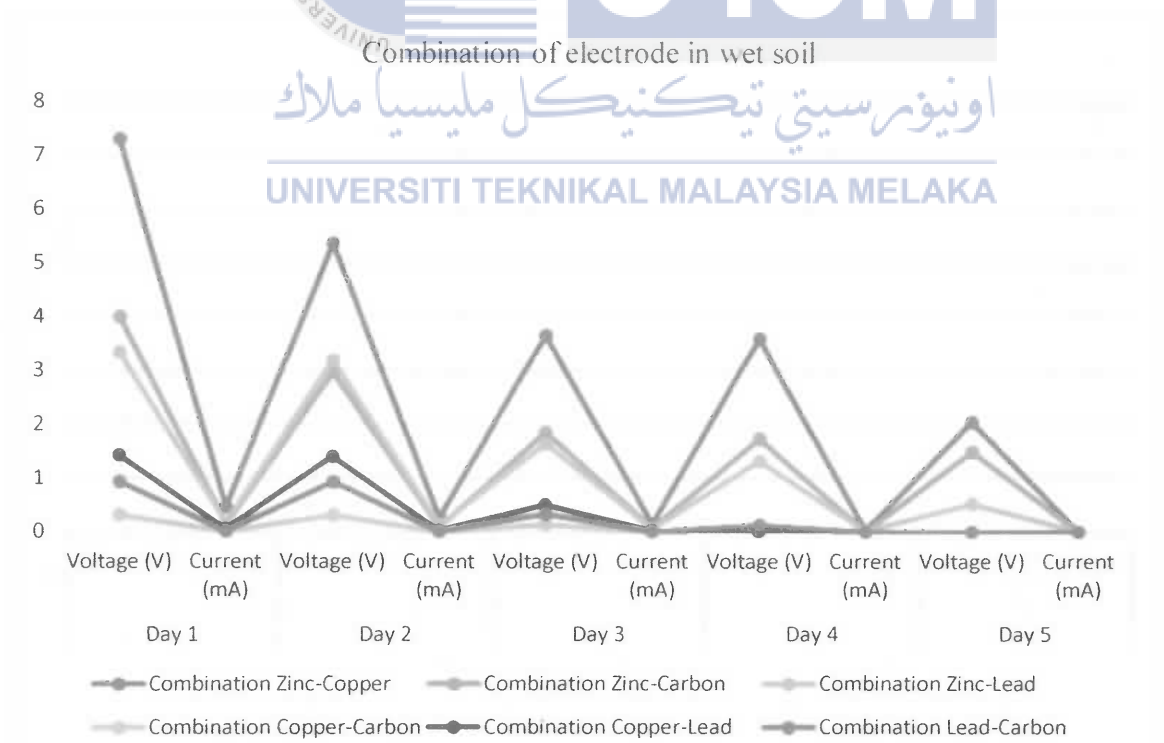


Figure 4.2: Combination of electrode in wet soil

4.3 Type of connection

The type of connection also important part to be measure because of it would affect the measurement of voltage and current. The type that to be measure are series connection and series-parallel connection. Type of connection also will measure with different combination of material and will observe in five times for five days. Data in the Table 4.1 and Table 4.2 are from series connection. In this research, the connection will be test in the wet organic soil condition. Table 4.3 shows the data from series connection while series-parallel connection in Table 4.4. Figure 4.3 and Figure 4.4 shows data collected in series and series-parallel connection. From the research, it clearly see that the series connection give the best amount of voltage than series-parallel connection. Moreover, the value current from series connection are not much different than series-parallel connection. The amount of voltage in series-parallel is lower because the quantity of ice cube is low. Another factor that would occur is resistance that produce in the connection is high. Figure 4.3 and Figure 4.4 shows that the graph of connection in series and series-parallel.

Table 4.3 Connection in series

Day		Combination					
		Zinc-Copper	Zinc-Carbon	Zinc-Lead	Copper-Carbon	Copper-Lead	Lead-Carbon
Day 1	Voltage (V)	7.30	4.00	3.33	0.31	1.41	0.93
	Current (mA)	0.46	0.14	0.16	0.00002	0.04	0.00
Day 2	Voltage (V)	5.36	2.96	3.20	0.31	1.39	0.93
	Current (mA)	0.27	0.10	0.13	0.00002	0.01	0.00
Day 3	Voltage (V)	3.65	1.85	1.65	0.14	0.50	0.34
	Current (mA)	0.15	0.07	0.06	0.00	0.01	0.00
Day 4	Voltage (V)	3.60	1.74	1.32	0.01	0.00	0.13
	Current (mA)	0.04	0.02	0.03	0.00	0.00	0.00
Day 5	Voltage (V)	2.05	1.50	0.53	0.00	0.00	0.00
	Current (mA)	0.02	0.01	0.01	0.00	0.00	0.00

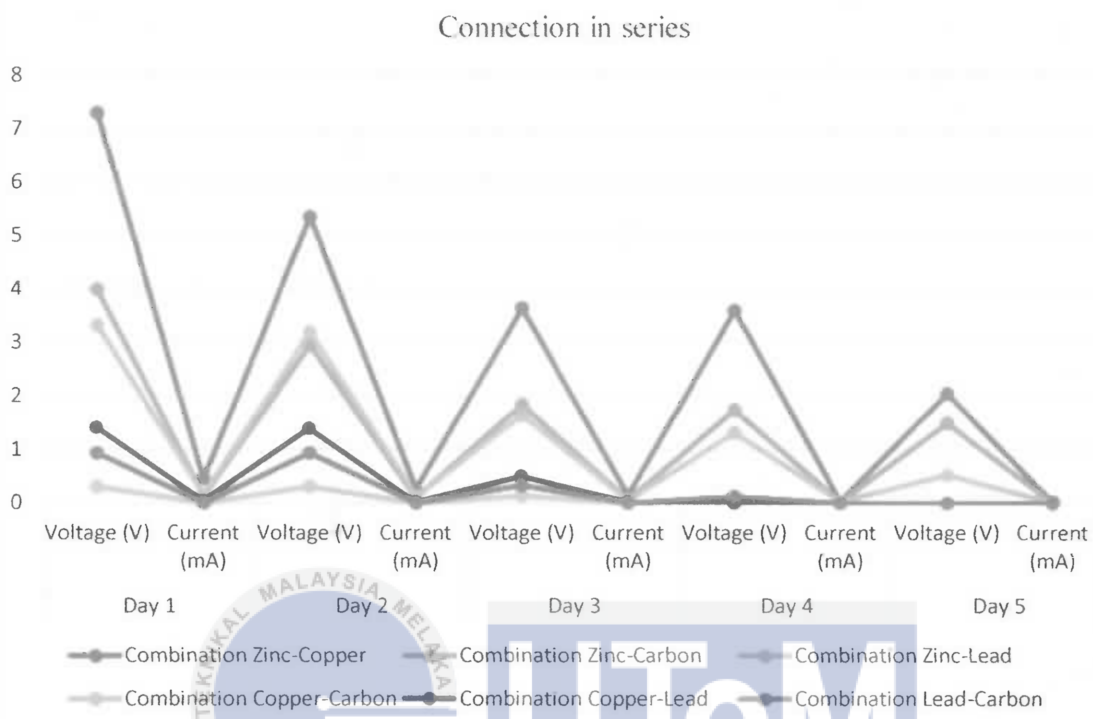


Figure 4.3: Connection in series

Table 4.4 Connection in series-parallel

Day		Combination					
		Zinc-Copper	Zinc-Carbon	Zinc-Lead	Copper-Carbon	Copper-Lead	Lead-Carbon
Day 1	Voltage (V)	2.40	1.65	0.64	0.21	1.03	0.74
	Current (mA)	0.54	0.33	0.16	0.05	0.10	0.05
Day 2	Voltage (V)	2.11	1.37	0.58	0.10	0.95	0.43
	Current (mA)	0.46	0.28	0.10	0.03	0.05	0.01
Day 3	Voltage (V)	1.84	1.21	0.42	0.01	0.58	0.26
	Current (mA)	0.33	0.13	0.09	0.01	0.03	0.00
Day 4	Voltage (V)	1.50	0.50	0.28	0.00	0.01	0.01
	Current (mA)	0.10	0.09	0.03	0.00	0.00	0.00
Day 5	Voltage (V)	0.32	0.04	0.15	0.00	0.00	0.00
	Current (mA)	0.08	0.00	0.01	0.00	0.00	0.00

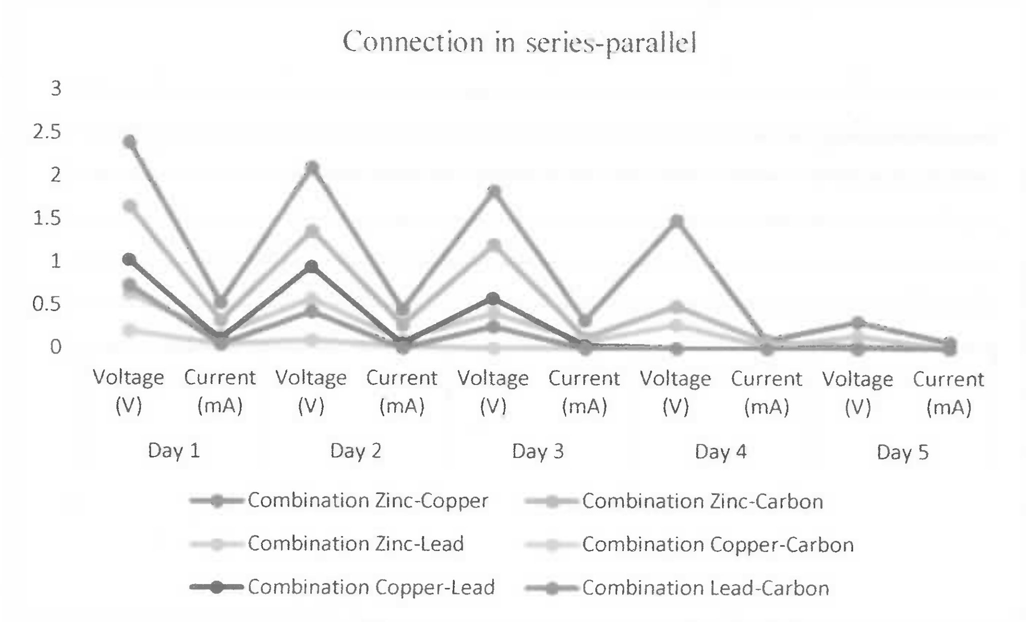


Figure 4.4: Connection in series-parallel

4.4 Effect moisture

The effect of moisture was determine to see the changes of humidity and temperature of soil whether in dry or wet condition. From the Table 4.5 it can see that the dry organic soil does not give very high impact changes in temperature and humidity while the wet organic soil give slightly changes and it shows that the measurement of voltage and current become low because of the changes. On top of that, humidity give effect to the reading. The higher the humidity of the soil, the higher output of voltage and current will become high.

Table 4.5 Effect moisture on the soil

Days	Dry organic soil		Wet organic soil	
	Humidity (% AH)	Temperature (°C)	Humidity (% AH)	Temperature (°C)
Day 1	70.0	31.7	92.0	31.3
Day 2	67.6	33.2	91.9	31.9
Day 3	68.0	33.2	85.7	31.1
Day 4	67.8	33.3	78.6	31.8
Day 5	67.2	33.4	73.1	32.5

4.5 Amount of soil

The amount of soil also will be the major effect in this research. It will be determine the value of voltage and current and also the output of led. From the Table 4.6 it can see the current for 3 scoop of sand is the higher but it distract the value of voltage and so the LED cannot light on. The quantity of soil will determine by using scoop of cap bottle. It happen due to high resistance of the soil and the amount of water added to the three scoop too much for that amount of soil. For two scoop of sand show the LED light on but it not very bright as shown in Figure 4.6. This is because the amount of current is still small. Figure 4.5 show the result from one scoop of sand and Figure 4.7 Result from three scoop of sand.

Table 4.6 Amount of soil

Scoop of sand	Voltage (V)	Current (A)	LED
1	2.56	0.23	No light
2	7.30	0.46	Dim
3	0.33	0.78	No light

Figure 4.5: Result from one scoop of sand

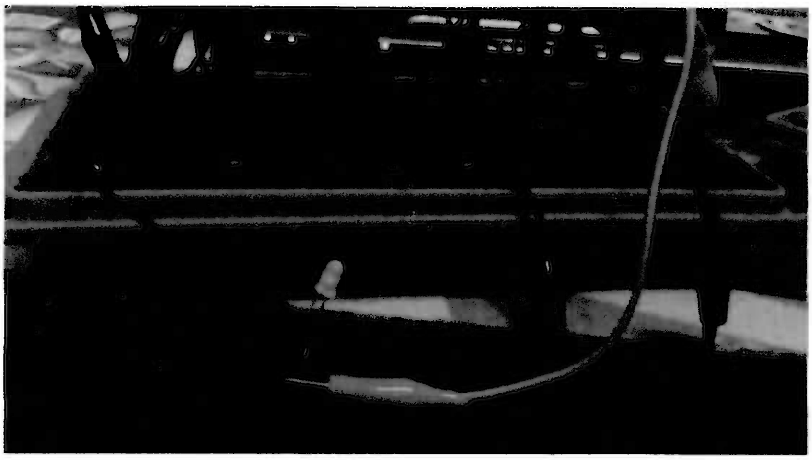


Figure 4.6: Result from two scoop of sand

Figure 4.7: Result from three scoop of sand

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

These days, the era of power from green innovation are generally utilized despite the fact that the expense of development is high. Soil can be one of the option sources that can be utilized to beat the expense of development on account of the material and the method to do the earth battery is exceptionally basic. In conclusion, the best combination of material are zinc and copper and it must be done in wet organic soil because of the composition of soil and the humidity of the soil that will increase the load of voltage and current. Furthermore, the material cannot use several times because of corrosion occur from the soil and will give impact to the reading. Other than that, the amount of water also need to be concern because it will affect the reading and series connection give the best amount voltage and current.

5.2 Future work and recommendation

Based from the outcome of the test and examinations, the researchers prescribed that further and thoroughly studies be made to rise the low ampere rating develop by the earth batteries for it is just conceivable to produce machines, for example, telephone charger, mini USB fan or light. It is additionally prescribed to find way on the most proficient method to build the ability to be created by an earth battery. Other than that, it is suggest that further study and trials be made to completely comprehend the earth battery idea and its properties.

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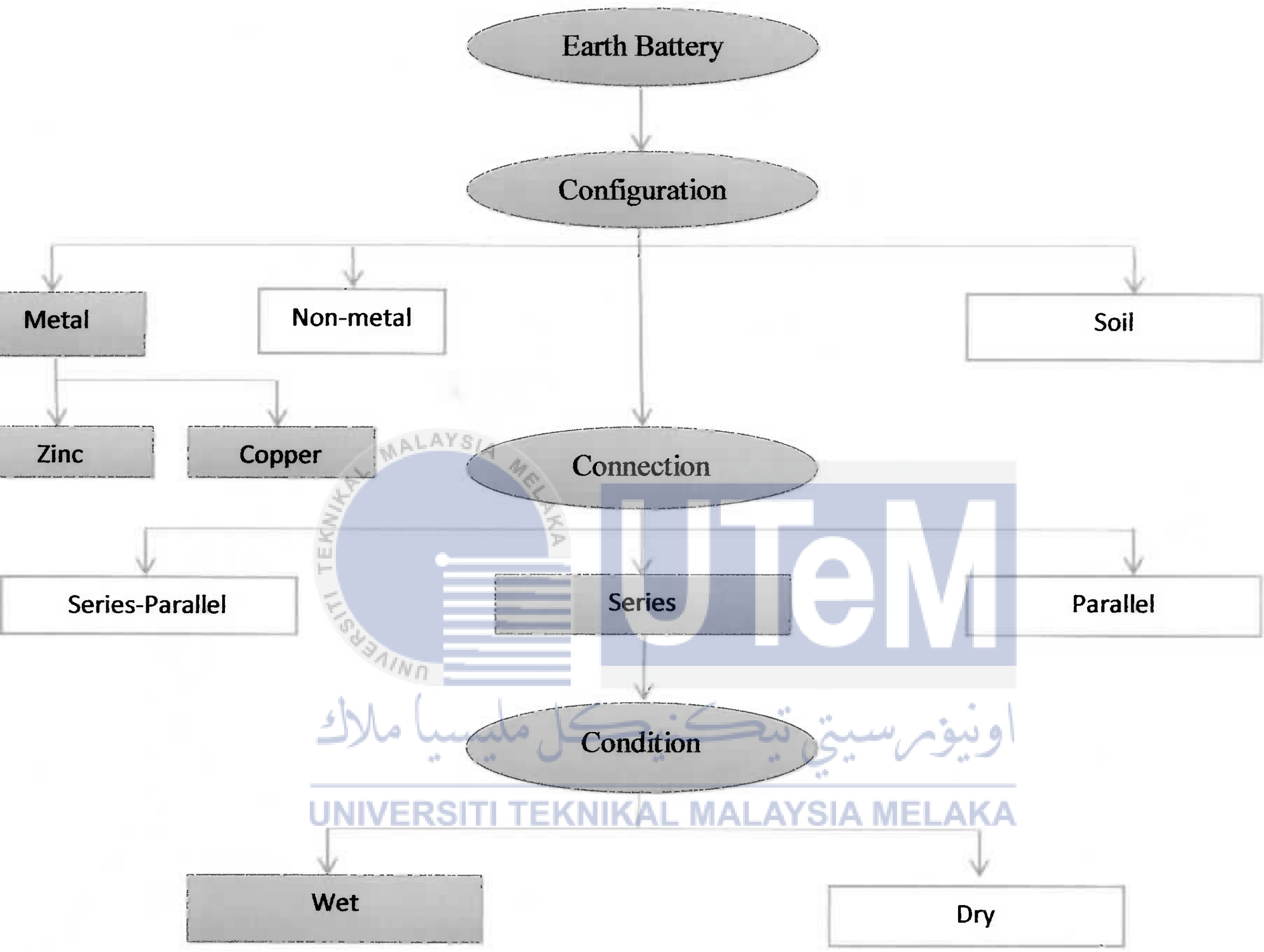
APPENDIX A

K-Chart



APPENDIX B

TASK	WEEK													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Name of Project Title and SV posted														
Brief for FYP 1 , Title Registration Form & Declaration Form Submission														
List Title, SV and Student Posted														
Read Article & Write Article Review														
Progress Report Evaluation														
Improve Report														
Find equipment for research and learn to get preliminary result														
FYP 1 Seminar														
FYP 1 Report Submission														

APPENDIX B

TASK	WEEK																	
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Continued Project (FYP 2)																		
FYP 2 Briefing																		
Final Report Draft Submission to Supervisor																		
Improve Final Report Draft																		
Final Report Submission to Panel and Supervisor																		
Seminar FYP 2																		
Final Report Improvement																		
Final Report Submission to FYP Committee																		