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Natural Discovery : Electricity Potential from Vermicompost (Waste to Energy)

R. A. Karim, N. M. A. Ghani, and N. N. S. Nasari

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***Abstract*—**Wastages such as grated coconut meat, spent tea and used sugarcane had contributed negative impacts to the environment. Vermicomposting method is fully utilized to manage the wastes towards a more sustainable approach. The worms that are used in the vermicomposting are *Eisenia foetida* and *Eudrillus euginae*. This research shows that the vermicompost of wastages has voltage of electrical energy and is able to light up the Light-Emitting Diode (LED) device. Based on the experiment, the use of replicated and double compartments of the component will produce double of voltage. Hence, for conclusion, this harmless and low cost technology of vermicompost can act as a dry cell in order to reduce the usage of hazardous chemicals that can contaminate the environment.

***Keywords*—**Wastages; vermiconpose; worm; voltage; organic cell.

I. Introduction

INSTEAD of using conventional composting method to dispose the tea waste, other alternative method which is vermicomposting method can be used for the disposal of the waste. The enzymatic and microbial activities that occur during vermicomposting process by worms gives a better end product than using the conventional composting. Food waste will be recovered for vermicomposting and the end products can be organic fertilizer, soil improver [1][2] and an alternative source of potential energy. Vermicomposting or vermiculture is an eco-friendly process whereby worms are used to breakdown the organic waste into soil and humus known as vermicast, vermicompost or earthworm compost. The objective is to process the organic material as quickly and efficiently as possible. During the breakdown of organic matter by the earthworm, humus which is a complicated material is formed. The material formed is high in content of nitrogen, calcium and phosphorus which is main elements required by plants for their growth, healthy and freshness.

The processed tea leaves had been used to make drinks for over thousand years. This spent tea is being thrown away recklessly and lead to pollution of environment by affecting the increases of solid waste daily. Next, sugarcane had been used to produce sugar widely in the world. However, the method to dispose the used sugarcane such as burning, emitted greenhouse gases and caused global warming. Grated coconut meat had also been disposed in the environment reluctantly by human to obtain the fresh white flesh of the fruit. This coconut marsh had carried very unpleasant effects to the environment such as soil pollution. The composting method by using bacteria and fungi as a treatment of these wastages caused air pollution as it smells bad and leads to various types of diseases to the workers.

The treatment wastages is usually costly and required a large space to compost it. Due to high cost of treatment, most of irresponsible parties choose to dispose their wastages in open dump sites or illegal dumping. Areas like field and river are the most popular places for people illegal dumping. Illegal dumping can cause river and land pollution. Besides, some irresponsible parties managed their wastages using incineration method. As the method of incineration involves combustion, therefore it is also known as thermal treatment. Hence, to tackle these problems, more solid waste management alternatives such as vermicomposting are needed.

On other hand, the worldwide battery industry generates US$48 billion in sales each year, with 6% annual growth according to 2005 estimation [3]. Batteries that are disposed incorrectly can seriously harm the environment. A battery convert chemical to electrical energy. The chemical by-products are hazardous which is dangerous and harmful. In general, the battery contains harmful substances mainly Zn, Hg, Ni, Pb and other heavy metals such as a variety of alkaline batteries and lithium batteries in liPP6 KOH electrolyte.

Today's alkaline batteries may contain approximately 0.025 percent mercury[4]. Mercury (Hg) and its compounds, especially organic mercury compounds, have high toxicity, bioaccumulation faster rate and a longer biological half-life of the brain organ. Easy cadmium, Cd accumulation in plants and animals affecting the growth of the plants and animals, is highly poisonous. Lead, Pb on human breast, kidney, reproductive, cardiovascular and other organ and system adverse effects, observed as mental retardation, kidney damage, infertility and high blood pressure. The toxicity of zinc (Zn) and nickel (Ni) is relatively small, but over a certain concentration range, would cause horrible effects and hazards. Used batteries in acid, alkali solution will affect the soil quality and thus affect the pH value of the water. Eventually this caused of water acidification or water alkalization. The high chemical doze in the electrolyte of batteries caused pollution to the environment.

Battery of heavy metal ions in soil or water soluble are absorbed by the roots of plants and thus starting the food chain. Finally, human body will mount up heavy metals. Human cannibalism food containing heavy metals, meat, and vegetables, water, along the food chain, and heavy metals in the body will be deepened. As the heavy metal ions in the

Authors are with Faculty of Electrical & Electronic, Universiti Malaysia Pahang (UMP), Pekan, Malaysia (e-mail: {rohanaak,normaniha}@ump.edu.my).

Open Science Index, Energy and Power Engineering Vol:5, No:10, 2011 publications.waset.org/7465/pdf

body are hard to excrete eventually they destroy the nervous system and liver function. The acidic or alkaline electrolyte in all types of batteries contain dangerous substances that effects human being and the environment. Electrolyte in batteries function as to react with the casings (anode and cathode) materials and to produce force in order to move the electrons.

The other burning issue nowadays is the hazard of chemicals inside the batteries that can lead to environment contamination. If the batteries are left in the environment, the chemicals can drain out and leech into water supplies, causing people to be exposed to the hazardous chemicals.

II. Related Works

Environment has great influence in the life of all the living things on this earth. Due to that, many researches were conducted for waste treatment. Researchers try to change wastages to the useful form without tarnish environment, economical and green technology to overcome global environmental issues and green the earth. Article [5] was invented BioPot and mulching from natural waste. BioPot produced from biodegradable film fabricated, used for seed plantation compared to polybags that cause functional roots damage, environmental effect and agent for mosquito breeding, while mulching prepared natural waste is used to nourish the soil.

While in generating electricity alternative resources have been discovered. Food, plant and animal wastes are biological wastage, that are conventionally disposed, are processed to generate electricity. Research article [6] was processed using vermicompose technique and applied to plant since it can significantly promote plant growth and improve the microbial environment in rhizosphere of two species as they were applied in iron tailing restoration. Compare to our research we implement vermicompose for electricity generation. Methods to convert animal manure to electrical have also been disclosed in several patented technologies. However, animal manure has drawbacks where additional process is needed to kill the existing bacteria and additional nutrient is needed due to the inconsistency of available nutrient of the animal manure.

Another method converts wastages to electrical energy by using biological material. A method is described to extract methane gas from animal manure and the methane gas is used to power an electrical generator. Research [8] was described and claimed a method of operating energy integrated farm operation with recovery of animal feed from liquid food waste. The method involves extracting methane gas from animal manure and using the methane gas to power an electrical generator. The electricity from the generator and the methane itself may be used to operate a dryer. The dryer is used to dry a liquid food waste stream to yield a dry food product. The dry food product recovered has enough nutritional value to be useful as animal feed. However, electrical energy is generated from the electrical generator ran by methane gas, not directly converting biological material to electrical energy.

Likewise animals manure, research on wastewater treatment also capable produces electricity [7] with maximum power density was 6.73mW/m^2 by using graphite electrodes. The amounts of electricity generation are considered lower.

Besides, Sanyo Electric Co., Ltd. (Osaka, JP) was introduced a waste treatment system permitting treatment of organic wastes at low cost is provided. In the waste treatment system, organic wastes such as sewage, garbage and sludge are introduced into a methane fermentation bath for anaerobic fermentation. The methane gas produced in the bath is refined in a gas holder and then supplied to an electric generator, where the methane gas is used as a raw material for power generation. Digested liquid within the methane fermentation bath is supplied to an electrolytic bath via a flow adjustment bath and a fine screen. In the electrolytic bath, the digested liquid is subjected to electrolysis, by applying potentials to an electrode pair in the electrolytic bath based on the electric power obtained by the electric generator. By the electrolysis, nitrogen components including organic nitrogen and ammonia nitrogen, and BOD, SS and phosphorus components are removed from the digested liquid [9]. Enhanced electrical output is achieved through the addition of NH4Cl and urea. However, sewage sludge compost contains pathogens which require additional time and cost-consuming composting process to kill the pathogens.

III. Methodology

In order to produce robust low power energy, a series of experimental was done. To prepare a vermicompose, the soils and spent tea were mixed together under percentage of 50% soils and 50% spent tea, 70% soils and 30% spent tea. The mixture is arranged accordingly to the procedure of vermicomposting method in the plastic container (specialty for undergoing vermicomposting). Example; 0.5 kg of spent tea is added into the plastic container and the pH value is measured. Then, 0.5 kg of soils is poured into the container. The pH value of the mixture is measured again using pH meter. The soil and spent tea is mixed together and the pH value is measured repeatedly until the soil neutralizes the spent tea. After the pH value is neutral, 10 worms are added into the container. This step is very important because worms cannot live in acidic or alkaline medium. Therefore, spent tea which is alkaloids have to mix with soils and waited until the pH value turns into neutral before the worms being put inside with the spent tea. The vermicomposting period occurred in 10 days. The pH value, salinity and conductivity are measured per day during the period until the vermicomposting process is completed. Results are shown in Table III. The worms are then being taken one by one and put back to their breeding container. This step is also taken with other types of waste such as used sugarcane and coconut marsh as a substrate in this vermicomposting process.

Electrode was used as an electrical conductor to touch base with a nonmetallic part of a circuit. Electrode was referred as either anode or cathode. Determination of anode or cathode was depending on the direction of current through the cell. Determinations of electrode are based on metal elements in periodic table of the elements. Two different metals are used as electrodes and vermicompost as electrolyte. Short magnesium and copper electrodes were being polished by sand papers to remove oxidation at electrode. The magnesium and copper electrodes were then immersed in the vermicompost inside the marker's cape. The marker's cape was being stabilized by inserted it into a transparent small

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container. The clip leads wires were connected to the electrodes, multi meter and LED in a series circuit. Multimeter is used for measure voltage between two electrodes. To series multiple electrode for increase the voltage, vermicompost cell must be isolated individually because it cannot immersed in same container due to short circuit [10].

IV. Results and Discussion

A. Analysing And Interpreting Data of Vermicompost Content

Vermicomposting can be used as a method to treat waste like spent tea, used sugarcane and coconut marsh. The vermicompost contains nine times nitrogen than that of the conventional compost. Nitrogen is the main trace element required by plant in order to stay healthy and thus promote natural growth and essential development. The nitrogen and other elements from such vermicompost of spent tea are calculated and the result is as shown in Table I and Table II respectively. Table I shows that nitrate (nitrogen) content is the highest among other nutrients in vermicompost of spent tea. Table II shows that the heavy metals that are harmful to the environment and people such as lead (Pb), chromium (Cr) and cadmium (Cd) is not detected in the vermicompost. This proves that the vermicompost is safe for the environment and people.

TABLE I
Contents of the Vermicompost Spent Tea

Final pH value	7.89
Water Holding Capacity %	77.9
Total Organic Carbon %	12.7
Nitrate (mg/kg)	46.5
Phosphate (mg/kg)	21.5
Total Potassium (mg/kg)	18.5

TABLE II
Heavy Metals in Vermicompost of Spent Tea

Cr (mg/kg)	Nd
Cu (mg/kg)	0.01
Cd (mg/kg)	Nd
Ni (mg/kg)	10.03
Zn (mg/kg)	5.66
Pb (mg/kg)	Nd

During the vermicomposting period, pH value is measured to ensure that the mixture of soils and spent tea is neutral as the worms cannot live neither in acidic condition nor alkaline condition. The salinity also is measured during the vermicomposting period. The result shows that the salinity decreases over the period. Salinity is measured to check on the content of salt in the vermicompost. The conductivity is also measured during the period. The conductivity remains 5.18mS after 10 days of vermicomposting period. This shows that the vermicompost has a high value of conductivity and is able to conduct electricity. The result is shown in Table III.

TABLE III
pH Value, Salinity and Conductivity of the Vermicompost of Spent Tea

	Initial Reading (Day zero)		
S – 50% T – 50%	pH Value	Salinity ($^0/_{00}$)	Conductivity (mS/cm)
First Test	7.38	4.40	8.02
Second Test	7.38	4.40	8.02
Third Test	7.38	4.40	8.02
Average	7.38	4.40	8.02
	Reading (Day seven)		
Control Mixture	7.62	7.40	13.04
First Test	7.73	4.20	7.73
Second Test	7.73	4.00	7.28
Third Test	7.73	3.00	5.74
Average	7.73	3.73	6.92
	Reading (Day Ten)		
Control Mixture	7.84	3.50	6.40
First Test	7.77	2.90	5.23
Second Test	7.70	3.00	5.66
Third Test	7.70	2.70	4.65
Average	7.72	2.86	5.18

B. Analysing And Interpreting Data Of Voltage produce from Vermicompost

The result in the Fig. 1 shows graph that the higher the number of beaker(s) used, the higher the voltage and current produced in a circuit. This means that the higher the number of beaker(s) containing 0.01 kg of waste vermicompost solution utilized, the higher the voltage produced. The increases of voltage is constant throughout the experiment from 1 beaker to 4 beaker used, at 5 beakers used the wires are too long and the resistance is high. However, the voltage is still increase. Electricity generated because of metals such as zinc (Zn), nickel (Ni), and copper (Cu) was found in the vermicompost. These elements provide ions which can form chemical reaction and produce force called electromotive force (EMF). This reaction occurs between the electrodes and the vermicompost solution. The ions inside the solution react with copper and magnesium electrode. The force produced deflected the voltmeter needle. The voltage and current produced by 3 beakers of 10g vermicompost and 30ml of tap water is 3 V and 1.5 µA respectively. The current produced is enough to light up LED device. This shows that the wastage can undergo vermicomposting method and the result proves that the vermicompost solution can generates electricity. This is due to the ions such as Zn^{2+} and Cu^{2+} inside the vermicompost as aresult of the enzymatic reaction by *Eisenia foetida.*(worm).

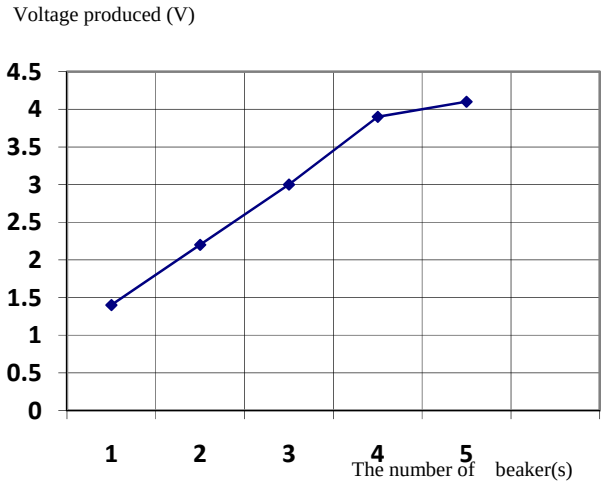


Fig. 1 The relationship between the number of beakers of vermicompost in aqueous

C. Analysing and Interpreting Data of Voltage Produced by Vermicompost in Compressed Condition

The result shows that the vermicompost produce high voltage in compressed condition where there are no water being utilized in the experiment. Fig. 2 shows that one small compartment that contains vermicompost produces 1.5 V while three small compartments that contain vermicompost produce 4.23 V as illustrated in Fig. 3. Relationship between compressed vermicompost and the voltage produced were depicting in Fig. 4. The higher the compartments used, the higher the voltage produced. This compressed condition of vermicompost is more practical to be used compared to the vermicompost in aqueous solution. This is because in compressed condition, the vermicompost is easier to carry and easier to be used. Moreover, the compressed vermicompost is more appropriate to be used as dry cells compared to the vermicompost in aqueous solution. The graph shows that the increase of voltage is due to the increase of number of compartments used.

For application purposes, the vermicompost can lighted up the LED and made wall clock's needle ticking as in Fig. 5, Fig. 6(a) and Fig. 6(b) respectively. The compressed vermicompost produced even higher voltage of electrical energy compared to the vermicompost in state of aqueous solution. This benefits in much more as the vermicompost can produce voltage without utilizing any solvent. In conclusion, the higher the number of compressed vermicompost, the higher the voltage produced.

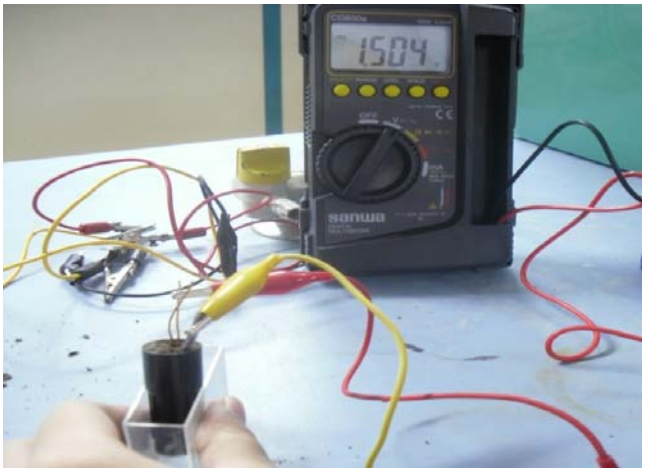


Fig. 2 One series of compacted vermicompost produces 1.504V



Fig. 3 Three series of compacted vermicompost produce 4.25V

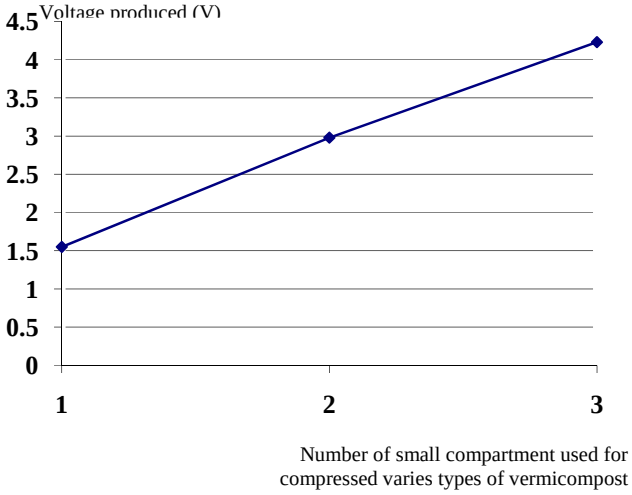


Fig. 4 Relationship between compressed vermicompost and the voltage produced

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Fig. 5 Two series of compacted vermicompost can light up LED



Fig. 6(a) One compacted vermicompost make wall clock's needle ticking

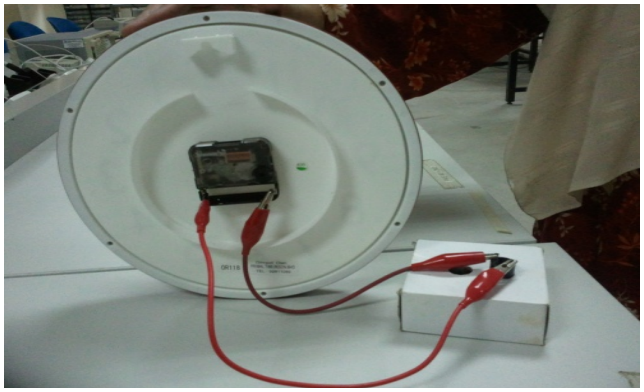


Fig. 6(b) Clip leads wires connection to vermicompost

D. Comparison between the usage of different type of electrodes

TABLE IV
REACTION BETWEEN VARIOUS TYPES OF ELECTRODES

The number of beaker(s)	Voltage (V)	
	Magnesium and copper electrodes	Aluminum and copper electrodes
1	1.400	0.907
2	2.200	1.359
3	3.000	1.791
4	3.900	2.288
5	4.100	2.743

Table IV shows that the reaction between magnesium and copper electrodes with the vermicompost produces high voltage. The magnesium ion is further to copper ion in position of electrochemical series (ECS) which is apparently producing higher voltage than the reaction between aluminum ions to copper ions. As for the aluminum, even though it does not produce high voltage like magnesium, its voltage production maintains to increase constantly. This shows that any types of metals used as electrodes can still produced voltage when react with the vermicompost solution.

V. CONCLUSION

The vermicompost can be used as an alternative method to replace the chemical electrolytes. As the vermicomposting process is a low cost technology and very commercialize to countries around the world, this process can be used to produce harmless vermicompost which can produce high voltage and generate electricity. The ions inside the vermicompost react with electrodes to produce high potential difference. At the beginning, the vermicompost is used for fertilizers to plants as it contains high nutrients needed by plantations. It is discovered that the vermicompost also can generate electricity in a circuit. By using only worms as its catalyst and main component, the product can be used for many benefits to mankind.

As a conclusion, the vermicomposting process is a method which can converts wastages such as used sugarcane, spent tea and grated coconut meat into valuable vermicompost which produces high voltage. The increase of compartments increases the voltage produced. The voltage produced by one compartment of vermicompost is equivalent to the voltage produced by one dry cell. Based on the experiment, it is concluded that the vermicompost generates electricity and light up the LED. The vermicompost can be used in battery to replace the chemicals used.

This research can be upgraded in further research whereas this battery of vermicompost can replace ultimately the usage of chemical electrolyte in dry cells. Furthermore, it can also

Open Science Index, Energy and Power Engineering Vol:5, No:10, 2011 publications.waset.org/7465/pdf

be upgraded and studied to be used as fertilizers in an area and at the same time the vermicompost produced electricity and act as a generator for a whole town. The vermicompost can also be used more widely as it will reduce a lot of wastages and decreases the cost and at the same time, it produces benefits to mankind. Besides, further eksperiment can be conducted to find solution for increasing current in the vermicompost.

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