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Electric Potential from Vermicomposting of Spent Tea waste by employing Exotic Earthworm *Eudrilus eugeniae*

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Abstract: Vermicomposting is a very effective, eco-friendly, cheap and easy method of recycling biodegradable waste using selected species of earthworms. Vermicompost is also rich in metal ions, acids and salts that has the potential to be used as an electrolyte. The main aim of this investigation is to exploit the potential lying in earthworm species to convert spent tea waste into high quality vermicompost that can be used as an electrolyte to generate electric current. The spent tea waste was vermicomposted for 60 days using *Eudrilus eugeniae*. An effective voltage was measured between copper and zinc electrodes immersed in vermicompost (electrolyte). The voltage was doubled when three isolated vermicompost cells were connected in series and could light up an LED bulb. The total macronutrients (N, P, K and Ca) and micronutrients (Fe, Cu, Mn and Zn) showed elevated levels in vermicompost when compared to control which contributed to the chemical reaction at the electrodes to create a potential difference across the electrodes thus giving a voltage. The present study reveals that the vermicomposting has a great future in generation of electrical energy from biodegradable waste.
Key Words: Vermicompost, Micro and Macronutrients, Electric potential, Spent tea waste, *Eudrilus eugeniae.*

INTRODUCTION

The problem of efficient disposal and management of organic solid wastes has become more rigorous due to rapidly increasing population, intensive agriculture and industrialization, over the last few years. The various types of environmental and disposal problems caused by the production of large quantities of organic waste all over the world requires sustainable approach in a cost effective manner and this has become a very important issue for maintaining healthy environment[1].

Due to the rapid growth in industrialization, the most of the rural population have shifted towards the urban area in search of employment. India produces 1,20,000 tonnes of solid wastes every day. The rapid increase in the volume of waste is one aspect of the environmental crisis, accompanying global development. Most common practices of waste processing are uncontrolled dumping. When waste is dumped into large heaps, air cannot get to the organic waste that is degrading.This creates a harmful greenhouse gas, methane which damages Earth's atmosphere.[2]

The spent tea waste is a by-product from tea dust after decaffeination process which is a solid waste that can be used in various ways. Apart from losing the economic value of the waste, a huge amount of capital is expended in disposing it. Some places, the waste constitutes environmental hazards through indiscriminate dumping and incineration[3].

Vermicomposting is a very useful biotechnique for converting solid organic waste into vermicompost[4]. The vermicomposting provides for the use of earthworms as natural bioreactors for cost-effective and eco friendly waste management[5]. Earthworm has the efficiency to consume all types of organic rich waste material including tea waste, vegetable wastes, leaf litter waste, industrial, dairy farm wastes, garden waste, sugar mill residues, slaughter house waste, hatchery waste and municipal wastes[7]. The ability of the exotic composting species, *Eudrilus eugeniae* to transform the spent tea waste into valuable compost is considerable[8].

Other than being an organic fertilizer, this secreted chemical mixture which is rich in metal ions, acids, salts and enzymes have the potential to be used as an electrolyte. Vermicompost being harmless do not cause any environmental pollution like the chemical electrolytes used in battery. The ions present in the vermicompost can react with the metal electrodes used in the cell and can produce a potential difference across the electrodes. This potential difference can generate enough voltage similar to that produced by a commercial battery cell[9].

The waste to energy can be considered as a renewable technology and a better solution to solid organic waste management. Even though food, plant and animal waste have been used as alternative resources for electricity generation, they have several drawbacks. Conventional composting and anaerobic digestion produces foul smell and harmful methane gas. According to the considerations of low cost, eco-friendly, fast and efficient, we choose to explore the suitability of vermicompost from spent tea waste as an alternative to replace chemical electrolytes.

MATERIALS AND METHODS

Collection of Waste

The spent tea waste (*Camellia assamica*) was collected from the Karunya University hostel campus, Coimbatore, Tamil Nadu, India. The collected wastes were dried and used for vermicomposting.

Collection of Earthworm

The exotic earthworms *Eudrilus eugeniae* were collected from Agronomic research station, Thrissur district, Kerala and cultured in laboratory conditions for proper growth and survival of earthworms.

Vermicomposting technique

Clay pots were used as containers for vermicomposting as it can maintain moisture and low temperature required for the worms to grow. Totally 3 pots were maintained for the experimental purposes. The pot T_1 was taken for vermicomposting of spent tea (with earthworms). T_2 was maintained as control for spent tea waste (without earthworms). T_3 was control for soil with earthworms .In pot T_1 500g of spent tea waste was taken and mixed with proper amount of soil to neutralize the pH of tea waste. The earthworm *Eudrilus eugeniae* was released into the pots T_1 and T_3 at the rate of 60 worms per square feet except control. Care was taken to avoid light and rainfall. Samples were taken from the control as well as the experimental pots on 60th day for the analysis of macro and micro nutrients, physicochemical analysis and electric potential.

NUTRIENT CONTENT:

MACRONUTRIENTS

Estimation of total nitrogen

The nitrogen in organic material is converted to ammonium sulphate by sulphuric acid during digestion. This salt, on steam-distillation, liberates ammonia which is collected in boric acid solution and titrated against standard acid[10].

Estimation of total phosphorus

Inorganic phosphate reacts with ammonium molybdate in an acid solution to form phosphomolybdic acid. Addition of a reducing agent reduces the molybdenum in the phosphomolybdate to give a blue colour, but does not affect the uncombined molybdic acid. The blue colour produced is proportional to the amount of phosphorus present in the samples[11].

Estimation of total potassium

In flame photometry, the solution under test is passed under carefully controlled conditions as a very fine spray in the air supply to a burner. In the flame, the solution evaporates and the salt dissociates to given neutral atoms. A very small proportion of this move into a higher energy state. When these excited atoms fall back to the ground state, the light emitted is of characteristic wavelength which is measured[11].

Estimation of total calcium

The pH of the sample is made sufficiently high (12-13) to precipitate magnesium as hydroxide, and calcium only is allowed to react with EDTA in the presence of a selective indicator[11].

MICRONUTRIENTS

Estimation of iron, manganese, zinc, copper

The technique involves determination of concentration of a substance by the measurement of absorption of the characteristic radiation by the atomic vapour of an element. When radiation characteristic to a particular element passes through the atomic vapour of the same element, absorption of radiation occurs in proportion to the concentration of the atoms in the light path[12].

ESTIMATION OF PHYSICOCHEMICAL PARAMETERS

pH

5gm of finely powdered vermicompost was taken in a volumetric beaker and 50ml of distilled water was added and the pH was measured by pH meter[11].

Moisture

The moisture content was then calculated as follows:

P = Weight of the empty plate

PW = Weight of the plate with wet sample

PD = Weight of the plate with the dry sample

$$\text{Percentage of moisture content} = \frac{(PW - PD)}{(PD - P) + (PW - PD)} \times 100$$

ESTIMATION OF ELECTRIC POTENTIAL

Electrode was used as an electrical conductor to touch base with a non-metallic 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. Determination of electrodes was based on the metal elements in periodic table. Two different metals, copper and zinc plates were used as electrodes and vermicompost as electrolyte. The electrode plates were polished using sand papers to remove oxides formed due to oxidation of metals. The copper plate acts as cathode and zinc plate acts as anode. The anode and cathode were then immersed into the vermicompost that is moistened to enhance the contact with the metal plates. The lead wires were connected to the electrodes, multimeter and LED in series circuit. Multimeter is used to measure the voltage between two electrodes.

RESULT AND DISCUSSION

Assay of Physicochemical Parameters in Vermicompost

Table-1: pH value, Moisture and Voltage of the vermicompost of spent tea

Sample	pH value	Moisture (%)	Voltage (V)
Vermicompost (T_1)	6.3	72	0.988
Spent tea waste (T_2)	6.0	67	0.794
Soil sample with worms (T_3)	6.9	70	0.670

Macronutrients and Micronutrients Present in Vermicompost

Table-2: Macronutrients

Macronutrients	**T_1 (compost)**	**T_2 (spent tea)**	**T_3(worm soil)**
Nitrogen	0.82	0.54	0.35
Phosphorus	0.67	0.46	0.50
Potassium	0.61	0.53	0.42
Calcium	0.49	0.41	0.37

Table-3: Micronutrients

Micronutrients	**T_1 (compost)**	**T_2 (spent tea)**	**T_3(worm soil)**
Iron	0.92	0.52	0.31
Manganese	0.62	0.46	0.45
Zinc	0.98	0.52	0.39
Copper	0.75	0.44	0.42

Plate 1: Single vermicompost cell produce 1.15V

Plate 2: Three vermicompost cells in series produce 2.52V

Plate 3: Vermicompost cell light up LED

Vermicomposting can be used as a method to treat waste like spent tea. The various macro and micronutrients, acids and salts present in the vermicompost enhance the availability of ions that can increase the flow of charge. The pH shows slightly acidic at the end of vermicomposting. This may be due to the various enzymes that are released from the worm's gut. The acidic nature makes it suitable for using as an electrolyte. A single compartment of 100g vermicompost mixed with 30ml of water produced a voltage of 1.15V. Whereas use of three isolated compartments of vermicompost gave a voltage of 2.52V. The study shows that the higher the number of beaker(s) containing vermicompost used, the higher the voltage and current produced in a circuit. The amount of voltage and current produced also depends on the size of electrode, amount of electrolyte (vermicompost), area of contact between electrode and electrolyte and the length of wires used. If the wires used are too long, the resistance in the circuit may be high resisting the current flow. However, the voltage remains high.

Electricity generated in the vermicompost cell is because of the presence of metals such as zinc (Zn), nickel (Ni), and copper (Cu) 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 zinc electrode. The current produced is enough to light up LED device. This shows that the organic wastes can undergo vermicomposting and the result proves that the vermicompost can generate electricity. This is due to the ions such as Zn^{2+} and Cu^{2+} inside the vermicompost as a result of the enzymatic reaction by *Eudrilus eugeniae* (worm).

The vermicompost has a very good moisture content. The experimental study reveals that the moisture content and the water holding capacity increases at the end of vermicomposting. The moisture content in the vermicompost gives proper contact with the electrode for the chemical reaction. Hence this can also be used in a compressed state without the addition of water to form a vermicompost cell. 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. For application purposes, the vermicompost can lighted up the LED and hence can be used for all applications where a chemical battery is used since it has the same capacity in generating electric current.

Further studies can be done to design an in-house vermicompost power unit where large electrodes can be placed in vermicomposting tanks thereby directly drawing the electric current during the process of vermicomposting. To avoid the problem of short circuiting the electrodes can be placed with an insulating material with pores for the moisture and ions to pass through. This can avoid any harm to the worms. Since large size electrodes can give more area of contact, more electricity can be generated. This can be implemented in farm houses in remote places where there is a scarcity of electricity. Thus, it may be possible to light up a village with a cheap resource and a cost effective technique.

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. Our present investigations revealed 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 convert spent tea waste 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 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 experiment can be conducted to find solution for increasing current in the vermicompost.

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