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RESEARCH ARTICLE

Development of Food Waste Energy System for Powering Mobile Phones

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ABSTRACT

Food waste is the discarding of edible and inedible foods. The accumulation of discarded food in landfills produces a large amount of methane that has an adverse effect on the environment, economic and community health. Decomposing food scraps in landfill are also a probable source of organic leachates that can contaminate surface and groundwater. However, the reality is that more than 50% of food waste takes place in our homes. Hence, we waste all the energy and water it takes to grow, harvest, transport, and package it. This work aimed at turning food waste into a viable and economic energy source for powering mobile phones. To achieve this goal, a wood-burning stove was developed using an old set of tire rims to burn the collected food waste without harming the environment. A thermoelectric generator was developed to convert the heat from the wood-burning stove into electrical energy. Thereafter, a power bank was developed for energy storage. The power bank was used as a power source for mobile phones. The developed system will help to minimize landfills, prevent climate change and improve the economy of the country.

Keywords: *Food Waste, Energy System, Wood Burning Stove, Thermoelectric Generator, Power Bank, Mobile Phones*

1. Introduction

Today the earth sustains 7.2 billion people and the population is expected to reach 9.6 billion by 2050. One-third of the food produced in the world to feed people every year is lost or wasted. Regardless of consumption and disposal practices, the growing world population has increased food waste. The minister of Agriculture and Rural Development in Nigeria said that 30% to 40% of many foods produced in Nigeria are ultimately wasted[3]. Food waste includes organic waste generated in homes, restaurants, hotels, and shopping malls in the form of leftover food, stale cooked, uncooked food, meat, vegetable refuse, fruits, tea bags, etc. Food waste ends up rotting in landfills thereby releasing methane, a greenhouse gas that is dangerous to the environment. Food waste contaminates surface and groundwater supplies because when it rains on landfills, the water allows for toxic chemicals (such as ammonia) to develop and leach into drinking water supplies thereby killing living organisms. Some of the waste clogs the drain and creates a breeding ground for insects. These insects spread diseases like malaria and cholera. The Society of Environmental Toxicology and Pollution Mitigation (SETPOM) in Nigeria had bemoaned that by 2023, food waste generation may smack 239.8 million tones of CO_2, Biodiversity will be harmed and as well lands will be wasted. Hence proper waste management should be carried out to ensure food waste does not affect the environment and cause health hazards to the people. The 12^{th} sustainable development goal calls for the World to cut food waste in half by 2030. However, meeting this ambitious goal will require a smart strategy considering that 1.3 trillion kilograms of food are wasted around the world every year[4]. A food waste management strategy needs to be devised to ensure its eco-friendly and sustainable disposal. It is difficult to recycle food waste since it is mixed with other waste during collection. Despite the support from international organizations to drastically reduce food wastage in developing countries, local solutions in affected communities could make a huge difference. These wastes can be burned to produce heat and electricity. The generation of electricity from food waste was proposed by the authors. The ground food wastes in a container and dipped two electrodes acting as anode and cathode. Chemicals such as Hydrochloric acid and potassium hydroxide were added to speed up the reaction. More electrodes were dipped and connected in series. They were used to glow four LEDs in series. The method is good but yielded low voltage and current. An increase in the number of series and parallel combinations of electrodes can only yield desired voltage and current.

Researchers proposed coupling hydrothermal liquefaction and anaerobic digestion for energy valorization from model biomass feedstocks. In their work, they used hydrothermal liquefaction where the waste is pressure cooked to produce a crude bio-oil that was refined into biofuel. The food waste in an aqueous state was anaerobically digested by microbes. The microbes converted the waste to electricity and heat. Their work takes a long period of months in turning the food waste into energy. Another researcher presented work on generating renewable electricity from waste. They used biogas power plants to digest food waste into methane and produced electricity. About 100kg of waste was placed in a tank filled with water and cow dung was digested together. The digested waste was pumped into the digester that consists only of water. The waste decomposed and generated methane that produced heat and electricity. The higher the amount of waste, the higher the amount of electricity but the process is expensive. In this work, food waste which is an untapped energy source will be converted to electrical energy that will be useful in powering mobile phones.

2. Literature Review

Food Waste to Energy

Food wastes are raw or cooked foods that are being discarded or left to spoil. They are lost during production, processing, retailing, and consumption. Food waste is mainly caused by economic behavior, poor stock management, or neglect. According to the Food and Agriculture Organization (FAO, 2018), food waste is responsible for 8% of greenhouse gas emissions. Food waste that ends up in landfills produces a large amount of methane that is more powerful than CO_2, causing global warming and climate change. Food waste is also a great waste of fresh water and groundwater resources since some of it is washed into the rivers and lakes thereby killing living organisms that inhabit those environments. Living near a landfill with food waste can cause harm to humans due to air pollution. Food waste to energy is the process of generating energy in the form of electricity from food waste. It is a sustainable way of managing waste that cannot be recycled in a technically or economically viable way. Burning food waste turns into energy and reduces the amount of material that would be buried in landfills. Food waste to energy is an effective way of reducing carbondioxide emission and replaces fossil fuels. It is a hygienic method of treating waste, reducing the volume, and protecting the climate

Thermoelectric Generator

Thermoelectric Generator is a solid-state device that converts heat into electrical energy. It utilizes the Seebeck effect to generate voltage. The Seebeck effect occurs due to the movement of charge carriers within the semiconductor. In doped p-type semiconductors, charge carriers are holes while in doped n-type semiconductors, charge carriers are electrons. The charge carriers diffuse away from the hot side of the semiconductor, build up at one end, and create a voltage potential that is directly proportional to the temperature difference across the semiconductor. Thermoelectric generators can last a very long time since it has no moving parts to break or wear out. It does not require any greenhouse gases to operate. Thermoelectric generators can be designed to output power levels smaller than microwatts and larger than kilowatts. Thermoelectric generators convert heat directly into electricity. Many energy conversion technologies require intermediate steps when converting heat to electricity but thermoelectric generators convert heat directly into electricity. Thermoelectric generators can be designed to be very compact and this leads to greater design flexibility.

Power Bank

A power bank is a digital device that is also known as a plug-in battery, charging a battery, and backup battery. It is a portable device that is used to charge electronic devices such as smartphones, digital cameras, or Tablets. Power banks are designed to minimize their power consumption thus charging phones efficiently. Power bank uses Lithium-ion or Lithium-polymer bather as their power source. Lithium-ion cells have a high energy density, limited in capacity, cheaper to manufacture and require low maintenance. Lithium polymer batteries have a larger capacity, low energy density, and are expensive to manufacture. The lithium-ion battery has relatively low self-discharge in comparison to Lithium Polymer cells.

Power banks have multiple sockets for charging and their quite compact and sleek design makes them very catchy and attractive.

3. Methodology

The wood stove was constructed using two tire rims. The top layer of the two tire rims was cut off with a grinder, placed on top of each other for more space inside, and welded together. After welding, it was completely sanded with cotton wool and painted with six coats of high heat resistant Rustoleum black paint as shown in Figure 1.

Figure 1: Wood Stove from Tire Rims

The high heat paint was used so that it won't peel off when the stove is in use. Then the thermoelectric generator was produced using thermoelectric coolers. Thermoelectric coolers are known as Peltier devices essentially work by moving heat from one side to the other. One side of the plate heats up while the other cools down which is called the Peltier effect. The cold side of this device can reach temperatures low enough to freeze water. More interestingly, this device can be used to generate electricity. By heating one side of the plate and cooling down the other voltage across, the thermoelectrical cooler is created and is called the Seebeck effect. The thermoelectric generator was manufactured by using eight thermoelectric coolers. The eight thermoelectric coolers were stuck on a flat aluminum tray using thermoelectric paste. The thermoelectric paste was applied on the blank side and glued with the letters facing up to ensure that the red and black wires from the thermoelectric coolers form pairs. Insulating tapes were used to prevent the wires from touching the tray and shorting out. The red and black wires were soldered together. More insulation tape was placed over the soldered points to avoid contact with other surfaces. At one end, the circuit was completed by bridging it over to the other plate while the other end was left to stay loose as shown in Figure 2.

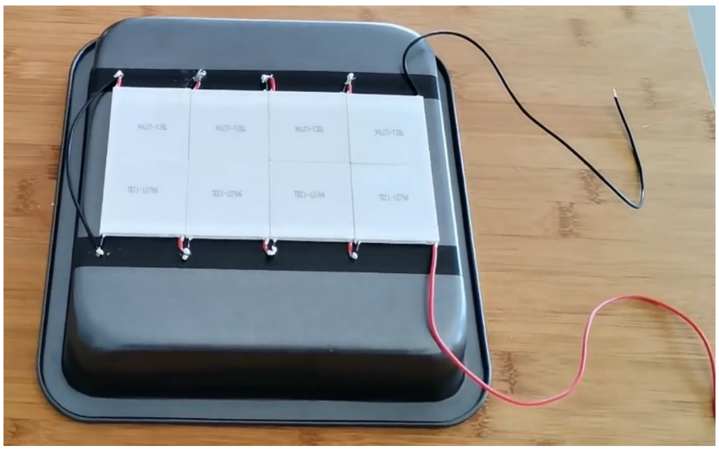

Figure 2: Thermoelectric Coolers on Flat Aluminum Tray

The next step was installing a voltage regulator. The voltage could potentially come up to 15volts which is too high for phones, so a voltage regulator was used to set it down to 5 volts. Support for the voltage regulator was built by cutting an aluminum strip and plying it to the edges to fit on the aluminum tray's sides. Three pieces of cork were glued to the support while the voltage regulator was glued on top of the cork to make sure it was also insulated. Because of the way the thermoelectric cooler pads were glued, the polarity was inverted. Hence, there is a need to invert the way the thermoelectric cooler pads are connected to the voltage regulator. The connection should be that the black wire goes to the plus terminal and the red wire to the minus terminal. Also, another piece of aluminum was cut off and glued on top of the thermoelectric cooler pads to collect more heat. A thermoelectric cooler works with temperature difference, the more heat it collects, the better the result. They were clamped together to ensure it was well glued and left to dry for about 12hours. Then, the power bank was constructed using the circuit diagram in Figure 3.

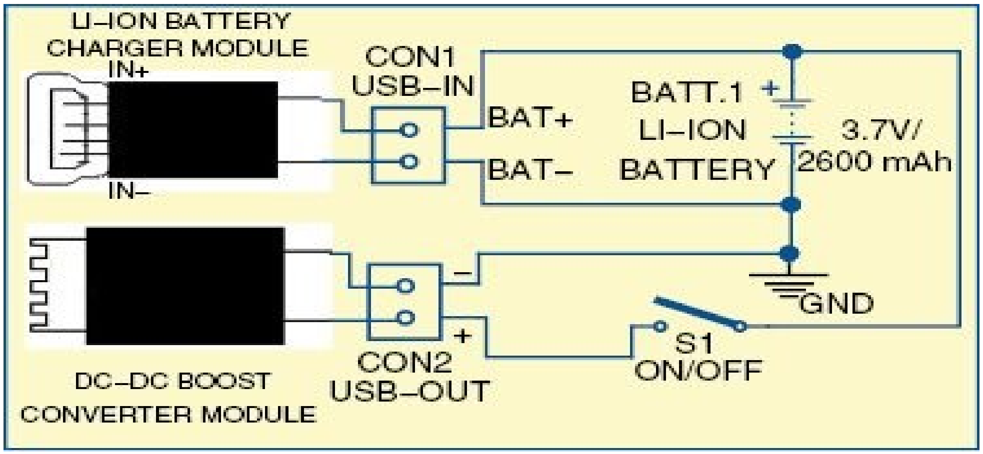

Figure 3: Circuit Diagram of Power Bank

The battery charger module TP4056 chip was connected to a 3.7v/2600mAh lithium-ion battery (BATT.1 LI-ION) to handle charging operation by processing the 5V DC input supply received through the CON1 USB-IN socket. BATT.1 LI-ION is used as the power reservoir. Two onboard SMD LEDs on top of the battery charger module provide the power status indications of which the red light indicates charging and the blue light indicates fully charged. Since the output of BATT.1 LI-ION is 3.7v, DC-DC boost converter module based on pulse frequency modulation was used to give a stable USB standard Dc supply through the standard USB socket at its output. Switch (S1 ON/OFF) was connected to route DC supply from BATT.1 LI-ION to the converter. The mobile phones are now charged by connecting to the USB socket of the converter module through a USB cable and closing switch of which a red-colored LED of the converter module will turn on indicating the charging status of the mobile phone.

4. Results

The wood stove is shown in Figure 4 has enough holes at the bottom for air to flow through for the fire. Pinewood was used to light it up because it is full of resin, burns quicker and better than other woods.

Figure 4: Burning Wood Stove

The Thermoelectric generator produced is shown in Figure 5.

Figure 5: Thermoeletric Generator

Pouring water in the tray and placing it on top of the wooden stove makes the red LED light up. Adding some ice cubes will help the temperature to drop fast but it is not mandatory though the voltage will start rising fast. The power bank produced is shown in Figure 6.

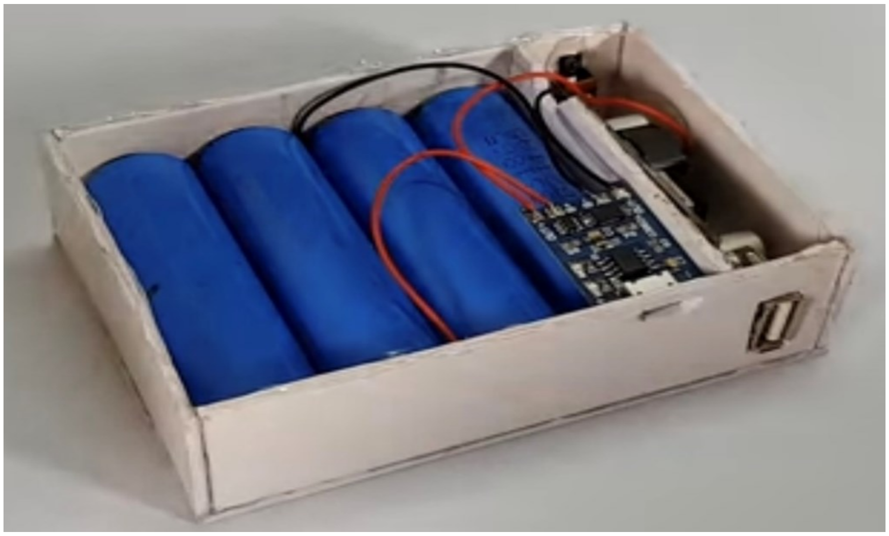

Figure 6: Power Bank

The voltage regulator was set to 5 volts and used to charge the power bank. The power bank serving as a power reservoir was used to power the mobile phone as shown in Figure 7.

Figure 7: Charging of the Mobile Phone

5. Conclusion

Food waste has become one of the major environmental issues for every nation and is affecting the lives of people. The generation of food waste is a result of multiple behaviors that relate to different aspects of food purchasing, preparation, and consumption. Food wastes are either discarded before or after it spoils. When feed waste decomposes in a landfill, it produces methane that contributes to the destruction of the Ozone layer. Most of the waste ends up in rivers, lagoons and creates serious health risks. This work ensured that food waste is converted to electrical energy and used in powering mobile phones. Future research on this work should focus on having a thermoelectric generator that can power all the appliances at home.

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