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Generation of Electricity from Food Waste

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Abstract: Waste has become one of the major environmental issues for every nation and is adversely affecting the lives on earth. In a developing country like India, there are many places which suffer shortage of electricity to date. Ironically they are the places which have become landfills for garbage. This paper gives a solution to the present scenario by converting food waste into electricity. This electricity is produced by the reaction between the electrodes with food waste as the medium. Different combinations and arrangements of electrodes are also taken into consideration. This is where our project plays an important role in finding an effective solution to the existing problem.

Keywords: electrodes; zinc; copper; electricity; food waste.

I. INTRODUCTION

India is the second most populated nation on the planet, estimating to a population of about 1.21 billion, and accounts for about 17.66% of the total world population. It is same as the combined population of Indonesia, Brazil, Pakistan, and Bangladesh. Population growth and rapid urbanization has had a huge impact on the waste generation. Increase in the global population and the rising demand for food and other essentials, has led to a rise in the amount of waste being generated daily by each household.

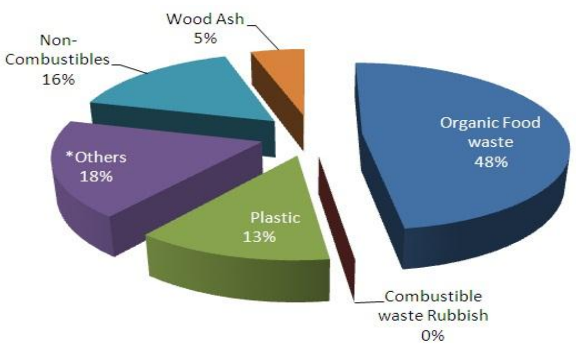

Fig. Different types of waste

It has been observed that more than 300 cities in India generate 45 million tons of waste presently, which is a 50% increase in one decade. From the total waste generated throughout; a majority of 48% is food waste in Fig.1. About 0.1 million tons of waste is generated in India alone everyday which is about close to 35 million ton a year. The landfills where the waste is dumped is always located away from the habitation clusters due to environmental impacts but this increasing waste means more land is required for disposing the waste , which increases the transportation cost. This waste is being recklessly dumped into villages. Everyday products that are used and thrown away are filled with hazardous and health-affecting chemicals. Indiscriminate dumping of wastes contaminates surface and ground water supplies. The waste clogs the drain, creating a breeding ground for insects. These insects spread diseases like dengue, malaria, cholera. Also the uncontrolled burning and improper disposal aggravates air pollution. Adding to this, the decomposition of waste also produces greenhouse gases. Hence proper waste management has to be undertaken to ensure that it does not affect the environment and does not cause health hazards to the people living there [1].

The present day treatment of waste involves reducing the amount of waste [1], such as Compaction, Incineration Pyrolysis gasification and Composting. Prevention of waste is a top priority when waste management techniques are concerned, but because this is humanly impossible for us with the lifestyles that we are used to, the next best is the recycling and reuse of materials.

Incineration is a combustion process for burning solid wastes in presence of air at high temperature. But in this treatment, Dioxins are produced which a cancer is forming chemical. Pyrolysis involves the thermal decomposition of biomass in the absence of oxygen. The end products are gas and coke. In gasification, the chemical reaction takes place in the presence of steam in an oxygen-lean atmosphere. The products of gasification are carbon monoxide which is harmful to the living beings. Another process is composting, which is the biological decomposition of food or plant waste by bacteria, fungi, and other organisms performed under controlled aerobic conditions. All of which requires lots of time, cost and land. Hence, in this paper we provide an effective solution for both waste management and producing electricity in the most efficient and user friendly way.

This paper describes the procedure of generating electricity in section II, followed by the result and the conclusion.

II. PROCEDURE FOR WASTE TO ELECTRICITY CONVERSION

In this project food waste was taken in two forms, grinded and not grinded. Each of them was further experimented with and without chemicals. Several methods were performed out of which two gave predominantly good results and they are as follows:

A. Method I

In a single container, grinded food waste was taken. Two electrodes acting as anode and cathode were dipped in the semi-solid waste. Here, a single pair of Platinum and Calomel was used. Using digital potentiometer, the voltage readings were noted down. To further enhance the voltage, we added chemicals such as Hydrochloric acid (HCl) and Potassium hydroxide (KOH).

TABLE 1 VOLTAGE READING OBTAINED FROM TOMATO PULP AND FOOD WASTE

Date	**Potentiometer readings in volts**	
	Without adding chemicals	**With adding chemicals**
	With tomato pulp	
25th July 2015	0.067	0.132
28th July 2015	0.080	0.163
3rd August 2015	0.151	0.178
18th August 2015	0.183	0.159
	With food waste	
2nd December 2015	0.271	0.178
4th December, 2015	0.180	0.164

The above Table 1 shows different voltage readings obtained from the grinded waste with and without addition of chemicals over a period of time. It was observed that the maximum voltage produced was 0.271V. The effect of addition of chemicals could not be studied as the voltage was fluctuating.

The experiment was carried out for the next method which is as follows:

B. Method II

Though from the previous experimental setup, voltage obtained was in milli volts, which was was not enough to run any load. Hence an understanding of different factors which have an effect in an electrochemical reaction was required. Our first approach was made on the material of different pairs of electrode. So, we experimented with different pairs ie. Zinc-Copper, Zinc-Aluminium, Aluminium-Copper. It was found that Zn-Cu Fig. 2, gives maximum reading and hence it was considered for the rest of the project. A pair of zinc and copper sheets dipped in a container of waste gave us a reading of 0.9V as shown in Table II. The understanding of the surface area of the electrode can be understood by the equation

$$\eta_a = a + [b * (\log(i))] \quad (1)$$

where η_a is the activation over potential, a and b are empirical constants and i is the current density from (1).The amount of voltage drop in the cell due to the electron transfer, increases linearly with the logarithm of the current density hence by increasing the surface area of the electrode ,the current density decreases which decreases η_a .

Further experimentation led us to connecting three pairs of zinc and copper sheets which gave us nearly 2.34V. This was more than sufficient to run the digital clock as shown in Fig 3. Similarly twelve pairs of Zn-Cu electrodes connected in series were used to glow four LEDs in series as shown in Fig 4. But the current was in milli range. Hence we decided to try out different arrangements of electrodes which were connected in series and parallel. The first combination as shown in Fig. 5 gave voltage of 3.4V and saturation current of 5.08mA. To further enhance the readings second combination as shown in Fig.6 was implemented from which we obtained voltage of 7.2V and saturation current of 14mA. Hence we can conclude that with the increase in the number of series and parallel combination of electrodes desired voltage and current can be obtained.

TABLE 2 VOLTAGE OBTAINED FROM DIFFERENT PAIRS OF ELECTRODES

Combination	**Voltage (in V)**
Aluminium-Copper	0.72
Aluminium-Zinc	0.4
Zinc-Copper	0.9

Fig2 Voltage reading for a single pair of Zn-Cu electrode

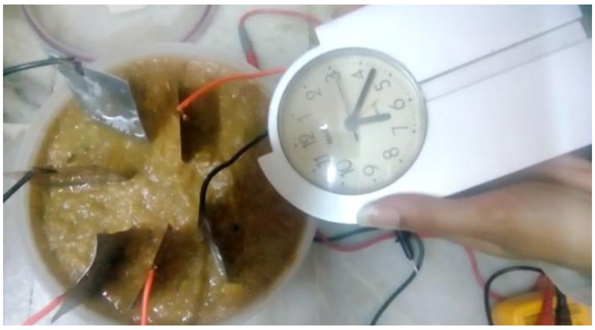

Fig 3 Analog clock used as load

Fig 4 Glowing of four LEDs in series

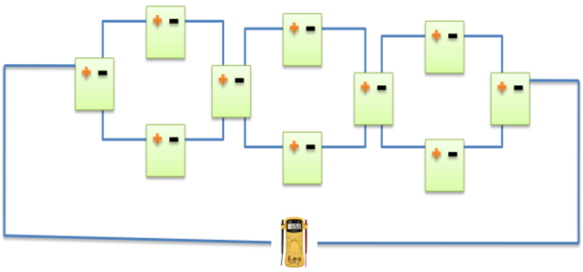

Fig 5 Series parallel combination I

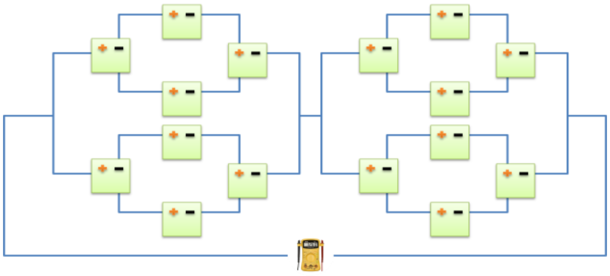

Fig 6 Series parallel combination II

III. RESULT

A. Method I

In method I the voltage reading for tomato pulp and food waste taken in a single container using platinum and calomel electrodes on the first day was 0.067V and 0.271V respectively. On the addition of chemicals, it was 0.132V and 0.178V respectively, as shown in Table I. The behavior of addition of chemicals like HCl and KOH could not be understood as the voltage readings were inconsistent.

B. Method II

Food waste was taken in single container along with three pairs of Zn-Cu sheets. Voltage obtained was 2.34V.Analog clock was used as load. Similarly with four pairs of Zn-Cu sheets immersed in four separate containers, voltage obtained was 3.7V and LED was used as load. On connecting 12 pairs of the electrodes in series connection, five LEDs were glowing. Series parallel combination was implemented to increase both current and voltage, the maximum saturation current obtained from the arrangement was 14mA and voltage was 7.2V.

C. Rate of Discharge

5 pairs of Zn-Cu sheets were immersed in separate containers, connected in series, with single LED as load. It was kept untouched and it was glowing for three days. Voltage was constant (1.7V). Current variation existed till the second day after which it reached its saturation point nearing 7mA. The readings corresponding to the rate of discharge are as shown in Table III.

TABLE 3 RATE OF DISCHARGE

Time	Voltage (in V)	Current (in mA)
February 28, 2016		
1:13PM	1.94	16.62
2:13PM	1.71	7.08
3:13PM	1.73	8.16
4:13PM	1.70	6.76
5:13PM	1.70	8.00
6:13PM	1.70	7.21
7:30PM	1.70	8.20
8:45PM	1.70	7.50
9:30PM	1.70	7.30
10:25PM	1.70	7.40
11:15PM	1.70	7.62
February 29, 2016		
12:15AM	1.73	7.74
1:25AM	1.72	7.83
2:05AM	1.74	7.73
3:15AM	1.74	7.86
Time	Voltage (in V)	Current (in mA)
February 29, 2016		
4:15AM	1.74	7.76
7:00AM	1.76	7.12
8:45AM	1.77	7.32
10:15AM	1.76	7.86
11:15AM	1.77	7.31
3:45PM	1.78	8.08
7:00PM	1.73	7.43
8:00PM	1.78	7.63
9:45PM	1.79	8.83
11:00PM	1.78	8.63
March 1, 2016		
9:05AM	1.79	7.04

D. Graph of voltage reading and number of pairs of electrodes

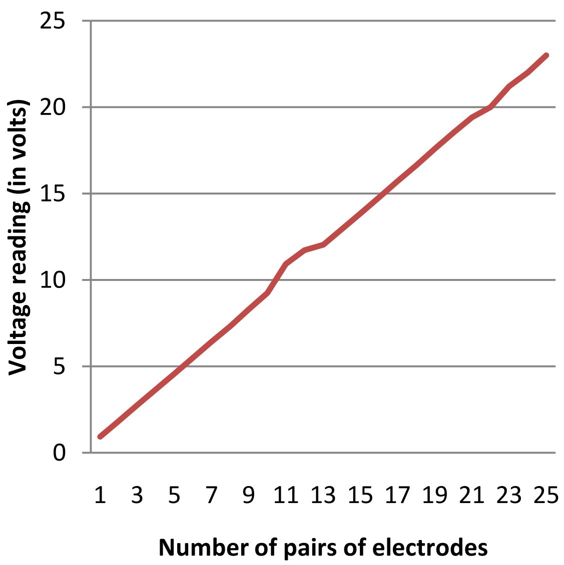

Fig 7 Voltage reading for increasing pair of electrodes

From the above graph, Fig.7 we can observe that the plot of Voltage readings Vs number of pairs of electrodes is almost linear. In other words, as the series connection of electrodes increase, the voltage gets added up. A single pair gives 0.9V so when number of electrodes say n are connected in series the voltage gets multiplied by n times which will give n*V Volts. Here we have taken 25 pairs which gives 22.5V.

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IV. CONCLUSION

Waste should be taken in semi solid or completely in liquid form; else the solid waste or peels etc should be lightly grinded before use. Addition of chemicals does not increase the voltage but speeds up the rate of reaction. The electrodes must be immersed in separate containers in method II as opposed to method I, because when many cells are immersed in single container it acts a single cell. The electrons move randomly and hence won't give the desired results. Immersing in separate containers constitutes every container acting as a cell hence gives the actual result. Depending on the load requirements, the cells can be arranged in series parallel combination. Zinc and copper combination gives the best result among the rest. The electrodes are taken into consideration depending upon their surface area, more the surface area more flow of electrons. Adding to this, the electrodes should be kept close to each other, as a result of which the current increases and therefore increases the rate of reaction. Rate of discharge proves how reliable the waste as a source is.

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