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Experimental Study of Earth Batteries

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Abstract: We report successful design, construction and operation of an earth battery as an alternate energy source for low power electric supply applications. Different combinations of metallic and non-metallic solid, liquid and gas electrodes were investigated for maximum potential difference. In view of robust and cost effective use of this natural power technology by unskilled village consumers most suitable combinations of the commonly available metals were selected for further detailed characteristic studies. Combinations of Magnesium anode and Coke cathode; Zinc anode and Graphite cathode; Aluminum anode and Carbon cathode; Zinc anode and Copper cathodes gave 2.05, 1.40, 1.10 and 0.9 volts per cell. Typical rated power of a single Zn-Cu cell was measured to be few tens of microamperes. Small power electronic devices such as calculators, electronic watches, baby toys and cell phones and white light LEDs were operated on site. The voltage level was found to increase linearly by connecting multiple earth battery cells in series like commercial lead acid battery. The load current was found to increase by connecting earth cells in parallel. The source current capacities were also found to increase by increasing surface areas of the electrodes. However, single cell voltage was found to remain constant irrespective of the electrode sizes. This paper reports detailed characteristic study of the most cost effective and accessible metal electrodes earth batteries. Operation of earth battery as a free electricity source was demonstrated successfully.

I. INTRODUCTION

Reported free energy holy grails may include electrostatic motors, geo-magnetic generators [1-2], air [3], sea [4] and earth batteries [5-8]. Some free energy believers have often been focusing on the perpetual motion machines using scientifically unworkable ideas such as over unity devices, millennium motors, resonance based self-charging and free wheeling devices. There exists nothing as free energy source such as mutual powering motor-generator set without any net input or gravity based free running machines or negative resistance based amplification. However, earth soil chemical reactions and electron affinity based earth batteries may be explored for low to high voltage DC potential to drive small scale white emission LED lighting loads in remote hilly areas or small scale electronic devices. They can also be considered to replace high voltage low current charging power supplies or ionization power supplies. Like earth batteries the sea batteries also may be considered for similar applications. However, air batteries can be used for bulk power production and grid system operation [3]. In view of global energy crisis to be caused by natural end of oil and gas within next 50 to 60 years time [9-11], it has become very important to look for alternative energy sources to hold back the human race from engagement to a great energy war [12-13].

Although, uranium [14] and coal [9] would continue to exist for few centuries but they can not replace oil and gas despite risks of radioactivity hazards (plutonium) and greenhouse gases (CO_2). Either, we can stop global warming at risk of nuclear radiation or make the planet nuclear free at risk of global warming due to increasing temperatures from1.4 to 5.8ºC from 1990 to 2100 by exponentially rising CO_2 concentrations. Rise in earth surface temperature in past ten hot years (1997-2007) was about 0.6ºC. Maximum temperature has been recorded to be 52ºC in major cities of Pakistan and 46ºC in Greece. Cool the home and heat the planet or adapt to natural ways of life. We must stop use of excessive energy for entertainment and retune ourselves to new lifestyles requiring minimum amount of energy in the form of cooling or heating. The scientists must work hard to explore new sources of energy else be prepared to be perished soon in a great energy war or global greenhouse effect none knows which prevails earlier. This work is a very honest effort to investigate the possibility of using earth batteries for remote village lighting, communication signaling and driving small scale electronic loads where there is no alternate source of electricity or simple to conserve electricity. Assuming uniform electrode profile the potentials of some common metals electrode pairs in soils are shown in Table 1. [15-17].

Table 1 Potential of Common Metals Suitable for Earth Battery

Anode materials		Cathode materials		Battery
Material	E^o(V)	Material	E^o(V)	Volts
magnesium	-1.75	coke	+0.30	2.05
zinc	-1.10	graphite	+0.30	1.40
zinc	-1.10	copper	+0.20	0.90
aluminium	-0.80	carbon	+0.30	1.10
iron	-0.50	coal	+0.30	0.80

To test the possibility of higher currents and voltage a few large size C, Mg and Al electrodes are under construction or testing. Unlike air batteries used in vehicles the earth batteries have very low Wh capacities. It can not drive even ordinary motorized baby toys. Above earth battery failed to drive even an LED despite 0.7mA current due to low voltage. It had an average 0.63µW power. It was still too small to drive any motorized load except electronic digital clock. A simple air battery may consist of aluminum foil (or magnesium) and activated charcoal (or iron). Oxygen from air may penetrate through saltwater soaked paper to react with aluminum. Electrodes attached to aluminum and carbon may produce enough useful voltage. Air battery cell voltage depends upon reduction potential. Typical reduction

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potentials of various materials at STP are shown in Table 2 [16-19]

Table 2 Standard Reduction Potentials of Elements at 25ºC

Anode materials		Cathode materials		Battery
Material	E°(V)	Materials	E°(V)	Volts
Li^+(aq)	**-3.045**	**F_2(g)**	**+2.870**	**5.915**
Na^+(aq)	-2.710	H_2O_2(aq)	+1.780	4.490
Mg^{2+}(aq)	-2.370	MnO_4^-(aq)	1.510	3.880
K^+(aq)	**-2.925**	**Au(aq)**	**+1.500**	**3.425**
Al^{3+}(aq)	-1.660	Cl_2(g)	1.360	3.020
Zn^{2+}(aq)	**-0.760**	**Cu^{2+}(aq)**	**0.340**	**1.100**

Per cell voltage ranges of air batteries are much lower than air batteries. The best, Mg-C, earth battery has a maximum 2.05 volts whilst the best Li^+(aq)-F_2(g) air battery has 5.915 volts. However, air battery design needs to consider several other economic aspects for commercial use. A common Zn-Air battery can supply 312kWh in comparison with 22kWh NiCd battery. Together they can power 200HP traction drive at speed of 20mph or 35 mph using higher capacity batteries. Recent trends are focused on increasing speed to 55mph to cope with energy crisis. This technology is in use in several countries since years. Air battery energy to weight and energy to size ratios are 200-250Wh/kg and 300-375 Wh/L.

II. EXPERIMENTAL SETUP

An experimental study was conducted to measure exact voltages and currents of an earth battery cells consisting of zinc and copper electrodes. The electrodes arrangement on earth's surface in open air environment consists of simple pricking of pointed electrodes on earth's surface. The electrode soil reaction voltage 0.92V may be used to drive small scale lighting and electronic loads. Outside on bare earth the currents and voltages were found higher at smaller distances and lower at relatively larger distances between cathode and anodes. The voltages and currents readings were found unstable on the digital multi-meter. Repetition of above experiment with interchange of electrodes from north to south resulted in relatively increased voltages and currents.

Average magnitudes of voltages and currents were measured to be 0.91±0.15V and 0.7±0.25mA for multiple electrodes. Earth battery potential depends upon the electrode materials and their standard reduction potentials. If we choose higher positive and negative reduction materials the earth battery voltage can be enhanced. Theoretical voltage of Zn-Cu earth battery is 0.92V but our measurements conducted with UNI-T professional digital VOAM # 1050444792 (Korea) were about 0.90±0.25V. To construct a high voltage battery suitable electrodes must be chosen. Common metals behave similarly except current magnitude depends on electrode surface areas. Variation of measured fluctuating voltages and currents are shown in Fig.1.

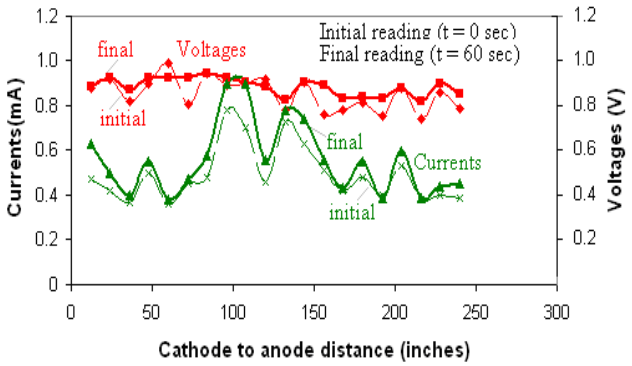


Fig.1 Copper (south)-Zinc (north) earth battery voltages and currents

When the same experiment was repeated inside lab using insulated box mud cells the voltage and current was found quite stable. It was supposed that the measurements made outside on bare earth might have extra telluric earth currents in addition to the normal earth battery currents. Further to estimate the impact of telluric earth currents on the natural directions on measured values of currents and voltages, the zinc electrode was fixed in earth and copper electrode was rotated for multiple directions from 0º (north) to 90º (east) to180º (south) and to 270º (west). The voltages and currents at fixed radius of 9 feet circle were found to vary slightly vary in magnitudes as shown in Fig.2.

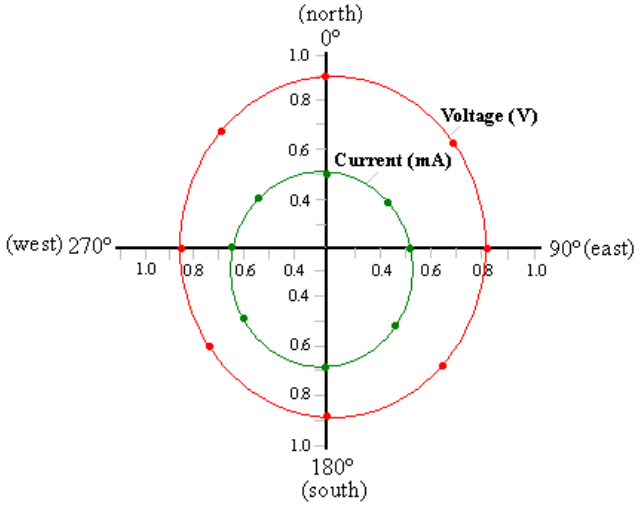


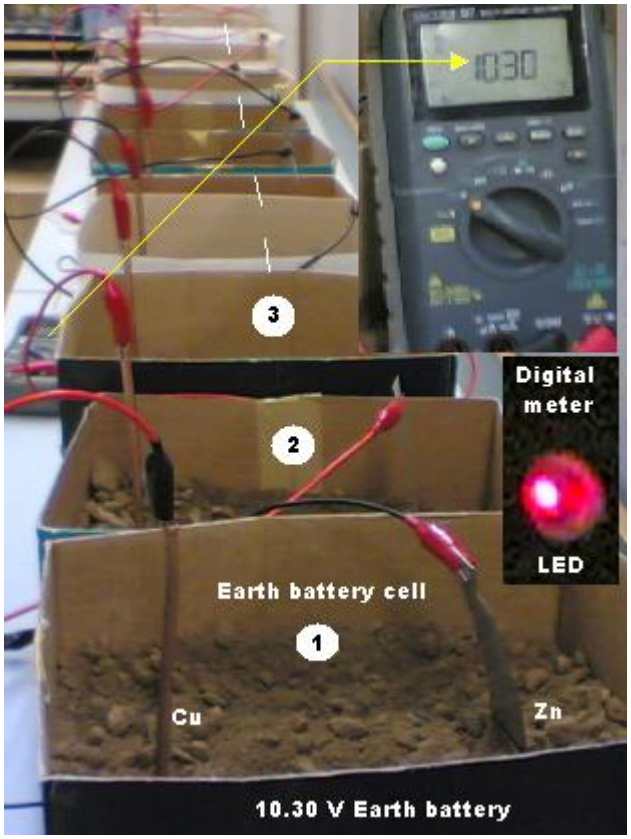
Fig.2 Earth battery V/I characteristics for fixed zinc and mobile copper electrode.

Electrode did not chemically corrode even after 8 to 9 hrs continuous use. Stronger currents flow from south to north and weaker currents from east to west. Currents were also stronger for positive north and negative south electrodes. Currents were found to flow from south to north. However, it was not possible to connect earth battery cells in series to increase the voltage as the electrodes from bottom become short circuited through earth electrolyte materials. Nevertheless, parallel connection of cells resulted in increased currents due to increased surface areas. Spiral

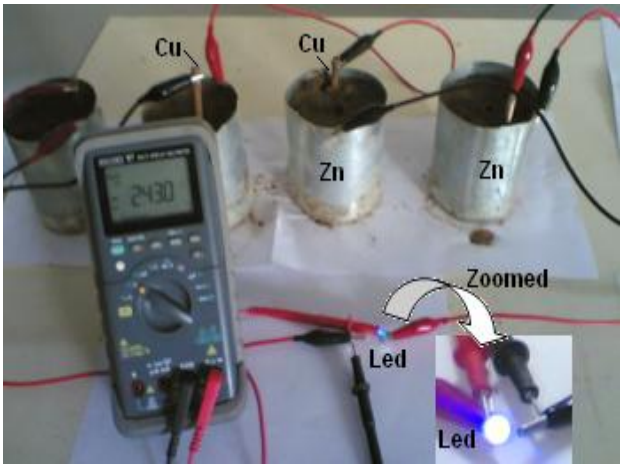
design of electrodes due to large surface areas increases the current magnitudes. Maximum magnitude of the measured voltage was found to be 0.9 ±0.35 volts with currents in the range of 3±0.25μA. When the same experiment was repeated outside on open land the magnitude of current increased to 15±10μA. Both the current and magnitudes continued to oscillate as if the some random potential source in addition to normal soil reaction voltage was found modulating the constant DC earth battery voltage.

III. SERIAL OPERATION OF EARTH BATTERIES

Due to short circuiting of electrodes the voltage can not increase on bare earth surface. We need to isolate individual cells to add up the voltage. To demonstrate serial addition of voltages 13 DC battery cells were prepared in separate paper boxes. The isolated earth battery cells were connected in series to increase the voltage as shown in Fig. 3. The distance between Zn and Cu electrodes in different cells varied from 8 to 10cm in Fig .3 (a) and 0.5 to 1cm in Fig.3 (b).
The voltage varied from 10 to 12V DC with low current but still able to light up an LED. The mud resistance between the electrodes was tens of MΩ. To reduce the resistance a thin film approach was applied by appending mud coatings on the 16 inch square I mm thick copper and zinc plates as shown in Fig.4.



a. A twelve cells 10.30V/45mA earth battery



b. A four cells 2.43V/0.20mA earth battery

Fig.3. Experimental demonstration of serial connection of earth batteries

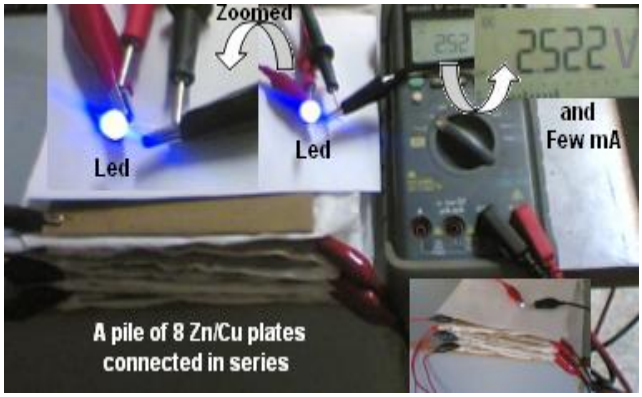


Fig.4 Four inch square Zn/Cu plate electrodes 2.5V/30μA earth battery

Four cells connected in series produced 2.5 to 3.25V DC with 30μA current due to larger surface areas. It is to note the voltage and current depend upon moisture content in dry much. When it is complete dry the current reduces to zero due to high resistance between electrodes. The reaction of metal with soil requires moisture. Better if we go for mud electrolyte instead of simple dry mud. The batteries electrodes become partially rusted after long term operation. A few results on rusting have already been published elsewhere [20]. Further studies on large surface areas of multiple electrodes are under investigation now.

IV. CONCLUSIONS

Results of experimental study on earth batteries using copper and zinc electrodes are very encouraging. The initial results for month operation of earth batteries has shown reasonable potential for use in remote locations for signaling as well as charging cell phone and white light illumination applications. This interesting study was

undertaken as part of HEC funded research project on Renewable Energy category. Being UET graduate (1984) I feel a lot pleasure to present this research work through ICEE 2008 held in UET Lahore, Pakistan.

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