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Generating Electricity from Soil Using Different Sources of Manure

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ABSTRACT
In this study three different types of manure (bird, cattle and sheep) with three doses (10, 20 and 30 g) were mixed with soil to investigate and compare the different performance of energy generation as well as provides the ways of increasing the efficiency for such an application. The mixed soil was incubated for ten days after wetting with tap water as needed, then the voltage and current readings were taken every twenty-four hours for ten days. Experiment results indicated that 30 g cattle manure was the best use for energy generating purposes, delivering a voltage peak of 7.4 mV and current of 0.48 mA compared to 7.4 mV; 0.34 mA for bird manure and 6.56 mV; 0.32 mA for sheep manure. Cattle manure produced the highest peak for voltage with all doses and was therefore the best to use. In general, all treatments provide enough voltage to power the LED bulb successfully.

Keywords: electricity generation, soil, manure, current, voltage.

INTRODUCTION

The increase in temperature leads to global environmental deterioration due to using combustion of coal and other natural gases in order to obtain energy. The emission during the production of electricity using these sources is harmful to the environment (Pavithra et al., 2018). Energy demand is very important due to growing world population (Sheffield., 1998; Soytasand Sari., 2003; Lee., 2005; Shiu and Lam., 2004; and Mackay, 2009). Worldwide energy generation is still mainly dependent on fossil resources (IEA, 2011). Nowadays, the demand for alternative energy generation has an increasing trend. Therefore, renewable, sustainable and clean forms of energy are needed. A microbial fuel cell is a bio electrochemical system making use of biocatalyst for converting chemical energy into electrical energy (Logan et al., 2006). This microbial fuel cell (MFC) is a device that converts chemical energy into electrical energy with the help of micro-organisms (Elvis et al., 2015). The direct conversion of organic matter to electricity using bacteria is possible in MFC; the use of compost is a future prospect. In this paper, a method of harvesting electrical energy from soil and studied additional factors that influence the applicability of the microbial fuel cell were presented. There are few publications available on this topic; this gives the project an added significance, as it would contribute to increase the knowledge about the soil in terms of power production capacity.

Therefore, the present work focuses on the following: checking if the soil treated with different types of manure is able to produce any power; checking which manure treatment produced the highest peak for voltage and current and when the power starts to drop.

MATERIALS AND METHODS

To achieve the aim of this study, silty clay soil was obtained from college of Agricultural Engineering Science–Duhok University, dried, ground and sieved from a 2 mm sieve and subjected to various routine analysis, as shown in Table 1. The pH and electrical conductivity (EC) were measured in 1:5 soil water ratios. Soluble ions (Ca^{+2},

Table 1. Physiochemical characters of soil used

Parameters	Units	Soil analysis
pH	-	7.85
EC	$dS.m^{-1}$	0.325
Ca	$mmole_c.l^{-1}$	2.71
Mg		1.5
Na		0.73
K		0.1
O.M	$mg\ kg^{-1}$	8.5
Sand	$g\ kg^{-1}$	90.1
Silt	$g\ kg^{-1}$	494.6
Clay	$g\ kg^{-1}$	415.1
Texture	$g\ kg^{-1}$	Silty clay

Mg^{+2}, K^+ and Na^+) were determined according to (Page et al., 1982). The particle size distribution was determined by using the hydrometer method and organic matter (O.M) was determined by the (Walkely and Black, 1934) method. The analysis of different types of manure (cattle, sheep and birds) was also done, see Table 2. The total phosphorous (TP) was determined by using wet digestion with H_2SO_4 (Okalebo, 2002) and the phosphorous (P) was determined following (Morphy 1962), while the Kjeldal digestion method was used to determine (TN) total nitrogen (Bremner 1965).

Each 1600 g of dried soil was treated with either 80,160 or 240 g of each type of manure and replicated three times, then incubated for ten days after adding appropriate amount of tap

Table 2. Some characters of manure used

Parameters	Units	Cattle manure	Sheep manure	Birds manure
pH	-	7.44	7.54	6.40
EC	$dS.m^{-1}$	10.11	6.03	3.19
TP	$mg\ kg^{-1}$	16.1	25.17	39.25
TN	$g\ kg^{-1}$	4.23	18.49	35.86
OM		496.6	366.44	390.42
OC		290.12	212.55	226.45
C:N ratio	-	68.58	11.49	6.33
C:P ratio	-	18.01	8.44	5.76

Figure 1. The layout of the experiment

water to the estimated field capacity. The samples were kept moist through the incubation period by adding tap water as needed. After the given time, the soil samples were air dried and each replicate (i.e 1600 g) was subdivided to eight parts (200 g each) and placed in plastic jars as shown in Figure 1. The eight jars were then placed in a plastic container, which was 23 cm wide, 30.3 cm length and 14 cm height (Figure 1). An anode made of carbon with 0.084 cm^2 and 16.4 cm^2 cathode made of zinc were inserted in soil of each jar and then tap water was gently added into the jars, depending on the maximum holding capacity of the soil and amount of manure added. Two types of wires differing in their thickness (0.3 and 0.8 mm) were used to connect the two electrodes to the external circuit with a resistance. An-LED-was connected with the circuit to light up and measure the current. A multi-meter was used to record the voltage and current every twenty-four hours for ten days (Figure 1). At the end of the experiment, the soil in each jar air dried and sieved through a 2 mm sieve and analyzed using the same methods mentioned above.

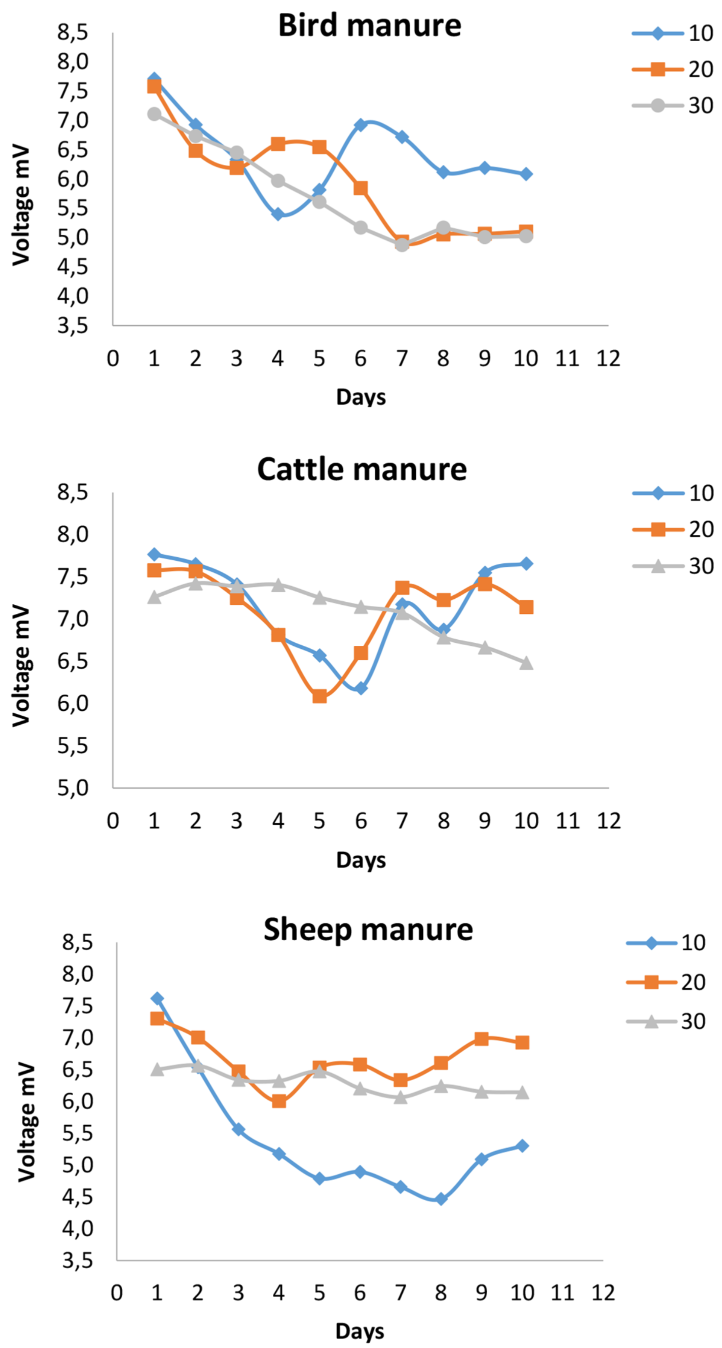

Figure 2. Voltage generated by varying amounts of different types of manure (thick wire)

RESULTS AND DISCUSSION

The experiment was operated for ten days. The voltage (V) and current (I) measurements were taken every 24 hours for the experimental period. Figure 2 shows the voltage readings which had same trends for all types and doses of manure as those achieved with current - see (I) Figure 3. When inspecting the types of manure, it was clear that cattle manure had better impact on (V) values. When comparing the amounts of bird-'s manure, it can be seen that the 30 g addition showed a decrease in cell (V), stabilizing around an average of 5.07 mV after seven days, thus producing an average current of 0.09 mA. However, there was flocculation with values of 10 and 20 g.

With cattle manure, the 30 g addition had a more desirable impact for generation (V) than 10 and 20 g. The (V) values slowly decrease to 6.48 mV at the last day. In the first day, maximization of (V) values were seen for 10 and 20 g, then after the second day, the reading dropped to the less values at day five and six followed by increase and kept producing high values until the end of the experiment. The sheep manure in the amount of 10 g did generate (V), but not as much as 20 and 30 g. It can be seen that 20 and 30 g were more optimal for generation energy than 10 g.

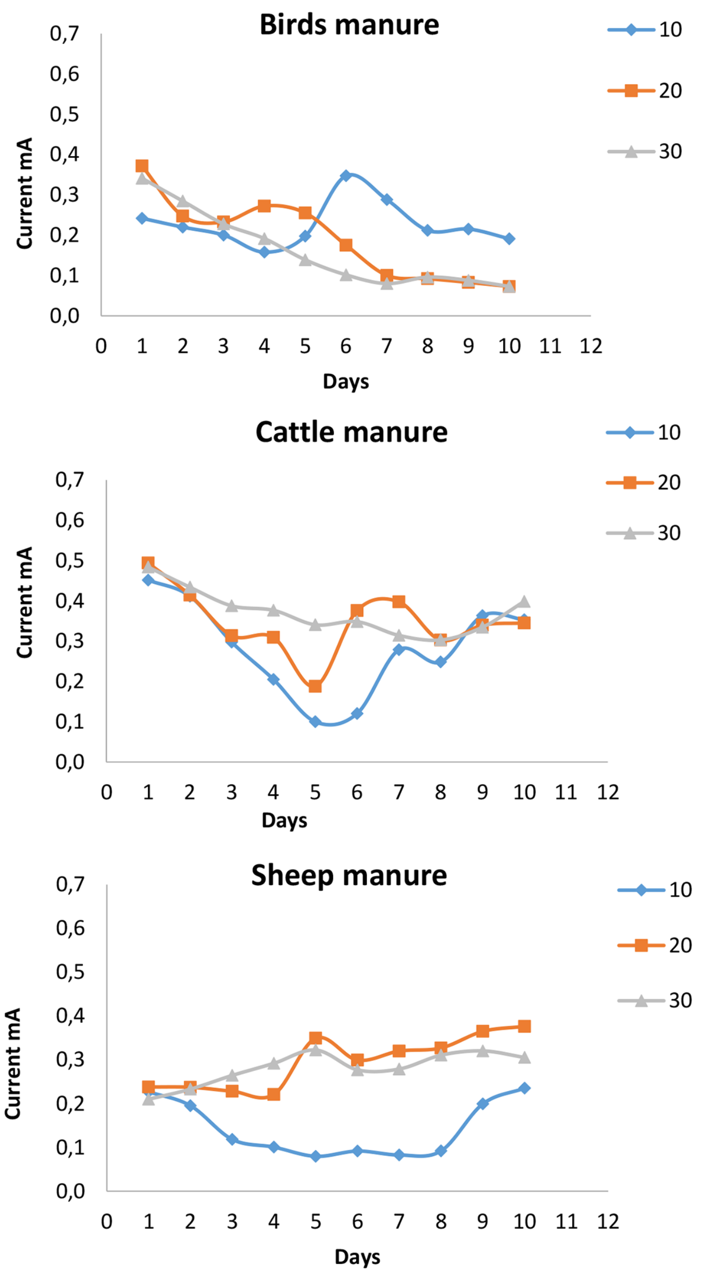

Figure 3. Current generated by varying amounts of different types of manure (thick wire)

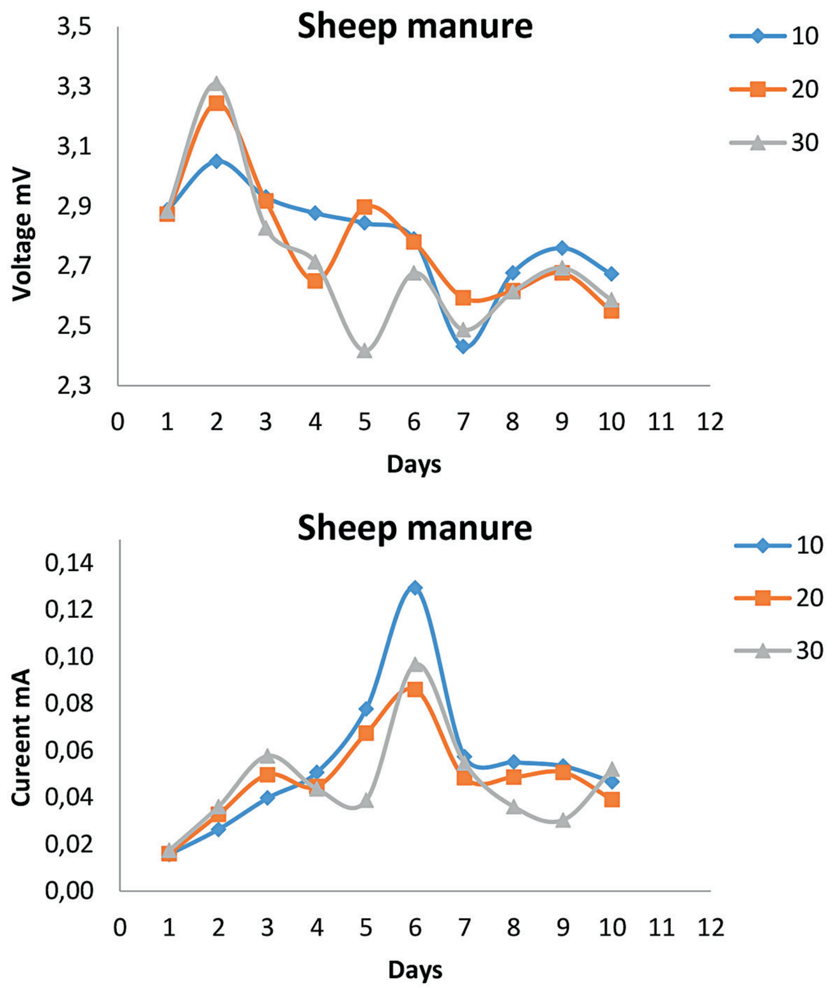

Figure 4. Voltage and current generated by varying amounts of different types of manure (thin wire)

Figure 3 showed the current generated by varying amounts of different types of manure. When started running the cells, the current (I) readings were initially high for the soil treated with 20 and 30 g of bird manure then decrease gradually for the 30 g addition, while for 20 g there was a second increase at days four and five, followed by a decrease reaching the lowest values after ten days. It was clear from the graph that the value of 10 g addition was initially lesser than 20 and 30 g, but increased and reached the peak after six days, then drifted towards the less values as the time progressed. However, after six days all readings of the 10 g addition were higher than 20 and 30 g.

As it can be seen from the same figure, cattle manure produced the best results, especially with 30 g addition. The peak for all additions (10,20 and 30 g) was at the first reading. The values for 30 g decrease slowly compared to rapid decrease with 10 and 20 g till day five, and then followed by increase. At day ten, all additions increased nearly to the same value.

With sheep manure, the 20 and 30 g additions followed the same trend, differing from 10 g which gave the lowest values. In general, the mean values for the current through the experimental period with bird manure were 0.228, 0.19, and 0.162 mA; with sheep manure were 0.143, 0.298 and 0.281 mA; with cattle manure were 0.283, 0.348 and 0.371 mA for the 10, 20 and 30 g additions, respectively.

The results seen in Figure 4 showed that sheep manure, using the thin wire (0.3mm), achieved the maximum (V) after 24 hours for the three additions, thus producing an average current of 0.033 mA. However, maximum (I) was obtained after six days with concomitant decrease in (V) values for the three additions of manure. From day one, the current (I) obtained by varying amounts of manure showed an increasing value with time, reaching maximum at day six; it then decreased at day seven. After that, the readings stabilize around an average of 0.046 mA for the three additions. Comparing the

Table 3. Characteristics of soil used at the end of the experiment

Parameters	Units	Cattle manure (g)			Sheep manure (g)			Birds manure (g)		
		10	20	30	10	20	30	10	20	30
pH	-	6.80	6.91	7.0	7.88	7.83	7.67	7.38	6.93	6.87
EC	dSm^{-1}	1.13	2.46	2.31	1.10	1.75	2.46	1.85	2.80	5.22
Ca^{2+}	mmolec l^{-1}	13.6	23.0	21.4	14.4	21.6	26.8	23.4	35.8	41.4
Mg^{2+}		12.0	19.6	23.0	15.4	18.8	25.2	15.0	20.8	23.0
Na^{+}		3.11	5.34	5.22	0.38	0.53	0.76	2.76	3.33	3.77
K^{+}		0.69	1.77	1.91	1.09	2.02	3.43	0.63	1.01	1.33
OM	g kg^{-1}	15.2	20.7	27.2	18.1	27.2	33.7	17.5	19.4	35.9

(V) and (I) values of sheep manure when thin and thick wire was used Figures 3 and 4, the values were higher when the thick wire was used. The lowest value of (V) was about 4.47 mV for thick wire, while the maximum value was only 3.31 mV when thin wire was used. Considering (I) readings, higher values were also obtained when thick wire was used.

Comparing the soil analysis data before and at the end of the experiment Tables 1 and 3, the pH values were lower than the initial values for all treatments. In contrast, the EC values increased, reaching maximum value of 5.22 dSm^{-1} with the 30 g addition of bird manure. Organic matter and all soluble cations were also increased at the end of the experiment; this could be due to the addition of different amounts and types of manure.

CONCLUSIONS

From the results, it can be concluded that cattle manure was most promising, delivering a (V) peak of 7.4 mV and current of 0.48 mA obtained with the 30 g addition, which worked the best for energy generation. Bird manure did generate energy, but sheep and cattle manure outperformed it. In general, the treatments provided enough voltage to power the LED bulbs successfully. To better understand the energy generating from soil, further investigation is required.

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