Chapter

Energy Efficiency and Sustainability in Outdoor Lighting - A Bet for the Future

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Abstract

Electricity from PKL tree has been developed using PKL extract previously. In this work, electricity production has been developed using living PKL tree. It has been studied that an electrochemical cell has been developed using living PKL tree. The experimental data have been demonstrated in that way, hence this method is feasible and effective. Electricity has been conducted from PKL (Pathor Kuchi leaf) using PKL extract with positive and negative electrodes. Several research papers have been published on it in the recognized journal at home and abroad. This research work has expressed the electricity generation from living PKL tree. It can be found that due to the difference of the pH between the soil and the living PKL tree, electricity can be produced. The performance of this electricity has been studied. This work has been developed by authors, which produced electricity from living PKL tree without damaging the PKL plants. The unused suitable land areas such as hilly areas, forest areas, and coastal areas, those could supply clean power for remote communities all over the world.

Keywords: cultivation, living PKL electricity, performance, capacity, energy efficiency

1. Introduction

Pathor Kuchi leaf is known as a medicinal leaf from ancient time. It has a great medicinal value, it is used for different kinds of diseases like dysentery, cholera, typhoid, kidney disease, etc. In the West Bengal, India there is no alternative about Pathor Kuchi leaf for folk medicine. People are using the leaf as a folk medicine. But, nowadays, it is using to generate electricity for low and medium power production [1–18]. Generally Zn and Cu metal is used as an electrode and the PKL extract is used as a source of the electricity [19–38]. Clean energy sources, which are pollution free and environmentally friendly, are one of the key challenges of world's future society.

The traditional sources of energy oil, gas and coal are diminishing day by day rapidly. Bangladesh is mainly dependent on gas based electricity. Conventional sources of energy will be finished within 2100 across the world. We have to depend on renewable energy sources like solar energy, wind energy, biogas energy, biomass energy, geothermal energy, wave energy, tidal energy, OTEC and hydropower, etc. PKL power from living PKL tree is the source of biomass energy. It is an innovative work around the world [39–44]. The solar PV system is providing electricity in the

remote areas. But during night time it is needed battery which is expensive. So that living PKL tree power can play an important role to provide electricity along the remote areas across the world.

Pathor Kuchi leaf is known as a medicinal leaf from ancient time. Because it has a great medicinal value, it is used for different kinds of diseases like dysentery, cholera, typhoid, kidney disease, etc. In the West Bengal, India there is no alternative about Pathor Kuchi leaf for folk medicine. People are using the leaf as a folk medicine. But now a days, it is using to generate electricity for low and medium power production [1–18]. Generally Zn and Cu metal is used as an electrode and the PKL extract is used as a source of the electricity [19–29]. Sustainable energy sources, which are pollution free and environmentally friendly, are one of the key challenges of world's future society. Researchers discovered that living plants are literally "green" power source, which may become one of future's electricity supplies that perfectly integrates in natural environments and is accessible all over the world. The issues of the global warming are the responsible for the generation of electricity using conventional energy sources like oil, gas and coal. The climate change is distributed due to un-balanced eco-system around many part of the world. It is difficult to protect the world from global warming in an artificial way, although a numerous science and technologies are booming surrounding us. It was possible to produce 1.1 V using voltaic cell method. Some researchers were possible to get 1.221 V [45–60] using single Ag/Zn-Aloe Vera cell without using any kind of boost converter and conditioning circuit. If we can generate electricity from living plants or trees, everyone wants to be planting the trees in ones surroundings for getting electricity. Governments of many countries also suggested and motivated such a process of plantation of trees and plants to get electricity [61–75]. As a result, the number of plants and trees in the globe will also increase, which indirectly will save our planet from the serious issue of global warming by the process of plantation in near future. It may be said that living plant & tree power is improbable to replace the power sources for the most of applications after finishing the fossil fuels. Also this kind of living plants and trees electrical system could provide low cost, continuous, pollution free and sustainable power system around the globe.

2. Methods and materials

The research methodology of the project is described as follows:

The electrons are living around PKL plant roots those are a waste product of bacteria. PKL tree excretes organic matter into the soil, which is broken down by bacteria. The electrons are released in the breakdown process and then it is possible to harvest electricity by using electrodes without affecting the plant's and leaf's growth of the PKL in any way.

Figure 1(a) and **(b)** shows the PKL tree in a tub and **Figure 1(c)** shows the cultivation of PKL in the open field for electricity generation.

Figure 2(a) shows the cultivation of PKL electricity through PKL living tree's leaf and (b) and (c) shows the cultivation of tree's leaf electricity. **Figure 2(d-m)** also shows the cultivation of PKL electricity through PKL living tree's leaf.

Finally the methodology of the project can be divided by the following:

i. **Design and fabrication:** Easy assembly, low fabrication cost, long life and high production efficiency are the key factors of the design and the operation and maintenance would be simple, easy and low cost.

ii. **Field experiments:** The production efficiency of the project will be evaluated by field experiments. A set of experiments will be carried out.

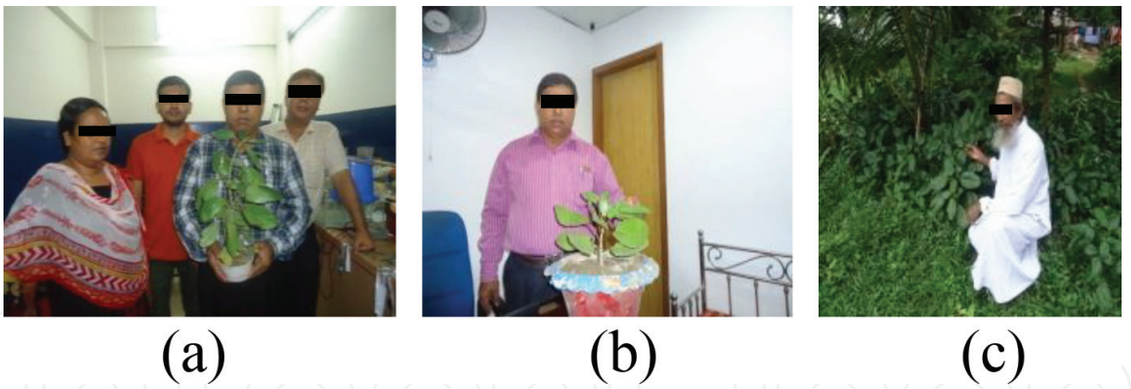

Figure 1.
Cultivation of PKL.

The effect of various factors such as open circuit voltage, short circuit current, voltage regulation, internal resistance, power & energy density, columbic efficiency, voltaic efficiency and energy efficiency will be observed.

iii. **Design parameter:** It may modify the design parameters of electricity production to fix any shortcomings regarding operational, maintenance, durability, quality and quantity. A further improved PKL electricity can be implemented in an arid, remote or a coastal area to remove the difficulties in acquiring green electricity and to save many human lives

iv. **Cost analysis:** The fabrication cost of PKL electricity will be calculated and be compared with other conventional techniques. The produced PKL electricity selling cost will be obtained and be compared with the commercial electricity price

v. **Electricity quality evaluation:** The quality of the produced electricity will be examined and monitored regularly to compare with PDB standards for electricity using.

vi. **A simulation model:** A theoretical production model of PKL electricity based on DC and AC theory may be developed

2.1 Definition of different parameters

i. Open circuit voltage V_{oc}:

The voltage without load is called open circuit voltage [51–53, 76–85]. Generally, it is denoted by $\mathbf{V_{oc}}$.

ii. Short circuit current I_{sc}:

The current without load is called short circuit current. Generally, it is denoted by I_{sc}.

iii. Voltage Regulation V_R:

It is defined by the following equation [54–60]:

$$V_R = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\% \quad (1)$$

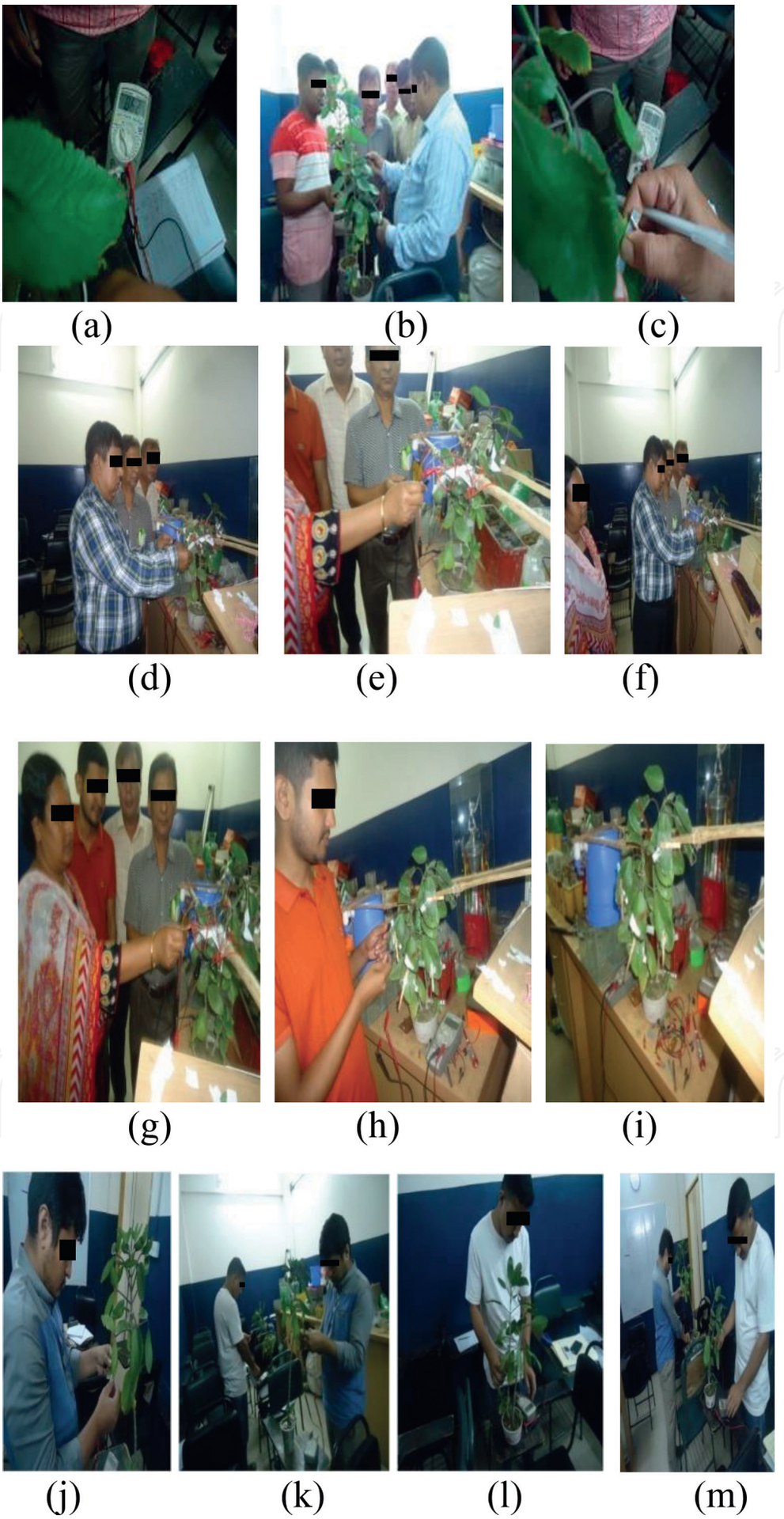

Figure 2.
Cultivation of electricity from living PKL.

where V_R = voltage regulation, V_{NL} = no load voltage, V_{FL} = full load voltage. Generally, $V_R \approx 0$ is desire, which is practically impossible [83–86].

i. PKL power density (PD) [83, 84]:

It is defined as the power extraction per kg PKL (Pathor Kuchi leaf).

$$\text{The Power Density (PD)} = \frac{\text{Power extraction (watt)}}{\text{kg}} \tag{2}$$

i. Energy density (ED) of PKL [85–94]:

It is defined as the energy (kWh) per liter:

$$\text{The energy density (ED)} = \frac{\text{power extraction (kWh)}}{\text{litre}} \tag{3}$$

Capacity of the PKL cell (AH) [95–104]:
How much current you will get for long time.
Generally, it is denoted by C.
$\therefore C = AH$
where A = current in ampere and H = Time in hour.

i. Energy efficiency of a PKL cell (η_c) [105–114]:

It is defined by the following equation:

$$\eta_C = \frac{P_{out}}{P_{in}} = \frac{V_{out}It}{V_{in}It} = \frac{V_D I_D t_D}{V_C I_C t_C} \tag{4}$$

where η_C = energy efficiency, V_D = discharging voltage; I_D = discharging current, t_D = discharging time, V_C = charging voltage, I_c = charging current, t_c = charging time.

i. Maximum power P_{max} [115–119]:

It is defined by the following equation:

$$P_{\max} = V_{OC} I_{SC} \tag{5}$$

where P_{max} = maximum power, V_{OC} = open circuit voltage, I_{SC} = short circuit current.

i. Load power P_L:

It is defined by the following equation [120–123]:

$$P_L = V_L I_L \tag{6}$$

where P_L = load power, V_L = load voltage, I_L = load current.

i. Fill factor:

It is defined as FF = $(V_m I_m)/(V_{oc} I_{sc})$, where V_m = useful voltage, I_m = useful current, V_{oc} = open circuit voltage, and I_{sc} = short circuit current [20, 34–38, 66–89, 124, 125].

ii. **Standard** PKL **cell condition:** The standard state condition of a solar cell is: The standard open circuit voltage of the solar cell is 0.5 V. The short circuit current of a solar cell = 0.5 A. The standard temperature of a extract of the

PKL cell = 25°C. The standard pressure = 1 atm pressure = 760 mm Hg pressure [90–114].

2.2 Vernacular name of the PKL

i. Stone chips

ii. Air plant

iii. Miracle leaf

iv. Mother of thousands

v. Mother of millions

vi. Leaf of life

vii. Devil's back bone

viii. Pregrant leaf

ix. Monekey's ear

x. Moneky ears

xi. Sotri

xii. Sotre, etc. [61–64]

2.3 Land situation in Bangladesh for cultivation of PKL

Total land = 55,000 sq. miles [24, 65–73]

$$1\,\text{square mile} = 640\,\text{acres}$$
$$= 3,500,000\,\text{acres}/2.5 = 14,080,000\,\text{hectors}$$

Total land (TL) in hector
Therefore, the nonagricultural land (NAL)
= 5,580,000 hectors.
The 2% of NAL

$$= 111600 \quad \textit{hectors} \times 7.5 = 837000\ \textit{Bigha}\ [1\,\textit{hector} = 7.5\,\textit{bigha}]$$

From 1 Bigha PKL, we can get 100 kW electricity.

From 837,000 Bigha PKL, we can get 83,700,000 kW electricity = 83,700 MW.

The AL (agricultural land) is needed to cultivated foods and crops [81–89]. The NAL is needed for housing, roads and other multipurpose use. So that the NAL of coastal areas, hilly areas and both sides of the road can be used for cultivation of PKL to generate electricity in Bangladesh, which would be approximately 2% of NAL [90–94].

2.4 Cultivation of PKL in Bangladesh

The cultivation of PKL is so much easy [126, 127]. This plants grow whether its leaf is kept on the ground and hence can be cultivated in a vested land, roof top of the house, courtyard and tubs what so ever [115–123]. Its leaves can be used for producing electricity within a month after cultivation of the plants [65–75, 124, 125, 128, 129].

2.4.1 E significance/rationale

The significance of the work is given by the following:

i. It is renewable energy sources

ii. It is biomass energy

iii. It is environment friendly

iv. It is echo friendly

v. It is cost effective

vi. It can be cultivated by anybody

vii. Even a handicapped person can cultivate this energy

viii. Unused land can be used for this purposes

ix. The two sides of the road across the country can be used to cultivate electricity

x. The PKL tree grows everywhere even in the sand

xi. The people of the remote areas can be used this power

xii. This technology is developed locally

xiii. This technology is innovated in Bangladesh

xiv. It can compare with solar PV electricity

xv. It will not need any extra battery during night time

xvi. It will work same during day and night time

It will also work same during rainy season whereas solar PV works less during rainy season.

3. Results and discussion

3.1 Selection of electrode pair as an energy source for living PKL electricity cultivation

It is shown in **Table 1**, the collected voltage has been tabulated using different electrodes of Cu/Zn, Cu/Fe, Al/Zn and Cu/Al.

Date	Local time	Time duration (h)	Voltage (Cu/Zn) in volt	Voltage (Cu/Fe) in volt	Voltage (Al/Zn) in volt	Voltage (Cu/Al) in volt	Comments
05/10/18	08 AM	00	0.95	0.61	0.42	0.5	Single pair
Do	09 AM	1	0.95	0.61	0.41	0.50	Do
Do	10 AM	2	0.95	0.60	0.40	0.51	Do
Do	11 AM	3	0.95	0.60	0.39	0.50	Do
Do	12 PM	4	0.95	0.61	0.40	0.49	Do
Do	13 PM	5	0.95	0.60	0.39	0.48	Do
Do	14 PM	6	0.95	0.61	0.38	0.48	Do
Do	15 PM	7	0.95	0.61	0.38	0.48	Do
Do	16 PM	8	0.95	0.60	0.37	0.48	Do
Do	17 PM	9	0.95	0.61	0.36	0.48	

Table 1.
Data for voltage harvesting for single pairs of electrodes.

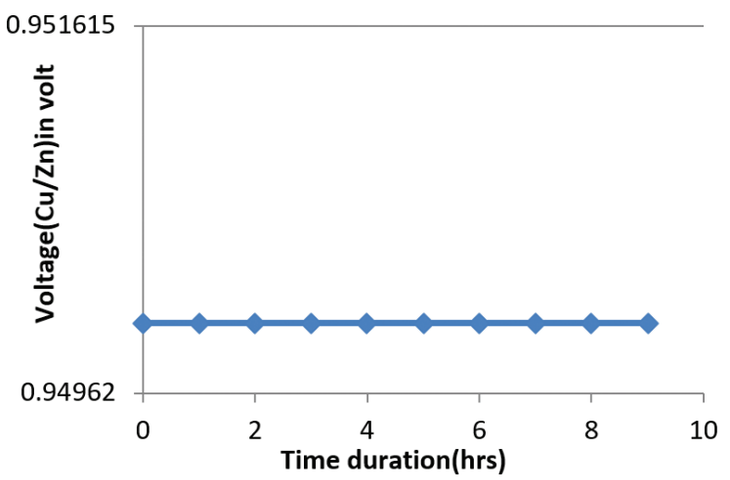

Figure 3.
Voltage-time duration profile for Cu/Zn single electrodes.

It is shown from **Figure 3**, the highest open circuit voltage (V_{oc}) for Cu/Zn single electrodes is 0.95 V and the lowest open circuit voltage (V_{oc}) is also 0.95 V. So that the difference between the highest and lowest open circuit voltage (V_{oc}) is zero volt.

It is shown from **Figure 4**, the highest open circuit voltage (V_{oc}) for Cu/Fe single electrode is 0.61 V and the lowest open circuit voltage (V_{oc}) is also 0.60 V. So that the difference between the highest and lowest open circuit voltage (V_{oc}) is 0.01 V.

It is shown from **Figure 5**, the highest open circuit voltage (Voc) for Al/Zn single electrodes is 0.42 V and the lowest open circuit voltage (V_{oc}) is also 0.36 V. So that the difference between the highest and lowest open circuit voltage (V_{oc}) is 0.06 V.

It is shown from **Figure 6**, the highest open circuit voltage (V_{oc}) for Cu/Al single electrodes is 0.51 V and the lowest open circuit voltage (V_{oc}) is also 0.48 V. So that the difference between the highest and lowest open circuit voltage (V_{oc}) is 0.03 V.

Finally, it is concluded that, **Figures 3–6** shows the variation of Voltage with the variation of time duration profile for Cu/Zn single electrodes. It is shown that the Cu/Zn single pair electrode produces the highest open circuit voltage around 0.95 V. It is also shown that it is almost constant for 9 h. Whereas the Cu/Fe, Al/Zn and

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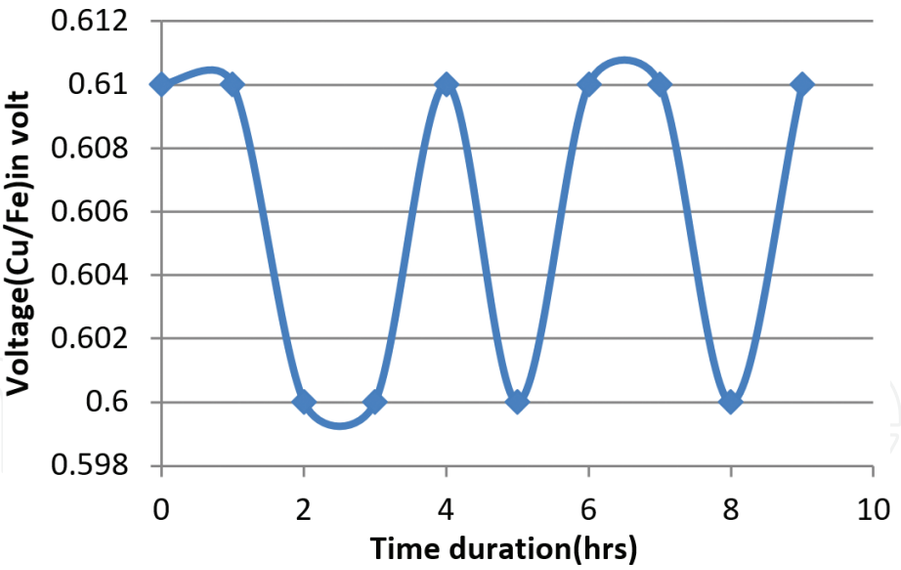

Figure 4.
Voltage-time duration profile for Cu/Fe single pair electrodes.

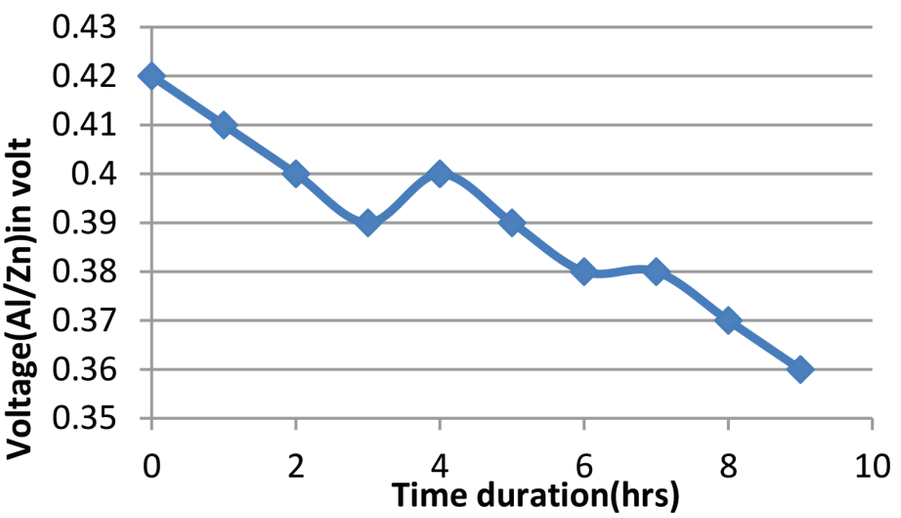

Figure 5.
Voltage-time duration profile for Al/Zn single pair electrodes.

Cu/Al producing highest open circuit voltages are 0.61, 0.42, and 0.5 V, respectively, the lowest open circuit voltages are around 0.60, 0.36, and 0.48 V, respectively. Finally, it is found and suggested that the Cu/Zn single pair electrode produces the highest open circuit voltage (V_{oc}) around 0.95 V and the Al/Zn single pair electrode-produces the lowest open circuit voltage (V_{oc}) around 0.42 V. It is also found that for Cu/Zn, Cu/Fe, Al/Zn and Cu/Al single pair electrodes, the cultivated voltage was stable up to 9 h during day time. The lowest open circuit voltage (V_{oc}) difference for Cu/Zn single pair electrodes is zero (0) V and the highest lowest open circuit voltage (V_{oc}) difference for Al/Zn single pair electrodes is 0.06 V.

It is shown in **Table 2**, the harvested voltage has been tabulated using different two pair electrodes of Cu/Zn, Cu/Fe, Al/Zn and Cu/Al with series combination.

It is shown from **Figure 7**, the highest open circuit voltage (V_{oc}) for Cu/Zn double electrodes is 1.85 V and the lowest open circuit voltage (V_{oc}) is also 1.78 V. So that the difference between the highest and lowest open circuit voltage (V_{oc}) is 0.07 V. Whereas it was zero (0) for Cu/Zn single pair electrodes. The reason behind it is that due to the connection of the electrodes by the wires, because it grows resistance for long wires due to the connections.

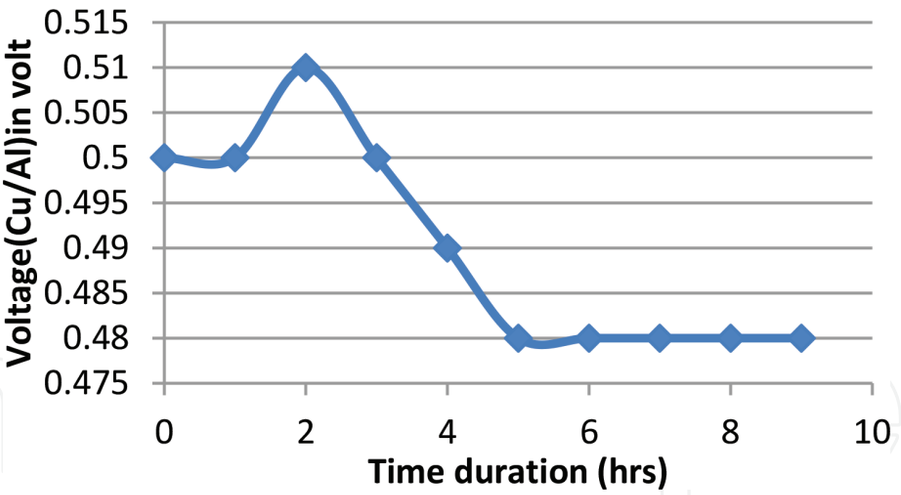

Figure 6
Voltage-time duration profile for Cu/Al single pair electrodes.

Date	Local time	Time duration (h)	Voltage (Cu/Zn) in volt	Voltage (Cu/Fe) in volt	Voltage (Al/Zn) in volt	Voltage (Cu/Al) in volt	Comments
05/10/18	08 AM	00	1.85	1.19	0.80	1.0	Two pairs
Do	09AM	1	1.84	1.20	0.81	1.0	Do
Do	10 AM	2	1.82	1.18	0.80	1.0	Do
Do	11AM	3	1.83	1.18	0.79	1.0	Do
Do	12PM	4	1.82	1.17	0.80	0.98	Do
Do	13PM	5	1.80	1.17	0.79	0.95	Do
Do	14 PM	6	1.80	1.16	0.78	0.94	Do
Do	15 PM	7	1.80	1.17	0.78	0.94	Do
Do	16 PM	8	1.80	1.17	0.77	0.94	Do
Do	17 PM	9	1.78	1.16	0.76	0.93	

Table 2.
Data for voltage harvesting for double pairs of electrodes (connected in series with each other).

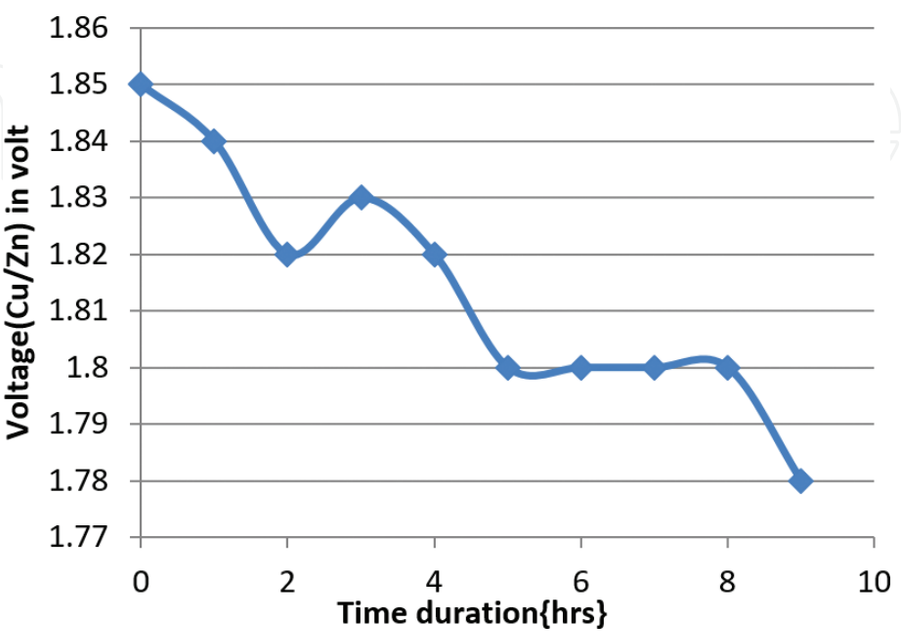

Figure 7
Voltage-time duration profile for Cu/Zn double pair electrodes.

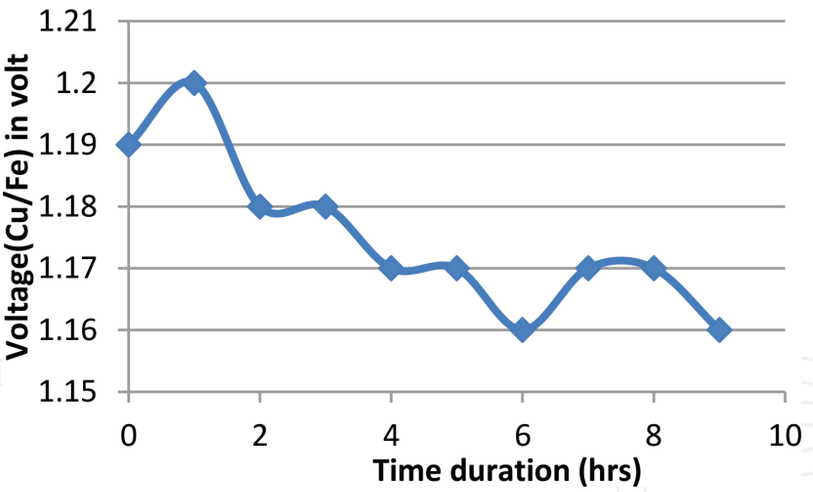

Figure 8
Voltage-time duration profile for Cu/Fe double pair electrodes.

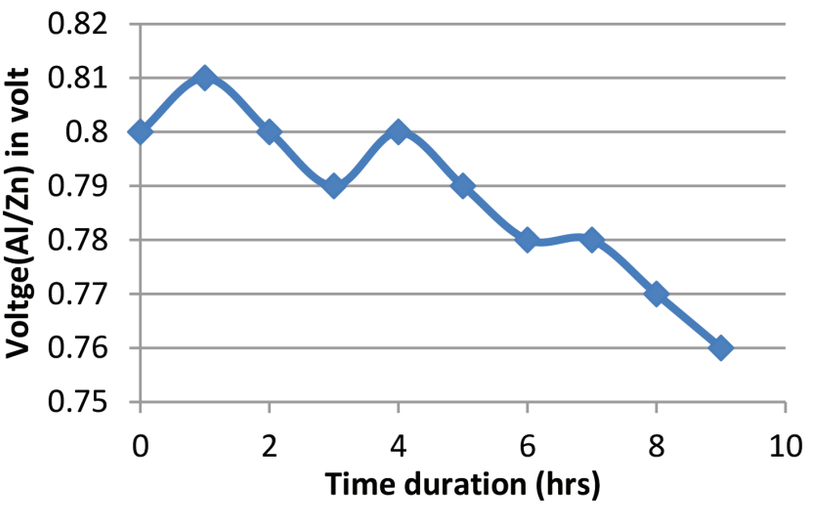

Figure 9.
Voltage-time duration profile for Al/Zn double pair electrodes.

It is shown from **Figure 8**, the highest open circuit voltage (V_{oc}) for Cu/Fe double electrodes is 1.20 V and the lowest open circuit voltage (V_{oc}) is also 1.16 V. So that the difference between the highest and lowest open circuit voltage (Voc) is 0.04 V. Whereas it was 0.01 V for Cu/Fe single pair electrodes. The reason behind it is that due to the connection of the electrodes by the wires, because it grows resistance for long wires due to the connections.

It is shown from **Figure 9**, the highest open circuit voltage (V_{oc}) for Al/Zn double electrodes is 0.81 V and the lowest open circuit voltage (V_{oc}) is also 0.76 V. So that the difference between the highest and lowest open circuit voltage (V_{oc}) is 0.05 V. Whereas it was 0.04 V for Al/Zn single pair electrodes. The reason behind it is that due to the connection of the electrodes by the wires, because it grows resistance for long wires due to the connections.

It is shown from **Figure 10**, the highest open circuit voltage (V_{oc}) for Cu/Al double electrodes is 1.0 V and the lowest open circuit voltage (V_{oc}) is also 0.93 V. So that the difference between the highest and lowest open circuit voltage (Voc) is 0.07 V. Whereas it was 0.03 V for Cu/Al single pair electrodes. The reason behind it is that due to the connection of the electrodes by the wires, because it grows resistance for long wires due to the connections. From the above results it is shown that the difference between the highest and lowest voltage output increases for

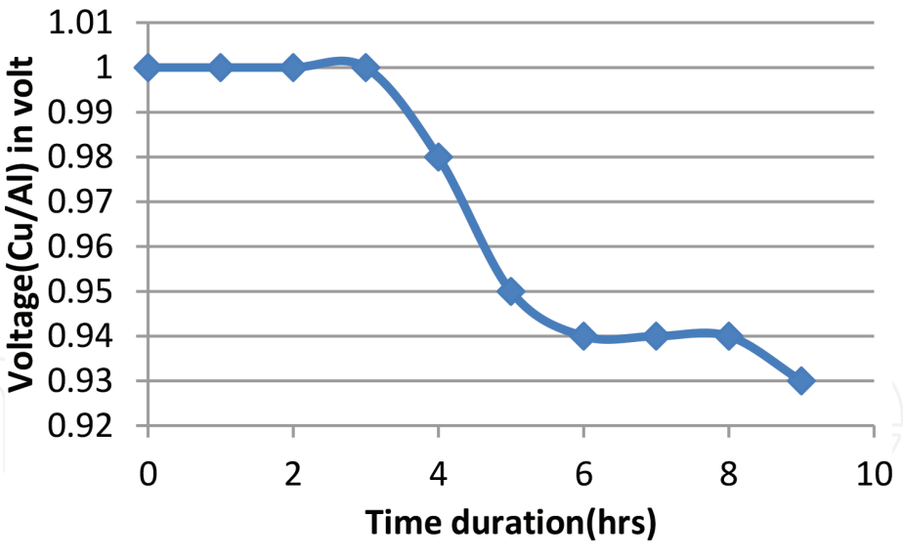

Figure 10.
Voltage-time duration profile for Cu/Al double pair electrodes.

Date	Local time	Time duration (h)	Voltage (Cu/Zn) in volt	Voltage (Cu/Fe) in volt	Voltage (Al/Zn) in volt	Voltage (Cu/Al) in volt	Comments
05/10/18	08 AM	00	2.70	1.77	1.20	0.99	Three pairs
Do	09 AM	1	2.71	1.77	1.20	0.98	Do
Do	10 AM	2	2.70	1.76	1.19	0.98	Do
Do	11 AM	3	2.69	1.76	1.19	0.98	Do
Do	12 PM	4	2.68	1.76	1.19	0.98	Do
Do	13 PM	5	2.68	1.75	1.19	0.97	Do
Do	14 PM	6	2.68	1.75	1.18	0.97	Do
Do	15 PM	7	2.68	1.75	1.18	0.97	Do
Do	16 PM	8	2.68	1.75	1.18	0.97	Do
Do	17 PM	9	2.68	1.75	1.18	0.97	

Table 3.
Data for voltage harvesting for double pairs of electrodes (connected in series with each other).

Cu/Zn, Cu/Fe, Al/Zn and Cu/Al double pair electrodes than the Cu/Zn, Cu/Fe, Al/Zn and Cu/Al single pair electrodes.

It is shown in **Table 3**, the harvested voltage has been tabulated using different three pair electrodes of Cu/Zn, Cu/Fe, Al/Zn and Cu/Al with series combination.

It is shown from **Figure 11**, the highest open circuit voltage (V_{oc}) for Cu/Zn 3-electrodes is 2.70 V and the lowest open circuit voltage (V_{oc}) is also 2.68 V. So that the difference between the highest and lowest open circuit voltage (V_{oc}) is 0.02 V. Whereas it was zero (0) for Cu/Zn single pair electrodes and 0.07 V for double electrodes respectively. The same reason behind it is that due to the connection of the electrodes by the wires, because it grows resistance for long wires due to the connections.

It is shown from **Figure 12**, the highest open circuit voltage (V_{oc}) for Cu/Fe three electrodes pair is 1.77 V and the lowest open circuit voltage (V_{oc}) is also 1.75 V. So that the difference between the highest and lowest open circuit voltage (V_{oc}) is

0.02 V. Whereas it was zero (0) for Cu/Fe single pair electrodes, 0.04 V for double electrodes respectively. The same reason behind it is that due to the connection of the electrodes by the wires, because it grows resistance for long wires due to the connections.

It is shown from **Figure 13**, the highest open circuit voltage (V_{oc}) for Al/Zn 3-electrodes pair is volt and the lowest open circuit voltage (V_{oc}) is also 1.65 V. So that the difference between the highest and lowest open circuit voltage (Voc) is 0.02 V. Whereas it was zero(0) for Cu/Fe single pair electrodes and 0.04 V for double electrodes respectively. The same reason behind it is that due to the connection of the electrodes by the wires, because it grows resistance for long wires due to the connections.

It is shown from **Figure 14**, the highest open circuit voltage (V_{oc}) for Cu/Al three electrodes pair is volt and the lowest open circuit voltage (V_{oc}) is also 1.65 V.

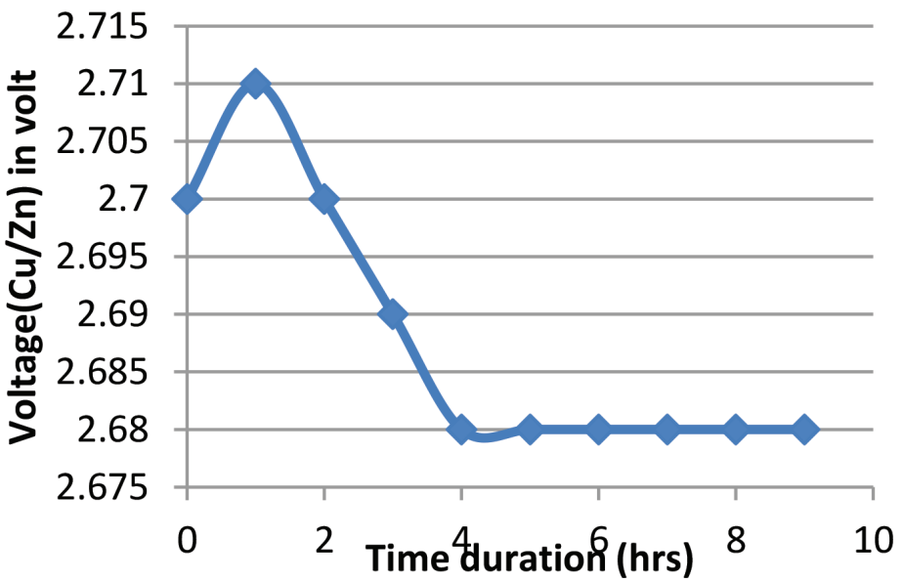

Figure 11.
Voltage-time duration profile for Cu/Zn three pair electrodes.

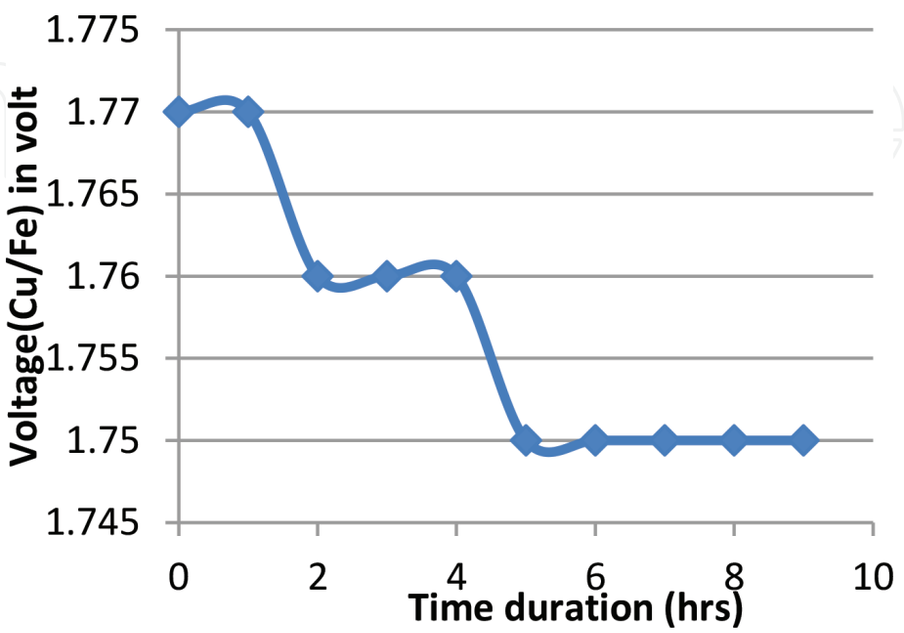

Figure 12.
Voltage-time duration profile for Cu/Fe three pair electrodes.

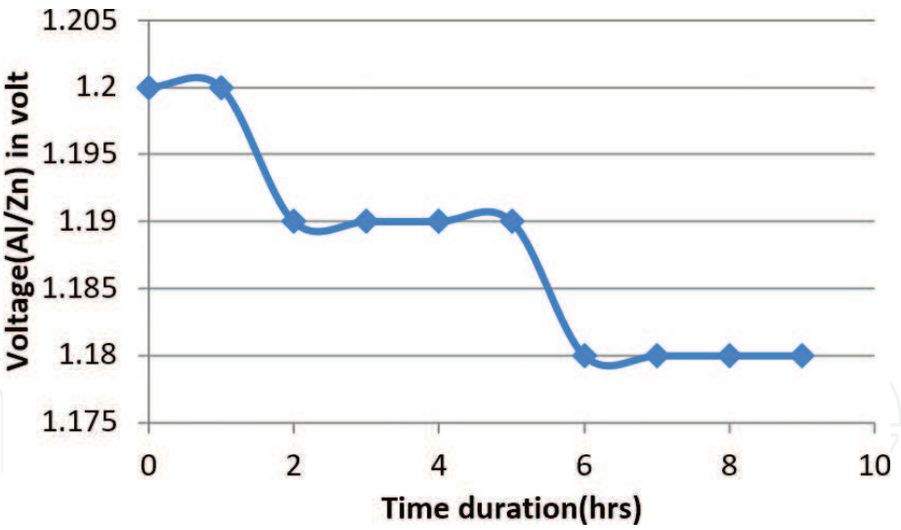

Figure 13.
Voltage-time duration profile for Al/Zn three pair electrodes.

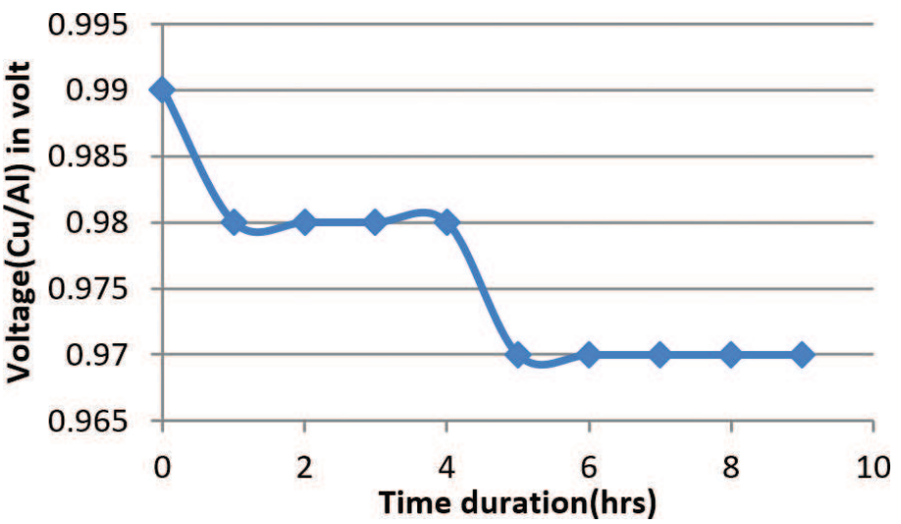

Figure 14.
Voltage-time duration profile for Cu/Al three pair electrodes.

So that the difference between the highest and lowest open circuit voltage (V_{oc}) is 0.02 V. Whereas it was zero (0) for Cu/Al single pair electrodes, 0.04 V for double electrodes and 0.02 V, respectively. The same reason behind it is that due to the connection of the electrodes by the wires, because it grows resistance for long wires due to the connections.

It is shown in **Table 4**, the voltage difference for Cu/Zn, Cu/Fe, Al/Zn and Cu/Al single, double and triple electrodes in volt.

3.2 Electrochemical cell made by two living PKL trees

3.2.1 Description of the electrodes

1. Description of the cathode

The length of the copper electrode is: 3 cm

The breadth of the copper electrode is: 1 cm

Number of pairs	Voltage difference for Cu/Zn in volt	Voltage difference for Cu/Fe in volt	Voltage difference for Al/Zn in volt	Voltage difference for Cu/Al in volt
1	0	0.01	0.60	0.02
2	0.07	0.03	0.05	0.07
3	0.03	0.02	0.02	0.03

Table 4.
Table for voltage difference for Cu/Zn, Cu/Fe, Al/Zn and Cu/Al in volt.

The area of the copper electrode is: (3 cm) (1 cm) = 3 cm^2

2. Description of the anode

The length of the zinc electrode is: 3 cm

The breadth of the zinc electrode is: 1 cm

The area of the zinc electrode is: (3 cm) (1 cm) = 3 cm^2

3.2.2 Description of the electrolytes

It was taken two living PKL plants (Tree-1 and Tree-2) for making an electrochemical cell. One leaf was selected from each tree. Each leaf was embedded by two electrodes. The voltage was collected from each leaf separately by a sophisticated multi meter. Then it was connected two living PKL plants in series connection. Then after the voltage was also collected for series connection.

4. Results and discussion

It is shown in **Figure 15** the variation of open circuit voltage with the variation of time duration(hr) for a single leaf in tree-1. Similarly, **Figure 16** the variation of open circuit voltage with the variation of time duration(hr) for a single leaf in tree-2. Finally, it is shown in **Figure 17** the variation of open circuit voltage with the variation of time duration (h) for both a single leaf in tree-1and tree-2. Comparing

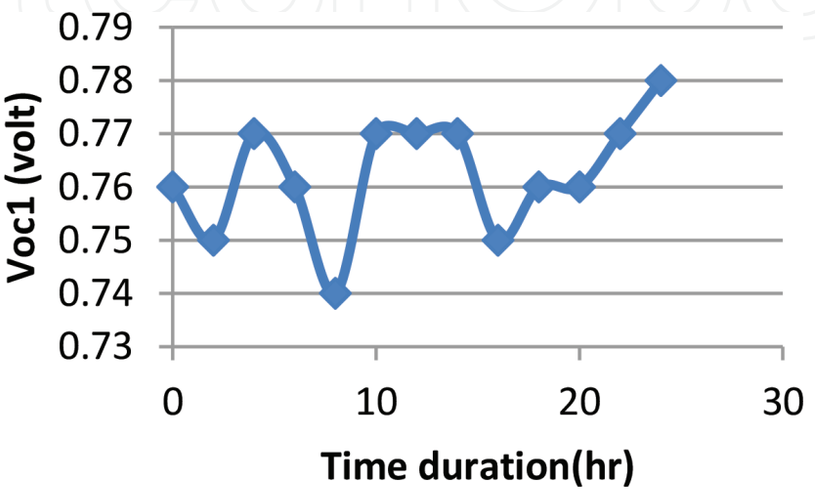

Figure 15.
Voc1-time duration curve for tree-1.

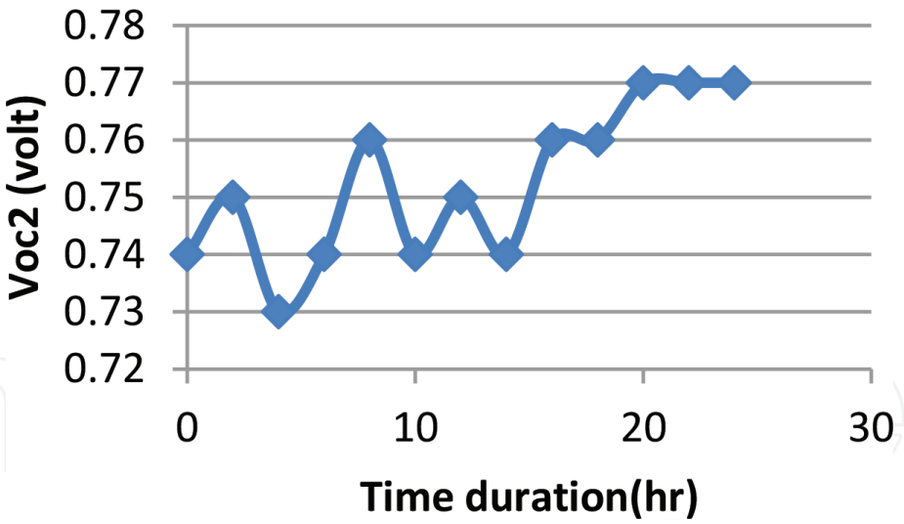

Figure 16.
Voc2-time duration curve for tree-2.

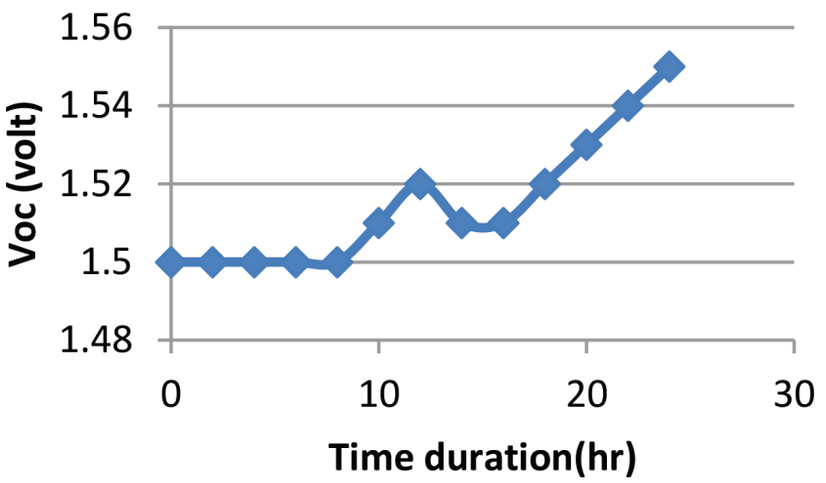

Figure 17.
Voc-time duration for both tree-1 and tree-2 in series connection.

above three figures, it can be concluded that living PKL tree can generate an electrochemical cell, since it follows the law of the series combination of voltaic cell.

5. Conclusion

The multi meters which were used are not calibrated properly. So that may be some errors during collection of the readings. In spite of that the authors tried to take readings very carefully. At present it is needed renewable, sustainable, pollution free and an efficient energy sources all over the world. To keep it in mind, it has been introduced some fundamental investigations are presented for producing electricity from living PKL plants. The power is produced by embedding the different electrodes like (silver and zinc, copper and zinc, etc.) and cells into the PKL living plant's leaf to allow flow of ions using redox reaction. Different experiments have been conducted using different types of the electrodes to determine the characteristics of the producing device. The research activities in this field are in infancy, in spite of that it was possible to get voltage difference around 1.10 V using single pair of electrodes and cell. Such hypothesis has been tested at different times

of the different month of the year. A comparative research works have also been done and used in combination to get better results for the development of such a green power. This green power may be the guide line to get low and medium power electrical and electronic appliances in near future.

Sustainable energy sources, which are pollution free and environmentally friendly, are one of the key challenges of world's future society. The interdisciplinary team of PKL energy foundation discovered that living plants are literally "green" power source, which may become one of future's electricity supplies that perfectly integrates in natural environments and is accessible all over the world. Researchers discovered that living plants can generate, by a single leaf, required Volts, enough to simultaneously power LED light bulbs. Researchers also showed that natural leaves can act as an innovative "green" electrical generator converting into electricity. Finally, the outcome of this research work is the reactant and product ions have been identified. The generated voltage can be considered with the Nernst equation. The generated voltage can be connected in series to run the load with LED bulb and DC fan. Using an inverter can be converted AC from DC for AC appliances.

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