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REVIEW ARTICLE

PERFORMANCE EVALUATION OF PKL (PATHOR KUCHI LEAF) ELECTRICITY FOR USE IN TELEVISION AND RADIO

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ABSTRACT

A new method of electricity generation based on Pathor Kuchi (Genus:*Kalanchoe*,Section:*Bryophyllum*) Leaf has been designed and developed at the Department of Physics, Jagannath University,Dhaka-1100,Bangladesh.For accurate sizing of Television and Radio PKL electric modules are necessary to optimize the module size for operation. It was realized that a vast majority of rural households in Bangladesh were left unelectrified by conventional gas based electricity. The field performance studies of the technical aspects, the projected specific capital cost and the average daily generation and efficiency of the PKL module have been found for both Radio and TV from collected data. Attempts have been made to correlate certain measurable parameters with anticipated performance of the PKL system. Chemical, physical and mechanical properties of the PKL, Short Circuit Current (I_{SC}), Open Circuit Voltage (V_{OC}),Temperature effect of the PKL malt, p^H of the PKL malt, Titratable acidity of the PKL malt, Generation of PKL electricity, Storage system of the PKL electricity, Practical utilization of PKL electricity use in Load(Television and Radio), Classification of PKL, Longevity of the PKL malt for PKL electricity generation, Preparation of PKL electric unit cell, module, panel, arrays and the constituent elements of the PKL have been studied. In experimental study, it is shown that ,the p^H of the PKL malt is ≈ 4.6 (without water), p^H of the PKL malt is ≈ 4.8(with 10% solution), the titratable acidity of the PKL malt is ≈ 0.88% and the constituent elements/ ions of the PKL malt is Fe^{++} and Cl^-. Most of the results have been tabulated and graphically discussed.

KEYWORDS

PKL, Television, Radio, pH, Chemical reaction, Performance evaluation.

1. INTRODUCTION

Electricity has a great impaction development of a society. In Bangladesh a lot of people cannot use electricity from national grid (Akter et al., 2017). Energy consumption per capita is extremely low compared to neibouring countries. In Bangladesh average demand of electricity is 5,800MW, but average generation is 3,900MW (Guha et al., 2018). Low consumption of electricity is affecting the entire development of the country. The total power generation in Bangladesh mostly depends on fossil fuels. Though use of fossil fuels enhances green house emission but for electricity generation natural gas is the major energy source (90%) and Bangladesh will not be able to arrange electricity from fusion reactors in near future (Hassan and Khan,2018). So it is required to search alternative sources of electric power. PKL electric power is one of the most important alternative sources of electric power.

In the past few years, whenever man had become obvious that fossil fuel resources are fast depleting and that the fossil fuel era is gradually coming to an end, just then he started the work of finding out the substitute energy of non-renewable energy (Hamid, 2013). The scientists have known by research that renewable energy is the only substitute energy of non-renewable energy. And the solar energy is easier able to get easy able to use and more effective energy. Man has needed and used energy at an increasing rate for his sustenance and well-being ever since he came on the earth a few million years ago. Primitive man required energy primarily in the form of food. He derived this by eating plants or animals which he

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hunted (Hamid et al., 2016). Subsequently he discovered fire and his energy needs increased as he started to make use of wood and other biomass to supply the energy needs for cooking as well as for keeping himself warm. With the passage of time, man started to cultivate land for agriculture. He added a new dimension to the use of energy by domesticating and training animals to work for him.

With further demand for energy, man began to use the wind for sailing ships and for driving windmills, and the force of falling water to turn water wheels (Hassan and Khan, 2016). Till this time, it would not be wrong to say that the sun was supplying all the energy needs of man either directly or indirectly and that man was using only renewable sources of energy. A new source of energy-nuclear energy-came on the scene after the Second World War. The first large nuclear power station was commissioned about 40 years ago, and already, nuclear energy is providing a small but significant amount of the energy requirements of many countries (Hassan and Khan. 2018; Hassan et al., 2016). At present solar energy is being used widely in the advanced countries of the world, though its demand is little in the developing countries of the world like Bangladesh (Hassan et al., 2016; Hassan et al., 2017). Yet it has no confusion to say that one day the whole world have to depend on solar energy. Because the others renewable energy have more limitation than the solar energy (Hassan et al., 2017; Khan et al.,2018).

2. METHODOLOGY

2.1 Working Principle

(a) An experimental set up of the PKL module

(b) An experimental set up of the two PKL Panel

Figure 1: Experimental set up of a PKL module and panel

Figure 1 (a) shows a single PKL module made by Zn/Cu based electrodes. There are 6 compartments in the PKL module which are connected in series combinations. But the Zn and Cu plates are in parallel combinations in each compartment. The plates are connected by copper wires. Fig.1(b) shows a PKL panel. It is fabricated by two PKL modules which are connected in series combinations. The box of each PKL modules are made by insulated plastic box. The PKL modules are connected by series combinations.

(a) PKL tree

(b) Extract from PKL

Figure 2: Shows a PKL tree for making extract

Fig.2 shows a PKL tree for making extract which has been used as a PKL electrolyte. Fig.2(a) shows the home made cultivation of PKL tree in top. Fig.2 (b) shows the extract with two electrodes Zn and Cu immersed partially into the extract of a plastic pot.

Figure 3: An experimental set up PKL electric module with TV

Figure 4: An experimental set up PKL electric module with Radio

Figure 3 shows an application of PKL electricity with TV. It also shows the measurement techniques of current and voltages by multimeter.Fig.4 shows an application of PKL electricity with radio. It is also shown from Fig. 4 that the PKL module can be small in size. It should be remembering that PKL electricity is DC (Direct Current). By using an inverter, it can be converted in to AC (Alternating Current).

2.2 Chemical Reactions for PKL electricity

Before adding any kinds of Secondary Salt-

$Zn - 2e^- = Zn^{2+}$

$2H^+ + 2e^- = H_2$

……

$Zn + 2H^+ = Zn^{2+} + H_2$

After Adding Copper sulphate as a Secondary salt-

$Zn - 2e^- = Zn^{2+}$

$Cu^{2+} + 2e^- = Cu$

……

Adding: $Zn + Cu^{2+} = Zn^{2+} + Cu$, Reactant Ions = H+ and Cu++ , Product Ions = Zn++

Total chemical Reaction: $Zn + Cu^{+2} + 2H^+ = Zn^{+2} + Cu + H_2$

2.3 Nernst Equation Related to EMF of Electrochemical Cell

Ecell = E0cell–(RT/nF) lnQ, Where, Ecell = Cell voltage, E^0_{cell} = Cell voltage at standard state, R = Molar gas constant = 8.314 J/mole/K, T = absolute temperature of the electrolyte, F = Faraday constant = 96500 coulomb, n= No. of transferred electrons = 2 and Q = Quotient constant = [product ion] / [reacted ion] = [Zn++]/[Cu++][H+].The [Cu++] and [Zn++] were measured by AAS and the [H+] was measured by pH meter. The target of our research was [product ion]<[Reactant ion]. If it is possible to establish this condition [product ion]<[Reactant ion] during the electricity production, then the electricity production from PKL would be sustainable (Khan et al., 2019; Khan et al., 2018; Khan., 1999).

3. RESULTS AND DISCUSSION

For different two loads (Television and Radio), the data has been collected and tabulated from the Table -1 to Table -16 for different date of the month which has given below:

Date: 29.10.09

Table 1: Current voltage relationship with load (television)

Time duration (hr)	Open circuit voltage, V_{oc}(V)	Short-circuit current, I_{sc}(A)	Voltage,V_L (V)	Current, I_L (A)	Power, P_L (W)	Ambient Temp(°C)	JuiceTemp.(°C)
0	13.34	1.35	1.34	0.46	0.62	28	26
1			1.34	0.44	0.59	28	26
2			1.34	0.44	0.59	27	26
3			1.33	0.42	0.56	28	25
4			1.32	0.40	0.53	28	26
5			1.30	0.38	0.49	27	26
6			1.28	0.37	0.47	27	26
7			1.27	0.37	0.47	28	26
8			1.25	0.36	0.45	28	26
9			1.24	0.35	0.43	27	25
10			1.22	0.34	0.41	28	25
11			1.21	0.33	0.40	28	25
12			1.20	0.31	0.37	28	26
13			1.18	0.30	0.35	28	26
14			1.15	0.29	0.33	28	26
15			1.13	0.27	0.31	27	25
16			1.10	0.25	0.28	27	25
17			1.08	0.23	0.25	27	25

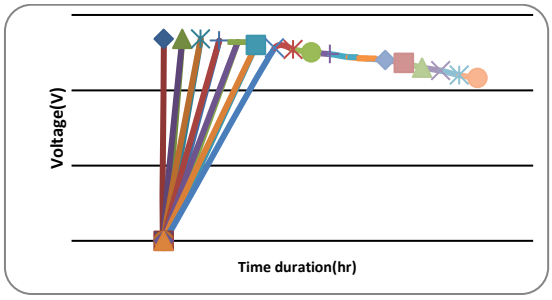

Figure 5: Voltage versus Time duration Curve

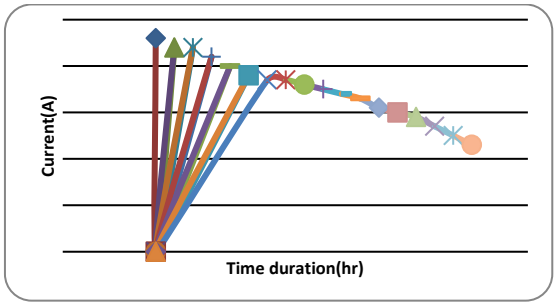

Figure 6: Current versus Time duration Curve

Figure 5 shows the variation load voltage with the variation of time duration for TV as a load. It is shown that the load voltage was almost constant for first 17 hours. The load voltage varies from 1.40 volt to 1.o8 volt. Figure 6 shows the variation load current with the variation of time duration for TV as a load. It is shown that the load current varies from 0.46 A to 0.36 A for first 17 hours.

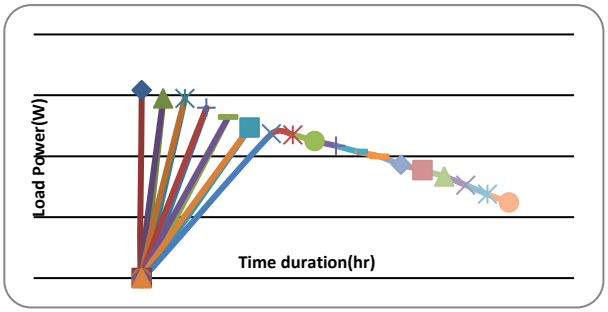

Figure 7: Load Power versus Time duration Curve

Figure 7 shows the variation load power with the variation of time duration for TV as a load. It is shown that the load power varies from .62W to 0.25 W for next 17 hours.

Date: 31.10.09

Table 2: Current voltage relationship with load (television)

Time duration(hr)	Open circuitvoltage V_{oc}(V)	Shortcircuit current I_{sc}(A)	Load Voltage V_L (V)	Load Current, I_L(A)	Load Power, P_L(W)	Ambient Tem.(°C)	JuiceTemp (°C)
0	12.25	1.25	1.25	0.35	0.44	28	25
1			1.16	0.34	0.39	28	25
2			1.09	0.34	0.37	27	25
3			1.05	0.32	0.34	28	25
4			1.02	0.30	0.31	28	25
5			0.94	0.29	0.27	27	25
6			0.94	0.28	0.26	27	24
7			0.92	0.27	0.25	28	24
8			0.90	0.25	0.23	28	25
9			0.88	0.24	0.211	27	25
10			0.86	0.22	0.19	28	25
11			0.84	0.21	0.18	28	25
12			0.81	0.19	0.15	28	25
13			0.79	0.16	0.13	28	25
14			0.77	0.14	0.11	28	24
15			0.75	0.12	0.09	27	25
16			0.73	0.10	0.07	27	25
17			0.70	0.10	0.07	27	25

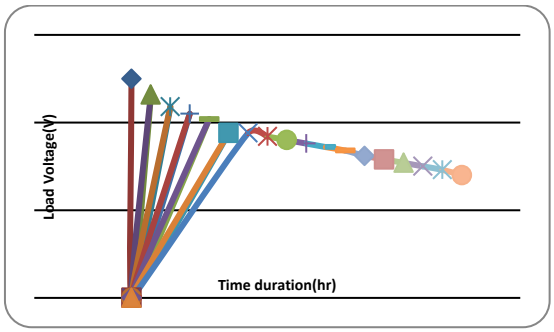

Figure 8: Voltage versus Time duration Curve

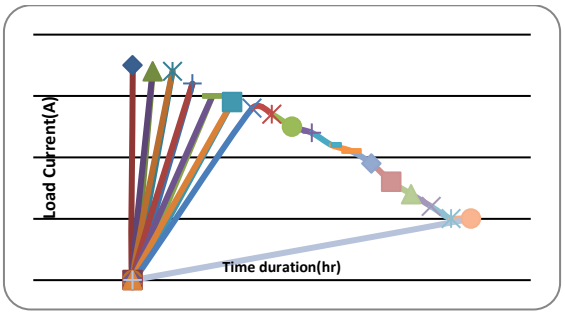

Figure 9: Current versus Time duration Curve

Figure 8 shows the variation load voltage with the variation of time duration for TV as a load. It is shown that the load voltage was almost constant for first 17 hours after 2 days of the 1st reading. The load voltage varies from 1.25 volt to 0.70 volt. Figure 9 shows the variation load current with the variation of time duration for TV as a load after 2 days of the 1st reading. It is shown that the load current varies from 0.35 A to 0.10 A for first 17 hours after 2 days of the 1st reading for the same set up.

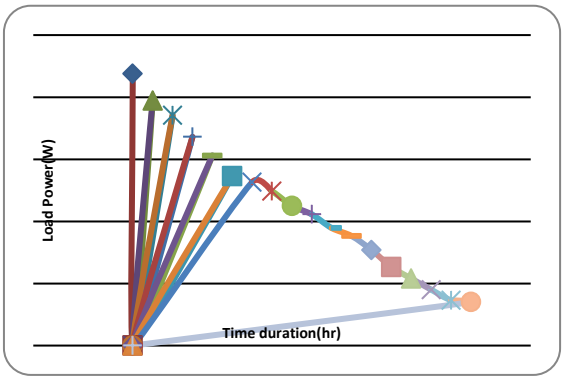

Figure 10: Load Power versus Time duration Curve

Figure 10 shows the variation of load power with the variation of time duration for TV as a load after 2 days of the 1st reading. It is shown that the load power varies from .44W to 0.07 W for next 17 hours after 2 days of the 1st reading for the same set up.

Date: 01.11.09

Table 3: Variation of voltage with the variation of time duration for without load	
Time duration (hr)	Voltage without load, V (V)
0	13.34
1	13.34
2	13.33
3	13.30
4	13.33
5	13.32
6	13.31
7	13.33
8	13.33
9	13.31

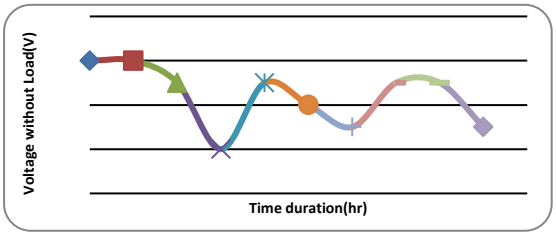

Figure 11: Voltage without load versus Time duration Curve

Figure 11 shows the Variation of open circuit voltage with the variation of time duration for without load after 2 days of the 1st reading. It is shown that the open circuit voltage varies from 13.34 V to 13.31 V for next 9 hours after 3 days of the 1st reading for the same PKL module.

Date: 01.11.09

Table 4: Variation of current with the variation of Local time for without load	
Time duration (hr)	Short circuit current, I (A)
0	1.35
1	1.34
2	1.34
3	1.35
4	1.32
5	1.31
6	1.34
7	1.33
8	1.33
9	1.32

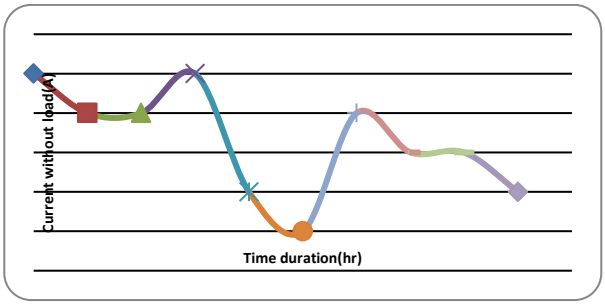

Figure 12: Current without load versus Time duration Curve

Figure 12 shows the Variation of short circuit current with the variation of time duration for without load after 2 days of the 1st reading. It is shown that the open circuit voltage varies from 1.35 A to 1.32 A for next 9 hours after 3 days of the 1st reading for the same PKL module.

Date: 02.11.09

Table 5: Variation of voltage with the variation of Local time with load (Television)	
Time duration (hr)	Voltage with load,V (V)
0	2.35
1	2.32
2	2.25
3	2.18
4	2.15
5	2.12
6	2.08
7	2.05
8	2.01
9	2.00

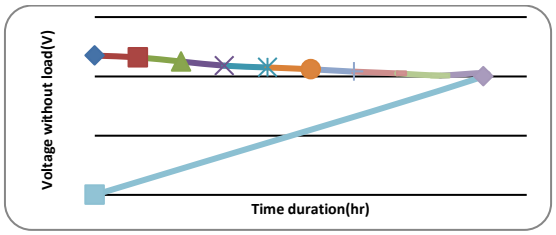

Figure 13: Voltage without load versus Time duration Curve

Figure 13 shows the Variation of load voltage with the variation of time duration for without load after 4 days of the 1st reading. It is shown that the open circuit voltage varies from 1.35 A to 1.32 A for next 9 hours after 4 days of the 1st reading for the same PKL module.

Date: 02.11.09

Table 6: Variation of load current with the variation of Local time with load (Television)

Time duration (hr)	Load Current, I_L (A)
0	0.58
1	0.57
2	0.56
3	0.56
4	0.55
5	0.54
6	0.52
7	0.51
8	0.51
9	0.50

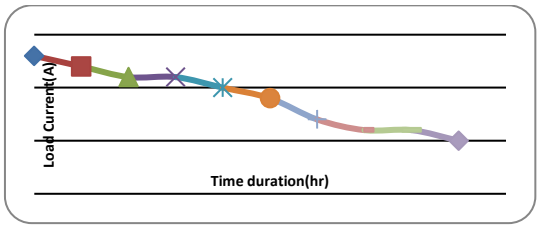

Figure 14: Load Current versus Time duration Curve

Figure 14 shows the Variation of load current with the variation of time duration for without load after 4 days of the 1st reading. It is shown that the open circuit voltage varies from 0.58 A to 0.50 A for next 9 hours after 4 days of the 1st reading for the same PKL module.

Date: (29.10.09-03.11.09)

Table 7: Variation of maximum voltage PKL module with the variation of different dates of the month for Television

Date of the month of the year	Maximum Voltage with load (TV) (V)
D_1 = 29.10.09	2.24
D_2 = 31.10.09	2.05
D_3 = 01.11.09	1.75
D_4 = 02.11.09	1.50
D5 = 03.11.09	1.05

Table 7 shows the Variation of maximum voltage PKL module with the variation of different dates of the month of a year for Television. It is seen that it varies from 2.24 volt to 1.05 volt for 5 days interval.

Date: (29.10.09-02.11.09)

Table 8: Variation of minimum voltage PKL module with the variation of different dates of the month for Television

Date	Minimum voltage with Load (V)
29.10.09	1.28
31.10.09	0.90
01.11.09	0.50
02.11.09	0.35
03.11.09	0.27

Table 8 shows the Variation of minimum voltage PKL module with the variation of different dates of the month of a year for Television. It is seen that it varies from 1.28 volt to 0.27 volt for 5 days interval.

Date: 04.11.09

Table 9: Current voltage relations with load (Radio)

Time duration (hr)	Open circuit voltage, V_{oc}(V)	Short-circuit current, I_{sc}(A)	Load Voltage,V_L(V)	LoadCurrent,I_L(A)	Load Power,P_L(W)	AmbientTemp(°C)	JuiceTemp(°C)
0	6.67	1.35	4.06	0.45	1.88	28	26
1			4.06	0.45	1.83	28	26
2			3.91	0.44	1.72	27	26
3			3.73	0.43	1.60	28	25
4			3.51	0.43	1.51	28	26
5			3.31	0.42	1.39	27	26
6			2.99	0.41	1.23	27	26
7			2.77	0.40	1.11	28	26
8			2.65	0.39	1.03	28	26
9			2.51	0.37	0.93	27	25
10			2.38	0.36	0.86	28	25
11			2.22	0.34	0.75	28	25
12			2.09	0.33	0.69	28	26
13			2.08	0.33	0.69	28	26
14			1.96	0.32	0.63	28	26
15			1.89	0.30	0.57	27	25
16			1.69	0.29	0.49	27	25
17			1.60	0.28	0.45	27	25

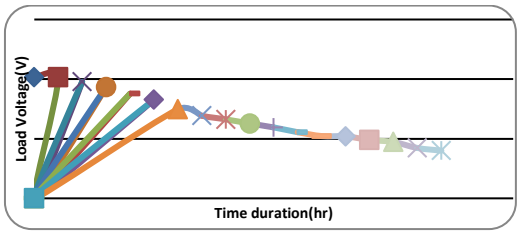

Figure 15: Voltage versus Time duration Curve

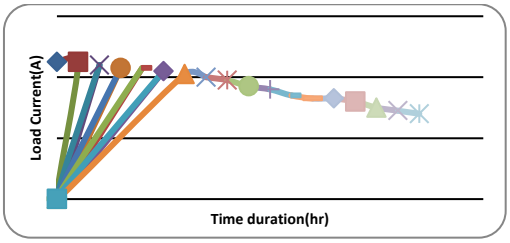

Figure 16: Load Current versus Time duration Curve

Figure 15 shows the variation load voltage with the variation of time duration for radio as a load. It is shown that the load voltage was almost constant for first 17 hours after 2 days of the 1st reading. The load voltage varies from 4.06 volt to 1.60 volt. It is mentioned that the PKL module for radio was small compared to the Television. Fig.16 shows the variation load current with the variation of time duration for radio as a load after 2 days of the 1st reading. It is shown that the load current varies from 0.45 A to 0.28 A for first 17 hours after 2 days of the 1st reading for the same module.

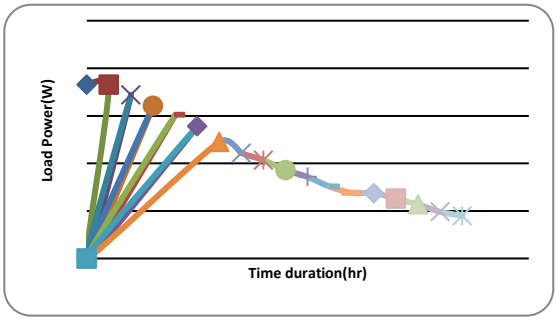

Figure 17: Load Power versus Time duration Curve

Figure 17 shows the Variation of load power with the variation of time duration for a radio after 4 days of the 1st reading. It is shown that the load power varies from 1.88 W to 0.45 W for next 17 hours after 2 days of the 1st reading for the same PKL module.

Date: 05.11.09

Table 10: Current voltage relationship with load (Radio)

Time duration (hr)	Opencircuit voltage V_{oc}(V)	Short circuit current I_{sc}(A)	Load Voltage,V_L(V)	Current,I_L(A)	Power, P_L(W)	Ambint Tem.(°C)	JuiceTem(°C)
0	6.04	1.15	3.65	0.32	1.17	28	26
1			3.61	0.32	1.16	28	26
2			3.55	0.31	1.10	27	26
3			3.50	0.30	1.05	28	25
4			3.42	0.29	0.99	28	26
5			3.35	0.27	0.90	27	26
6			3.26	0.26	0.85	27	26
7			3.15	0.26	0.82	28	26
8			3.09	0.25	0.77	28	26
9			3.02	0.24	0.72	27	25
10			2.95	0.23	0.6785	28	25
11			2.77	0.22	0.6094	28	25
12			2.57	0.22	0.57	28	26
13			2.42	0.21	0.51	28	26
14			2.31	0.20	0.46	28	26
15			2.15	0.19	0.41	27	25
16			1.90	0.17	0.32	27	25
17			1.77	0.15	0.27	27	25

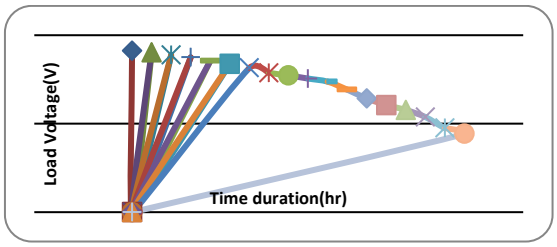

Figure 18: Voltage versus Time duration Curve

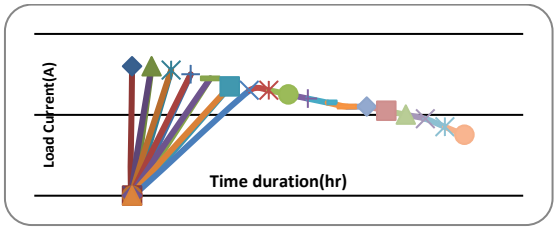

Figure 19: Load Current versus Time duration Curve

Figure 18 shows the variation load voltage with the variation of time duration for radio as a load. It is shown that the load voltage was almost constant for first 17 hours after 3 days of the 1st reading. The load voltage varies from 3.65 volt to 1.77 volt. It is mentioned that the PKL module for radio was small compared to the Television. Figure 19 shows the variation load current with the variation of time duration for radio as a load after 2 days of the 1st reading. It is shown that the load current varies from 0.32 A to 0.15 A for first 17 hours after 3 days of the 1st reading for the same module.

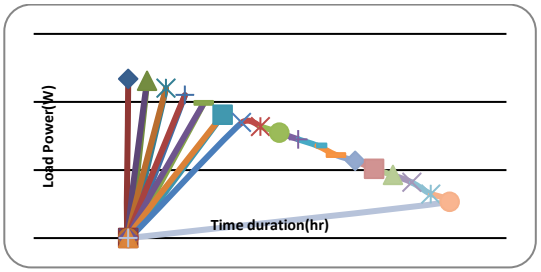

Figure 20: Load Power versus Time duration Curve

Figure 17 shows the Variation of load power with the variation of time duration for a radio after 4 days of the 1st reading. It is shown that the load power varies from 1.17 W to 0.27 W for next 17 hours after 3 days of the 1st reading for the same PKL module.

Date: 06.11.09

Table 11: Variation of voltage with the variation of Local time for without load

Time duration (hr)	Open circuit voltage, Voc(V)
0	6.65
1	6.63
2	6.63
3	6.62
4	6.61
5	6.61
6	6.60
7	6.61
8	6.60
9	6.60

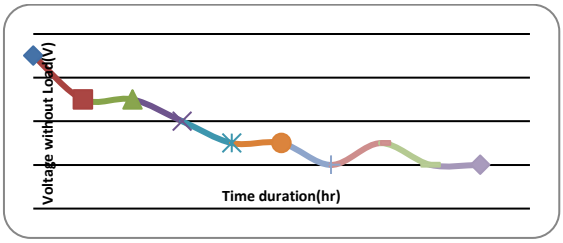

Figure 21: Voltage opencircuit Load versus Time duration Curve

Figure 21 shows the Variation of open circuit voltage with the variation of time duration for without load after 4 days of the 1st reading. It is shown that the open circuit voltage varies from 6.65 V to 6.60 V for next 9 hours after 4 days of the 1st reading for the same PKL module.It is shown that the difference of the open circuit voltage is 0.05 volt.

Date: 06.11.09

Table 12: Variation of current with the variation of Local time for without load

Time duration (hr)	Current without load, I (A)
0	1.35
1	1.34
2	1.34
3	1.35
4	1.32
5	1.31
6	1.34
7	1.33
8	1.33
9	1.32

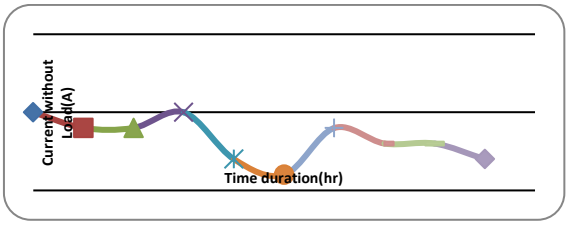

Figure 22: Current without Load versus Time duration Curve

Figure 22 shows the Variation of short circuit current with the variation of time duration for without load after 4 days of the 1st reading. It is shown that the open circuit voltage varies from 1.35A to 1.32 A for next 9 hours after 4 days of the 1st reading for the same PKL module. It is shown that the difference of the open circuit voltage is 0.03 A.

Date: 07.11.09

Table 13: Variation of voltage with the variation of Local time with load (Radio)

Time duration (hr)	Load Voltage, V_L (V)
0	4.30
1	4.15
2	4.07
3	4.02
4	3.89
5	3.75
6	3.68
7	3.62
8	3.55
9	3.50

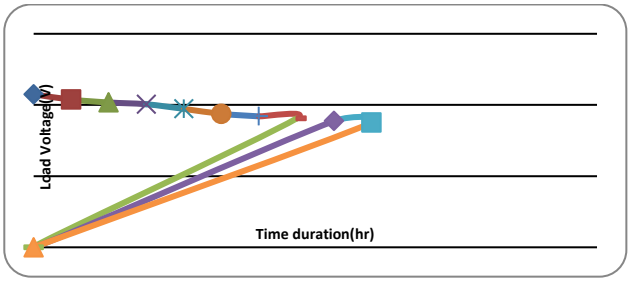

Figure 23: Load voltage versus Time duration Curve

Figure 23 shows the Variation of load voltage with the variation of time duration for without load after 6 days of the 1st reading. It is shown that the load voltage varies from 4.30V to 3.50 V for next 9 hours after 6 days of the 1st reading for the same PKL module. It is shown that the difference of the load voltage is 0.80V.

Date: 08.11.09

Table 14: Variation of current with the variation of Local time with load (Radio)

Time duration (hr)	Load Current, I_L(A)
0	0.74
1	0.73
2	0.72
3	0.70
4	0.68
5	0.65
6	0.62
7	0.60
8	0.58
9	0.55

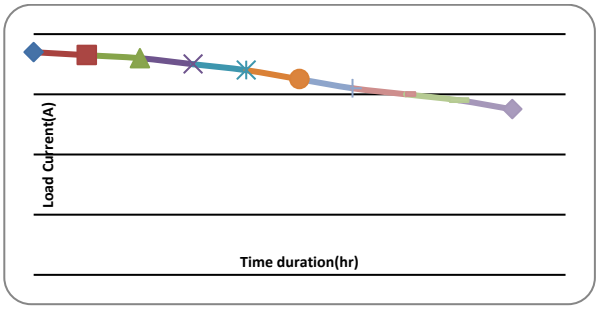

Figure 24: Load Current versus Time duration Curve

Figure 24 shows the Variation of load current with the variation of time duration for without load after 6 days of the 1st reading. It is shown that the load current varies from0.74A to 0.55A for next 9 hours after 6 days of the 1st reading for the same PKL module. It is shown that the difference of the load current is 0.19 A.

Table 15: Variation of maximum voltage PKL module with the variation of different dates of the month for Radio.	
Date of the month of the year	Maximum Voltage with load (Radio) (V)
D_1 = 04.11.09	4.40
D_2 = 05.11.09	4.26
D_3 = 07.11.09	4.00
D_4 = 08.11.09	3.89
D5 = 09.11.09	3.61

Table 15 shows the Variation of maximum voltage PKL module with the variation of different dates of the month for Radio. It is seen that it varies from 4.40 volt to 3.61 volt for 5 days interval.

Table 16: Variation of minimum voltage PKL module with the variation of different dates of the month for Radio.	
Date	**Minimum voltage with Load (V)**
04.11.09	3.65
05.10.09	3.55
07.11.09	3.50
08.11.09	3.40
09.11.09	3.35

Table 16 shows the Variation of minimum voltage PKL module with the variation of different dates of the month for Radio. It is seen that it varies from 3.65 volt to 3.35 volt for 5 days interval.

4. Conclusion

Electricity production by Pathor Kuchi Leaf (PKL) power plant is a successful technology which can avenue for income generation to the needy people of Bangladesh. A handicapped person can operate it to produce electricity. The cost of small size Pathor Kuchi Leaf power plant will be within the rich of the people. Anybody can set-up this power plant and can earn a lot of money. This Biomass technology can be exploited and commercialized all over the country. This technology is quite simple and successful for convenient electricity production. This technology is likely to generate the employment among the needy people of Bangladesh. Any company can take up this technology for its commercialization all over the country for the betterment of the economic conditions of the people.

Further Studies

1. NPs (CuO, ZnO and Fe_3O_4) production from PKL Leaf extract
2. Characterization: SEM, FESEM, TEM, VSM, TGA, AAS, XRD, FTIR, EDS, EDX etc
3. Electrochemical conversion of CO_2 into useful chemicals and PKL electricity
4. Determination of energy efficiency, Voltaic efficiency, Voltage regulation, Self discharge characterization, Pulse performance and Internal Resistance, coulombic efficiency, self discharge characteristics, Discharge characteristics with load after adding different NPs with the PKL extract.
5. Preparation of modified surface electrodes like paper electrodes.
6. Preparation of pencil batteries using PKL (Pathor Kuchi Leaf)

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