



# INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

## A Study on PKL Electricity – Bangladesh Context

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### ABSTRACT

Constructing an affordable cost, environment-friendly simplified electrical energy source with Patharkuchi Leaf (PKL) for power electrification will significantly upgrade the lifestyle of 1.6 billion people especially, those who live in rural areas of Bangladesh. However, one-fifth of the world's population still lacks access to electricity-well, mainly in Sub-Saharan Africa and South Asia (Bangladesh, India, Sri Lanka, Pakistan, Nepal, and Bhutan). This innovative technology will meet essential requirements such as lighting, telecommunication as well as information access. Electrodes are put into the *Bryophyllum Pinnatum* Leaf (BPL) or Patharkuchi Leaf (PKL) sap and they produce substantially sufficient amounts of electricity to power energy-consumed electronics and electrical appliances.  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  solution is used as a secondary salt. The role of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  solution has been studied. The electrical and chemical properties, a very important factor for PKL electricity generation devices have been studied in this research work. The electrical properties are internal resistance, voltage regulation, energy efficiency, pulse performance, self-discharge characteristics, discharge characteristics with load, the capacity of the PKL cell, temperature characteristics, and the life cycle of the PKL cell. The chemical properties are variation of voltage, and current with the variation of  $[\text{Zn}^{2+}]$ ,  $[\text{Cu}^{2+}]$ , and time. The performance of the production of the two bi-products (fertilizer and hydrogen gas production) has been studied. Variations of concentration of  $\text{Zn}^{2+}$  and  $\text{Cu}^{2+}$  with the variation of percentage of the secondary salt ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ), percentage of the water, and the percentage of PKL sap have been studied. The change in PKL power efficiency with time has also been studied. Most of the results have been tabulated and graphically discussed. This study showed that internal resistance is nearly 0.60 ohm, voltage regulation is close to 9%, pulse performance is very good and energy efficiency is about 65%. Internal resistance is very much higher than the acceptable range. It is not needed to charge the PKL cell using external energy sources. Voltage and current reduce exponentially and the concentration of copper decreases gradually with time for PKL cells which also reflects the higher lifetime of the cell. Current is linearly proportional to voltage. The voltaic efficiency of the PKL cell is significant for the generation of electricity. Voltage and current linearly decrease with decreasing the concentration of copper. After extraction of electricity, the bi-product contains sufficient amounts of zinc waste which can be used as zinc fertilizer.

**Keywords:** Pathorkuchi leaf, electricity, renewable energy, Bangladesh

### INTRODUCTION

Energy is the most important element in society. We cannot imagine civilization without electricity. Nowadays electricity is needed everywhere, even in the deep forest. It needs to go from space to the deep sea. The need for electricity is increasing day by day. As new technology is invented, new electricity demand is created. Now electricity is needed not only for lighting or to run the factory or industry but its use is everywhere. We are using electricity to run our computer, mobile telephone, various household appliances, toys, etc. Everywhere we need electricity. Therefore the present global trend is to increase the production of electricity. All over the world, the production of electricity depends on non-renewable sources, mainly oil, gas, and coal. These all are natural resources and not unlimited. The total reserve of

these resources is fixed. So it is a great concern what will happen after these resources are finished. A lot of research is going to find alternate solutions for the production of electricity. Now we are using solar energy, wind energy, tidal energy, biogas energy, hydropower, wave energy, etc. These all are alternative sources of energy and renewable energy. These sources will never run short. All over the world has emphasized these renewable resources for its improvement.

The generation of electricity from Patharkuchi Leaf (*Bryophyllum Pinnatum*) is an addition to the list of renewable energy. It was invented in Bangladesh and it has great advantages over other renewable resources. For example, in the case of solar energy it is not possible to produce electricity during the night, in the case of wind energy wind must be blown for the production of electricity, in the case of tidal energy, wave energy, and hydro energy we need specific requirements. But for the production of electricity from Patharkuchi Leaf we are free from these drawbacks. We can produce it anywhere, anytime, anyplace without any complexity. Not only that this technology is so easy to make it possible to make and use without any previous technical knowledge. Moreover, it provides electricity directly from the system which is very convenient, easy, and cheap.

Bangladesh is a developing country. For the proper development of the country, the supply of electricity is a must. But we have a great shortage of electricity. This shortage of electricity is creating a great barrier to our development. Most of the people in Bangladesh live in rural areas and the majority of them are poor. So, to reduce poverty in the majority part of the country it is important to provide energy to them. The rural people in Bangladesh are tied to poverty because they use very little energy and in an inefficient way. This is a great challenge for the government of Bangladesh to meet the future demand for electricity in rural areas. Production of electricity from Patharkuchi Leaf can be a means of providing electricity to the villagers. Pathor Kuchi tree grows everywhere in Bangladesh. It grows in the corner of our yard, in free land, even on the roadside. We can use the leaves of this tree to produce electricity. We can produce juice from the leaf and can preserve it for a long time without any special arrangement. So it is very much convenient to produce electricity using the juice of the leaf. We can even use this electricity to light up our boats on the river at night or charge our valuable mobile devices for communication.

### **OBJECTIVES OF THE STUDY**

The main objectives of the study are to

1. To study conventional and nonconventional electricity scenarios in the world as well as Bangladesh.
2. To study the electricity generation of Patharkuchi Leaf.
3. To study the performance of generated electricity from PKL.
4. To study the usability of electricity produced from Patharkuchi Leaf (PKL) in Bangladesh.

### **METHODOLOGY**

Different information was collected from both primary and secondary sources. Laboratory tests and questionnaire survey methods were followed to collect primary data. Both descriptive and exploratory approaches were adopted to conduct the study. After the collection of data, it will be processed and analyzed using proper methods.

The methodologies used are as below:

- i. Collecting data regarding renewable and nonrenewable energy sources from secondary sources.
- ii. Laboratory Study of the Electricity Generation from the Patharkuchi Leaf.
- iii. Collecting data regarding the performance parameters of cells and batteries from secondary sources.
- iv. Laboratory study of the Performance of PKL electricity.
- v. Comparing the laboratory data with the standard parameters.

### **Sources of Data Collection**

The required data for the study were collected from both primary and secondary sources. The primary and secondary sources are as below:

**Primary sources:** Primary data was collected through laboratory study, questionnaire survey, field visits, and observation in the field.

**Secondary sources:** Secondary data was collected from various websites, journals, reports, organizational data, etc.

## PRODUCING ELECTRICITY FROM PKL

The generation of electricity from Patharkuchi Leaf is quite simple. It is even possible to produce electricity from PKL for a layman. Since the produce voltage and current as well as the power is low there is almost no danger for humans as the electricity has.

To get the electricity from Patharkuchi Leaf we have to undergo some very simple process. These processes are as below:

1. Collecting and making Juice of PKL
2. Collecting Zinc and Copper Plates as electrodes and the appropriate container
3. Placement the Zinc and Copper plates in the container
4. Connecting the Zinc and Copper plates properly.

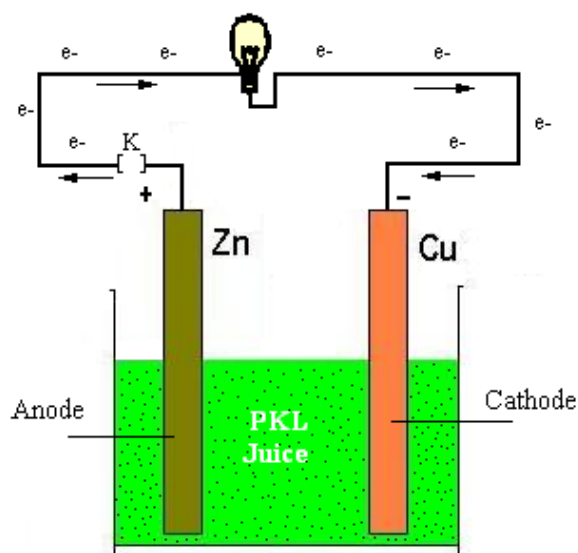
## PKL Unit Cell

A simple PKL unit cell can be made from copper and zinc metals with solutions of PKL juice. In the process of the oxidation and reduction reactions, electrons can be transferred from the zinc to the copper through an electrically conducting path as a useful electric current. In 2008, Dr. Md. Kamrul Alam Khan invented this PKL unit cell.

The fabricated Unit cell of PKL electric voltage is around 1.1 volts. The PKL electricity depends on various parameters. The parameters are given by the following:

- The concentration of the malt.
- Area of the electrodes.
- Distance between the two electrodes.
- The constituent elements of the electrodes.
- The volume of the PKL malt/juice.
- The temperature of the PKL malt.
- The age of the PKL.
- PH of the PKL juice

The PKL unit cell is illustrated in Figure 1.



**Figure 1: PKL Unit cell**

## PKL Electric Module and Panel

A PKL unit cell can produce only 1.1 voltages which is not sufficient to meet the practical situation. Therefore to meet the practical application PKL cells are grouped in module and panel.

### PKL Electric Module

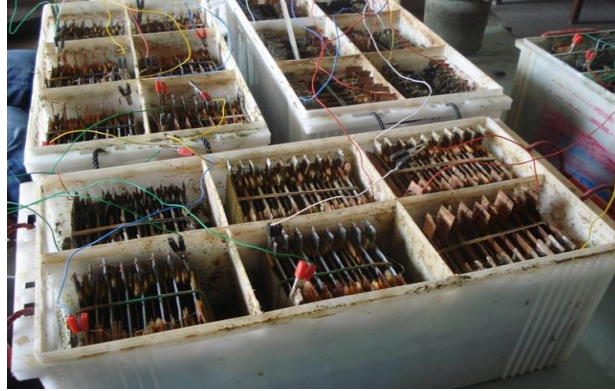
It is made more than one Unit cell. The PKL Unit cells are connected by wires. The voltage of the electric modules is more than 6.6 volts. A six cell PKL module is shown in figure 2 (a).

### PKL Electric Panel

It is made of more than one PKL electric modules by physically and electrically connected. The voltage of the PKL electric Panel is higher than the PKL electric modules. A PKL panel with three modules is shown in figure 2 (b)



(a)



(b)

**Figure 2: PKL Electric Module and Panel.**

### Collecting and Making Juice of PKL

In order to produce electricity from the leaf of the Bryophyllum, first of all, its leaves have to be collected and then blended by blenders. Thereafter a mixture, containing pest and water with proportion generally 8:1, will have to be prepared. This mixture can be used directly for electricity production. This juice can be filtered out to get the clean juice for the use of electricity generation. Figure 10.3 shows the picture of preparation process of juice.



**Figure 3: Preparation of Juice of PKL.**

After blending the juice is pouring and reserved in a plastic container or pot. This juice can be reserved / preserved there for long time. Figure 4 shows the picture of prepared juice.

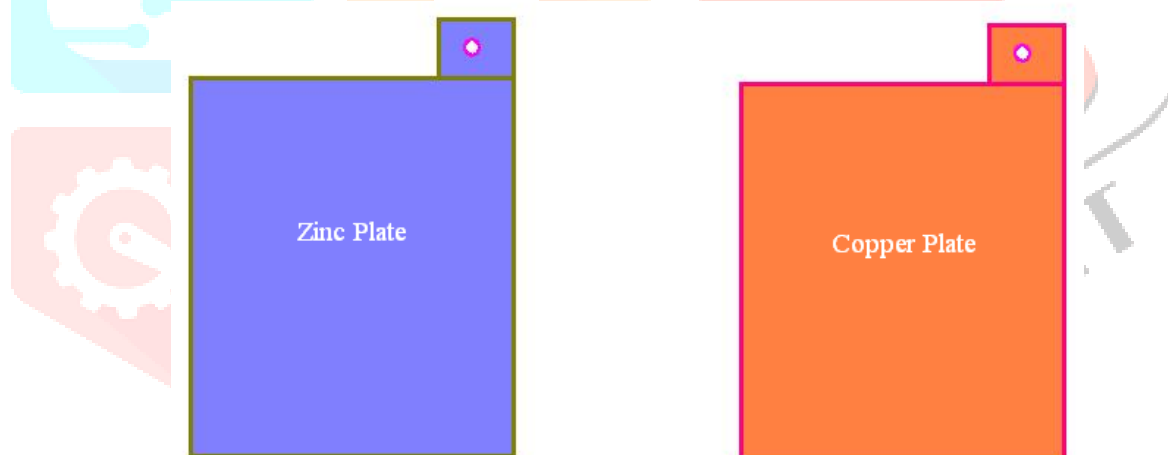


**Figure 4: Prepared Juice of PKL.**

### Preparing Electrodes

For the production of electricity we need to make the electrodes for the cell. We need two plates for the production of electricity. One is Zinc plate and other is Copper plate. Zinc plate acts as negative plate or negative terminal and Copper plate acts as positive plate or positive terminal.

In local market the Zinc and Copper plates are available in large sheet forms. Though the Zinc plate is cheaper but the Copper sheet is relatively costly. But fortunately though the Zinc plates are dissolved in the solution during the production process of electricity but the copper plates do not dissolve. Figure 10.5 shows the typical preparation of Zinc and Copper plates.



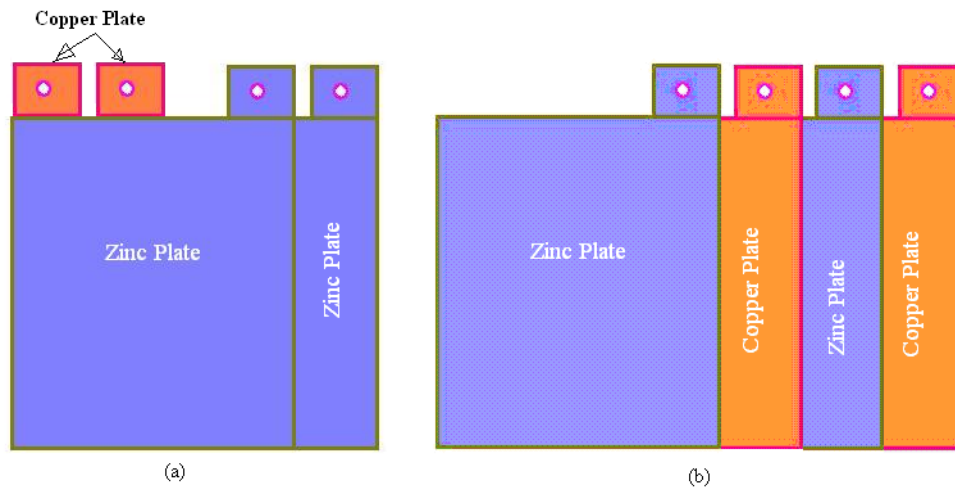
**Figure 5: Preparing of Zinc Plates and Copper plates for use in the production of electricity from PKL cell.**

### Placement of Electrodes

At this stage we need the plastic container or pot to arrange the plates. We can also use a clay pot as the substitute of a plastic container. This plastic container can be easily found in the market in different sizes as a battery box.

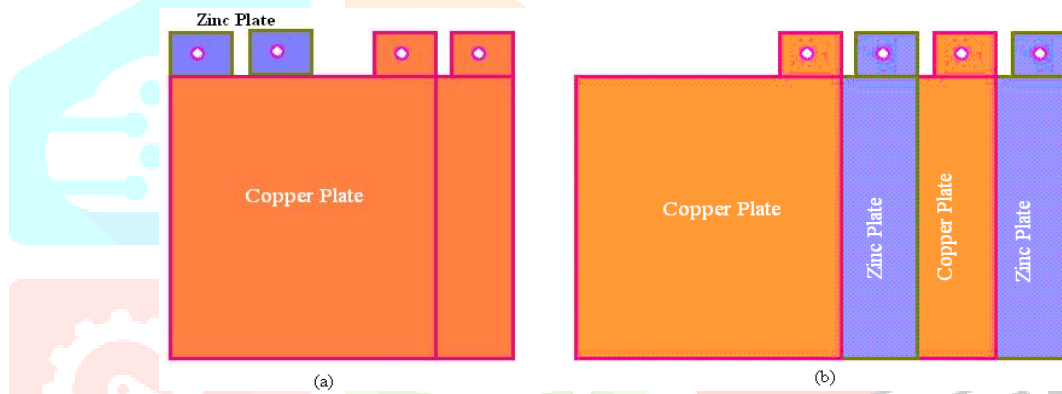
Now the Copper plates and Zinc plates are placed or arranged in the container one after another. That is if we start with a Zinc plate then first a Zinc plate then a Copper plate then a Zinc plate then again a Copper plate and so on. In reverse way, if we start with a copper plate then first a copper plate then a Zinc plate then a Copper plate then again a Zinc plate and so on. It should be noted that we have to follow only one sequence for all the cells in a particular battery arrangement.

A typical sequence with Zinc plate is shown plate in figure 6.



**Figure 6: Arrangement of plates keeping Zinc plate first.**

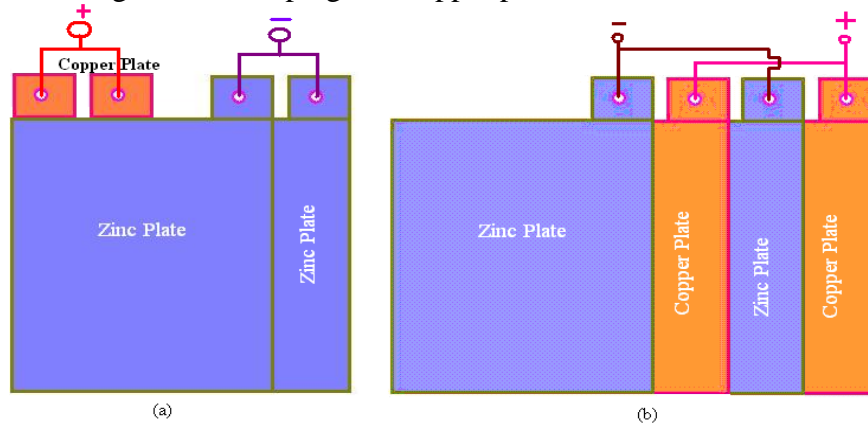
This arrangement of plates can also be done keeping the copper plate first i.e. first a Copper plate than a Zinc plate than a Copper plate than again a Zinc plate and so on. A typical sequence with Zinc plate is shown plate in figure 7.



**Figure 7: Arrangement of plates keeping Copper plate first.**

### Making Connections between Electrodes

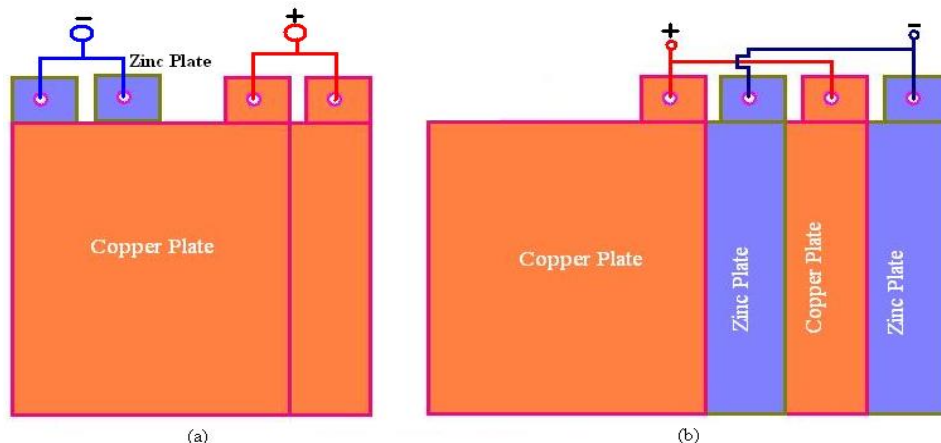
After placing the plates we need to make the internal connection between plates. It may be noted here that the Copper plate will be the Positive plate and the Zinc plate will be the negative plate. So in a particular cell we have to connect all the Zinc plates together and all the copper plates together. A typical illustration of connection is shown in figure 10.8 keeping the Copper plate first.



**Figure 8: Connection arrangement of plates keeping the Zinc plate first.**

For the group of plates keeping the Copper plate first, the same connection shall be made connecting all the copper plates in one group and all the Zinc plates in another group using copper wire. A typical illustration of connection is shown in figure 9 keeping the Zinc plate first.

It can be pointed out here that between Copper and Zinc plate we must have to keep some gap so that the two plated never touch each other. Alternately we can use a suitable separator in between. But keep in mind that the plates should be as close as possible to get the better result.



**Figure 9: Connection arrangement of plates keeping the Copper plate first.**

In this way Copper plate and Zinc plate should be placed to one cell. If we use more plates per cell current shall be increased keeping the per cell voltage fixed. Theoretically per cell voltage of PKL is 1.1 volts.

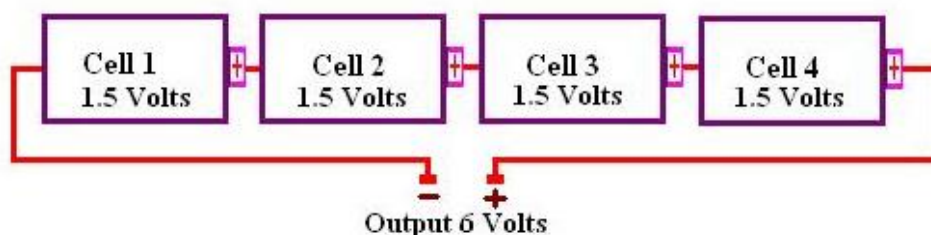
### Series and Parallel Combination Characteristics of Cells

Series combination and parallel combination of cells is very much important to get the desired voltage and current as well as power from the system. These are discussed below.

#### Series Combination of Cells

When two or more cells are connected in series than the combination is called series combination of cells. In this case the positive terminal of one cell shall be connected with the negative terminal of the other cell and the positive terminal of that cell will be connected with the negative terminal of the next cell and so on. In this case the cells voltages are add to give the output voltage but output current remains the same as a single cell. This combination is used when the increased system voltage is required.

Let us consider the case of dry cell battery each cell with cell voltage 1.5 volts. Now if we want to run an appliance the voltage rating of which is 6 voltage than we need 6 divided by 1.5 equals 4 cells [i.e.  $6/1.5 = 4$  cells] in series to get six voltage and to get it we have to connect the cells in series. That is, the positive terminal of one cell shall be connected with the positive terminal of the load and negative terminal will be connected with negative terminal of the load or appliances. This arrangement is shown in figure 10 below.



**Figure 10: Series Combination of Cells. Voltage is four times higher of each cell voltage.**

Here each cell voltage = 1.5

Number of cell in series = 4

Therefore, System voltage = each cell voltage  $\times$  Number of cell in series.

$$\begin{aligned} \text{i.e. System Voltage} &= 1.5 \times 4 \text{ Volts} \\ &= 6 \text{ Volts} \end{aligned}$$

System current = One cell current.

#### In general,

For system voltage,

$$V_{\text{System}} = V_{\text{Cell 1}} + V_{\text{Cell 2}} + V_{\text{Cell 3}} + \dots + V_{\text{Cell n}}$$

i.e.  $V_{System} = \sum_n^{x=1} V_{Cell\ x}$

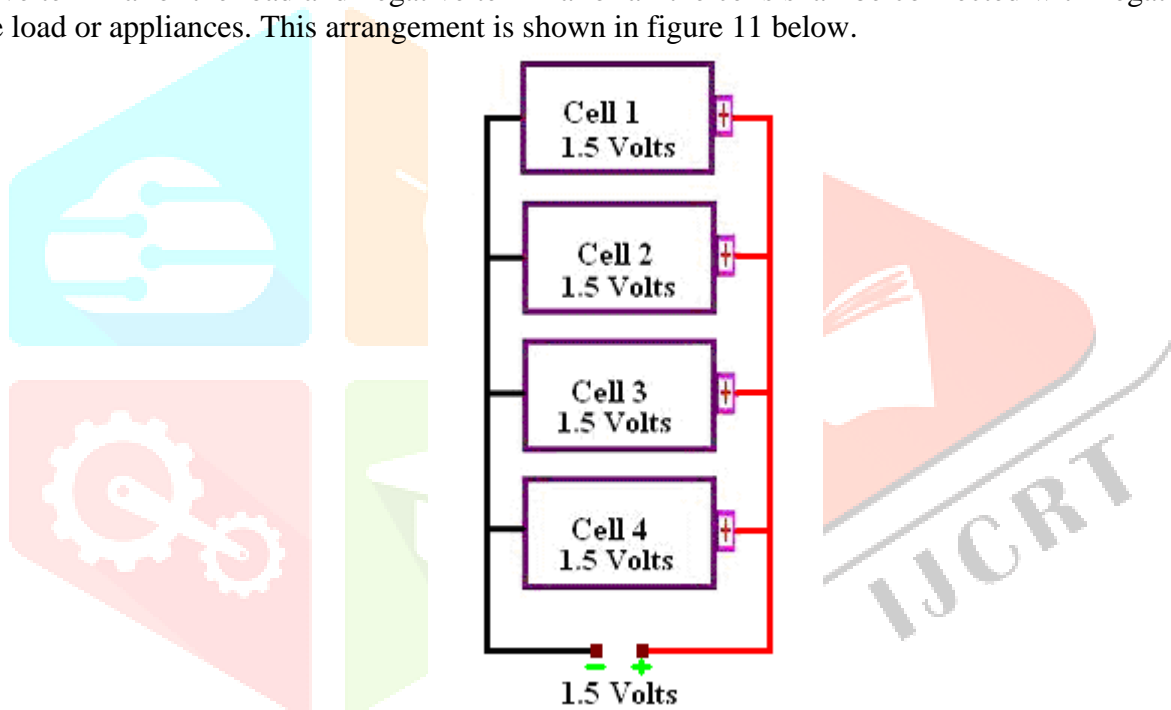
For system current,

$I_{System} = I_{Cell\ 1} = I_{Cell\ 2} = I_{Cell\ 3} = \dots = I_{Cell\ n}$

**Parallel Combination of cells**

When two or more cells are connected in parallel than the combination is called parallel combination of cells. In this case the positive terminals of all the cells are connected together and forms the positive terminal of the system and all the negative terminals of all the cells are again connected together to form the negative terminal of the system. In this case the cells currents are add to give the output current but output voltage remains the same as a single cell. This combination is used when the increased system current is required.

Let us again consider the case of same dry cell battery each cell with cell voltage 1.5 volts. Now if we want to run an appliance the voltage rating of which is 1.5 volts but current rating as high as four cells. In such case we need to connect the cells in parallel which will increase the system current four times but will keep the system voltage the same i.e. 1.5 volts. The positive terminal of all the cells shall be connected with the positive terminal of the load and negative terminal of all the cells shall be connected with negative terminal of the load or appliances. This arrangement is shown in figure 11 below.



**Figure 11: Parallel combination of cells. Current is four times higher of each cell current**

Here each cell voltage = 1.5

Number of cell in parallel = 4

Therefore, System voltage = One cell voltage = 1.5 Volts

System Current = Each cell Current × Number of cell in parallel.

i.e. System Current = (Each cell current × 4 ) Ampere

**In general,**

For system Current,

$I_{System} = I_{Cell\ 1} + I_{Cell\ 2} + I_{Cell\ 3} + \dots + I_{Cell\ n}$

i.e.  $I_{System} = \sum_n^{x=1} I_{Cell\ x}$

For system Voltage,

$V_{System} = V_{Cell\ 1} = V_{Cell\ 2} = V_{Cell\ 3} = \dots = V_{Cell\ n}$

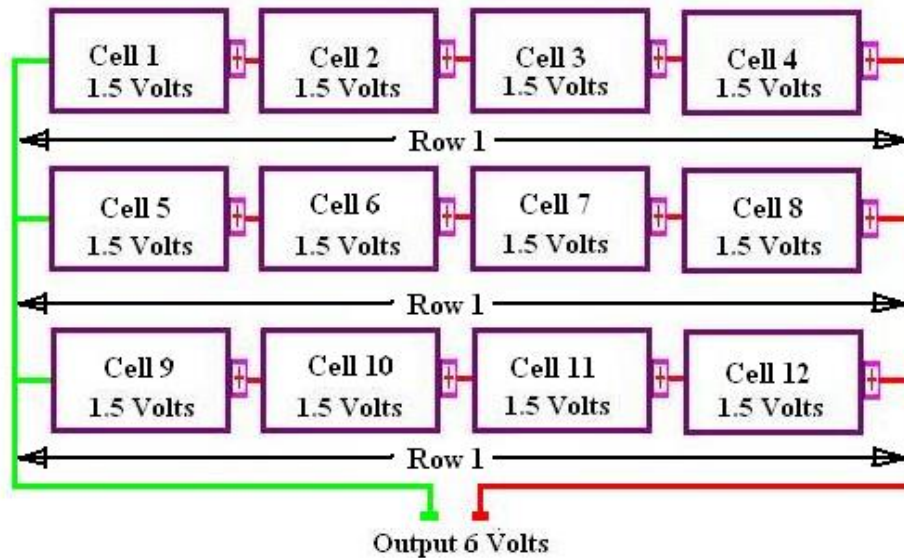
It can be noted here that for better combination and avoiding circulating current between cells voltage of every cells should be equal.



**Series Parallel Combination of Cells**

The most important and most useful combination of cells is the series parallel combination. In this case some cells are connected in series to form the required voltage. Now if the current or power requirement is higher than one cell then another series combination is formed and the later series combination is connected with the pervious series combination in parallel. In this way we can increase both the system voltage and current requirement. Here we can increase the power as we need.

Let us again consider the case of same dry cell battery each cell with cell voltage 1.5 volts. Now if we want to run an appliance the voltage rating of which is 6 volts and current rating as high as three cells. In such case we need 16 cells to support the required power. We need to connect four cells in series to form  $1.5 \times 4 = 6$  volts. Let us call this cell in parallel which will increase the system current four times but will keep the system voltage the same i.e. 1.5 volts. The positive terminal of all the cells shall be connected with the positive terminal of the load and negative terminal of all the cells shall be connected with negative terminal of the load or appliances. This arrangement is shown in figure 12 below.



**Figure 12: Series parallel combination of cells. Voltage is 4 times higher of each cell voltage and current is three times higher of each cell current.**

Here each cell voltage = 1.5  
 Number of cell in a row = 4  
 Total number of row = 3

Therefore, System voltage = One cell voltage × Number of cell in one row  
 i.e. System voltage =  $1.5 \times 4$  Volts  
 = 6 Volts

System Current = Each cell Current × Number of row in parallel.  
 i.e. System Current = (Each cell current × 4) Ampere

**In general,**

For system voltage,

$$V_{System} = V_{Row 1} = V_{Row 2} = V_{Row 3} = \dots = V_{Row n}$$

Where,  $V_{Row} = V_{Cell 1} + V_{Cell 2} + V_{Cell 3} + \dots + V_{Cell n}$

i.e.  $V_{Row} = \sum_{n=1}^{x=1} V_{Cell x}$

For system Current,

$$I_{System} = I_{Row 1} + I_{Row 2} + I_{Row 3} + \dots + I_{Row n}$$

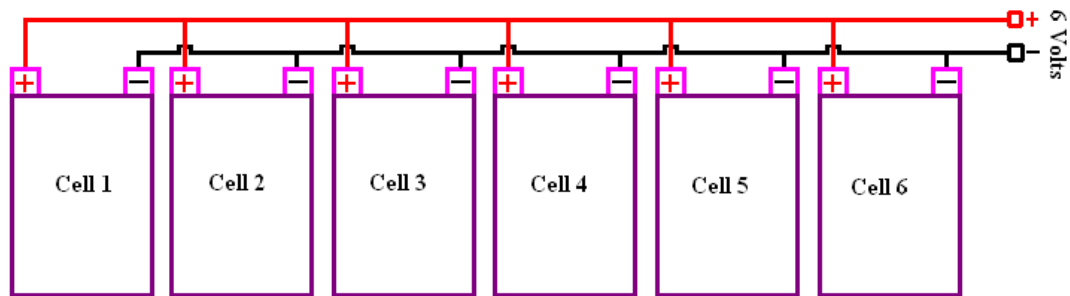
i.e.  $I_{System} = \sum_{n=1}^{x=1} I_{Row x}$

Where  $I_{Row} = I_{Cell 1} = I_{Cell 2} = I_{Cell 3} = \dots = I_{Cell n}$

It should be noted that the number of cells in each row must be the same. Otherwise a circulating current will flow through the rows and no current or few current will flow through the load. The circulation current may lead to damage the system.

### Combination of Cells

The power we get from the cell of PKL is direct current (D.C). The electrical appliances available in our country are of 6 volts, 9 volts, 12 volts etc. Since the practical appliances available in the market are of higher voltages than that of per cell voltage of PKL, so for the practical application we need to increase the system voltage by adding the multiple PKL cell in series. For example, we can get six voltage by connected the six PKL cell in series. Such an arrangement is shown in figure 10.13. Here six cells are used and connected in series. This will give an output voltage of 6 volts [theoretically  $1.1 \times 6 = 6.6$  volts]. But this will keep the current same i.e. output current remain the same as per cell current.



**Figure 13: Six cells are connected in series for an output of six volts.**

Similarly, if we want to increase both the voltage and current hence the power we need to go for series parallel combination of the PKL cells. This will increase both output voltage and current and hence the output power. Since the power in D.C. system is the product of voltage and current.

Power,  $P = V \times I$  Watts

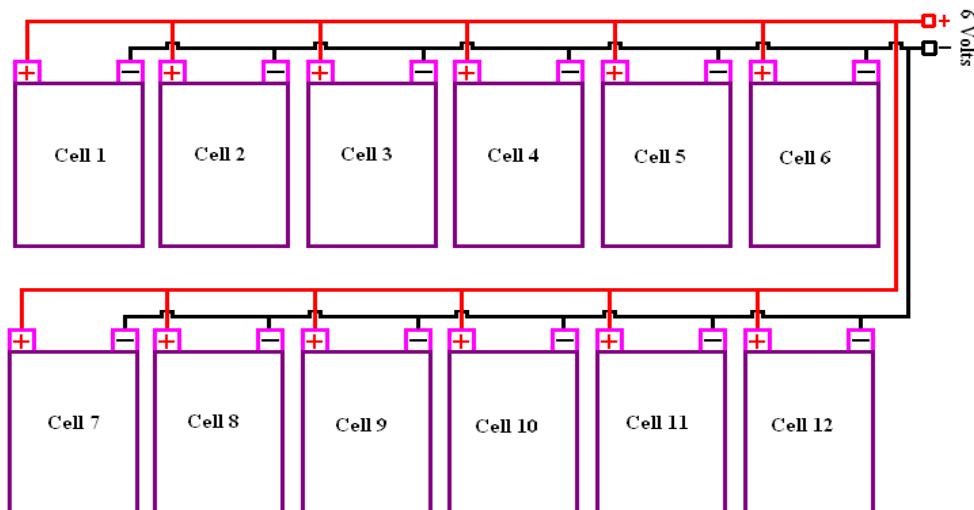
Where,

$P$  = Power in Watt

$V$  = Voltage in Volts

$I$  = Current in Ampere

Figure 14 shows such a system which will provide a output voltage 12 volts and will provide current equal to two PKL cells.



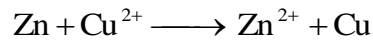
**Figure 14: Twelve cells are connected in series parallel combination to get an output of 6 volts with increases power.**

If we want to get more power we will need to use more cells in series parallel combination of cells.

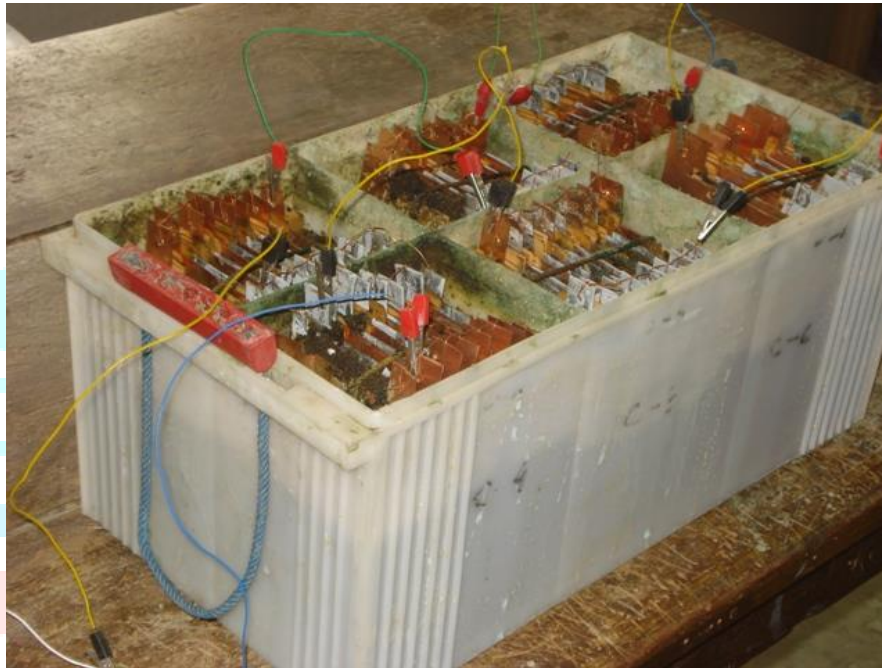
## Producing Electricity

When the connections of electrodes are ready we are at the final stage of producing electricity from PKL. At this stage the final task is to pouring the juice of PKL to the container or pot where the electrodes are placed. A chemical reaction is then taken place, which in turn, creates positive and negative potentiality around the plates. Now if we connect the Zinc and Copper plate through a proper load the current will flow from the cell to the external circuit.

Oxidation will occur at anode (Zinc) and reduction at the cathode (Copper). This will create a movement of electrons from Zinc to Copper and will produce current in the circuit. The net cell reaction will be as below:



Thus metal at anode loses electrons and dissolved and metal at cathode gains electrons and grows. An experimental setup of the process is illustrated in figure 10.15 below.



**Figure 15: Experimental Setup of Cells of PKL.**

## Problems of the PKL Electricity Production

As other cells PKL cell has also some common problem in producing electricity. It has been seen that there are two problems in PKL electricity generation system

1. Local Action
2. Polarization

### Local Action

The Zinc available in the market is not pure. When Zinc is used as anode and put into the PKL juice, it makes a small electric cell with the impurities. As a result Zinc plate destroys without any reason and it a great loss. This error is called local action. Generally it can be removed by mixing Hg layers on the Zn plate.

### Polarization

When chemical reaction starts in the PKL solution, then hydrogen ion ( $\text{H}^+$ ) collects electron from the copper electrode and makes molecule of Hydrogen gas. As a result the potential of the copper plate increases. But when more Hydrogen gas ( $\text{H}_2$ ) stores at Cu plate, and make a barrier to take electron from the copper plate. Therefore the potential of the copper plate decreases and the flow of current are also decreases. This is called polarization. Generally using a brush or polarization reduction material has been used to reduce polarization. The  $\text{CuSO}_4$  solution is also good for reducing polarization.

## CONCLUSION

The generation of electricity from PKL is quite simple. This is an invention of our own. The poor villagers or the people in remote areas of the country can easily make it; and can easily use it for their power requirement. It does not need any expensive material or does not need any in-depth knowledge about electricity to produce. Moreover, since the generated electricity is of low voltage and does not use any harmful substance it is also very safe to produce and use. We can collect the PKL or can easily cultivate the PKL in a corner of our unused land and easily collect the electrodes from the local market and can make it easily.

## RECOMMENDATION

1. In the manufacture of eco-friendly electrical appliances for low cost.
2. Introduce a sustainable platform to combat the power crisis of this world in future.

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