

From Waste to Energy: Recycling Batik Waste to Electricity

Ahmad Mujahid*, Miranda Refamala Ayuk Artika, Trisna Amalia Ramadhani

Students of Islamic Psychology of IAIN Surakarta
Jalan Pandawa, Pucangan, Kec. Kartasura, Kab. Sukoharjo, Jawa Tengah 57168.
Email*: ahmad.creatoz@gmail.com

Abstract. The World's electricity consumption continues to increase as the shift from conventional products to electronic products weight the electricity burden in every state. Besides that, power outages inhibit social and industrial activities as the last one occurred in Jabodetabek, August 2019. In this research it is pointed out that the composite of batik waste, charcoals, *bilimbi*, and tamarinds wrapped in aluminium foil is able to generate 0.5-volt electrical voltage per unit. Experiment method is used in this research by involving 13 samples with different compositions to yield a stable electrical voltage. The most stable one is derived from the composition of charcoal, *bilimbi*, and tamarind with the addition of batik waste water, which generated 0.5 volt electrical voltage per unit. In order to verify the generated voltage, an electrical circuit with 7-unit structure was made and examined to a 3-volt flip-flop lamp circuit. To further develop this prototype in a bigger scale, therefore, the supports from various parties are needed for the sake of a continuous research, so that it can give rise to society's interest to develop environmentally-friendly products and to provide solutions for batik waste water problem that takes place in *Sentra Industry Batik*, Laweyan, Surakarta that tends to be disposed vainly.

Keywords: electricity, *bilimbi* electricity, environmentally-friendly

INTRODUCTION

As the increasing in the society's electricity consumption and the shift of conventional to electronic products, many Indonesian Industries use electricity to produce their products. Not to speak of, in the societal scope, electricity is really needed that no day is without electricity. The Corporate Planning Director of PT Perusahaan Listrik Negara company, announced that the electricity consumption in the first-half of 2018 was 112.46 TWh or grew 4.7% yearly (CNN, 2018).

Electricity has become one of society's basic needs; if only just one day an outage takes place, there will be many disadvantages either in villages or in cities. Syofi, The Corporate Planning Director of PLN, also mentioned that industries's electricity consumption takes 30% of 221.07 TWh of the electricity consumption target throughout the year. As the result, when the industries' operational activities stop, the effect on the overall electricity consumption is quite significant.

Laweyan batik industry centre, Surakarta gives a positive impact to its society; one of which is in the economic aspect. On the other hand, the higher increase of batik production that is not compensated by a waste management will pollute the environment. Surakarta's batik industries's waste pollutes Bengawan Solo watercourse the most. Even, in 2017, two other rivers were heavily polluted by the batik waste which exceeded the quality threshold. The lack of WWTP or Wastewater Treatment Plant has become one of many pollution factors in Bengawan Solo. Staff of Pollution Control of the Environmental Services of Surakarta, Edi

Suparmanto, added that the WWPT existence is not able to contain all the batik craftsmen's waste.

This research focuses on the use of batik waste water to avoid vain disposal by the addition or substitution of *bilimbi*, charcoal, and tamarind to generate 0.5-volt electrical voltage per unit. The waste used is taken from Laweyan batik industry centre, Surakarta.

Electricity is a charge consists of positive and negative charges. An electric current is an electric charge that moves from the high-potential point to the low-potential point through an electrical conductor. One of electrical conductors is a media made by metal, namely free electron which moves from one atom to the next one, and water electron which is brought by electrolyte contained by the media.

Electricity has two different kinds of current, namely direct current and alternative current. The DC is an electric current which streams continuously in one direction. It is used in industries employing electrolysis process such as metal refining and metal coating or plating. Likewise, the AC is an electric current which streams alternately. It is used in the houses and factories, and usually has 110 volt or 220 volt voltage. The AC is more hazardous than the DC one.

Bilimbi is a tree-type plant which is usually can still be found in rural villages nowadays. The stem can grow of about 15 meters with few branches. It tastes sour, having flat seeds, and by the time it is ripe, it contains a lot of water. It is also popular as cooking star fruit for it tastes quite sour and usually used as a kitchen herb or herb concoction. It contains much tannin, saponin, sulphur glucose, formic acid, peroxide, flavonoid, and also triterpenoid.

Solutions in form of compounds like sulphuric acid, oxalic acid, formic acid, and citric acid are known as electrolyte solutions. Galvani cell system employs electrolyte to bring ions from the anode to the cathode, so that it can generate electricity. As we know that *Bilimbi* has high acidity level, the formic acid in it potentially generates electricity.

Tamarind fruit is tropical cultivar and belong to pod plants. The stem which is quite solid can grow to be a shady big tree. It has several chemical compounds namely appelic acid, citric acid, grapes acid, sulfonic acid, and pectin dangula invert. The pH value it has range about 2, 1, -2, and 3. It shows that tamarind fruit might be used as electrolyte replacement in batteries. If it use as the electrolyte in batteries, the soil pollution caused by the real battery electrolyte will decrease.

Atina (2015) did a research that yielded a ranking list of fruit based on the electrical voltage and electric current it generates by its acidity. The highest to the lowest electrical voltage and electric current of fruit are key lime (1.005 pH; about 0.0002 volt), bilimbi (0.976 pH; about 0.0027 volt), apple (0.974 pH; about 0.0046 volt), pineapple (0.920 pH; about 0.0002 volt), and tomato (0.876 pH; about 0.0067 volt). The pH value is inversely proportional to the electric current, for the higher pH value is, the fewer conveyer ions will be that the electrical voltage and electric current will be smaller and vice versa.

Active charcoal is a product derived from carbonization modification which has many benefits and has been utilized since World War the first (Austin in Mody Lempang, 2014). Chemical properties of activated charcoal does not solely contain carbon atom, but also a little amount of chemically-bound oxygen and hydrogen in form of various functional groups such as carbonyl group (CO), carboxyl (COO), phenol, lactone, and some of ether group. Oxygen in the active charcoal surface sometimes originates from raw materials or occurs by the activation process with steam (H₂O) or air which can determine the charcoal to be acidic or basic. The charcoal raw material, generally, has mineral components in it. They become denser by the time of the charcoal activation process. Besides that, the chemical materials used in the process lead to chemical properties changing of the produced charcoal. Based on its physical properties, active charcoal varies in characteristics, namely in form of black solids, tasteless, odourless, hygroscopic, water insoluble, acidic, basic or organic solvents (Hassler, 1974). Active charcoal will not decay of temperature or pH increase in the process of activation.

Batik is a process of wax adhesion on a white cloth before a colouring process (Samsi, 2011: 7). Batik industrial activities oftentimes involve chemical materials. The one which uses many of them is the coloration (Sulaiman, 2011: 1). According to the research of Diena Ruslanjani, Andri Kurniawan, and

Dulbaahri (2008), Batik industries' waste damage people's health and a cause of conflicts which is cantered in industrial area. Rivers are one of the factors that spread the pollution impact and widen the conflict area.

In her research, The Effects of Electrode Substances to Bilimbi (*Averrhoa Bilimbi*) Electricity as a Solution to Environmentally-friendly Alternative Energy (2017), Shinta Marito Siregar did an experiment using bilimbi solution with 1.6 pH value. She tried to use it as the electrolyte to turn an LED lamp on and the electrode pair which generate the highest electrical voltage are copper and zinc with 3.5 volt voltage.

In a similar research, The Sustainable Water Waste Management of Micro Small and Medium Batik Enterprises Centre in Sukoharjo Regency (2013), M. Wawan Kurniawan tested the quality of the waste water. The test shows that the batik waste water of the micro small and medium batik enterprises' that use stamping and printing methods has BOD/COD number comparison between 0.4 to 0.49 which is higher than 0.4. Thus, the alternative process he chose was biological process.

Wiwik Purnawanti Widyaningsih Margana's research, Electron Power Inverter (EPI) Power Plants Using Bilimbi and Banana Peel, proves that the bilimbi and banana peel composite with galvalis zinc electrodes (Zn) and copper (Cu) cannot replace sulphuric acid (H₂SO₄) for the electrolyte of bilimbi and banana peel cannot be charged but can alternatively replace electrolyte liquid in accu.

MATERIALS AND METHODS

Type of Research

The type of research used in this paper is the field experiment method. The researchers examine the electrolyte solution considered to have a high acidity (pH) level. Hence, it is yielded a material combination which has the most stable electrical voltage and tested on an electrical circuit to light a 3.5-volt lamp.

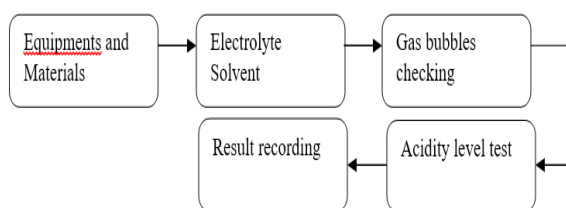
Research Equipment and Materials

Table 1. Equipments and Materials.

Materials	Equipment
wood charcoal	scissors and cutters
textile water waste	sieve
bilimbi	spoon
tamarind	containers
cables	hammer
3.5 volt flip-flop lamps	voltmeter
aluminium foil	nails
beverage bottles	blender

The Flow Diagram and The Manufacturing Procedure

1. The Electrolyte Solution Testing



*) the checking uses electrodes.

*) the acidity level test uses pH meter and pH universal.

2. The Procedure for Making Electrical Circuit Units

- Prepare all the equipments and materials needed.
- Cut the cable into 7 cm long and strip both rubber tips.
- Cut the bottle, take the bottom part of it of 3 cm high and make a hole on the left and the right side.
- Cut the aluminium foil, make it as wide as the cut bottle, and use it as the layer in the bottle. Repeat this step 7 times, and make 7 covers from the aluminium foil.
- Mash the charcoal until it becomes subtle and place it in the first container.
- Blend the bilimbi and the batik water waste as the solvent and the place it in the second container.
- Blend the tamarind and remove the pulp from the seeds by adding the batik water waste and place it in the third container.
- Mix those three substances: the charcoal, bilimbi, and tamarind which has been blended with batik water waste.
- Pour the mixture into the container, and then install the cable in one side of it.
- Before installing it, it is better to check every unit using the voltmeter. Then, insert one cable end on the unit to the cut bottles' hole. After that, connect the tips of every unit so that it can adhere to the aluminium foil, and so forth.
- Connect the lamp circuit to the edge of the unit circuit: one tip to the cable and the other to the aluminium foil.

DISCUSSION

Problem Analysis

Laweyan is an area known as one of the big batik industries centres in Surakarta, but unfortunately, the society of Laweyan batik village is less in utilizing and managing the batik water waste. It, consequently, pollutes the water with batik water waste. Regarding to this problem, the researchers tried to make use of the batik water waste stored in a tank in Laweyan, Surakarta,

as the substitution to the environmentally-friendly electrical circuit prototype.

Alternative Problem-solving Model

1. Electrolyte Solvent Bubble Checking Using Electrodes

Table 2. Gas Bubble Checcking.

No	Solvent	Not Yielding Bubbles	Yielding Bubbles
1.	Tamarind and batik water waste		✓
2.	Bilimbi and batik water waste		✓
3.	Composite (bilimbi, tamarind, and batik water waste.		✓

In the electrolyte solvent, there are 2 kinds of it, namely the strong solvent and the weak solvent. The strong electrolyte solvent can be recognized by the lamp light and gas bubbles. On the other hand, the weak one is indicated by the dim lamp light or even unlighted lamp. This condition also happens in the strong acid and basic solvent indicated by the bright lamp light and gas bubbles.

2. Electrolyte Solvent pH Test

The pH measurement results of the composite of bilimbi, tamarind, and batik water waste using pH meter and pH universal are as follow:

Table 3. pH Test Result.

No	Solvent	pH meter	pH universal
1.	Tamarind and batik water waste	2.64	2-3
2.	Bilimbi and batik water waste	2.04	1-2
3.	Composite (bilimbi, tamarind, and batik water waste.	2.43	2-3

The acid-basic strength can be determined by the pH solvent with the same concentration. The strong pH acidityvalue is smaller thanthe weak pH acidity one, while the strong base pH number is bigger that the weak base pH one. Weak base is a weak electrolyte compound. In the water, this compound imperfectly yields OH^- Ions so that it cannot light the lamp. It has POH value or a low pH value range from 9 to 11. Strong base is aweak electrolyte compound. In the water, it can yield OH^- ions perfectly. Every base molecule composes ions, that it can light the lamp and produce gas bubbles. Strong base has a low POH value or a low pH value range from 12 to 13. Weak acid is a weak electrolyte compound. In the water, it yields H^+ imperfectly so that it can light the lamp and produce few gas bubbles. It has a high pH value that ranges between 3-5. Strong acid is a strong electrolyte compound. In the water it can yield H^+ ions perfectly that it produces lots of gas bubbles and

lights the lamp. It has a low pH value that ranges from 1 to 2. Therefore, bilimbi belongs to the strong acid since it has 2.04 pH value.

3. Environmentally-friendly Electric Unit Prototype Model

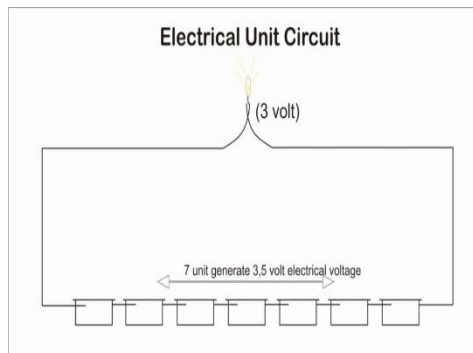


Figure 1. Electrical Unit Circuit.

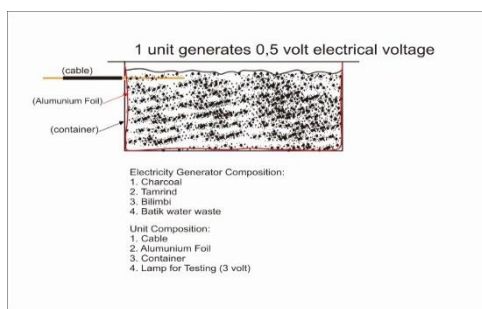


Figure 2. Detail Unit.



Figure 3. Detail Eksperimen.

Prior to the experiment, the researchers had done several tests using other electrolyte solvents, but they could not generate a stable electric current. We also used NaCl solvent or best known as sea-salt solvent. However, during a very short phase of 1-2 days, the circuit was damaged because of the sea-salt's corrosive nature to metal and aluminium. So, we tried to employ another substance which does not damage the circuit in order to be able to last long. Hence, we used tamarind as one of the substances for it is glutinous and strapping so that the circuit would not dry and decay. This electric

circuit showed 3.5 volt stable electrical voltage and was able to light the flip-flop lamp quite brightly. The power in it could last for 1440 minutes and is refillable by pouring the same electrolyte solvent into the container. The refill should be executed before the electrical unit voltage decreases.

CONCLUSION AND SUGGESTION

Based on the research result, it can be concluded that the utilization of batik water waste as an alternative energy in the making of electrical circuit can be used as a solution to reduce the impact of pollution in the environment of Laweyan, Surakarta.

The result of batik water waste substitution can be utilized to make a 3.5 volt electrical circuit which can light a 3 volt flip-flop lamp, and last for 1440 minutes. We, as the writers, therefore, give suggestion to the government to take an action to resolve the batik water waste problem. It can start with an education of batik water waste management to the batik business owners or the local community and build a batik water waste management centre, in order to solve the problem well. Accordingly, to develop this prototype in a bigger scale, it needs the supports from various parties to support the facilities and sustainable researches. In addition, society has to possess an awareness to be a creative in cultivating batik water waste to be something more highly valuable. For the next researches, we hope to be more focus on the environmental studies at the first place.

REFERENCES

- Agung, A. I. (2013, vol. 2). Potensi Sumber Energi Alternatif dalam Mendukung Kelistrikan Nasional. *Jurnal Pendidikan Teknik Elektro*, hlm. 892-897.
- Atina. (2015, vol. 12). Tegangan dan Kuat Arus Listrik dari Sifat Asam Buah. *Sainmatika*, hlm. 28-42.
- Azmi, J. (n.d.). Prototipe Baterai Dari Buah Belimbing Sayur Sebagai Energi Alternatif. *Jurnal Ilmiah Pendidikan Fisika (Lensa)*, Vol. 3(No. 2), 294-296.
- Bahri, S., Swistoro, E., & dkk. (2015). Menentukan Karakteristik Listrik Jeruk Nipis, Belimbing Wuluh, dan Pisang Tanduk Serta Implementasinya Dalam Pembelajaran Fisika. *Jurnal Pendipa*, Vol. 2(No. 1), 20-26.
- Diena. Ruslanjani, A. K. (2008, vol. 1). Potensi Bencana Sosial yang Diakibatkan oleh Kegiatan Industri Batik dan Tekstil di Kabupaten/Kota Pekalongan. *Jurnal Kebencanaan Indonesia*, hlm. 301-322.
- Effendi Arsad, S. H. (2010, vol. 2). Teknologi Pengolahan dan Pemanfaatan Karbon Aktif untuk Industri. *Jurnal Riset Industri Hasil Hutan*, hlm. 43-51.
- Eko, P. (2019, Januari 05). *Energi & Tambang*. Retrieved from liputan6.com: <http://www.m.liputan6.com/bisnis/read/3863789/konsumsi-listrik-terus-meningkat-ri-menuju-negara-maju>

- Fauzi, F. (2019, Januari 24). *detikFinance*. Retrieved from detik.com: <http://www.m.detik.com/finance/energi/d-4399323/konsumsi-listrik-nasional-naik-jadi-1064-kwh-per-kapita>
- M. Wawan Kurniawan, P. P. (2013, vol. 11). Strategi Pengelolaan Air Limbah Sentra UMKM Batik yang Berkelanjutan di Kabupateen Sukoharjo. *Jurnal Ilmu Lingkungan*, 62-72.
- Riska Andriani, H. (2017, vol. 1). Toksisitas Limbah Cair Industri Batik terhadap orfologi Sisik Ikan Nila Gift (*Oreochomis Nilotocus*). *Jurnal SainHealth*, hlm. 83-91.
- Setyawan, S. J. (2014, vol. 12). Pembuatan Arang Aktif dari Tempurung Kelapa dan Aplikasinya untuk Penjernihan Asap Cair. *Spektrum Industri*, hlm. 73-86.
- Siregar, S. M. (2017, vol. 2). Pengaruh Bahan Elektroda Terhadap Kelistrikan Belimbing Wuluh (*Averrhoa Bilimbi*) sebagai Solusi Energi Alternatif Ramah Lingkungan. *Jurnal Penelitian Pendidikan MIPA*, hlm 166-173.
- Suprihatin, H. (n.d.). Kandungan Organik Limbah Cair Industri Batik Jetis Sidoarjo dan Alternatif Pengolahannya. *Pusat Penelitian Lingkungan Hidup Universitas Riau*.
- Wiwik Purwati Widyaningsih, M. (2018, vol. 14). Pembangkit Listrik Elektron Power Inverter (EPI) dengan Memanfaatkan Buah Belimbing Wuluh dan Kulit Pisang. *Jurnal Teknik Energi*, hlm. 66-71.

