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優勝作品專輯

作品編號	**200021**
參展科別	**環境工程**
作品名稱	**Utilization of Escherichia coli in Contiminated Water in the Citarum River as a Dual Chamber Baed On Microbial Fuel Cell (MFC) Substrat**
得獎獎項	

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關鍵詞　**Escherichia coli、Citarum River and Microbial Fuel Cell (MFC)**

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BAB 1. INTRODUCTION

1.1. Background of the Study

Citarum River is the longest and largest river in West Java. The upstream of the Citarum River starts from Mount Wayang, Bandung Regency and ends at the mouth of the Java Sea which is located in Muara Gembong, Bekasi Regency. The Citarum River plays an important role as raw water for PDAM drinking water, supplies electricity in Java-Bali and provides water for rice field irrigation in West Java. Citarum watershed is dominated by the manufacturing industry sector such as chemicals, textiles, leather, paper, pharmaceuticals, metals, food and beverage products, and others.

Based on data from the World Bank, every day, the Citarum River is polluted by approximately 20,000 tons of waste and 340,000 tons of waste water with the majority of the waste contributors coming from 2,000 textile industries. By looking at these events, there is no doubt that the sustainability of the ecosystem and the environment in the Citarum River is damaged and polluted. (Zahra Fani Robyanti; 2020).

The West Java Regional Environmental Management Agency stated that the content of *E. coli* bacteria in the Citarum River had increased. The bacteria that cause diarrhea come from industrial and household waste. In addition to *E. coli* bacteria, other pollutants in the Citarum River that have increased are *biological oxygen demand (BOD), chemical oxygen demand (COD)* and Suspended Solids.

One of the efforts that can be done regarding *E. coli* bacteria that pollute the Citarum river is to make it as a substrate for *Microbial Fuel Cell (MFC)*. Bacteria present in organic media convert organic matter into electrical energy. The nature of bacteria that can degrade organic media (enrichment media) in MFC produces electron and proton ions. It is these ions that produce an electric potential difference so that energy can be generated.

Generally in conventional systems, MFC consists of two chambers consisting of anode and cathode chambers. The two spaces are separated by a membrane where *proton exchange occurs*. This system has not fully worked with bacteria because only the anode side contains bacteria, while on the cathode side it still works using chemical compounds such as *Polyaluminum Chloride (PAC).* However, recently MFC has been developed using bacteria at the cathode, or better known as biocathode. Bacteria in the cathode space have the same function as electron mediators that were previously carried out by chemical compounds.

In many studies on MFCs, acetate is commonly used as a substrate for bacteria to generate electricity. These chemical compounds are easier for bacteria to process than wastewater. Acetate is a simple chemical compound that serves as a carbon source for bacteria. Another advantage of acetate is that this compound does not cause other reactions to bacteria such as fermentation and methanogenesis at room temperature.

Based on this thought, the author will design a study entitled ***Utilization of Escherichia coli Bacteria in Contaminated Water in the Citarum River as a Dual Chamber Based Microbial Fuel Cell (MFC) Substrate.***

1.2. FORMULATION OF THE PROBLEM

Based on the background described above, there are several problem formulations, as follows:

1. How to utilize *Escherichia coli* bacteria in Citarum River polluted water as a *Microbial Fuel Cell* substrate optimally which has potential as a raw material to generate electricity? ;
2. How to obtain or meet energy needs through the manufacture of alternative energy using *Microbial Fuel Cell (MFC).*

1.3. OBJECTIVE OF THE STUDY

The objectives of this research are:

1. Calculating the electrical value of the *Microbial Fuel Cell (MFC)* with the use of *Escherichia coli* bacteria in polluted water of the Citarum River;
2. Looking for microbial concentration *e. coli* in generating electricity using the *Microbial Fuel Cell (MFC)* method.

1.4. SIGNIFANCE OF THE STUDY

The signifance of this research are:

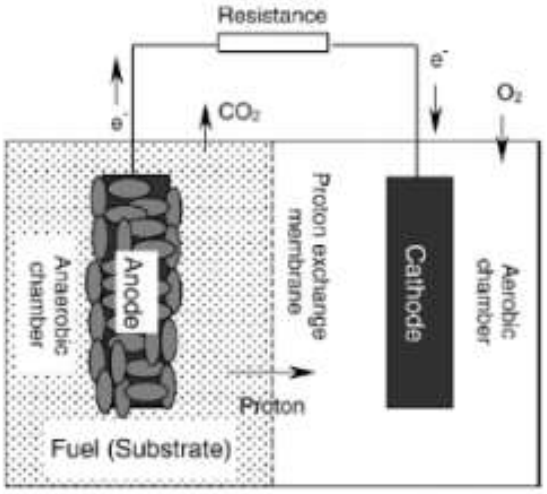
1. To find out how to optimally use *Escherichia coli* bacteria in Citarum River polluted water which has the potential as a raw material to produce electricity, the Microbial Fuel Cell (MFC) method ;
2. To determine the concentration of *Escherichia coli* microbes in the formation of electricity using the *Microbial Fuel Cell (MFC)* method.

BAB 2. REVIEW OF LITERATURE

2.1. Microbial Fuel Cell (MFC)

The *fuel cell* works on the principle of chemical electric combustion, this *cell* will produce direct current electrical energy. This *fuel cell* consists of an electrolyte that separates the cathode from the anode, the electrolyte can only conduct ions, while electrons cannot pass through the electrolyte, so this electrolyte is not a conductor of electricity and also avoids chemical reactions.

Microbial fuel cell (MFC) is one way to produce energy sustainably in the form of electricity from degradable materials. *Microbial fuel cell* is a tool to convert chemical energy into electrical energy with the help of catalytic reactions of microorganisms (Allan and Benneto 1993). *Microbial fuel cells* generate electricity by oxidizing organic matter anaerobically with the help of bacteria. The catalytic activity and proton transfer are carried out using enzymes or additional mediators. *MFC* scheme as shown in Picture 2.1



Picture 2.1. MFC scheme

According to Lovley (2006), microbial fuel cells have several advantages, namely they can generate electricity from organic waste and renewable biomass. Bacteria are able to be catalysts and adapt well to different organic materials found in environmental waste so as to produce electrons. Various forms of organic matter can be used as substrates in microbial fuel cells such as glucose, starch, fatty acids, amino acids and proteins, as well as wastewater from humans and animals (Idham , 2009). Experiments on microbial fuel cells on various types of substrates can be seen in Table 2.2. Inorganic materials can also be used as substrates in microbial fuel cells such as nickel foam (Karthikeyan, 2016).

Based on another definition, *Microbial Fuel Cell (MFC)* is a system that utilizes bacteria to oxidize organic and inorganic materials. The working principle of the MFC system is that bacteria in

the vessel produce electrons which are then transferred to the anode and flowed to the cathode which is connected to a conductivity device to generate electricity that can run the device (Logan 2008).

The mechanism of electron transfer at the anode of *MFCs* is a major issue in understanding the theory of how *MFCs* work. Microbes transfer electrons through an electron transport system consisting of a series of components of the bacterial extracellular matrix or together with electron transfer dissolved in a bulk solution (Du et al. 2007).

2.2. Bacteria *Escherichia coli*

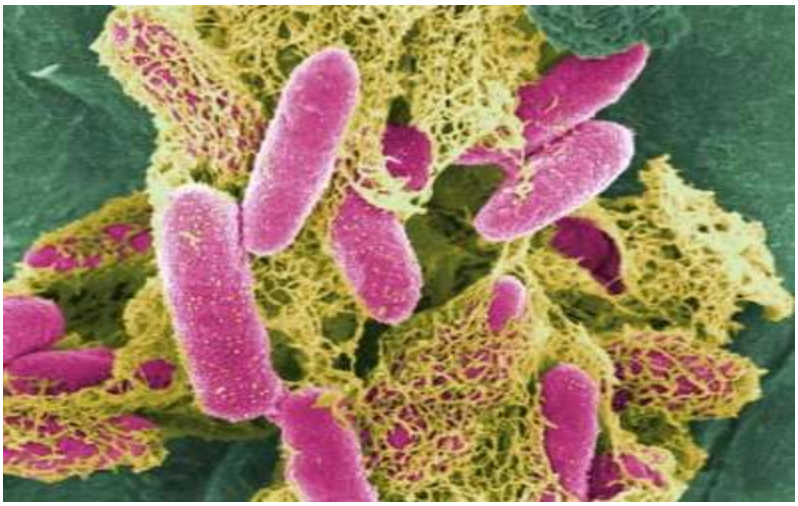
Escherichia coli is a type of bacteria that normally lives in the digestive tract of both humans and healthy animals. The name of this bacterium is taken from the name of a bacteriologist from Germany, namely Theodor Von Escherich, who succeeded in isolating this bacterium for the first time in 1885. Dr. Escherich also succeeded in proving that diarrhea and gastroenteritis in infants were caused by Escherichia coli bacteria (Jawetz et al., 1995).

Escherichia coli nomenclature classification as follows::

Superdomain : *Phylogenetica*
Filum : *Proterobacteria*
Class : *Gamma Proteobacteria*
Ordo : *Enterobacteriales*
Family : *Enterobacteriaceae*
Genus : *Escherichia*
Species : *Escherichia Coli (Jawetz et al., 1995).*

Escherichia coli is a short rod-shaped Gram negative bacteria that has a length of about 2 *μm*, a diameter of 0.7 μm, a width of 0.4-0.7 μm and is a facultative anaerobe. The morphology of Escherichia coli bacteria can be seen in Figure 2.2. The shape of the cell from a coocal-like shape to forming along the filamentous size. No spores were found. The cells may be single, in pairs, and in short chains, usually not encapsulated. Escherichia coli forms round, convex, smooth colonies with marked edges (Jawetz et al., 1995).

The capsule or microcapsule is made of polysaccharide acids. Mucoid sometimes produces extracellular discharge which is nothing but a polysaccharide of certain antigen specificity or is present in the polysaccharide acid formed by many Escherichia coli as in Enterobacteriaceae. Subsequently described as M antigen and composed by cholanic acid (Smith-Keary, 1988).



Picture 2.2. Morfologi Escherichia coli (Collier, 1998)

Usually these cells move with petrichous flagella. *Escherichia coli* produces a variety of different fimbria or pili, varying in structure and antigen specificity, including filaments, proteinaceus, hair-like appendages around the cells in varying numbers. Fimbriae are hydrophobic chains and have specific heat or organ-specific effects of adhesion. It is an important virulence factor. *Escherichia coli* is a facultative anaerobic bacteria, chemoorganotropic, has the type of metabolism of fermentation and respiration but its growth is at least mostly under anaerobic conditions (Collier, 1998).

BAB 3. METHOD OF RESEARCH

3.1. Location and Time of the Research

3.1.1. Location of the Research

This research will be carried out by the physics laboratory of SMA Taruna Bakti Jl. L.L.R.E Martadinata No. 52 Bandung. Samples of polluted water from the Citarum river will be taken from the Citarum river in areas that have heavy pollution, namely, the Cigebar area, Bojongsoang District, Bandung Regency and the factory area in Majalaya, Bandung Regency.

3.1.2. Time of the Research

The research execute on a time frame as follows:

Activity	June	July	August	September
Literature study and gathering information				
Preparation of the materials and the experiment				
Experiment results and gathering the information				
Retrieval of electrical data from the MFC system				
Formulating reports from the experiment results				
Submitting reports of the experiment results				

3.2. Data Sources, Tools, and Materials

The data source comes from the *MFC* design that uses the principle of voltaic cells using *Escherichia coli* bacteria as a bacterial substrate in polluted water of the Citarum River.

3.2.1. Materials for the Research

- Aquadest
- Bacteria *Escherichia coli*
- Jely swalow

3.2.2. Tools for the Research

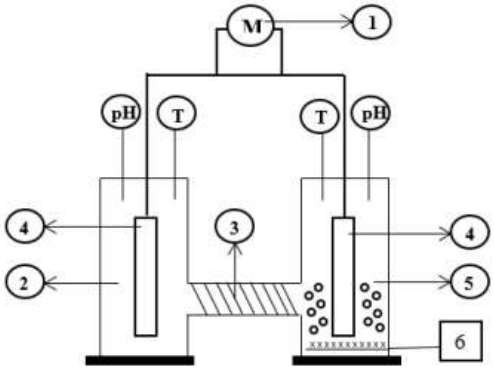
Tools that will be needed:

- Test tube rack and test tube

- Dropper Pippete
- Erlenmeyer
- Beaker
- Measuring Cylinder
- Multimeter (voltmeter dan ampermeter)

3.3. Method of Research

The data collection method was carried out experimentally by preparing 2 main sources, namely the substrate from polluted water from the Citarum river and the design of the MFC device which was stated in the following scheme.



Picture 3.1. Design of Microbial Fuel Cell

Design description :

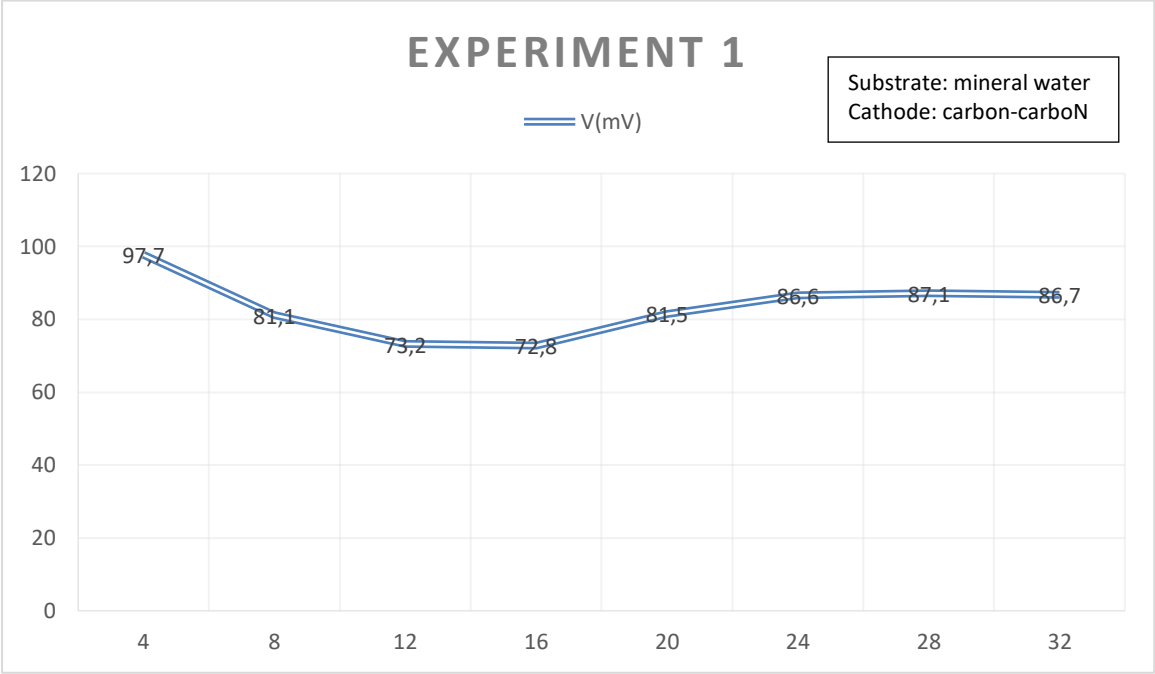
1. Multimeter (Voltmeter/Amperemeter)
2. Anode Chamber (anaerobic) (bacteria and organic waste)
3. Salt bridge
4. Electrode
5. Cathode Chamber (aerobic) (ferricyanide solution)
6. Aerator

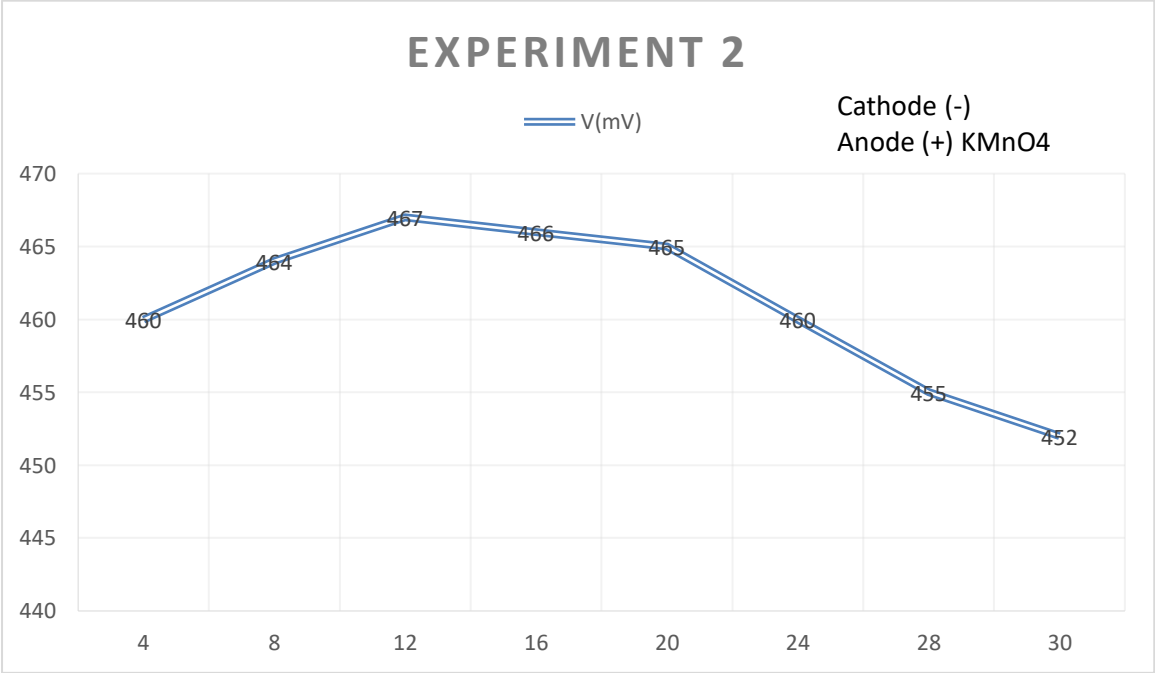
3.4. Data Processing and Analysis Method

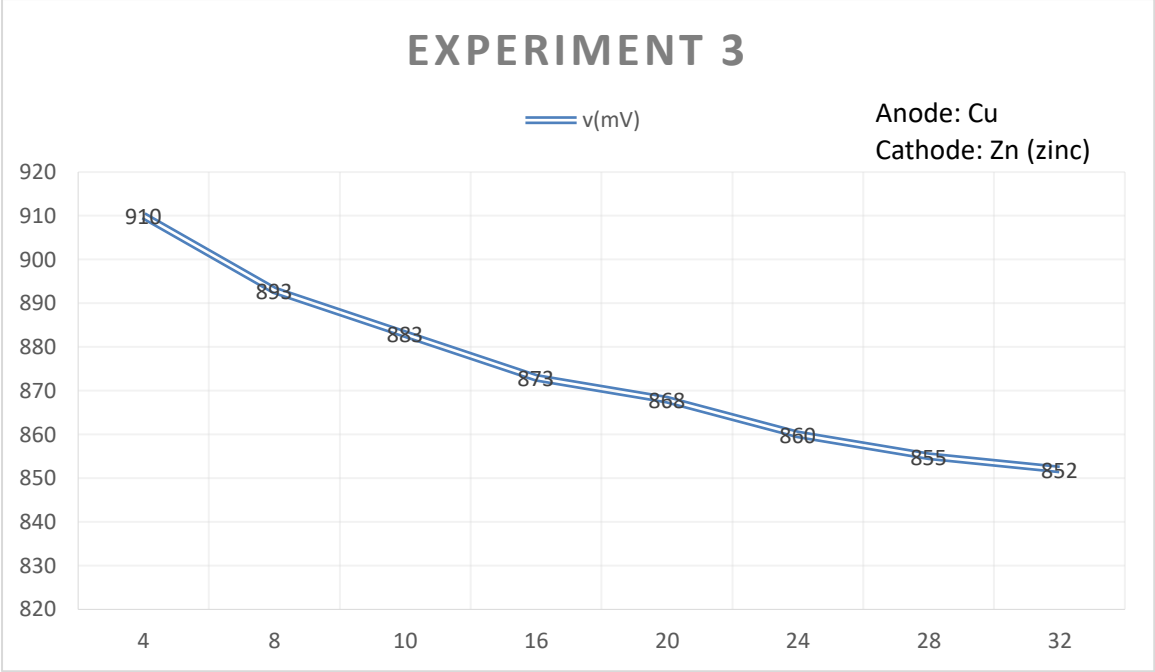
The first step in performing data processing is the analysis of Ph. The pH measurement was carried out using an alcohol thermometer inserted into the cathode and anode chambers. A digital multimeter was connected to the two electrodes, with a positive pole at the cathode and a negative pole in the anode chamber. Voltage and current readings are recorded every 24 hours. From the current and voltage strength data, the power density (mW/m2) value can be obtained, which is power per unit area of the electrode surface. Power density can be calculated using the following equation (Momoh et al, 2010).

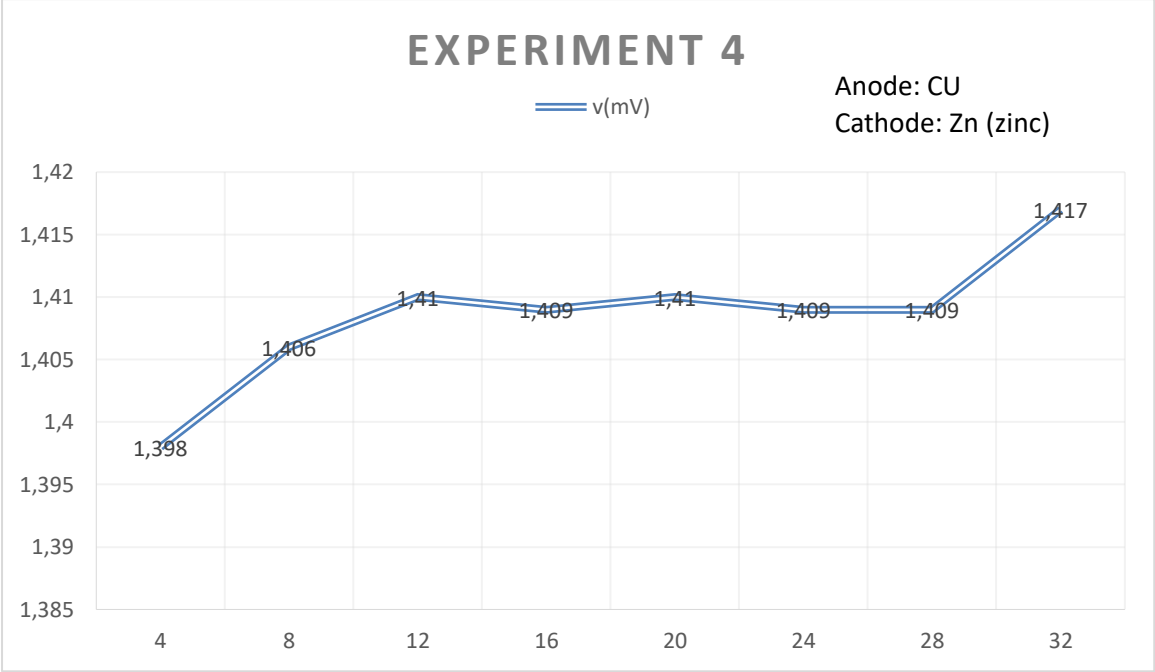
$$Power\ Density\ (mW/m^2) = \frac{I\ (mA)\ x\ V\ (mV)}{A\ (m^2)}$$

Where I is the current, V is the potential difference and A is the surface area of the electrode






EXPERIMENT 3
v(mV)
Anode: Cu
Cathode: Zn (zinc)
920
910
900
890
880
870
860
850
840
830
820
910
893
883
873
868
860
855
852
4
8
10
16
20
24
28
32


EXPERIMENT 4
v(mV)
Anode: CU
Cathode: Zn (zinc)
1,42
1,415
1,41
1,405
1,4
1,395
1,39
1,385
1,398
1,406
1,41
1,409
1,41
1,409
1,409
1,417
4
8
12
16
20
24
28
32

BAB V
CONCLUSIONS AND SUGGESTIONS

a. Conclusions

From this experiment, it can be concluded that the method of obtaining data by means of an experiment that prepares 2 main sources, namely the substrate from polluted water of the Citarum river and the design of the MFC device can produce electrical energy. This is proven and obtained through the table of 4 experiments above. From experiments conducted using three subjects and two different pairs of electrodes. It was concluded that the results that produced electricity were more stable when mineral water was used as the substrate and carbon as the cathode. However, so that the results obtained are more efficient, it is recommended to use Cu - Zn as the electrode.

b. Suggestions

From the research that has been done, the researcher suggests several things:

1. Also try to do this research while trying to use other solution
2. This research can not only be carried out using Citarum river water as the main ingredient, but can also use other polluted river water.
3. Use new electrodes (Carbon – Carbon or Cu – Zn) for more efficient results and reactions.

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The research topic is interesting and the concept is innovative for solving water pollution problems and generating electricity. However，presentation and interpretation of the data collected should be systematic.