Kaunia, Vol.XII, Num.1, April 2016, pp. 23~28
ISSN 1829-5266 (paper), ISSN 2301-8550 (online)
Available online at http://ejournal.uin-suka.ac.id/saintek/kaunia

Acid Mine Drainage Water For Alternative Electrical Energy Sources

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Abstract

Acid Mine Drainage (AMD) refers to the outflow of acidic water from metal mines or coal mines. AMD has high acidity, which has potency for conductor. The aim of this research was to demonstrate the ability of acid mine water as an alternative conductor of electrical energy. The research revealed that 500 ml AMD could supply 1,5 watt lamp for 30 days.

Keywords: Acid Mine Drainage, Electric source, alternative energy.

Introduction

Acid mine drainage, acid water containing metal or acid and metalliferous drainage (AMD) refers to amount of acidic water from metal mines or coal mines.

Acid Mine Drainage water is acidic water (pH 7) and it is formed as a result of mining activities. Acid Mine Drainage has a have negative impact for environment as well as community both directly and indirectly, if not managed properly.

The formation of acid mine drainage can not be avoided in the coal mining operations. This was due to dismantling of rock in mining process. It will form acid mine drainage.

Acid mine drainage is a solution that contains a strong acid. Therefore, this study was conducted to test whether the acid mine water can generate electricity. It could be a new alternative energy source from acid mine drainage into something more useful as a new alternative energy.

Study Literature

Acid Mine Drainage

Acid mine drainage is a general term used to describe leachate, seepage or flow (drainage) that have been affected by natural oxidation of sulphide minerals contained in rocks that are exposed during mining activity.

Rocks containing sulphide minerals can be exposed at the surface as a result of land clearing or demolition of rock during mining progresses. Mineral sulfide is oxidized to form the oxide compounds and when it comes in contact with water (rainwater or groundwater) to form iron (II) sulphate and sulfuric acid. The acidic water if not neutralized will cause acid mine water flow into the surrounding environment and can cause environmental pollution.

Acid mine drainage can occur on mining in both the open pit mine and an underground mine. Moreover, it can also come from activities hoarding material and processing activities. In general, this situation occurs because the elemental sulfur contained in the rock naturally oxidized sulphide. Furthermore, the condition of rainfall is quite high and dilution will occur, causing the formation of acid mine drainage. The formation of acid mine drainage at the mine site would have a negative impact on the environment. As for the negative impact of acid mine drainage, among others, as follows:

a. Communities around the mining area.
   Acid mine drainage on humans are having an impact that is quite dangerous. Heavy metals contained in acid mine water is highly toxic (poisonous to living things. If it gets into the body, heavy metals will undergo bioaccumulation or stay inside living tissue and can move through the food chain. In the human body, copper (Cu) can lead to depression, affects the liver and kidney function and cause a vascular disorder.
b. Aquatic biota.
   The negative impact on aquatic biota is the changing diversity of marine organisms such as plankton and benthos. Benthos presence in a body

of water can be used as an indicator of water quality. In an uncontaminated waters benthos will abundance. In contrast, contaminated waters will not be suitable for benthos. In addition to living thing, acid mine drainage may affect flora and fauna on mined land and organism along the rivers.

c. Surface Water Quality.
   The formation of acid mine drainage results pyrite oxidation will lead to decreased quality of surface water. Water quality parameters that are changing are Ph, dissolved solids, suspended solids, COD, BOD, sulphate, iron, and manganese.
d. Soil Quality.
   Heavy metals such as iron, copper, and zinc are contained in many acidic soil, which is basically a micro nutrients that plants needed, while the macro nutrients, such as phosphorus, magnesium, and calcium is far less. Poisoning in plants because of excess in micro-nutrients, is characterized by decay of plant roots.

Negative impact caused by acid mine drainage can be minimized is by doing proper management of the acid mine water that has formed (Gautama, 2012).

Figure 1 Acid mine drainage of PT. Bukit Asam (Persero), Tbk.

Electrolysis Reaction

The solution is a mixture that is homogeneous or uniform. If 2 tablespoons white sugar (granulated) dissolved in a glass of water, it will get the sugar solution. The solution can be classified as the electrolyte solution and non-electrolyte solution. Meanwhile, the electrolyte can be grouped into the strong electrolyte solution and weak electrolyte solution.

Electrolyte solution is a solution formed from the electrolyte substance. Meanwhile, the electrolyte substance itself is a substance that decomposes in water to form ions. Electrolyte substance decomposed in the water are called strong electrolytes and the solution is a strong electrolyte solution. Electrolyte substance only partially decompose to form ions in water are called weak electrolytes and it form a weak electrolyte solution.

Atom or group of atoms called ions electrically charged it. Positive ion are called cations, while negatively charged ions are called anions. Electrolyte solution that conduct electricity. Substances that are classified as electrolytes are acids, bases and salts. Examples of strong electrolyte solution: HCl, HBr, HI, HNO_3, acid mine drainage and others. Examples of weak electrolyte solution: CH_3COOH, $Al(OH)_3$ and Na_2CO_3.Non electrolyte solution is a solution formed from non-electrolyte substances. While non-electrolyte substances themselves are substances that do not decompose in water in the form of ions, but decomposes in molecular form.

In 1884, Svante Arrhenius, famous Swedish chemist put forward the theory of electrolyte hitherto the theory persisted even though he was almost not given her doctorate at the University of Upsala, Sweden, as revealed this theory. According to the Arrhenius, the electrolyte solution in water dissociates into electrically charged particles called positive and negative ions (positive ions and negative ions). The number of positive ionic charge will be equal to the charge of negative ions, so that the charge of ions are neutral in solutions.

A solution that can conduct electric current is called an electrolyte solution. This solution provides symptom onset form of flaring lamps or gas bubbles in solution. The electrolyte solution containing charged particles (cations and anions). Based on experiments conducted by Michael Faraday, an electric current flowed into the electrolyte solution will be a process of electrolysis which produces gas. These gas bubbles are formed due to the positive ions undergo reduction reaction and negative ions undergo oxidation. For example, in a solution of HCl electrolysis reaction that produces hydrogen gas as follows :

$$HCl_{(aq)} \rightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$$

Reduction proccess:

$$2H^{+}_{(aq)} + 2e^{-} \rightarrow H_{2(g)}$$

Oxidation proccess:

$$2Cl^{-}_{(aq)} \rightarrow Cl_{2(g)} + 2e^{-}$$

Electrolyte solution consists of a powerful electrolyte solution for example HCl, H_2SO_4, and a weak electrolyte solution example CH_3COOH, NH_3, H_2S. Electrolyte solution can be sourced from ionic compounds (compounds that have an ionic bond) or polar covalent compounds (compounds that have a

 ISSN 1829-5266 (paper), ISSN 2301-8550 (online)

polar covalent bond). Electrolyte substance that decomposes in water into ions. Some examples of the electrolyte substance are as follows:

$$NaCl_{(aq)} \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$$
$$HCl_{(aq)} \rightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$$
$$H_2SO_{4\,(aq)} \rightarrow 2\,H^{+}_{(aq)} + SO_4^{2-}{}_{(aq)}$$
$$NaOH_{(aq)} \rightarrow Na^{+}_{(aq)} + OH^{-}_{(aq)}$$
$$CH_3COOH_{(aq)} \rightarrow CH_3COO^{-}_{(aq)} + H^{+}_{aq)}$$

Non electrolyte substances does not decompose into ions, but remains in the form of molecules. Example:

$$C_2H_5OH_{(l)} \rightarrow C_2H_5OH_{(aq)}$$
$$CO(NH_2)_{2\,(s)} \rightarrow CO(NH_2)_{2\,(aq)}$$

Electrochemical cell where oxidation-reduction reaction occurs spontaneously and generate a potential difference is called galvanic cell. In a galvanic cell chemical energy is converted into electrical energy. Galvanic cell also often called Volta cells. Examples of galvanic cell is a battery.

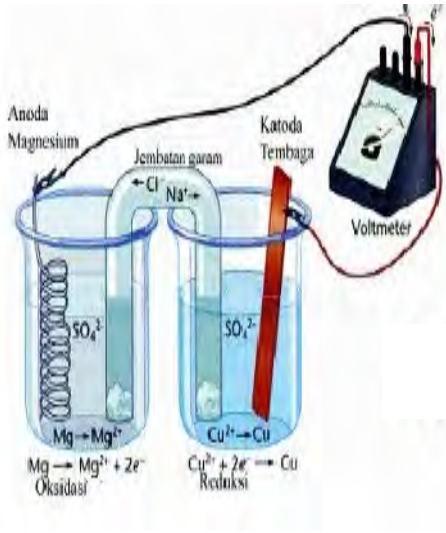


Figure 2 Cells Galvanized Magnesium-Copper (Andy, 2010).

Sometimes the chemical changes that occur in a galvanic cell can be seen easily, such as magnesium-copper galvanic cell shown in figure 2. Because magnesium is more easily oxidized than copper, magnesium loses electrons and is oxidized, forming Mg2. Magnesium anode potential becomes more negative due to the increased pressure of electricity from electrons loose. At the same time, Cu^{2+} ions capture electrons from the copper electrode and is reduced to metallic copper. Copper electrode potential becomes more positive as electric pressure drops when electrons are removed from the cathode. If the cable is connected to the two electrodes, a current flows from the electrode to electrode copper magnesium, and voltmeter on the outside of the circuit will show the voltage 2.696 V.

The energy released by cells can be used to supply the radio by connecting a cable from the electrode to the radio. The overall reaction copper-magnesium cells are redox reactions.

$$Mg_{(s)} + Cu^{2+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + Cu_{(s)}$$

The function of the salt bridge is when half the reaction continues, magnesium ions released into solution at the anode, and copper ions move to the cathode. Ions must be able to move freely between the two electrodes to neutralize the positive charge (cations MG2) is generated at the anode and the negative charge (anion) left on the cathode. Ions in the solution of the salt bridge may neutralize the positive and negative charges in solution and prevent overloading on the electrode. The same redox reaction occurs when the metal magnesium placed directly in a solution of copper sulfate, the reaction is:

$$Mg + Cu_2 \rightarrow Mg_2 + Cu$$

However, this is not a galvanic cell because the electrons do not flow through the external circuit. Electrons move directly from magnesium metal to copper ions, forming metallic copper (Andy, 2010).

Research and Methodology

Time and Location

This research was carried out for 5 months from March to July 2015. The process of making a solution of acid mine drainage and accumulators to the trial were for 2 weeks in PT. Bukit Asam (Persero), Tbk.

Table 1 Research activities schedule.

	Kind of Activity	Week		Location
		1	2	
1	Introduction			PLPT Office PT. Bukit Asam (Persero), Tbk.
2	Sampling in Mud Precipitation Compartement (MPC)			MPC Stockpile 1 Cik Ayip PT. Bukit Asam (Persero), Tbk
3	Content Testing Electrical (CTE)			Electrical Workshop PT. Bukit Asam (Persero), Tbk.
4	Experiments charging to the accumulator			Electrical Workshop PT. Bukit Asam (Persero), Tbk.
5	Experiments accumulators to lamp bulb power stations			Electrical Workshop PT. Bukit Asam (Persero), Tbk.

Completion of paper and liquid batteries reactor for testing electrical conductivity of acid mine drainage is done at Forestry Vocational School of Pekanbaru campus on June 15 to July 23, 2015.

Research Method

This research was done by using R & D (Research and Development) combined with qualitative and quantitative data. The research method carried out by reading the textbook or a scientific journal (secondary data) relating to the rehabilitation techniques of mining, the environmental impact of acid mine drainage and electrical energy in our life. Primary data retrieved by taking samples directly in the area Mud Precipitation Compartement (MPC) and retrieval of documentation directly to acid mine drainage conditions contained in the MPC.

Tools and Materials

The tools are: 4 pieces plastic containers, 1 piece of sandpaper iron, 12 volt accumulator, 6 volt accumulator, Universal Ph, 2 LED lights, 2 Diode LED lights, 5 crocodile cables, 1 needle multimeter, 4 pieces of zinc slab, 4 pieces of copper plates, 12 volt dry battery component, 1000 ml ex-mineral water bottle. The materials are 600 ml acid mine drainage.

Steps of work:

1. Prepare tools and materials to be used.
2. Take 600 ml acid mine drainage PT. Bukit Asam (Persero), Tbk.
3. Prepare 4 pieces of plastic container.
4. Insert the container to acid mine water each 150 ml per container.
5. Insert the right and left on the side of each container 1 plate of zinc (as a positive pole) and one copper plate (as a negative pole) to make a series circuit.
6. Connect each slab zinc and copper wires with alligator clamps.
7. Measure the electrical conductivity respectively zinc and copper plates with a multimeter measuring instrument needle.
8. Connect the cable clamp multimeter alligator with a needle. See how electrical conductivity generated.
9. Then connect the positive and negative poles of the plates was to light the LED diodes.
10. See how long the light that comes out of the LED diode.
11. With the release of light emitting diode LED, it proved to acid mine water can conduct electricity.

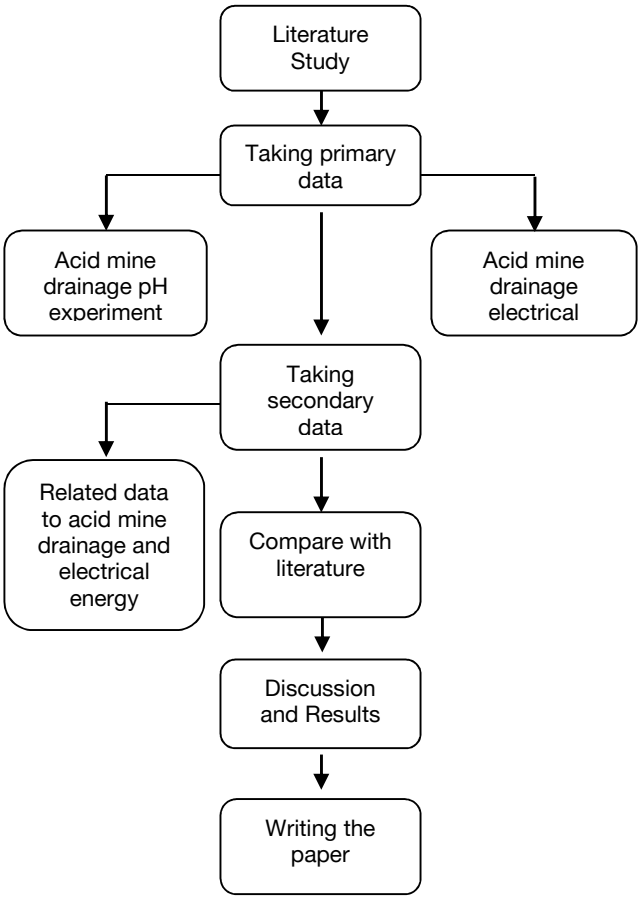


Figure 3 Flow chart of the study.

Results and Discussion

From the experiments, it can be shown that by installing a series of battery liquid containing acid mine water could generate electric current at 3,8 volts using a multimeter needle.

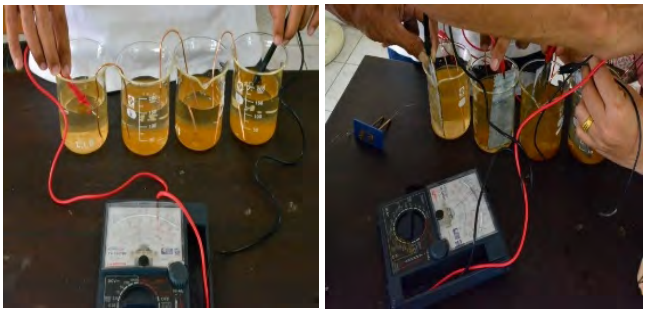


Figure 4 Process of testing electric conductivity of acid mine drainage.

The following is the observation of reactor liquid battery acid mine water containing 500 ml for 30 days from 23th of june at 09.00 pm until 23th of July 2015 at 09.00 pm.

 ISSN 1829-5266 (paper), ISSN 2301-8550 (online)

Table 2 The results of experiments on the reactor liquid battery in turn on the lights.

No	Time	Lights	A Volt difference
1	24 – 28 June 2015	Constant bright flame	3 Volt
2	29 June – 03 of July 2015	Constant bright flame	3 Volt
3	04 – 08 July 2015	Constant bright flame	3 Volt
4	09 – 13 July 2015	Constant bright flame	3 Volt
5	14 – 18 July 2015	Constant bright flame	3 Volt
6	19 – 23 July 2015	Constant bright flame	3 Volt

From the battery installation process liquid in the picture above, 4 pieces of cells that contain acid mine water 500 ml was able to turn the LED diode light at 1,5 watts for 30 days (full month). Each container containing 125 ml of acid mine water using zinc and copper slab which serves for the flow of electric current from one container to another container.

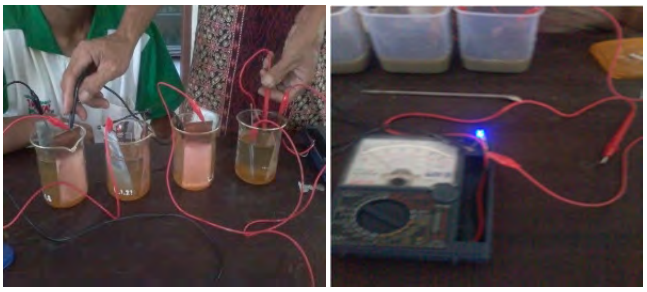


Figure 5 Intallation process reactor.

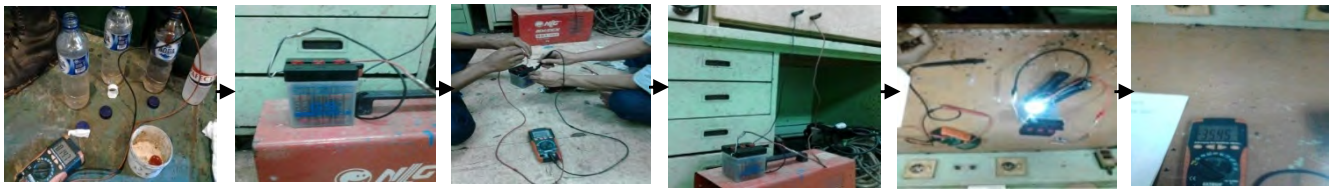
From the experiments, it can be seen that the sewage turns to acid mine drainage potential to be an alternative source of electrical energy. Economically, it can be provent that the waste acid mine water is very beneficial when used by the local community to generate electricity. Acid mine drainage solutions do not reguire special treatment. If a 1. 5 Watt lamp watts for 30 days requires a 500 ml solution of acid mine drainage, then for 12 monts (365 days) require 6 liters of acid mine drainage.

Acid mine drainage is potential solution to be alternative electrical resources. Potential electrical conductivity can be used in daily life such as the accumulator. The following is the observation of the use of a solution of acid mine water as a substitute H_2SO_4 solution to the accumulator.

Table 3 The results of observational studies.

Testing time	Electrical conductivity		Information
	Volt	Amper	
Before charge	2,9 Volt	0 milliampere	There has been no change
One hour after charge	3 volt		Air bubbles begin to form
Two hours after charge	3,3 volt		Bubbles grow
Three hours after charge	3,5 volt		The battery cells begin to change color
Four hours after charge	3,8 volt		Cell battery cells become white
Five hours after charge	4,2 volt	3,9 milliampere	Cell battery cells become white

The table above shows that the battery contains acid mine water before it in charge containing electrical conductivity of 2,9 volts. After charging, the electrical conductivity increase to 4,2 volts battery. This proves that the battery contains acid mine water can conduct electricity well to the 6 volt battery capacity. Therefore, waste acid mine water can be utilized as a source of new alternative energy producing electricity to be used as a solution of the charge battery as well as the presence of this study it is expected that the potential for acid mine water is quite abundant in coal mines be utilized as much as you to support sustainability a better environment and sustainable energy development.



Battery charging solution (Before Charge)

Testing electrical conductivity

Testing with light (after charge)

Conductivity with the unit miliampere after

Figure 6 Groove trial testing.

Acid mine drainage is a kind of solution containing high concentrations of acid. Based on the theory of acids and bases, the acidic nature can cause corrosiveproperties (rust) on a slab of iron, steel and nickel. In tehe reactor, there is a slab of lead dioxide and pure lead in stacking each have an insert to form one pair of accumulator cells adjacent to each other and separated by an insulating material such as an insulator. If the acid mine water is introduced into the accumulator, then the long run will appear events occurring corrosion on the plates of lead dioxide and pure. Consequently, will affect the quality of acid mine water as filler such accumulator. Then, need the addition of soda ash ($Ca(OH)_2$) to neutralize the acid contained in the solution of acid mine drainage . The neutralization reaction is :

$$CaCO_3 + H_2O \rightarrow Ca(OH)_2$$

Below is an accumulator treated with the addition of soda ash ($Ca(OH)_2$).

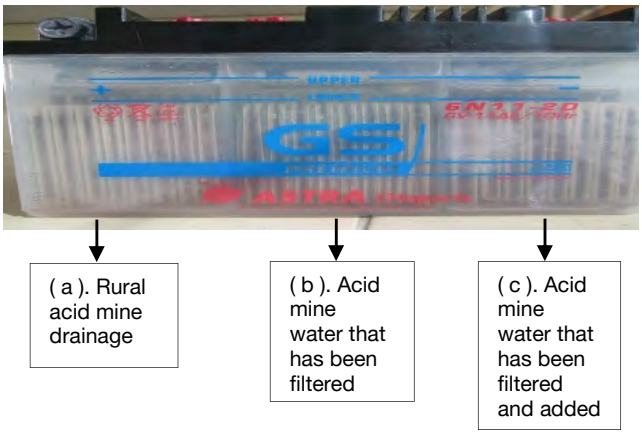


Figure 7 The accumulator by three types of treatment.

Shown in the image above that the treatment of acid mine (a) acid mine drainage that inserted into the accumulator causing rusting. This is caused by the nature of acid mine water acidic and corrosive. In treatment (b) acid mine drainage that is inserted into the accumulator experienced rusting fewer compared to the treatment (a). This is caused by mine water filtering process by using filter paper will reduce the degree of acidity so the corrosive nature of the acid mine drainage can reduce. The treatment of (c) can be seen on the plates of zinc and copper in the accumulator does not undergo rusting. This is because the acid mine water that has been coupled with soda ash ($Ca(OH)_2$), the nature of the acid mine drainage can be neutral and soda ash to reduce corrosion caused by acid mine water when used as a replacement H_2SO_4 solution for accumulator. This prove that the nature of soda ash can reduce corrosion caused by acid mine water when inserted into the accumulator, but does not affect the electrical conductivity of the solution.

Conclusions

From the research that has been done, it can be concluded :

Based on the result of this study, acid mine water that has a high level of acidity that it can conduct electricity. Acid mine drainage solution of 500 ml is able to turn lights LED diodes 1,5 watt for 30 days (full month). When used for a full year (365 days) reguired 6 liters of a solution of acid mine drainage. Acid mine drainage can also be used as H_2SO_4 solution for accumulator. Therefore the acid mine drainage potential to be an alternative source of electrical energy.

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