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Post-mining Water Management Using Macrophytes and Substrate Media

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Abstract: Feldspar mine may cause environmental problem. Post-mining lake water pollute the environment because it has a low pH containing heavy metals such as aluminium (Al). The research objective was to analyze the effectiveness of water quality changes using *Eichornia*sp and Thypaangustifolia plants with organic substrates, and to analyze the results of water quality management based on wastewater quality standards. The results showed that the treatment using water from pit lake + material pit lake + clumps of Thypaangustifolia + organic substrate was declared effective in increasing pH and reducing TSS and dissolved metals at 15 days of treatment, indicated by a pH value of 6.7-7.04, a TSS value of 1,710 mg/l to 108 mg/l, and decreased grade Al from 233.0975 mg/l to 190.77 mg/l. The quality standard for Al dissolved metal management has not reached the waste water quality standard, while the results of pH and TSS management are in accordance with the quality standards stipulated with the provisions concerning the wastewater quality standard.

Key words: Post-mining, passive remediation, water quality.

1. Introduction

Open pit mining activities can produce post-mining lakes (pit lakes). Pit lake has a negative impact on the environment, associated with sulfides oxidized by water and oxygen [1-3]. Dissolved metal content is the result found in oxidized minerals [4-7]. Sulfide minerals are exposed to oxygen and the presence of water as a medium for decomposing dissolved metals, causing oxidation to produce acidic water containing sulfur and releasing dissolved metals [8-10].

One way of managing water is passively. The important components of passive processing are water plants and organic substrates. Water plants that have been studied to be effective for water management are *Eichornia*sp and Typha angustifolia because they can neutralize pH and are able to absorb heavy metals from contaminated solutions. Typaangustifolia grows in swamps with water levels of 53-80 cm [11]. This species supports the wetland wastewater treatment system and has a positive effect in reducing Cu values up to 90%, Fe and Mn up to 80% [12]. Whereas organic substrates can increase the pH obtained from the alkalinity content of compost [13].

This study analyzed the effect of *Eichornia*sp and Typha angustifolia plants with organic substrates in changing water quality so that the utilization of pitlake water quality could be evaluated.

2. Objective

The purpose of this study is to analyze the effectiveness of the ability of *Eichorniasp*, Typha angustifolia and organic substrates in changing the quality of pitlake water based on the quality standards of wastewater.

3. Methods and Material

The research location is the feldspar mining area in Bukit Ragas, Clering Village, Jepara Regency, Central Java Province, Indonesia. Based on the survey results, the research area is several pit lakes with a lake depth

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of about 1-5m. This study uses experimental methods to examine the effect of treatment on research subjects [14]. The experimental method used *Eichornia*sp and Typha angustifolia plants and organic substrates. The experimental method was carried out in the field by making artificial ponds filled with water from ex-feldspar mining holes. Another activity is to determine the measure of the effectiveness of water quality management.

Before the experimental activities were carried out, the *Eichornia*sp and Typha angustifolia plants were collected and acclimatized. Cleaning plants with water has the aim of removing dirt on the roots of the plant. The next activity is to carry out the plant acclimatization process by placing the plants in a water pond. The plant acclimatization stage was carried out by growing the plants in plain water for 7 days. The purpose of plant acclimatization is to stabilize and adapt to new environmental conditions to start the waste treatment process [15,16]. Next is to make an organic substrate from cow dung and pit lake material.

The experimental pond was built near the mine pit manually. The size of the artificial pond is 100 × 100 × 50 cm, the volume of water is 350 liters, and the water level is 35 cm. The artificial pond is given different treatments. Finally, the treatment used water plant media *Eichornia*sp and Typha angustifolia and organic substrates using several treatments (see Fig. 1)

Explanation:

A1: Control 1 = Water from pit lake + Material from pitlake;

A2: Control 2 = Water from pit lake + Material from pitlake + 4 kg of organic substrate;

B1: Treatment B1 = Water from pit lake + Material from pit lake + 25 Clumps of Thypaangustifoliaplants;

B2: Treatment B2 = Water from pit lake + Material from pitlake + 25 Clumps of Thypaangustifolia plants + 4 kg of Organic Substrate;

C1: Treatment C1 = Water from pitlake + Material from pitlake + 25 Clumps of *Eichornia*sp;

A1	A2
B1	B2
C1	C2

Fig. 1 Pond treatment design.

C2: Treatment C2 = Water from pitlake + Material from pitlake + 25 Clumps of *Eichornia*sp + 4 kg of organic substrate.

This study used the residence time variable to evaluate the effectiveness of increasing pH and decreasing dissolved metals in artificial ponds. Observations of residence time and sampling were the 3rd day, 6th day, 9th day, 12th day and 15th day. Previous studies stated that residence time has an effect on heavy metal absorption and pollutant removal by plants [17].Testing of water quality parameters in this study were pH, TSS and Al. Evaluation of the effectiveness of increasing pH, reducing heavy metals and determining water quality is based on applicable regulations.

4. Results

The former feldspar quarry hole is the result of artisanal mining activities. Until now the holes in the quarry have not been specially handled. The age of the quarry holes varies from 2-5 years. The total area of the quarry hole is 5.3 hectares with a depth of 1-5 m. The volume of water from the quarry hole is around 108,062 m^3. Table 1 shows the water quality in the former feldspar quarry holes.

The water quality in the former feldspar quarry holes pollutes the environment and has high grade Fe and Al metals. The high level of pollution requires treatment. This study evaluated water quality using *Eichornia* sp, Typha angustifolia media and organic substrates. Fig. 2 shows the change of pH in each treatment.

Table 1 Water quality of pit lake.

Parameter	Quality standards	Test results
pH	6-9	6.7
TSS	200 mg/l	1,710 mg/l
Al	0.2 mg/l	233.1 mg/l

There was no increase of pH in treatment A1, because A1 was the control. Treatment A2 was able to increase the pH value for each treatment day until it was closer to neutral. This proves that the organic substrate is active in neutralizing the quality of acid mine drainage. Organic substrate in the form of cow dung can stimulate plant growth. This substrate has a function to increase alkalinity or increase pH [18]. In B1 treatment (*Eichornia*sp), there was an insignificant change in pH, changing about 0.08 for 15 days. In B2 treatment with Typha angustifolia plants and organic substrates, it was able to increase the pH value to neutral for 15 days. This shows the fluctuation in pH concentration. The cause of pH fluctuation is a passive processing system using the activity of living plants [19]. Up to 15 days, C1 treatment (*Eichornia*sp) increases the pH value up to 6.78. The C2 treatment (*Eichornia*sp and organic substrates) increased the pH value to near neutral (6.95) for up to 15 days.

Fig. 3 shows the change in TSS in each treatment.

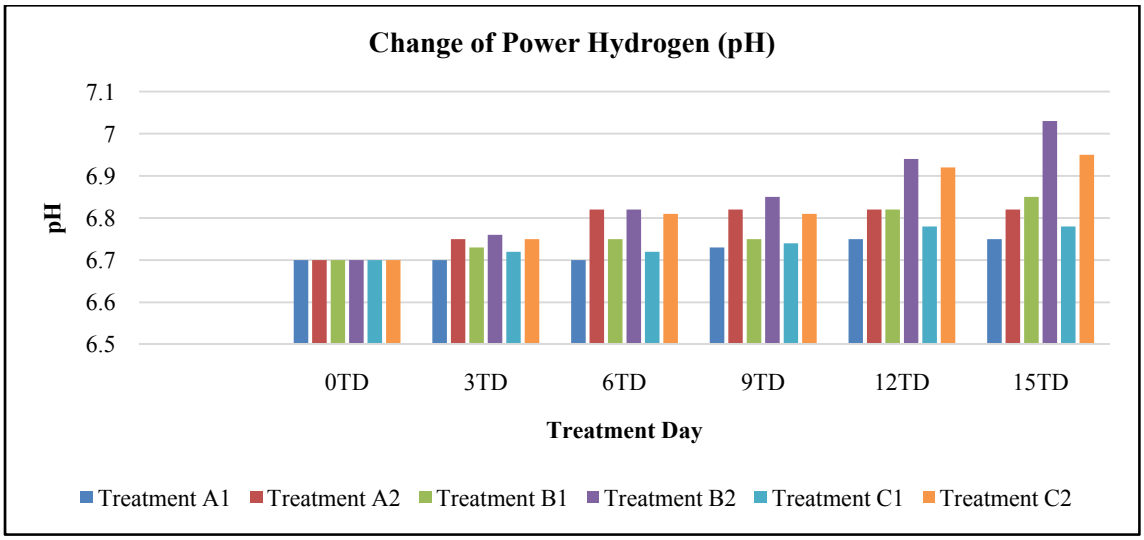

Fig. 2 Change of pH.

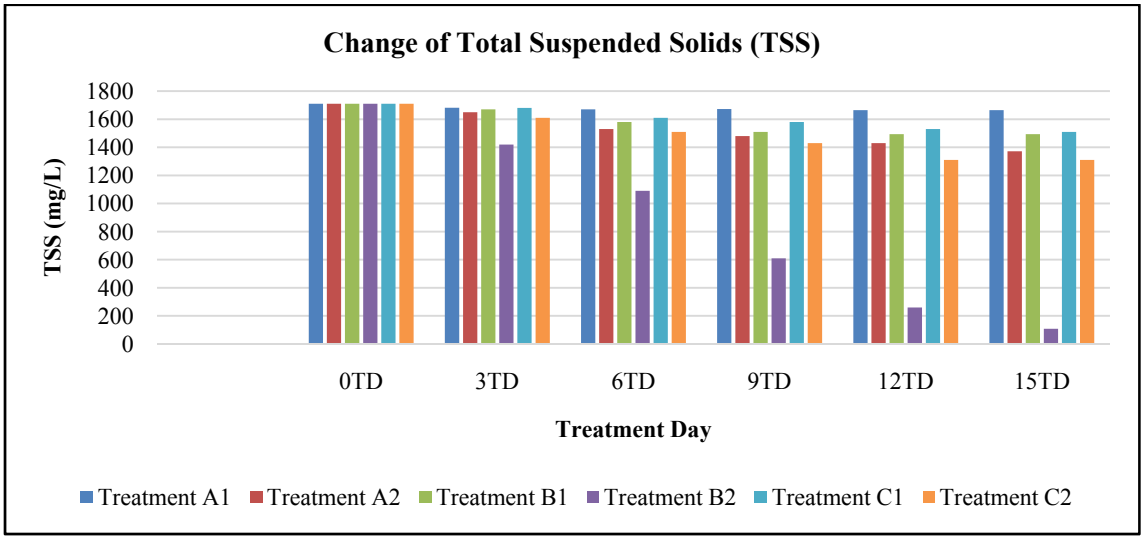

Fig. 3 Change of TSS.

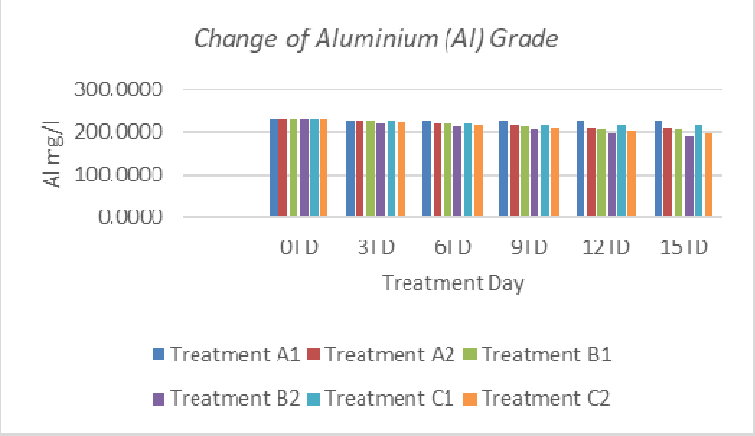

Fig. 4 Change of Aluminium Grade.

Treatment A1 did not change the TSS value significantly, because treatment A1 was a control. Treatment A2 (organic substrate) was able to reduce TSS values up to 1,372 mg/l on 15 days of observation. The result of B1 treatment (Typha angustifolia) has changed the TSS value to 1,493 on 15 days of observation. This yield is lower than A2 (organic substrate) treatment. In the treatment of B2 (Typha angustifolia) using an organic substrate showed a change in TSS value to 108 mg/l at 15 days of observation. Treatment C1 (*Eichornia*sp) was able to reduce TSS to 1510 mg/l. Treatment of C2 (*Eichorniasp*) using organic substrate within 15 days of observation reduced TSS to 1,310 mg/l. Based on these results, the organic substrate had an effect on reducing TSS.

Fig. 4 shows the change of Al grade in each treatment.

Grade Al did not decrease significantly in A1, because there was no treatment. In A2 treatment, the decrease in Al dissolved metal was greater than the control. These results prove that giving organic substrates improves water quality by increasing pH and decreasing dissolved metal levels. Microorganisms absorb heavy metal contaminants. In B1 treatment, Typha angustifolia plants absorbed heavy metals Al. The decrease in grade Al reached 28.1 mg/l within 15 days of observation. Decreased grade Al up to 90.76 mg/l in treatment B2. Typha angustifolia and sulfate reducers remove contaminants. The method of removing contaminants is to multiply the microorganisms in polluted water. Treatment B1 was slower to reduce Al levels compared to treatment A2. Typha latifolia, Typha angustifolia, Phragmintes australis and several Bulrush species are the best plants for wetland construction. These plants absorb up to 90% of metals [20, 21]. Treatment C1 was able to reduce Al metal up to 215.98 mg/l for 15 days of observation. This value is greater than the control. These results prove that *Eichornia* sp. Absorb heavy metals. *Eichornia* sp absorbs dissolved metals in wastewater, therefore this plant reduces pollution [22]. In C2 treatment showed a decrease in grade Al to 198.42mg/l. Sulfate reducers in C2 treatment (*Eichornia* sp) reproduce these microorganisms in polluted water.

Table 2 shows the results of evaluating the effectiveness of each treatment.

Table 2 shows the B2 treatment: water from pitlake + pitlake material + 25 clumps of typha angustifolia + 4kg organic substrate has a high effectiveness value.

Table 2 Percentage of Treatment Effectiveness.

Parameter	Treatment					
	A1	A2	B1	B2	C1	C2
pH	1%	2%	2%	5%	1%	4%
TSS	3%	20%	13%	94%	13%	23%
Al	3%	9%	12%	18%	7%	15%

Table 3 Comparison of Waste Quality Standards and Treatment.

Parameter	Unit	Quality Standards	Treatment B2
pH	-	6-9	7.03
TSS	mg/l	200	108
Al	mg/l	0.2	190.77

Table 3 shows pH and TSS parameters (B2 treatment) have met the wastewater quality standard. The table shows that dissolved metal Al (in treatment B2) has not met the quality standard because the content of dissolved Al metal in the post-mining feldspar hole water is very high.

5. Conclusion

Based on the results of the study, it is concluded as follows:

1. Water quality management of post-mining lakes using *Eichornia*sp with organic substrates is not effective, while the use of Typha angustifolia plants and organic substrates is effective in increasing pH and reducing TSS and dissolved metals.

2. The results of treatment for Al dissolved metal do not match the quality standards of wastewater, but the results of pH and TSS management are in accordance with the wastewater quality standards.

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