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Comparison of Characteristic Aquatic Local Plants for Phytoremediation with Different Media of Acid Mine Drainage Passive Treatment

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ABSTRACT

Acid mine drainage treament using more passive methods to reduce costs and be more environmentally friendly. This passive method is to drain the acid mine water in wetlands that have been built with a suitable plant to neutralize the acid mine water and also to absorb the dissolved metal. The purpose of this study to determine the types of aquatic local plants suitable as a medium phytoremediasi and also to the extent to which organic matter compost/*bokashi* can increase pytoremediasi acid mine water compared to using the original medium acid mine drainage. Also to comparison result of the best one aquatic plants for phytoremediation, and than the plants selected will using for aerobic wetland of acid mine drainage passive treatment. The method used is sampling the a aquatic local plants at the mine and planted in acid mine drainage media and using 11 aquatic plants consist of 3 kinds as : Emergent, floating leaf and submersed with 2 design (with add organic matter and without organic matter). The research results shown the design 2 (with organic matter on media) better than for Imprved pH and reduce metal Fe and Mn from acid compare with design 1 (without organic matter on media. Design 2 can improved pH average 131% from 2.54 to 5.86 and reduced Fe Average 54% from 3.00 ppm to 1.38 ppm, than reduced Mn 76% from 27.1 ppm to 6.48 ppm.This study shows that the local plant in the vicinity of the coal mining could be phytoremediasi plant in the treatment of acid mine drainage passive. Taro red (Colocasia esculenta- red), Kale Water (Ipomea aquatic), Water plants (Hydrilla Sp), Lotus (Nymphaea lotus L.) recommended for aerobic wetland system to passive treatment acid mine drainage for improvement pH level and reduced metal as Fe and Mn on acid mine drainage water.

KEYWORDS: acid mine drainage, acid mine drainage characteristics, passive management, phytoremediation, heavy metals.

INTRODUCTION

The advantages of this passively processing according [1] as follows: It is cheaper, does not require mechanical devices, hazardous chemicals and building, requiring no electricity, operation and maintenance is not every day, more natural to the environment and help the growth of plants and ecosystems around it. Management of passive acid mine drainage is a simple method and its use of low-cost management [2] and has been a proven way to increase the population of bacteria and improve water quality [3] and is used in many countries such as in Turky [4], South Korea has been built from the year 1996 to 2002 with the SAPS method (successive alkalinity producing systems) [5], South Africa [6], the Chinese use a system of SRB (sulfate - reducing bacteria) reducing the acidity of the water from pH 2.75 to 6:20 and remove Fe^{2+} by 86% [7].

Hiperakumulator plants as heavy metals are: Plants that have the ability to concentrate metals in unusually high levels. Some water plants and many species are able to accumulate metals in heavy metal contaminated waters [8]. The use of plants as agents of recovery polluted environment, quoting from the U.S. energy department report, [9] suggests the following prerequisites:1). Accumulation rate should be high even at low environmental levels of contaminants.2). Ability to accumulate high levels of contaminants.3).Ability to accumulate various kinds of heavy metals.4). Grow fast,5). High biomass production,6). Resistant to pests and diseases.

The term is derived from the English word phytoremediation; This word itself is composed of two parts of the word , iephyto derived from the Greek word python (= " plant ") and remediation derived from the Latin word remedium (= " cure " , in this case also means " solve the problem by repairing faults or shortcomings ")

Phytoremediation can be defined as: the use of plants to remove, transfer, stabilize, or destroy contaminants both organic and inorganic compounds Fitoremedasi also the use of plants to absorb and accumulate toxic substances from the soil. Phytoremediation systems is a system where certain plants , either alone or in cooperation with microorganisms in the growing media , can transform contaminants into less harmful or not, the concept of phytoremediation to heavy metals have also been believed and applied in other Asian countries such as Pakistan [10]. Most advantages in the use of phytoremediation is less expensive operating costs when compared to conventional treatment such as incineration , soil washing system based

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chemical and energy required . The basic principle of this technology is phytoremediation of contaminated soil to recover, repair sludge, sediment and ground water through a process of displacement, degradation or stabilization of a contaminant.

Natural ecosystem functions of Organic Matter is present throughout the ecosystem. After degrading and reacting, it can then move into soil and mainstream water via waterflow. Organic matter forms molecules that contain nutrients as it passes through soil and water. It provides nutrition to living plant and animal species. Organic matter acts as a buffer, when in aqueous solution, to maintain a less acidic pH in the environment. The buffer acting component to be crucial for neutralizing acid rain [11] Organic matter infiltrating into the subsurface from rivers, lakes, and marine systems [12] .

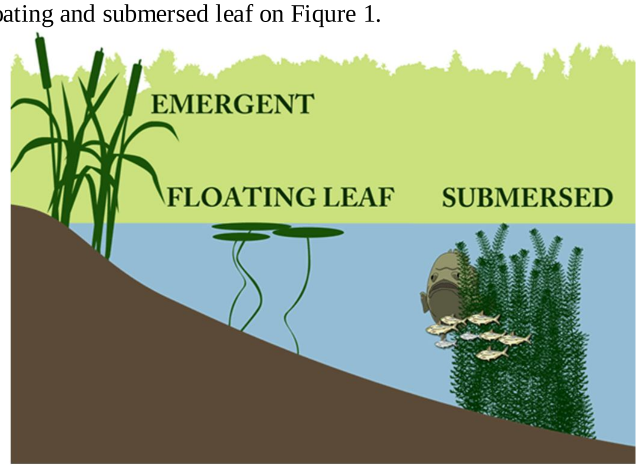
Bokashi means “fermented organic matter/ compost in Japanese”. Bokashi composting uses a selected group of microorganisms to anaerobically ferment organic waste. The microorganisms are applied using a impregnation carrier such as wheat bran. The fermentation process breaks the organic matter down in a process that is odor free. Bokashi fertilizer can to repair the physical, chemical, and biological properties of soil , increase crop production and maintain the stability of crop production , and to produce the quality and quantity of agricultural produce environmentally sound. Bokashi fertilizer did not increase soil nutrients, but only fix the physical, chemical, and biological properties of soil, so it is still necessary inorganic fertilizers [13]. Bokashi fertilizer , such as compost more , can be used to improve the content of organic material in the soil is hard as podzolic soil so that it can improve soil aeration and reduces soil bulk density [13], [14]. Based on the research results [13], addition of bokashi fertilizer made from rice husk can increase the value of liquid limit and plastic limit latosolland , but an increase in plasticity index. Bokashi can also be used to reduce the stickiness of land to plow tools and machinery so as to improve the performance of the tools and machines plow[15].

The purpose of this study was to determine the typesof aquatic plants suitable as a medium phytoremediasi of the 11 types of water plants and also to the extent to which organic matter can increase pytoremediasi acid mine water compared to using the original medium acid mine drainage. Also to comparison result of the best one aquatic plants for phytoremediation, and than the plants selected will using for aerobic wetland of acid mine drainage passive treatment

MATERIALS AND METHODS

Location and Materials

This study uses the method of mini-scale project in the area that had been carried out laboratory perusahanaaPT.Jorong Barutama Greston coal mining in July-August 2012, which is located in District Jorong, Kabupaten Tanah Laut, South Kalimantan Province – Indonesia. Eleven of the plants on this research Consist of 3 category are emergent, floating and submersed leaf on Fiqure 1.



Fiqure1 : Some type of Aquatic Plants (*resources : http://www.lmvp.org/Waterline/volume14num1/plants.html*)

The emergent plant Consist of 7 types as follow: 1. Umbrella grass (*Cyperusodoratus*), 2. Purun Rat (*Eleocharisdulcis*), 3. Velvetleaf (*Limnocharisflava*), 4. Fern (*Stenochlaenapalustris*), 5. Fragrant leaf (*Pandanusamaryllifolius*), 6. White taro (*Colocasiaesculenta*), 7. Red taro (*Colocasiaesculenta*). The plants show on Fiqure 2.

Fiqure 2. 7 of the emergent plant : 1. Umbrella grass (*Cyperusodoratus*), 2. Purun Rat (*Eleocharisdulcis*), 3. Velvetleaf (*Limnocharisflava*), 4. Fern (*Stenochlaenapalustris*), 5. Fragrant leaf (*Pandanusamaryllifolius*), 6. White taro (*Colocasiaesculenta*), 7. Red taro (*Colocasiaesculenta*).

The Floating leaf Consist of 3 types as follow: Lotus (*Nymphaea lotus L.*), water hyacinth (*Echhornicrassipes*), Water Watercress (*Ipomea aquatic*). The plants show on Fiqure 3.

Fiqure 3.The 3 of floating leaf : Lotus (*Nymphaea lotus L.*), water hyacinth (*Echhornicrassipes*), Water Watercress (*Ipomea aquatic*).

The submersed plants just have one type as water plants (*HydrillaSp*).The plants show on Fiqure 4.

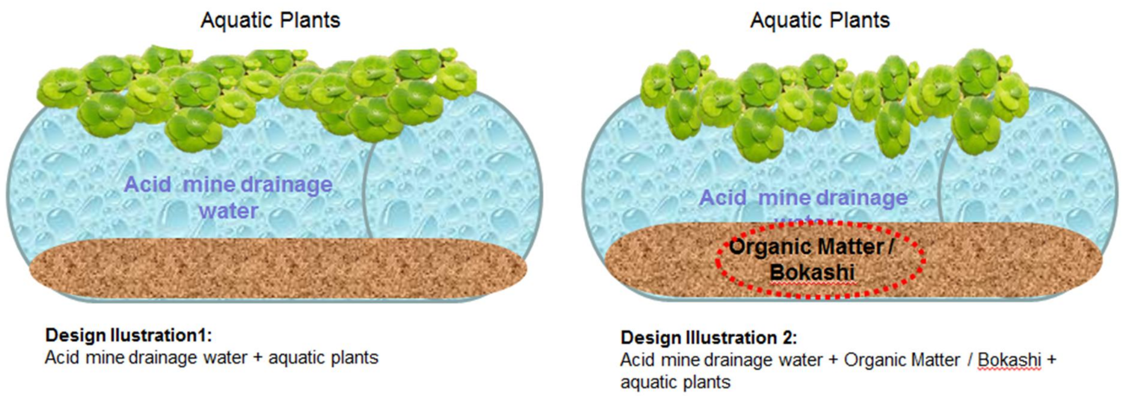
Fiqure 4.The submersed (*HydrillaSp*)

Methods

Acid mine water used for this research came from the void of Pit mining area. We used bucket for medium of testing, every aquactic local plants put on bucket and added acid mine drainage water as Figure. 5 below:

Fiqure 5. Process testing and fiqure on aquatic plants during testing 1 month.

Simulation of this research used 2 design. Design 1 used media as: acid mine drainage water + aquatic plants and Second desingused mediaas: acid mine drainange water + organic matter and + aquatic plants. The design show on the illustration in Figure 6.



Fiqure6.Ilustration Design of Phytoremediation Media.

We use bokashi from local production of mining company community as organic matter/compost on design 2 simulation of aerobic wetland because have some surpluss as follow: Bokashican reduce dependence of farmers on chemical fertilizers and pesticides, Bokashi is eco-friendly and safe for human health because not contain chemical residue, Bokashi can optimize the quality and quantity of agricultural productions, Bokashi is cheap and easy to made by farmers because it uses natural materials from around farmland, Bokashi can improving physical, chemical, and biological of soil, Bokashi provide complete elements required by plant.

Plants treated water tested in two conditions, ie with acid mine drainage medium alone and with added ingredients organk / bokashi as a growing medium with 3 parameters chemical properties pH, Fe, Mn calculated for 1 month left to change the result of acid mine drainage characteristics after ditanamani 11 types of aquatic plants for one month. Monitoring the quality of acid mine water quality after phytoremediation process with 11 aquatic plants during 1 month carried out in the laboratory of acid mine water PT.Jorong Barutama Greston for the parameters pH and Heavy Metal Fe Mn using a Horiba pH meter brands, HACH-DR 2800 Spectrophotometer for measuring metals Fe and Mn, beakers,aquades, *reagent ferrous* (Cat No.1037-69) and *reagent manganese* (Cat No.24300-00).

Data analysis

1. Analysis of the data for the degree of acidity (pH) using graphics will be compared between original water and final result after phytoremediaton 1 month for 11 of kind aquatic plants, the degree of acidity is the activity of hydrogen in water [16]. And also shows the concentration of hydrogen ions (H +) in water. The effectiveness of phytoremediation can be seen from this case due to the low hydrogen ion is the main characteristic of acid mine drainage.
2. Analysis of the data using a graph for metals Fe and Mn to describe the tendency of the change and its relation to water quality standards in accordance with applicable laws and regulations of the department of environmental water used for mining [17]. Water quality standards for pH <6-9, Fe <7 ppm, Mn<4 ppm. These criteria will be comparable to the quality of acid mine water that has been managed through a multilevel process of phytoremediation. Due to the high level of acidity and heavy metal content above the threshold has led to the loss of aquatic biota in a small stream that gets the effects of acid mine water

effluent that without management [18;19;20] and Counting indekx bioremediation for 1 months retention period. Bioremediation index (IBR) is the rate of decrease in the concentration of metals (Fe and Mn) during a certain time period compared to the initial concentration [21].IBR = (Starting concentration – final concentration / starting concentration) x 100%.

3. Comparison Result of design 1 and design 2 for the best ones of phytoremediation process for acid mine drainagepasif treatment with aerobic wetland method.

RESULTS AND DISCUSSION

pH

The results 11 plants consist os 3 kind of aquatic plant as : emergent, floating leaf and submesrsed with 2 design during 1 month an average pH for the parameters shown in Table 1.

Table 1. Measurement of pH of water mine drainage after phytoremediation process with 3 kind of aquatic plants with 2 design in 1 month.

No	Aquatic Plants	pH Design 1	pH Design 2	% ImprovePhDesign 1	% Improve Design 2	Remark
0	**Acid mine drainage water ***	**2.54**	**2.54**	**NA**	**NA**	**C**
1	Umbrella grass (*Cyperusodoratus*)	3.15	7.00	24%	176%	E
2	Purun Rat (*Eleocharisdulcis*)	3.88	2.63	33%	4%	E
3	Velvetleaf (*Limnocharisflava*)	3.36	7.28	32%	187%	E
4	Fern (*Stenochlaenapalustris*),	3.28	3.96	29%	56%	E
5	Fragrant leaf (*Pandanusamaryllifolius*)	3.49	5.42	37%	113%	E
6	Taro white(*Colocasiaesculenta*)	3.23	4.47	27%	76%	E
7	Taro red (*Colocasiaesculenta*)	6.07	7.62	139%	200%	E
	Average E*	**3.7**	**5.5**	**46%**	**116%**	
8	Lotus (*Nymphaea lotus L.*)	7.33	7.78	189%	206%	F
9	Water hyacinth (*Echhornicrassipes*)	2.53	2.64	0%	4%	F
10	Watercress (*Ipomea aquatic)*	3.21	8.17	26%	222%	F
	Average F*	**4.4**	**6.2**	**72%**	**144%**	
11	Water plants (*HydrillaSp*)	2.72	7.46	7%	194%	S
	Average S*	**2.72**	**7.46**	**7%**	**194%**	
	Average E,F,S	**3.80**	**5.86**	**49%**	**131%**	**All**

Remark:
*Acid mine drainage water * = controlling factor for the final aquatic plants phytoremediationresult.*
Average E = Average for aquatic plants of Emergent Type.*
Average F= Average for aquatic plants of Floating leaf Type.*
Average S = Average for aquatic plants of Submersed Type.*
Design 1 = Acid mine drainage water + aquatic plants
Design 2 = Acid mine drainage water + organic matter + aquatic plants
Formula of % improves= (Final phof aquatic plants -pH Controlling / pH Controlling) x 100%.
C = Controlling (acid mine drainage water original) E = Emergent (Type of aquatic plants)
F = Floating leaf (Type of aquatic plants)S = Submersed (Type of aquatic plants)

Table 1. Shows the results of measurements of the pH of the acid mine draianage water after planted by11 types of aquatic plants for phytoremediation proced experimental. Measurements were carried out for 1 month in phytoremediation of acid mine water showed a pH change that is getting better both of design. Design 1 consist of 7 kind of emergent aquatic plants shown average improvement on acid mine drainage % pH improvement as much as 46% from pH 2.54to pH 4.4, floating aquatic plants consist of 3 kind of plants show % pH improvement 72% from pH 2.54 to pH 5.5 and submersed aquatic plant shown % pH improvement 7% from pH 2.54 to pH 2.72. Design 2 emergent aquatic plants shown % pH improvement as much as 116% from pH 2.54 to pH 5.5, floating aquatic plants show % pH improvement 144% from pH 2.54 to pH 6.2 and submersed aquatic plant show % pH improvement 194 % from pH 2.54 to pH 7.46.

Fe

The decrease in the amount of Fe metal (7%) in the process phytoremediasi the wetland system in the study showed that the use of bokashi (organic matter) has a reactive composition which stimulates the growth of sulfate reducing bacteria to raise the alkalinity and set aside in the form of metal sulfide precipitate, Use of sulfate reducing bacteria (BPS): Desulfovibriosp, spDesulfomaculum, sulfate reducing bacteria (BPS) type of Desulfovibriosp and spCarnobacterium can increase the pH within 24 hours, lowering the Fe and Mn within 10 days to achieve efficiency> 81% [22].

The results of measurements on 5 types of plants with 3 replications for 29 days on an average of the results obtained for Fe parameters shown in Table 2.

Table 2. Result Fe (ppm) on water mine drainage after phytoremediation process with 3 kind of aquatic plants with 2 design in 1 month.

No	Aquatic Plants	Fe Design 1	Fe Design 2	IBR Fe Design 1	IBRFe Design 2	Remark
0	**Acid mine drainage water ***	**3**	**3**	**NA**	**NA**	**C**
1	Umbrella grass (*Cyperusodoratus*)	16.00	0.61	-433%	80%	E
2	Purun Rat (*Eleocharisdulcis*)	0.14	4.32	95%	-44%	E
3	Velvetleaf (*Limnocharisflava*)	0.71	0.07	76%	98%	E
4	Fern (*Stenochlaenapalustris*),	0.11	0.36	96%	88%	E
5	Fragrant leaf (*Pandanusamaryllifolius*)	0.18	5.20	94%	-73%	E
6	Taro (*Colocasiaesculenta - white*)	1.05	1.08	65%	64%	E
7	Taro (*Colocasiaesculenta- red*)	0.13	0.02	96%	99%	E
	Average E*	**2.62**	**1.66**	**13%**	**44%**	
8	Lotus (*Nymphaea lotus L.*)	0.20	0.11	93%	96%	F
9	Water hyacinth (*Echhornicrassipes*)	4.54	2.14	-51%	29%	F
10	Watercress (*Ipomea aquatic)*	0.64	0.01	79%	100%	F
	Average F*	**1.80**	**0.75**	**40%**	**75%**	
11	Water plants (*HydrillaSp*)	1.42	1.26	53%	58%	S
	Average S*	**1.42**	**1.26**	**53%**	**58%**	
	Average E,F,S	**2.28**	**1.38**	**24%**	**54%**	**All**

Note :IBR (Index Bioremediasi) = (Starting concentration – final concentration / starting concentration) x 100%.

Table 2. Shows the results of measurements of the Fe (ppm) that can to reduce metal Fe from acid mine drainage after planted by 11 types of aquatic plants for phytoremediation proced experimental. Measurements were carried out for 1 month in phytoremediation of acid mine water showed a Fe change that is getting better both of design. Design 1 consist of 7 kind of emergent aquatic plants shown average improvement on acid mine drainage % IBR Fe improvement as much as 13% from 3 ppm to 2.62 ppm, floating aquatic plants consist of 3 kind of plants show % IBR Fe improvement 40% from 3 ppm to 6.20 and submersed aquatic plant shown % IBR Fe improvement 53% from 3 ppm to pH 1.42 ppm. Design 2 emergent aquatic plants shown % IBR Fe as much as 44 % from pH 3.00 ppm to 1.66 ppm, floating aquatic plants show % IBR Fe 75% from 3.00 ppm to 0.75 ppm and submersed aquatic plant show % IBR Fe 58 % from 3.00 ppm to 1.26 ppm.

Mn

Weakly adsorbed manganese, vulnerable to competition with Fe, Cu and Zn for adsorption sites, and generally require a pH above 8 and excess H_2S to precipitate as carbonate so it is not surprising that manganese is not removed items [37;38]. In addition, Mn does not significantly removed in the bioreactor system in which the ferrous iron concentration exceeds 1 mg / L [23].

Oxidation of abiotic Mn occurs at pH> 8, while microorganisms are expected to catalyze the reaction at pH> 6. Manganese precipitation occurs much more slowly than sensitive to the presence of Fe and Fe^{+2}, which causes the chemical reduction of oxidized Mn. Result in a net alkaline water aerobics, Fe and Mn precipitate sequentially, not simultaneously, suggested aerobic constructed wetland in series if it wants iron and manganese removed at once [24].

The results of measurements on 5 types of plants with three replications in different pools for 29 days on average results obtained for Mn parameters shown in Table 3.

Table3. Result Mn (ppm) of water mine drainage after phytoremediation process with 3 kind of aquatic plants with 2 design in 1 month.

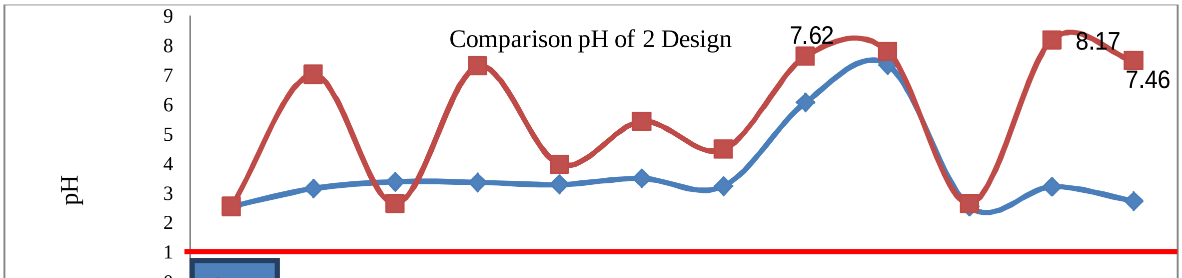
No	Aquatic Plants	Mn Design 1	Mn Design 2	IBRMn Design 1	IBRMn Design 2	Remark
0	**Acid mine drainage water ***	**27.1**	**27.1**	**NA**	**NA**	**C**
1	Umbrella grass (*Cyperusodoratus*)	5.10	0.90	81%	97%	E
2	Purun Rat (*Eleocharisdulcis*)	4.60	27.0	83%	0%	E
3	Velvetleaf (*Limnocharisflava*)	5.40	0.20	80%	99%	E
4	Fern (*Stenochlaenapalustris*),	2.20	1.70	92%	94%	E
5	Fragrant leaf (*Pandanusamaryllifolius*)	2.50	2.40	91%	91%	E
6	Taro (*Colocasiaesculenta - white*)	5.20	7.00	81%	74%	E
7	Taro (*Colocasiaesculenta- red*)	12.70	0.30	51%	99%	E
	Average E*	**5.34**	**5.6**	**80%**	**79%**	
8	Lotus (*Nymphaea lotus L.*)	0.70	0.20	97%	99%	F
9	Water hyacinth (*Echhornicrassipes*)	27.60	27.70	-2%	-2%	F
10	Watercress (*Ipomea aquatic)*	12.40	2.60	54%	90%	F
	Average F*	**13.57**	**10.17**	**50%**	**62%**	
11	Water plants (*HydrillaSp*)	18.40	1.30	32%	95%	S
	Average S*	**18.40**	**1.30**	**32%**	**95%**	
	Average E,F,S	**8.80**	**6.48**	**68%**	**76%**	**All**

Note :IBR (Index Bioremediasi) = (Starting concentration – final concentration / starting concentration) x 100%.

Table 3. Shows the results of measurements of the Mn (ppm) that can to reduce metal Mn from acid mine drainage after planted by 11 types of aquatic plants for phytoremediation proced experimental. Measurements were carried out for 1 month in phytoremediation of acid mine water showed a Mn change that is getting better both of design. Design 1 consist of 7 kind of emergent aquatic plants shown average improvement on acid mine drainage % IBR Mn improvement as much as 80 % from 27.1 ppm to 5.34 ppm, floating aquatic plants consist of 3 kind of plants show % IBR Mn improvement 50% from 27.1 ppm to 13.57 and submersed aquatic plant shown % IBR Mn improvement 32% from 27.1 ppm to 18.40 ppm. Design 2 emergent aquatic plants shown % IBR Fe as much as 79 % from pH 27.1 ppm to 5.6 ppm, floating aquatic plants show % IBR Mn 62% from 27.1 ppm to 10.17 ppm and submersed aquatic plant show % IBR Mn 95 % from 27.1 ppm to 1.30 ppm.

Comparison Result

Ph

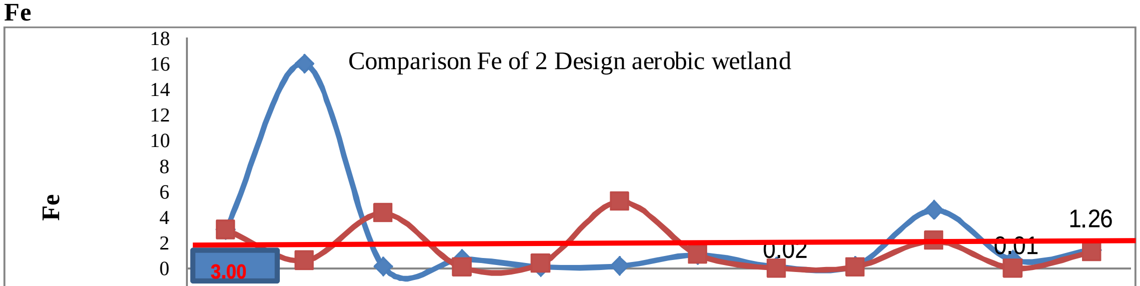


	Drainage water	(Cyperus Odoratus)	(Eleocharis dulcis)	(Limnocharis flava)	(Stenochlaena palustris)	(Pandanus amaryllifolius)	(Colocasia esculenta white)	(Colocasia esculenta red)	(Nymphaea lotus L.)	(Echhorni crassipes)	(Ipomea aquatic)	(Hydrilla Sp)
pH design 1	2.54	3.15	3.38	3.36	3.28	3.49	3.23	6.07	7.33	2.53	3.21	2.72
pH Design 2	2.54	7.00	2.63	7.28	3.96	5.42	4.47	7.62	7.78	2.64	8.17	7.46

Figure 6.Comparison pH result with 2 design phytoremediation media.

Figure 6.Shows a pH comparison for average results of all plants to design 1 and design 2 to phytoremediasi acid mine drainage. Design 2 with organic matter (red line) showed 131% from pH 2.54 to 5.86 betterthan results than design 1 improved 49% from pH 2.54 to 3.80.Emergent of aquatic plants (design 2) shown the best one was Taro red (*Colocasiaesculenta- red*) improved 200% pH from 2.54 to 7.62and than for floating leaf of aquatic plants on design 2 the best one shown by Watercress (*Ipomea aquatic)* improved pH 222% from 2.54 to 8.17. Submersed aquatic plants by Water plants (*HydrillaSp*) on design 2 can improve pH 194% from 2.54 to 7.46.

Fe



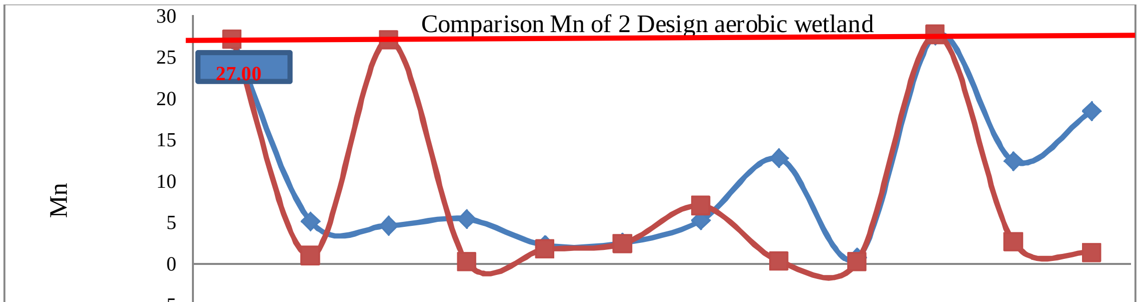
	Acid Mine Drainage water	(Cyperus Odoratus)	(Eleocharis dulcis)	(Limnocharis flava)	(Stenochlaena palustris)	(Pandanus amaryllifolius)	(Colocasia esculenta white)	(Colocasia esculenta red)	(Nymphaea lotus L.)	(Echhorni crassipes)	(Ipomea aquatic)	(Hydrilla Sp)
Fe design 1	3	16.00	0.14	0.71	0.11	0.18	1.05	0.13	0.20	4.54	0.64	1.42
Fe Design 2	3	0.61	4.32	0.07	0.36	5.20	1.08	0.02	0.11	2.14	0.01	1.26

Figure 7. Comparison of Fe at 5 Phytoremediation on aquatic plants.

Figure 7.Shows averagesFe comparison for all plants results of design 1 and design 2 to phytoremediasi acid mine drainage. Design 2 with organic matter (red line) can reduced Fe metal with IBR 54% from 3.00 ppm to 1.38 ppm on acid mine drainage better than design 1 can reduced 24% from 3.00 ppm to 2.28 ppm .Emergent of aquatic plants (design 2) shown the best one for reduce metal Fe from acid mine drainage was Taro red (*Colocasiaesculenta- red*) reduced Fe with IBR 99% from 3 ppm to 0.12 ppmand than for floating leaf of aquatic plants on design 2 the best one shown by Watercress (*Ipomea aquatic)* redued with IBR 100% from 3.00 ppm to 0.01 ppm. Submersed aquatic plants by Water plants (*HydrillaSp*) on design 2 can reduced with

IBR 58% pH from 3.00 to 1.26 ppm. According to [25] water kale (*Ipomea aquatic*) has the potential to absorb 75% of the metal chromium metal and is one of the Asian plants for phytoremediation nomination and is also able to accumulate Pb and metals from polluted water in Thailand without being affected negatively on the plant [26]. Umbrella grass (*Cyperusodoratus*) without organic matter not recommended for phytoremediation plants because can improved Fe 433% from 3 ppm to 16 ppm on acid mine drainage water from original water. The mechanism of the decrease in dissolved metals (Fe, Mn, other), it is possible some of the following: 1) Hydrolisis oxidation and metal that causes metal deposition, 2). Interaction between sulphide produced in the process of sulfate reduction with 2 valence metal (such as Fe^{2+} and Mn^{2+}) to form metal sulfide precipitates. 3). Metal adsorption by organic matter (compost), 4). Metal biosorption process by water vegetation and microorganisms, such as bacteria, fungi, and algae are grown on a layer of organic material/ compost/ *bokashi*[27].

Mn



	Acid Mine Drainage water	(Cyperus Odoratus)	(Eleocharis dulcis)	(Limnocharis flava)	(Stenochlaena palustris)	(Pandanus amaryllifolius)	(Colocasia esculenta white)	(Colocasia esculenta red)	(Nymphaea lotus L.)	(Echhornia crassipes)	(Ipomea aquatic)	(Hydrilla Sp)
Mn design 1	27.1	5.10	4.60	5.40	2.20	2.50	5.20	12.70	0.70	27.60	12.40	18.40
Mn Design 2	27.1	0.90	27.00	0.20	1.70	2.40	7.00	0.30	0.20	27.70	2.60	1.30

Figure 8.Comparison of Phytoremediation 5 Levels of Mn in aquatic plants.

Figure 8.Shows averageMn comparison for all plants results of design 1 and design 2 to phytoremediasi acid mine drainage. Design 2 with organic matter (red line) showed IBR 76% reduced Mn from 27.1 ppm to 6.48 ppmbetter than results than design 1 reduced Mn 68% from 27.1 ppm to 8.80 ppm.Emergent of aquatic plants (design 2) shown the best one for reduce metal Mn from acid mine drainage was Velvetleaf (*Limnocharisflava)* reduced Fe with IBR 99% from 27.1 ppm to 0.2 ppm and than for floating leaf of aquatic plants on design 2 the best one shown by Lotus (*Nymphaea lotus L*.)redued with IBR 99% from 27.1 ppm to 0.2 ppm. Submersed aquatic plants by Water plants (*HydrillaSp*) on design 2 can reduced with IBR 58% pH from 3.00 to 1.26 ppm.Water hyacinth (*Echhornicrassipes*) showed weak phytoremediasi ability to absorb manganese metal with numbers - 2% for the bioremediation of index (index IBR) means, because it is not recommended to s phytoremediation plants.

CONCLUSION

1. The research results shown the design 2 (with organic matter/ *bokashi*/ compost on media) for Imprved pH and reduce metal Fe and Mn from acid mine drainage water better than design 1 (without organic matter on media) for testing 11 of aquatic plant and 3 types of aquatic plant as emergent, floating leaf and submersed. Design 2 can improved pH average 131% from 2.54 to 5.86 and reduced Fe Average 54% from 3.00 ppm to 1.38 ppm, than reduced Mn 76% from 27.1 ppm to 6.48 ppm.
2. pH Improvement can shown the best one by design 2 as follow: emergent of aquatic plants for PhytoremediationisTaro red (*Colocasiaesculenta- red*) improved 200% pH from 2.54 to 7.62and floating leaf of aquatic plants shown by Watercress (*Ipomea aquatic)* improved pH 222% from 2.54 to 8.17. The best submersed aquatic plants improve pH 194% from 2.54 to 7.46.Fe reduced can shown the best one by design 2 as follow: Emergent of aquatic plants isTaro red (*Colocasiaesculenta- red*) reduced Fe with IBR 99% from 3 ppm to 0.12 ppm and than for floating leaf of aquatic plants by Watercress (*Ipomea aquatic)* redued with IBR 100% from 3.00 ppm to 0.01 ppm. Submersed aquatic plants can reduced with IBR 58% pH from 3.00 to 1.26 ppm. Mn reduced can shown the best one by design 2 as follow:Emergent of aquatic plants isVelvetleaf (*Limnocharisflava)* reduced Fe with IBR 99% from 27.1 ppm to 0.2 ppm and than for floating leaf of aquatic plants by Lotus (*Nymphaea lotus L*.) redued with IBR 99% from 27.1 ppm to 0.2 ppm. Submersed aquatic plants by reduced with IBR 58% pH from 3.00 to 1.26 ppm

3. This study shows that the local aquaticplanst in the vicinity of the coal mining could be phytoremediasi plant in the treatment of acid mine drainage passive.Taro red (*Colocasiaesculenta- red*), Kale Water (*Ipomea aquatic*), Water plants (*HydrillaSp*),Lotus (*Nymphaea lotus L.*) recommended for aerobic wetland system to passive treatment acid mine drainage for improvement pH level and reduced metal as Fe and Mn on acid mine drainage water.
4. This research needs to continue to look for new types of plants that can be used as plant phytoremediasi for acid mine drainage and also applied in the field scale for better results.
5. Using Bokashi/organic matter/ compost for phytoremediation of aerobic wetland on acid mine drainage treatment will reduce cost of treatmen, also good relationship for improve the economic of local community and support community development program by mining company for local people.

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