Water Plants Characteristic for Phytoremediation of Acid Mine Drainage Passive Treatment

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***Abstract*— This study aims to determine the best type of local plants as aquatic plants phytoremediation candidate in acid mine water management system with a passive model of wetland / aerobic wetland rise by testing several kinds of local plants around the coal mines as a medium of Phytoremediation. System used multilevel methods to be more effective in lowering the levels of acid, metals absorb capability and in accordance with the characteristics of each of these plants. Local plants used in order to found a new species that is easy to apply in the field and also to reduce costs and also more friendly to the surrounding ecosystem-especially in the coal mining company in South Kalimantan and generally in Indonesia. Management of acid mine water by means phytoremediation using aerobic wetland system to test 5 different water plants as candidates who are at the mine, namely: 1. *Eleocharis dulcis*, 2.*Cyperus odoratus*, 3.*Hydrilla Vercilata*, 4.*Ipomea aquatic*, 5. *Pistia Stratatiotes* with a retention period of each plant for 29 demonstrate the ability to reduce the acid levels in the water to raise the pH of acid mine average of 41% and lower levels of iron (Fe) with an average index bioremediation 7% and lower levels of manganese (Mn) with an average of 19% index bioremediation. The best candidates phytoremediation plants to lower acid levels by raising the pH is Kale Water (*Ipomea aquatic*) to raise the pH of 53%. To reduce levels of iron in acid mine water is to use *Eleocharis dulcis* reduce levels of iron (Fe) 70% to reduce manganese from the water so it is *Pistia Stratatiotes* lower levels of manganese (Mn) as much as 55%.**

***Index Term*—** Acidity **of acid mine drainage, phytoremediation of wetlands, local water plant, metal content of iron and manganese, index bioremediation.**

I. INTRODUCTION

The most common minerals in coal mining is pyrites (FeS2). Prevention of acid mine drainage in coal mining usually by placing material containing pyrites under surface by clay soil cover or water (water cover) then the conversion reaction ferrous iron into ferric iron becomes slower. The intensity of leaching is determined by (i) the sulfur content and (ii) the level of acidity of acid mine drainage [1]. Here is the reaction of an increase in alkalinity with sulfate reducing bacteria and elimination of metal in the form of metal sulfide [2]:

$$SO_4^{2-} + 2CH_2O + 2H^+ \rightarrow H_2S + 2CO_2 + 2H_2O$$

$$Me^{2+} + S^{2-} \rightarrow MeS$$

Oxidation of pyrite occurs in biochemistry and chemistry.

Biochemistry: <u>*Thiobacillus*</u> *ferrooxidans*, ferric into ferrous and sulfide to sulphate.

$$Fe^{2+} + 1/4O_2 + H^+ \rightarrow Fe^{3+} + ½ H_2O$$

$$2S^{2-} + 3O_2 + 2 H_2O \rightarrow 2H_2SO_4$$

Chemistry: oxidation of pyrite by ferric:

$$FeS_2 + 7/2O_2 + H2O \rightarrow Fe^{2+} + 2SO_4^{2-} + H^+$$

$$FeS_2 + 14Fe^{3+} + 8 H_2O \rightarrow 15Fe^{3+} + 16H^+ + 2SO_4^{2-}$$

Management of passive acid mine drainage is a simple method and its use of low-cost management [3] and has been a proven way to increase the population of bacteria and improve water quality [4] and is used in many countries such as in Turkey [5], South Korea has been built from the year 1996 to 2002 with the SAPS method (successive alkalinity producing systems) [6], South Africa [7], 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% [8].

Acid mine water management system passively gaining so much attention that there are some models that are applied in outline consists of 3 basis points are: aerobic and anaerobic processes, systems and processes of care from the tendency of chemical or biological reactions during the process [9;10]. Management of acid mine water passive one is Aerobic wetlands or wetland [11] by means of acid mine water flow in wetlands that have been constructed with suitable plants to neutralize also absorb dissolved metal.

Plants serve as a medium of Phytoremediation (phytoremediation) 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 (Alia et al.2013) [12]. Plants used in phytoremediation are capable to translocation of hyper cumulates plant pollutant elements [13]. Most advantages in the use of phytoremediation is less expensive operating costs when compared to conventional processing. Aerobic wetlands are designed to provide sufficient residence time to allow the metal oxidation and hydrolysis, thereby causing precipitation and physical retention of Fe and Manganese hydroxides. Wetland plants, such as *Typha*, *Juncus*, and *Scirpus sp*, Encouraging a more uniform flow, helping to stabilize the substrate, helps maintain the microbial population, and provide aesthetic quality to wetlands.

This study aims to determine the best type of local plants as candidates phytoremediation water plants in acid mine water management system with a passive model of wetland / aerobic wetland stratified by testing several kinds of local plants in the vicinity of the mining of coal as a medium of Phytoremediation.

II. MATERIALS AND METHOD

This study uses the method of mini-scale project in the area that had been carried out in laboratory on company laboratory of PT.Jorong Barutama Greston in coal mining business on July-August 2012, which is located in District Jorong, Tanah Laut County, South Kalimantan Province – Indonesia. Acid mine water that is used for this research came from the void M2W Pit mining area of PT. Jorong Barutama Greston taken using a water truck and stored in a 10,000 liter capacity reservoir in the study area. Land PAF (Potential Acid Forming) derived from the same mine site with mine acid water sources were taken from the mine site using a dump truck and dumping at the sites as much as 5 tons. Types of plants used in Figure 1. for phytoremediation consists of 5 types of plants, namely: 1. Purun Rat (*Eleocharis dulcis*), 2.Rumput Umbrella (*Cyperus odoratus*), 3. Water Plants(*Hydrilla Vercilata*), 4. Kale Water (*Ipomea aquatic*), 5.Kayapu (*Pistia Stratatiotes*). Each plant water into phytoremediation media taken from locations around the mine / original habitat depicted in Figure 1.

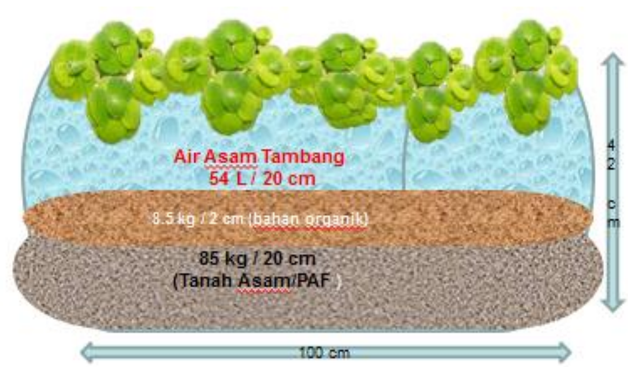
Fiq. 1. Purun Rat (*Eleocharis dulcis*), Umbrella Grass (*Cyperus odoratus*), water plants (*Hydrilla Vercilata*), Kale Water (*Ipomea aquatic*), Kayapu (*Pistia Stratatiotes*) (Source: Documentation Herniwanti, January 2013).

Fiq. 2. Monitoring ponds for 5 kinds of local water plant in the phytoremediation process for 29 days .

Monitoring the quality of acid mine water quality carried out in the laboratory of acid mine water PT.Jorong Barutama Greston for the parameters pH and Heavy Metal Fed and 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)

Methods

Simulation of this research is to use plastic drum 200L capacity is cut transversely and prepared as much as 3 series consist of 2 series of experiments with replications and 1 for check (blank). Each drum with a length of 42 cm and a width of 200 cm and the volume of 54 liters of water filled with acid soil condition / PAF (Potential Acid Forming) as high as 20 cm 85 kg then added organic matter (*bokashi*) 10% = 8.5 kg as high as 2 cm as a growing medium, acid water added as many as 54 L / 20 cm, then planted five kinds of crops planted phytoremediation is being nominated in each drum with the same 3 replications and 1 pond comparator as shown by the illustration Figure 3. following.



Fiq. 3. Design of aerobic wetland for acid mine drainage pond.

The composition of the pool of five terraced wetland plant species are used as medium of phytoremediation recorded for each pond in Table I. and Figure 4. as follows:

Table I
Composition of Material Aerobic wetland for acid mine drainage passive treatment.

No Ponds	Kind of water plants	Soil PAF (Kg)	*Organic Matter (Kg)*	*Spacing of plants (cm)*	*Quantity (Kg)*	*Quantity clump (pcs)*
1	Purun Tikus (*Eleocharis dulcis*)	85	8.5	22.5	3.00	4
2	Rumput Payung (*Cyperus odoratus*)	85	8.5	22.5	1.25	4
3	Tanaman air (*Hydrilla Vercilata*)	85	8.5	NA	1.00	NA
4	Kangkung Air (*Ipomea aquatic*)	85	8.5	NA	1.00	NA
5	Kayapu (*Pistia Stratatiotes*)	85	8.5	NA	1.00	30

Fiq. 4. Composition of aerobic wetland (PAF Soil, organic matters, plants water, water of acid mine drainage).

Monitoring and analysis process carried out several times during the 29 day study, water samples were taken from each drum and parameters measured for pH, Fe, Mn by using a pH meter HORIBA brand and Fe measurements using a Spectrophotometer HACH method 2800 to 8146 and the number of measurement Mn with method number 8034.

Data analysis

1. Analysis of the data for the degree of acidity (pH) using graphics will be compared between baseline and final influent enfluen H0 and H10, the degree of acidity is the activity of hydrogen in water [14]. 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 [15]. 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 [16;17;18].
3. Counting indekx bioremediation for 10 days 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 [19].
IBR = (Starting concentration – final concentration / starting concentration) x 100%.

III. RESULT AND DISCUSSION

Wetlands planted with five kinds of local plants and coupled with organic materials with multilevel system was able to reduce levels of acidity, metals Fe and Mn from acid mine drainage. Reported that net wetland receiving AMD alkaline (pH range of 4.5 to 6.3, Fe <70 mg / L, Mn <17 mg / L, Al <30 mg / L,) which is capable of removing metal [20]. These results are consistent with studies conducted in Coal Mining Anna S, Tioga County with a combination of vertical water flow method and an-aerobic wetlands after 6 years of producing acidity towards neutral pH 3.1 to 6.9 and Fe from 7 to 3 mg / L and Mn from 8 to 7 mg / L [21], in South Korea using the passive management of the year 1996 to 2002 using the three pools are: 1.SAP (successive alkalinity producing systems), 2.oxidation ponds and 3. aerobic wetland, the results showed that the condition is still good for reducing acidity and also reduces levels of iron [6].

Management of passive acid mine drainage can reduce the acidity of 41% on average of the five types of water plants from pH 4.81 to pH 6.79 and lower levels of 7% Fe from 12.11 to 12.09 mg / L and lower the metal content of 19% Mn 4.59 to 5.67 mg / L by using 5 pools with 5 types of local plants: 1. Purun Rat (*Eleocharis dulcis*), 2.Rumput Umbrella (*Cyperus odoratus*), 3.Water Plants (*Hydrilla Vercilata*), 4. Kale Water (*Ipomea aquatic*), 5.Kayapu (*Pistia Stratatiotes*) with a retention period of each plant for 29 the days. The results of measurements on 5 types of water plants with three replications in different pools for 29 days and measured several times in the peridoe average results obtained for the parameters pH, Fe, Mn is shown as follows:

pH

The results of measurements on 5 different types of plants dengan3 replications and 1 comparison on different pools for 29 days showed an average pH for the parameters shown in Table II.

Table II
Measurement of pH at 5 Water plants with 29 day retention period.

Day	Date	Blank	*1.Eleocharis dulcis*	*2.Cyperus odoratus*	*3.Hydrilla Vercilata*	*4.Ipomea aquatic*	*5.Pistia Stratatiotes*
0	**12-May-13**	**4.86**	**5.29**	**4.70**	**4.86**	**4.56**	**4.66**
3	15-May-13	5.95	4.83	5.40	5.59	5.58	5.05
6	18-May-13	6.09	5.85	5.88	6.12	6.09	5.77
9	21-May-13	6.77	6.23	6.38	6.52	6.53	6.52
12	24-May-13	6.74	6.65	6.59	7.02	6.78	6.45
15	27-May-13	7.22	7.03	6.91	7.19	7.11	6.80
18	30-May-13	6.85	6.39	6.57	6.76	6.96	6.46
21	02-Jun-13	6.24	6.30	6.24	6.25	6.24	6.24
24	15-Jun-13	7.02	6.92	6.82	7.77	7.31	6.46
29	**10-Jun-13**	**7.04**	**6.76**	**6.76**	**6.91**	**6.96**	**6.56**
Improved pH from H-0 to H-29		2.18	1.47	2.05	2.05	2.40	1.90
% Improved H-0 to H-29		45%	**28%**	44%	42%	**53%**	41%

Improved Average pH = 41% (without blank)

Table II. Shows the results of measurements of the pH of the pond water samples were planted 5 types of water plants for phytoremediation process experimental ponds. Measurements were carried out for 29 days in each pool phytoremediation of acid mine water showed a pH change that is getting better. On day 29, the pH of acidic water on blank samples (original acid mine water) pH rise as much as 45% of the 4.86 becomes 7.04, planted next to the pool Purun Rat (*Eleocharis dulcis*) pH rise as much as 28% from 5:29 to 6.76, Umbrella Grass (*Cyperus odoratus*) 44% increase in pH from 4.70 to 6.76, aquatic plant (*Hydrilla Vercilata*) 42% increase in pH from 4.86 to 6.91, Kale water (Ipomea aquatic) 53% increase in pH from 4.56 to 6.96, Kayapu (*Pistia Stratatiotes*) increase in pH 41 % from 4.66 to 6.46.

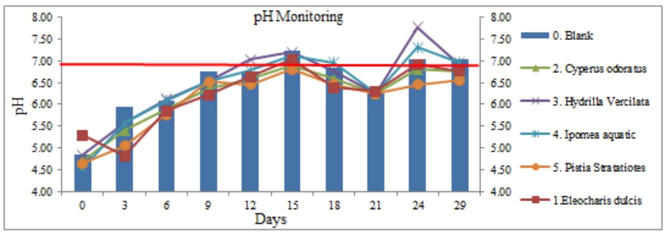


Fig. 5.Phytoremediation 5 Comparison of pH on aquatic plants.

Figure 5. Results of water quality monitoring pH in an acid mine phytoremediation for all 5 types of plants showed an increase of pH, the highest shown by, Kale Water (*Ipomea aquatic*) pH increased by 53% from 4:56 to 6.96 and the lowest Purun Rat (*Eleocharis dulcis*) pH rise as much as 28% from 5.29 to 6.76. Research Rougeux # 1 site has flow 20 L / min and chemical parameters: pH 2.9, 445 mg / L acidity, Fe 45 mg / L, Mn 70 mg / L. After flowing through the two-celled aerobic wetlands, some researched found that pH increased 2.9 to 3.2 so that acidity decreased by 43%, 50% Fe, 17% Mn [22]. Wetlands costs about $ 15/m2 (U.S. 150.000/m2 assuming $ 1 = 10,000) to build in 1992 and the size of the wetland depends on the quality of the water is done processing [23;24;25;26;27;28] heavy metal uptake by phytormedesiasi system also occurs in the Industry Aluminum [29].

Fe

The decrease in the amount of Fe metal (7%) in the process phytoremediation 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): *Desulfovibrio* sp, sp *Desulfomaculum*, sulfate reducing bacteria (BPS) type of Desulfovibrio sp and sp *Carnobacterium* can increase the pH within 24 hours, lowering the Fe and Mn within 10 days to achieve efficiency> 81% [30].

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 III.

Table III

Measurement of Fe (ppm) at 5 Plants water for 29 days

Days	Date	Blank	*1.Eleocharis dulcis*	*2.Cyperus odoratus*	*3.Hydrilla Vercilata*	*4.Ipomea aquatic*	*5.Pistia Stratatiotes*
0	**12-May-13**	**0.06**	**0.19**	**0.09**	**0.08**	**0.13**	**0.06**
3	15-May-13	0.14	0.39	0.36	0.09	0.26	0.05
15	27-May-13	0.25	0.19	0.16	0.11	0.22	0.10
21	02-May-13	0.23	0.42	0.20	0.25	0.24	0.20
29	**10-Jun-13**	**0.20**	**0.06**	**0.07**	**0.06**	**0.15**	**0.09**
Deflaction (ppm) of Fe from H-0 to H-29		-0.14	0.13	0.02	0.02	-0.02	-0.04
Index IBR		-233%	**70%**	18%	24%	-13%	**-65%**
Average of IBR Fe		7% (without blank)					

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

Table III. Shows the results of measurements on a sample of pond water Fe planted 5 types of water plants for phytoremediation process at the measurement pool. Measurements were carried out for 29 days showed changes varying Fe and reduced levels (ppm). On day 29, the levels of iron in the sample blank (original acid mine drainage) rose as much as 233% from 00:06 to 12.27 (ppm), Purun Rat (*Eleocharis dulcis*) fell by 70% from 12.19 to 0.06 (ppm), Umbrella Grass (*Cyperus odoratus*) fell by 18% from 12.09 to 12.07 (ppm), aquatic plants (*Hydrilla Vercilata*) decrease iron levels as much as 24% from 12.08 to 0.06 (ppm), Kale water (*Ipomea aquatic*) rose as much as 13% from 12.13 to 12.15 (ppm) , Kayapu (*Pistia Stratatiotes*) iron content rose by 65% from 0.06 to -0.09 (ppm).

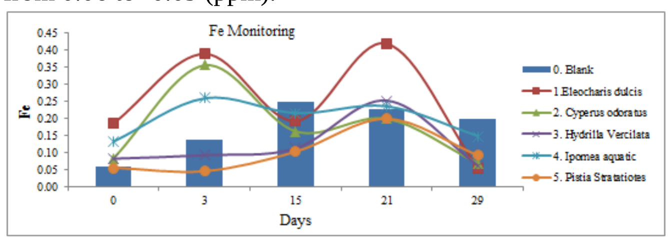


Fig. 6. Comparison of Fe at 5 Phytoremediation on aquatic plants.

Figure 6. Results of water quality monitoring Fe in an acid mine phytoremediation showed a decrease which varies from day to day. For a pool filled with acid mine water plant visits without increasing the iron content from day 0 to day 29, in contrast to a pool filled with 5 types of plants although there is a tendency to increase at day 3 but decreased again on day 29. On day 3 and 21 to the high metal levels rise in the retention period for these types of plants showed an increase Purun Rat (*Eleocharis dulcis*) and Watercress and Water (*Ipomea aquatic)* and Umbrella Grass (*Cyperus odoratus*). Umbrella grass (*Cyperus odoratus*) is a plant that has the potential to absorb heavy metals from contaminated water environment (Fonkuo et al. 2005) [31].

Water kale (*Ipomea aquatica*) - 13% and Wood Apu (*Pistia stratiotes*) - 65% showed weak phytoremediasi ability to demonstrate bioremediation index (index IBR) is low in iron metal absorbs although according to [32] 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 [33].

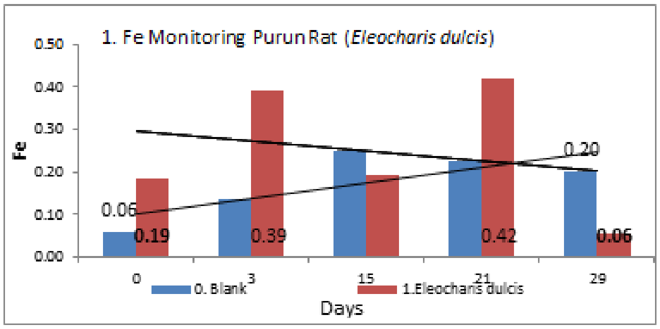


Fig. 7.Comparison of Fe on Phytoremediasi Purun Rat (*Eleocharis dulcis*).

Figure 7 . Demonstrated ability as a candidate crop phytoremediation best demonstrated by Purun Rat (*Eleocharis dulcis*) with HEB 70 % in the 29 day retention period . In the H - 0 0.19 ppm iron levels even at day 3 increased to 0.39 ppm and also at day 21 to 0.42 ppm of H - 29, but after a significant decline be 0.06 ppm. Compared to the original pool / blank used as a comparison to the H-0 = 0.06 ppm iron levels and continue to rise thereafter and after the H-29 = 0.20 or IBR as much as -233 ppm. Purun Rat (*Eleocharis dulcis*) is recommended to be a major crop in the process of aerobic wetland phytoremediation in a multilevel system. According to [34] Purun Rat (*Eleocharis dulcis*) is able to live on land acidic and low pH conditions and high soluble Fe [35] can also cope with the reclamation of waste acid sulfate soil is able to absorb elemental Fe and 1.386 ppm 923 ppm Mn [36].

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 [39].

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 [40].

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 IV.

Table IV
Measurement of Mn (ppm) at 5 Plants water for 29 days

Days	Datel	Blank	*1.Eleocharis dulcis*	*2.Cyperus odoratus*	*3.Hydrilla Vercilata*	*4.Ipomea aquatic*	*5.Pistia Stratatiotes*
0	12-May-13	5.37	6.43	5.53	4.93	6.17	5.27
3	15-May-13	5.37	8.27	7.10	4.97	5.30	4.20
15	27-May-13	10.57	7.30	6.07	4.83	6.40	4.67
24	05-June-13	8.13	6.33	6.47	4.40	8.23	5.40
29	10-June-13	9.63	3.97	5.20	4.47	6.93	2.37
Deflaction of Fe from H-0 to H-29		-4.27	2.47	0.33	0.47	-0.77	2.90
Index IBR		-80%	38%	6%	9%	-12%	55%
Average IBR Mn		19% (without blank)					

Table IV. Shows the results of measurements of Mn in pond water samples were planted 5 types of water plants for phytoremediation process at the measurement pool. Measurements were carried out for 29 days showed changes varying Mn. Levels of manganese in the blank sample (original acid mine water) up 80% from 5.37 to 9.63 (ppm), Purun Rat (*Eleocharis dulcis*) 38% decrease from 6.43 to 3.97, Umbrella Grass (*Cyperus odoratus*) decreased by 6% from 5.53 became 5.20 (ppm), water plants (*Hydrilla Vercilata*) down 9% from 4.93 to 4.47 (ppm). Water plants (*Hydrilla Vercilata*) can absorb as much as 91.2% in Fe 5ppm for 5 days [41] and also capable of optimally for phytoremediation of household waste [42]. Water kale (*Ipomea aquatic*) up 12% from 6.17 to 6.93 (ppm), Kayapu (*Pistia Stratatiotes*) decrease 55% from 5.27 to 2.90 (ppm).

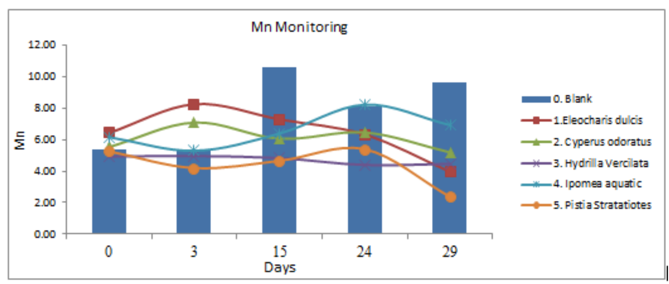


Fig. 8. Comparison of Phytoremediation 5 Levels of Mn in aquatic plants.

Figure 8. Results of water quality monitoring Mn ph acid mine phytoremediation showed a decrease in the pool that varies from day to day. For a pool filled with water without any acid mine manganese content of plants seen relatively stable from day 0 to day 29, in contrast to a pool filled with 5 types of plants although there is a tendency to increase at day 3To Purun plants Rat (*Eleocharis dulcis*) and Grass Umbrella (*Cyperus odoratus*) but decreased again on day 29. On day 3 and 24 is the retention period showed increases in some types of plants and the best reduction in retention during day 3 and day 29. To plant. Water Watercress plant (*Ipomea aquatic*) showed weak phytoremediation ability to absorb manganese metal with numbers - 12% for the bioremediation of index (index IBR) means, because it is not recommended to be the first pool in the terraced pools phytoremediation.

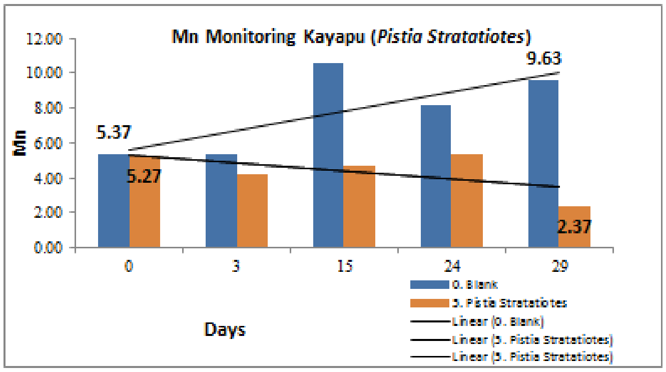


Fig. 9. Comparison of Mn levels on a 5-storey Phytoremediation of aquatic plants.

Figure 9 . Showed Kayapu (*Pistia stratiotes*) is a good ability to absorb metals Mn is the IBR rate 55 % , so it is recommended as a plant phytoremediation on aerobic wetland systems storey. In the H - 0 levels of manganese in acid mine drainage 5.27 ppm after 29 days retention period be 2.37 % , compared with being 0:42 ppm but after the H - 29, a significant decrease becomes 0:06 ppm . Compared to the original pool / blank comparison to the H – 0 = 5.37 ppm manganese levels and after the H - 29 rose to 9.63 ppm with IBR -80 % . According to [41] Kayapu (*Pistia Stratatiotes*) may decrease the concentration of Cd exposure time to 10 days , Kayapu (*Pistia Stratatiotes*) also has a weak ability to regulate metal into the body , especially non- essential metals . *Pistia Stratatiotes* can reduce the metal of the trunk when the threshold through the process of diffusion to control levels and distribution in tissues (Cornell and Miller, 1995) [42].

IV. CONCLUSION

[1] Management of acid mine water by means phytoremediation using aerobic wetland system to test 5 different water plants as candidates who are in the vicinity of the mine are: 1. Purun Rat (*Eleocharis dulcis*), 2. Umbrella Grass (*Cyperus odoratus*), 3. Water Plants (*Hydrilla Vercilata*), 4.Kangkung Water (*Ipomea aquatic*), 5.Kayapu (*Pistia Stratatiotes*) with a retention period of each plant for 29 demonstrated ability to reduce the acid levels in the water to raise the pH of acid mine average of 41% and lower levels of iron (Fe) with an average of 7% bioremediation index and lower levels of manganese (Mn) with an average of 19% index bioremediation

[2] The best candidates phytoremediation plants to lower acid levels by raising the pH is Kale Water (*Ipomea aquatic*) to raise the pH of 53%. To reduce levels of iron in acid mine water is to use Purun Rat (*Eleocharis dulcis*) reduce levels of iron (Fe) 70% To reduce manganese from the water then it is best to Kayapu (*Pistia Stratatiotes*) reduce levels of manganese (Mn) as much as 55%.

[3] This study shows that the local plant in the vicinity of the coal mining could be phytoremediation plant in the management of acid mine drainage passive.

[4] Kale Water (*Ipomea aquatic*) good repair acidity of acid mine water while purun good for lower levels of iron (Fe) and Kayapu (*Pistia Stratatiotes*) well to reduce levels of manganese (Mn) in the management of acid mine water by wetlands methods

[5] This research needs to continue to look for new types of plants that can be used as plant phytoremediation for acid mine drainage and also applied in the field scale for better results.

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REFERENCES

[1] Suryaningtyas.D.T dan Gautama.R.S, 2008, Simulated leaching of Fe $^{3+}$ and Al $^{3+}$ In Coal Mining Overburden, Department of Soil Science and Land Resources, Bogor Agricultural University and the Department of Mining Engineering, Institute of Technology Bandung. *Acid Mine Water Conference and Ex-Mining Land Reclamation in Indonesia*, 1-2 July 2008 Bandung.

[2] Neculita.C.M, Zagury.G.J, Bussiere. B, 2007. Passive treatment of acid mine drainage in bioreactors using sulphate-reducing bacteria: critical review and research needs. *J. Environ. Qual.* 36 200), pp. 1–16.

[3] Carmen, Gerald G, Bruno B. 2007. Passive Treatment of Acid Mine Drainage in Bioreactor using Sulfate-Reducing Bacteria: Critical Review and Research Needs. *Journal of Enviromental Quality ;* Jan/Feb 2007 ; 36,1;ProQuest.

[4] Strosnider W. H., Winfrey B. K., Nairn R. W., 2011. Alkalinity Generation in a Novel Multi-stage High-strength Acid Mine Drainage and Municipal Wastewater Passive Co-treatment. *System Springer-Verlag 2010, Mine Water Environ (2011)* 30:47–53, DOI 10.1007/s10230-010-0124-2.

[5] Cakmak. B, Apaydin.H, 2010. Review.Advances in the management of the wastewater in Turkey: Natural treatments or constructed wetlands, Department of Farm Structures and Irrigation. Faculty of Agriculture. University of Ankara, *Spanish Journal of Agricultural Research 2010* 8(1), 188-201, Available online at www.inia.es/sjar ISSN: 1695-971-X.

[6] Ji.S, Kim.S, Ko.J, 2008. The status of the passive treatment systems for acid mine drainage in South Korea, The Environmental Hazardous Group,The Korea Institute of Geoscience and Mineral Resources (KIGAM), 30 Gajeong-dong, Yuseong-gu,Daejeon 305-350, South Korea, *Springer-Verlag 2007, Environ Geol (2008)* 55:1181–1194, DOI 10.1007/s00254-007-1064-4.

[7] Botes. E, Jordan.R, deFlaun.M.F, Howell.J, Borch. R, van Heerden.E, 2010. Bioremediation using a two-phase bio / abiotic approach to treat acid mine drainage in south Africa, University of the Free State, Department of Microbiology, Biochemistry and Food Biotechnology, South Africa. *Elseivier Journal of Biotechnology volume 150, Suplement, November 2010*, Pages 269-270.

[8] Baia.H , Kanga.Y, Quana.H , Hana.Y, Suna.J, Fengc.Y, 2013. Short communication of Treatment of acid mine drainage by sulfate reducing bacteria with iron in bench scale runs, School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, China. *Elseiver Volume 128*, January 2013, Pages 818–822.

[9] Gazea, B., K.Adam, and A.Kontopoulos. 1996. A review of passive systems for the treatment of acid mine drainage. *Miner Eng.* 9:23-42.

[10] Ziemkiewicz, PF., J.G. Skousen, and J. Simmons. 2003. Long-term performance of passive acid mine dranage treatment systems. National Mine Land Reclamation Ctr, Div of Plant and Soil Sciences, West Virginia Univ, Morgantown, WV. *Mine Water Environ*. 22:118-129.

[11] Faulkner, B.B. and J.G. Skousen. 1994. Treatment of acid mine drainage by passive treatment systems. p. 250-257. In: *International Land Reclamation and Mine Drainage Conference*, 24-29 April 1994, USDI, Bureau of Mines, SP 06A-94, Pittsburgh, PA

[12] Alia.H, Khanb. E, Sajadc.M.A, 2013. Review of Phytoremediation of heavy metals—Concepts and applications, Department of Biotechnology, University of Malakand, Chakdara 18800, Dir Lower, Khyber Pakhtunkhwa, Pakistan. *Elseiver- Chemosphere, Volume 91, Issue 7,* May 2013, Pages 869–881.

[13] Mangkoedihardjo, S. , 2005. Fitoteknologi and Ecotoxicology in Waste Composting Operation Design, *National Seminar on Environmental Technology III ITS* – Surabaya, Indonesia.

[14] Sawyer, Clair N., Perry L.M and Gene F.p, **2003**. *Chemistry for Environmental Engineering and Science*. McGraw-Hill Inc., New York.

[15] *Regional Environmental Impact Management Agency of South Kalimantan Province, 2008*, South Kalimantan gubernatorial Nomor.036, 2008 132 Appendix: Raw water quality of mining waste, South Kalimantan- Indonesia.

[16] Lo´pez-Archilla, A.I., Marı´n, I., Amils, R., 2001. Microbial communitycomposition and ecology of an acidic aquatic environment: the Tinto river,Spain. *Microbial Ecol*. 41 (1),20–35.

[17] Gonza´lez-Toril, E., Llobet-Brossa, E., Casamayor, E.O.,Amann, R., Ails, R.,2003. Microbial ecology of an extremeacidic environment, the Tinto River. *Appl. Environ.Microbiol*. 6, 4853–4865.

[18] Niyogi, D. K., W. M. Lewis dan D. M. McKnight. 2002. Effects of Stress from Mine Drainage on Diversity, Biomass dan Function of Primary Producers in Mountain Stream. *Ecosistems vol*. *5*. 5554-567.

[19] Palapa, T. M., 2009. Mercury (Hg) Bioremediation with Aquatic Plant as An Alternatif of Remediation of Artisanal Gold Mine Waste. *Agritek*, 17(5): 150-163. [in Indonesia]

[20] Brodie GA (1993) Staged, aerobic constructed wetlands to treat acid drainage: case history of Fabius Impoundment 1 and overview of the TVA's Program.In: Moshiri GA (ed), constructed Wetlands for *Water Quality Improvement*, Lewis Publ, Boca Raton, FL, p157-166.

[21] Hedin.R, Weaver.T, Wolfe.N, Weaver.K, 2010. Passive Treatment of Acidic Coal Mine Drainage: The Anna S Mine Passive Treatment Complex, Hedin Environmental, 195 Castle Shannon Blvd, Pittsburgh, PA 15228, USA. Springer-Verlag 2010, *Mine Water Environ* (2010) 29:165–175, DOI 10.1007/s10230-010-0117-1

[22] Hellier WW, Giovannitti EF, Slack PT (1994) Best professional judgment analysis for constructed wetlands as a best available technology for the treatment of postmining groundwater seeps. *Proc, Internatl Land Reclamation and Mine Drainage Conf*, USBM SP 06A-94, Pgh, PA, p 60-69.

[23] Ziemkiewicz, PF., J.G. Skousen, and J. Simmons. 2003. Long-term performance of passive acid mine dranage treatment systems. National Mine Land Reclamation Ctr, Div of Plant and Soil Sciences, West Virginia Univ, Morgantown, *WV. Mine Water Environ*. 22:118-129.

[24] Henny. C, Ajie.G.S, Susanti E, 2010. Management of acid mine water using passive treatment system, Research Center for Limnology-LIPI, *Proceedings of the National Seminar Limonology V* in 2010.

[25] Chang, I.S., Shin, P.K., Kim, B.H., 2000. Biological treatment of acid mine drainage under sulphate-reducing conditions with solid waste materials as substrate. *Water Res.* 34,1269–1277.

[26] Gilbert, O., de Pablo, J., Cortina, J.L., Ayora, C., 2003. Evaluation of municipal compost/limestone/iron mixtures as filling material for permeable reactive barriers for in situ acid mine drainage treatment. *J. Chem. Technol. Biotechnol*.78, 489–496.

[27] Gibert, O., J. de Pablo, J. L. Cortina, and C. Ayora. 2005. Municipal compostbased mixture for acid mine drainage bioremediation: Metal retention mechanisms. *Applied Geochemistry* .20:1648–1657.

[28] Waybrant, K. R., C. J. Ptacek dan D. W. Blowes. 2002. Treatment of Mine Drainage Using Permeable Reactive Barriers: Column Experiment. *Environ Sci. Technol*. 36. 1349-1356.

[29] Asad P.R, S. Ghiyasi and A. Godari, 2013. The Role of the Plants for the Removal of Heavy Metals around Industrial Plant, *Journal of Applied Environmental and Biological Sciences*, J. Appl. Environ. Biol. Sci., 3(6)1-6

[30] Widyati.E. 2008, Acid Mine Water Management in Pt.Bukit Acid (Persero), Tbk Bioremediation Research Cooperation Sulfate Reducing Bacteria (BPS) Puslitbanghut in Acid Mine Water *Seminar And Former Mine Land Reclamation in Indonesia*, 1-2 July 2008 Bandung- Indonesia.

[31] Fonkou T, Agendia P, Kengne I, Akoa A, Derek F,1 Nya J and Dongmo F, 2005. Heavy Metal Concentrations in some Biotic and Abiotic Components of the Olezoa Wetland Complex (Yaoundé–Cameroon, West Africa), *Water Qual. Res. J. Canada*, 2005 • Volume 40, No. 4, 457–461

[32] Weerasinghea A, Ariyawnasaa S, Weerasooriya R, 2007. Phyto-remediation potential of Ipomoea aquatica for Cr(VI) mitigation, *ELSEVIER, Chemosphere, Volume 70*, Issue 3, January 2008, Pages 521–524.

[33] Gothberg.A, Greger.M, Bengtsson.B.E, 2002. Accumulation of heavy metals in water spinach (Ipomoea aquatica) cultivated in the Bangkok region, Thailand. Institute of Applied Environmental Research (ITM), Laboratory for Aquatic Environmental Chemistry, Stockholm University, Sweden, *Environ Toxicol Chem*. 2002 Sep;21(9):1934-9.

[34] Noor.M. , 2004. Wetlands and nature of acid sulphate soil management problematic. *PT.Raja Grafindo Persada*. Jakarta.

[35] Priatmdi, B, J, Mahbub, Syaifudin and Muslikin, 2006. Adaptation of plants to acid sulfate soil chemical properties in South Kalimantan. *Scientea Borneo*.

[36] Suriakarta, D.A and A. Abdurachman, 2000. The use of plants Purun Rat (Eleocharis dulcis) and Prumpung (Phragmites karka TRIN) in an effort to cope Waste Reclamation Natural acid sulfate soils, in *Proceedings of Agriculture.*

[37] Neculita.C.M, Zagury.G.J, Bussiere. B, 2007. Passive treatment of acid mine drainage in bioreactors using sulphate-reducing bacteria: critical review and research needs. *J. Environ. Qual.* 36 2007), pp. 1–16.

[38] Christian.D, Wong.E, Crawford R.L, Cheng.I.F, Hess.F, 2010. Heavy metals removal from mine runoff using compost bioreactors, *Environmental Technology. Vol. 31*, No. 14, 14 December 2010, 1533–1546.

[39] Hallberg.K.B and Johnson D.B, 2005. Biological manganese removal from acid mine drainage in constructed wetlands and prototype bioreactors, Sci. Total Environ. 338 (2005), pp. 115–124.

[40] Skousen.J.G, Sexstone.A, Ziemkiewicz.P.F, 2000. Acid Mine Drainage Control And Treatment - Reclamation of Drastically Disturbed Lands, American Society of Agronomy and American Society for Surface Mining and Reclamation. *Agronomy No. 41*. Chapter 6.

[41] Begum A and Krishna S.H, Jan – Mar 2010. Bioaccumulation of Trace metals by aquatic plants, 1Department of chemistry, P.E.S School of Engineering,Hosur Road, (Near Electronic city),Bangalore-100,India. 2Shirdi Sai Engg. College,Anekal, Bangalore,India. *International Journal of ChemTech Research* CODEN(USA): IJCRGG ISSN : 0974-4290 Vol.2, No.1, pp 250-254.

[42] Irawanto R, 2010. Fitoremidiasi Environment In Bali Parks, Gardens Plant Conservation Unit Purwodadi-LIPI, *Local Wisdom, Volume: II, No. 4*, Pages: 29-35.