Advanced Studies in Biology, Vol. 7, 2015, no. 3, 97 - 109
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/asb.2015.41056

Exploration of Plant Adaptives at Ferro-Nickel Post Mining Land in Pomalaa Southeast Sulawesi Indonesia

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Abstract

Exploration of plant adaptives using descriptive method was conducted at the area of ferro-nickel post mining land of PT. Antam (Persero) Tbk Pomalaa, Southeast Sulawesi Indonesia. The purpose of exploration was to identify the native plant which could be adaptable in that area and to determine the concentration of heavy metals which could be dominant in soil and plant. The area of exploration was chosen in that area with or without removing overburden. The species of native plants were identified and the concentartions of nickel (Ni), iron (Fe), cobalt (Co) and lead (Pb) in soil and plant tissues were measured. Results showed that there were five species of endogen adaptive plants found such as *Scleria lithosperma* (Linnaeus) Swartz, *Machaerina glomerata* (Gaudich) T. Koyama, *Trema cannabina* Lour., *Alstonia macrophylla* Wall Ex G. Don, and *Scleria purpurascens* L. The five species plants were tolerated for heavy metals concentration in the range of 735.18–752.99 mg/L for Ni, 0.398–2.139 mg/L for Fe, 0.463–1.100 mg/L for Co and 0.111–0.147 mg/L for Pb. *Scleria lithosperma*, *Machaerina glomerata*, *Trema cannabina*and *Alstonia macrophylla*were categorized as the phytoextraction plants.

Keywords: exploration, endogen, fero-nickel, post land mining, heavy metals and adaptive plants

1 Introduction

Ferro-nickel mining is generally known as the open mine causing physically destruction of environment and accumulation of heavy metals which toxic to plants [8]. Accumulation of toxic heavy metals is one of the reason on failing of the reclamation of the post land mining. However, a number of native plants have the capability to tolerate high heavy metal concentrations allowing plants can grow well [5].

One of the plant characters is known as the phytoextraction plant. Phyto extraction is a plant mechanism where some plants have the ability to store in amount

of contminants and heavy metal concentrations in their shoot leaf [11, 13, 14]. Plants which have characters as the phytoextraction is known as the hyperaccumulator plant [3, 11, 19, 20]. Using hyperaccumulator plant and its technology in preventing organic or inorganic contaminants at post land mining areas is called phytotechnology [7, 10, 15, 22, 23]. Phytotechnology can be consist of phytoremediation [6, 12, 18] which could be used in bioremediation process to clean environment from contaminants [17, 18, 20].
A number of hyperaccumulator plants are *Eichornia crassipes* and *Brassica juncea* which could absorb heavy metals such as selenium (Se), lead (Pb), cadmium (Cd) and cuprum (Cu) (6). Rhizomes and roots of *Phragmites australis* can be roled as a filter and acted to preccipitate and toxic heavy metals (6). Water plants such as *Scirpus calipornicus*, *Zizaniopsis miliaceae*, *Panicum helitomon*, *Pontederia cordata*, *Saggitaria lancifolia* and *Typha latifolia* are suitable to manage animal wastes (6). There are found the accumulation of Cd in *Silene dioica* (6). *Populus deltoides* and *Willow sp.* from family of Salicaceae can reduce organic compounds such as: atrazin, chlordane, chlorinated solvent, nitrobenzena, trinitrotoluena (TNT), trinitroetilena, pentachlorofenol and phenanthrene and inorganic compounds such as nitrate and ammonium [6]. Poplar (*Populus deltoides*) is also used as phytoremedition for lands which contain Polychlorinated Biphenyl (PCB) [16]. *Thlaspi cearulescens*is found to be able to absorb Zn; while roots of *Silene dioica* are to absorb Cd and Ni (14). Cadmium in waste industrial tannin can be reduced by *Vigna radiata* (L.) [1]. Some reseraches reported that *Aliyssum sp.*, *Berkheya sp.* and *Serbetia acuminate* were able to absorb a heavy metal of Ni [6]. Sunflower (*Helianthus annuus* L.) and jatropha (*Jatropha curcas* L.) are suitable for plant cultivation at post mining land of ferro-nickel [2].

Direct research has not been conducted on native plants which adaptively grown at ferro-nickel post land mining. This research is necessary to gain species of endogen plants that could be suitable grown naturally at the nickel mine land which has been cantaminated with toxic heavy metals. This is the reason to carry out an explorative research with title “Exploration of plant adaptive at ferro-nickel post mining land in Pomalaa”. The success of this research is one of the advantage and part of efforts to rehabilitate the post Ni mining lands.

2 Materials and Methods

Tools used in the reasearch are camera, loupe, rolled-ruler, wattle 30 x 50 cm, scissors, knife, GPS, soil boring, spade and balancing weights. Materials used consist of work map, transparantly plastic bag 40 x 60 cm alcohol (or ethanol) 70 %, rice straw paper, string and labels. (This part/paragraph may not be necessarily needed, or we can deleted it)

Research procedure was begun with the establishment of observation location and sampling collection. This establishment was combination between observation using satellite image and terrestrial method to get the sample collecting point at area of land mine of PT. Antam (Persero) Tbk Pomalaa, Southeast Sulawesi, Indonesia. The area of research was chosen at the land mine which has been mined since 2007 with or without removing overburden and has not been rehabilitated until 2013.

Inventory on the whole species of plant growing in that area was observed. Identification of plant species, taking its photograph and coordinate position where plant was found were noted. Unidentified plant species was collected and stored as herbarium plant which then sent to the Centre of Biological Research (LIPI Jakarta) for identification. Heavy metals on shoot leaf of identified plants and soil samples from the rhizosphere area of plants were analysis. Analysis of plant tissue and soil samples consist of Ni, Fe, Co, and Pb with extraction method (which one the specific method name used?) using three acids HCl, HNO_3 and $HClO_4$. The concentrations of heavy metal elements were measured by using Atomic Absorption Spectrometry (AAS) at the Laboratory of Applied Sciences, Halu Oleo University.

3 Results and Discussion

3.1 Species of Endogen Plants Adaptive

The species of endogen plants adaptive were found at the ferro-nickel post mining land. They were: *Scleria lithosperma* (Linnaeus) Swartz, *Machaerina glomerata* (Gaudich) T. Koyama, *Trema cannabina* Lour, *Alstonia macrophylla* Wall Ex G. Don, and *Scleria purpurascens* L.

1. Morphology of *Scleria lithosperma*

Photograph 1. *Scleria lithosperma* (Linnaeus) Swartz

2. Morphology of *Machaerina glomerata* (Gaudich) T. Koyama

Photograph 2. *Machaerina glomerata* (Gaudich) T. Koyama

3. Morphology of *Trema cannabina* Lour.

Photograph 3. *Trema cannabina* Lour.

4. Morphology of *Alstonia macrophylla* Wall Ex G. Don

Photograph 4. Morfologi *Alstonia macrophylla*

5. Morphology of *Scleria purpurascens* L.

Photograph 5. *Scleria purpurascens* L.

The ability of five species which grown and developed at ferro-nickel post mining in Pomalaa could be observed through their morphologically performances. Morphological appearances such as broom-needle stem form were shown on *Scleria lithosperma* L.; long internode stem which formed by midrib of leaves was shown on *Machaerina glomerata*; sharp hairy stem was indicated on *Scleria purpurascens* L; slippery-rounded shining stem was on *Trema cannabina* and triangle stem was found on *Scleria purpurascens*.

Adaptation of plants in hot and dry environment is categorized as xerophyte plants. This type of adaptation is called morphologically adaptation [21]. Besides adaptation of stem, the species of plants also could adapt to follow the leaf formed. For examples: rigid and small leaves which then changed to become plant thorns on *Scleria lithosperma* L. and narrow flatty leaf to erecting or widening to follow the sunshine position. The forms of leaf cause the surface area of leaf becoming partly narrow facing for incoming sun light.

Existence of cuticule layers on the leaf of *Scleria purpurascens* L. would be able to prevent over transpiration. Plant adaptation due to the forms of stem and leaf contributed to plant growth for survival in dry land without water lost.

Plants adaptable at ferro-nickel mining land also had underground creeping roots on *Scleria lithosperma* L.; while *Machaerina glomerata* and *Scleria purpurascens* L. had a number of long fibrous roots which wide spreading along the roots enabling roots absorbed water and nutrients in wide areas.

3.2 Heavy Metal Concentrations in Plant Shoots and Rhizospheres

Concentration of Ni heavy metal in plant shoots among five adaptive plants were similar with exception in *Scleria purpurascens* (Fig. 6). The highest Ni concentration was shown in *Alstonia macrophylla* 75.001 mg/L followed respectively by *Trema cannabina* 74.948 mg/L, *Scleria purpurascens* 74.692 mg/L, *Machaerina glomerata* 74.168 mg/L and the lowest was found in *Scleria lithosperma* L. 53.482 mg/L.

The five species of adaptive plants tolerated with high concentrations of Ni in soil rhizosphere (Fig. 6). However, there was no significantly different in Ni concentrations among five plants. The highest (746.357 mg/L) Ni concentration in rhizosphere was found in roots areas of *Trema cannabina* L.and the lowest (735.180 mg/L) was shown in *Scleria purpurascens*. The Ni concentration in soil of rhizosphere of *Machaerina glomerata* (744.837 mg/L) was higher than in *Scleria lithosperma* (744.467 mg/L) and in *Alstonia macrophylla* (744.403 mg/L).

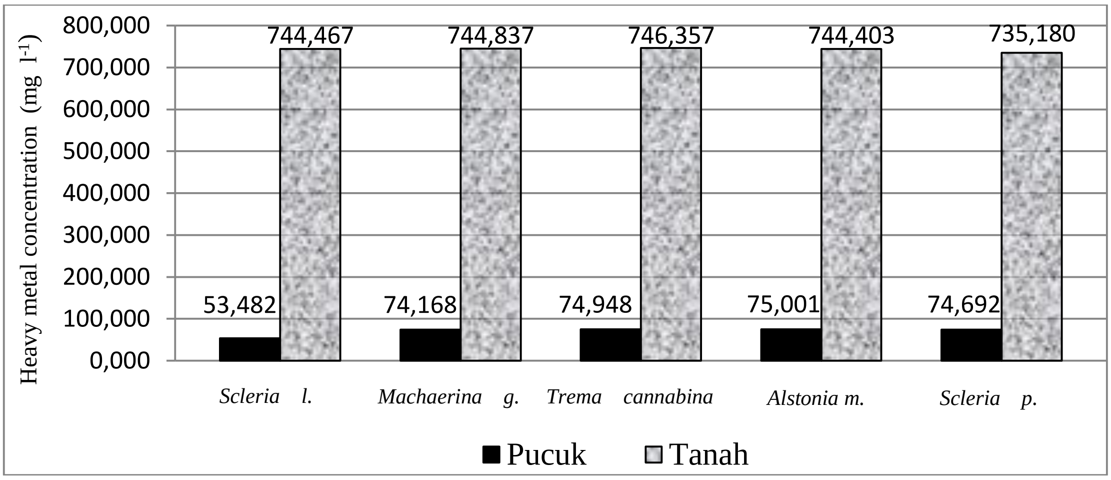

Figure 6. Nickel(Ni) concentration (mg/L) in plant shoot and soil rhizosphere of five adaptive plant at post miningland in Pomalaa (The values were mean of 3 replicates).

The five species of plants were different in bioaccumulation value (BV) (Table 1.). Based on the data presented in Table 1, those plants were not categorized as the hyperaccumulator plants on heavy metal of Ni due to their BI was only 0,1 for Ni [5, 9]. This BV in accordance with other research stating that in a number of particular plants had greater accumulation Ni in rhizosphere areas rather than in shoot [4, 9]. Furthermore, monocotyl plants had a greater capability to accumulate heavy metals than dicotyl plants [4].

Table 1. Comparation of bioaccumulation value (BV) of five species plants on four heavy metals.

No.	Species	Plant Types	Bioaccumulation Value			
			Ni	Fe	Co	Pb
1.	*Scleria lithosperma*	Monocotyledonous	0,1	**10**	**1,5**	**1,6**
2.	*Machaerina glomerata*	Monocotyledonous	0,1	**1,4**	0,9	**1,2**
3.	*Trema cannabina*	Dicotyledonous	0,1	0,4	**1,1**	**1,1**
4.	*Alstonia macrophylla*	Dicotyledonous	0,1	0,3	0,2	**1,0**
5.	*Scleria purpurascens*	Dicotyledonous	0,1	0,4	0,01	0,9

Concentrations of Fe in plant shoots and soil rhizosphere were shown in Figure 7. Iron concentration was extremely high in plant shoots of *Scleria lithosperma* compared with other plants. Sequentially, *Scleria lithosperma* (8.068 mg/L)> *Machaerina glomerata* (1.356 mg/L)>*Scleria purpurascens* (0.961 mg/L)>*Alstonia macrophylla* (0.698 mg/L)>*Trema cannabina* (0.533 mg/L).

In soil rhizosphere, the highest Fe concentration was found in *Scleria purpurascens* (2.139 mg/L) respectively followed by *Alstonia macrophylla* (2.037 mg/L), *Trema cannabina* (1.363 mg/L), *Machaerina glomerata* (0.941 mg/L) and *Scleria lithosperma* (0.806 mg/L).

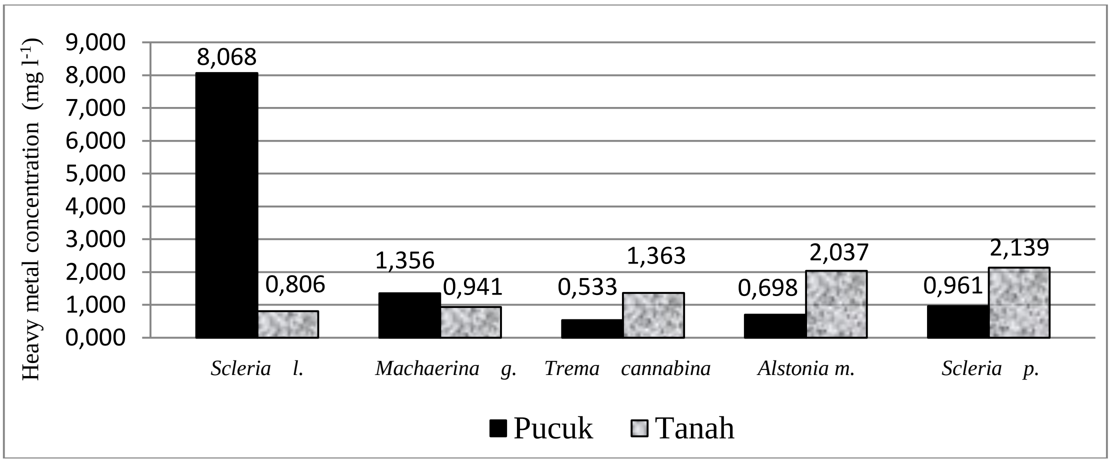

Figure 7. Iron (Fe) concentration (mg/L) in plant shoot and soil rhizosphere of five adaptive plant at post mining land in Pomalaa (The values were mean of 3 replicates).

Based on the BV (Table 1), *Scleria lithosperma* and *Machaerina glomerata* were classified as hyperaccumulator plants for Fe with BV 10 and 1.4 respectively [5, 9].

Concentrations of Co containing in plant shoots and soil rhizosphere are shown in Figure 8. The highest concentration of Co (1.163 mg/L) was shown by *Scleria lithosperma*, followed by *Machaerina glomerata* (0.735 mg/L), *Trema cannabina* (0.674 mg/L), *Alstonia macrophylla* (0.187 mg/L) and *Scleria purpurascens* (0.016 mg/L).

In soil rhizosphere, the highest Co concentration was found in*Alstonia macrophylla* (1.008 mg/L) and the lowest (0.100 mg/L) was indicated in *Scleria purpurascens*. However, Co concentration in *Machaerina glomerata* (0.794 mg/L) was higher than in *Scleria lithosperma* (0.769 mg/L) and in *Trema cannabina* (0.629 mg/L).

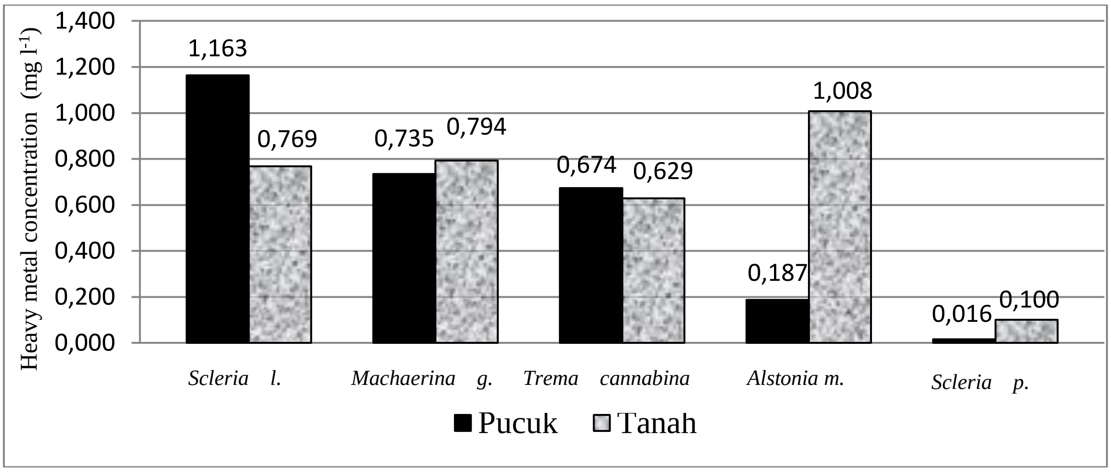

Figure 8. Cobalt (Co) concentration (mg/L) in plant shoot and soil rhizosphere of five adaptive plant at post mining land in Pomalaa (The values were mean of 3 replicates).

As shown in Table 1, there are only *Scleria lithosperma* dan *Trema cannabina* categorized as the hyperaccumulator plants for Co heavy metals with the BV 1.5 and 1.1 [5, 9].

Concentrations of Pb in plant shoots and in soil rhizosphere are shown in Figure 9. The highest Pb concentration in plant shoots was shown in *Scleria lithosperma* (0.212 mg/L) and the lowest was in *Scleria purpurascens* (0.134 mg/L). Lead concentration was higher in *Machaerina glomerata* (0.172 mg/L) than in *Trema cannabina* (0.146 mg/L) and in *Alstonia macrophylla* (0.137 mg/L).
In soil rhizosphere, Pb concentration in *Machaerina glomerata* was found equally to as in *Scleria purpurascens* (0.142 mg/L). Equivalently result was observed in *Scleria lithosperma*and in *Alstonia macrophylla* (0.131 mg/L). However, Pb concentration in *Trema cannabina* (0.135 mg/L) was higher than in *Scleria lithosperma* and in *Alstonia macrophylla*.

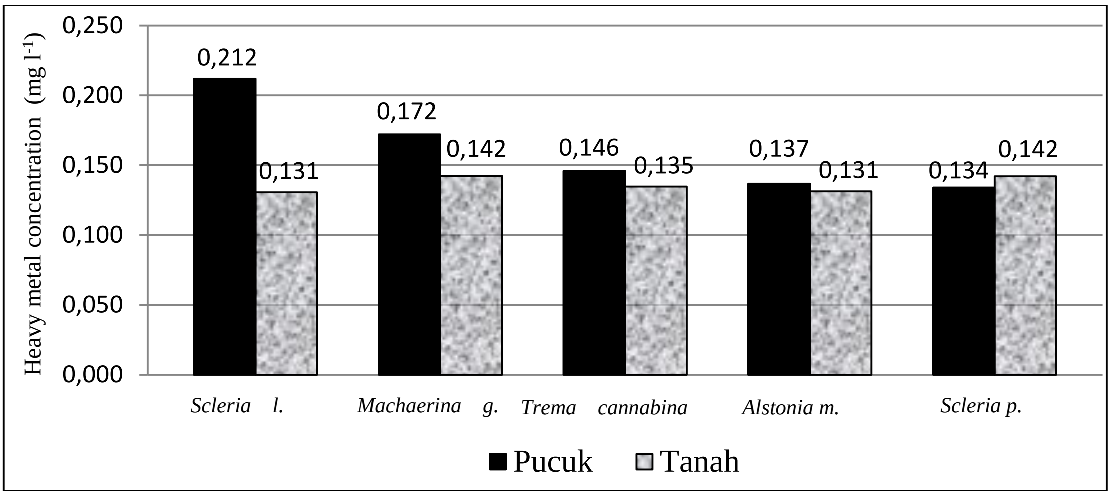

Figure 9. Lead (Pb) concentration (mg/L) in plant shoot and soil rhizosphere of five adaptive plant at post mining land in Pomalaa (The values were mean of 3 replicates).

Bioaccumulation values as indicated in Table 1, plant species of *Scleria lithosperma, Machaerina glomerata*, *Trema cannabina, Alstonia macrophylla*were classified as hyperaccumulator plants with BV 1,6 > 1,2 > 1,1 > 1,0 respectively [5, 9]. However, *Scleria purpurascens*was not categorized as a hyperaccumulator plant.

Absorption mechanism and translocation of heavy metals in plants of *Scleria lithosperma* L., *Machaerina glomerata*, *Trema cannabina*, *Alstonia macrophylla*are categorized as *phytoextraction* mechanisms.These mechanisms are part of *tolerance* mechanismsshowing that through *phytoextraction* mechanisms the plants are able to store contaminant substances and pollutants in high concentrations in parts of plant such as in shoot leaves. These plants are known as *phytoaccumulator* or *hyperaccumulator* plants [3, 11, 19, 20].

The capability of plant species as *hyperaccumulator* on two to three types of heavy metals (Ni, Fe and Co) is categorized as *multiple uptake hyperaccumulator* plant as shown by *Scleria lithosperma* L., *Machaerina glomerata* dan *Trema cannabina* [4]. *Alstonia macrophylla* which is only able to tolerate one type of heavy metal such as Pb is known as specific uptake hyperaccumulator [4].

Conclusion

Based on theresearch, the results can be summarized asfollows:

1) Species of plants found adaptively to post ferro-nickel mining land at Pomalaa are *Scleria lithosperma* (Linnaeus) Swartz, *Machaerina glomerata* (Gaudich) T. Koyama, *Trema cannabina* Lour., *Alstonia macrophylla* Wall Ex G. Don and *Scleria purpurascens* L.

2) The adaptability of five plant species is related to the capability of these plants to absorb heavy metals in high concentrations of Ni, Fe, Co and Pb in shoot leaves known as *hyperaccumulator* plants. *Hyperaccumulator* plants on two to three types of heavy metals (Ni, Fe and Co) are shown by *Scleria lithosperma* L., *Machaerina glomerata*and T*rema cannabina*; while one type (Pb) is indicated by *Alstonia macrophylla*.
3) Low or high concentrations of heavy metals in soil rhizosphere are not related to the capability of the five plant species to accumulate heavy metals in shoot leaves.

Acknowledgements. This research was financially supported by BPOPTN of Halu Oleo University. The authors thanks to Prof. Edi Cahyono for his fruitful discussion.

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Received: October 15, 2014; Published: January 19, 2015