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Identification of Wild Grass as Remediator Plant on Artisanal Gold Mine Tailing

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Abstract

Tailings, waste processing from gold ore separation (amalgamation), is generally disposed of on agricultural land, so the land became polluted and unproductive. Remediation of contaminated land can use wild plants as a potential agent of phytoremediation. Surrounding the mine area are found various kinds of wild plants that grow well and potentially as remediator plants. This study aimed to obtain the kinds of plants that grow around the gold mining activities of the people and has the potential as a crop Remediator. The study was conducted in the areas surrounding the gold mine of the people in Pesanggaran, Banyuwangi District East Java Province. Exploration carried out using wild plants transect method. Plants that had the highest IIV value has the life skills and high adaptability. Soil analysis results in tailings disposal site showed a low content of soil fertility, such as pH 7.7 to 7.9 (alkaline), C-organic (0.14%), N (0.13%), P (5.7 mg kg^{-1}), K (0.11 me/100g), and CEC (13 me/100g). The content of heavy metals Hg and Pb were detected has exceeded the threshold value (NAV) is required, which is 251.2 mg kg^{-1} and 135.2 mg kg^{-1}. The results showed that the people around the gold mine site, there are about 31 species of wild plants that have adapted, 6 species of plants which have potential as Remediator. ie *Eleusine inica*, *Chromolaena odorata*, *Ageratum conyzoides*, *Amaranthus*, spp., *Sesbania grandiflora* and *Momordica charantia*, with IIV 22.27%, respectively 22.02%, 15.20%, 14.57%, 13 , 97%, and 12.49%.

Keywords: wild grass, remediator plant, artisanal gold mine tailing

1. Introduction

Soil contamination by heavy metals due to human activities is a very important environmental issues around the world. The main source of soil contamination by heavy metals is varied, including mining activities. Heavy metals in the soil that can not be resolved will be absorbed by the flora, fauna, and humans, thus endangering human health.

Heavy metal contamination in the environment, either in small amounts or large can not be eliminated entirely. However, its effect on the ecosystem can be mitigated through immobilization. There are various methods that are effective, inexpensive, and environmentally friendly to immobilize heavy metals in contaminated soil. One of them is phytoremediation technique. This technique uses plants to accumulate heavy metal contaminants (fitoekstraksi) and also inhibit the spread from pollution sources (fitostabilisasi) (Ogundiran & Osibanjo, 2008). Phytoremediation has several advantages, i.e. low cost, slightly damaging the environment, ecosystem protection, can be applied to almost any type of heavy metal, recyclable metal rich plant residue, and accepted by many people.

There are a variety of plant species that have been identified and tested its ability to absorb and accumulate heavy metals (Lone, He, Stoffella, & Yang, 2008). Currently there are about 400 species of plants which potentially as accumulator, unfortunately the information about these species is still very limited. According Hidayati, Juhaeti, and Syarif (2009), there are some plants that are indicated as remediator plant because it has a high tolerance and potentially accumulate mercury in the roots and canopy more than 20 mg kg^{-1}.

Sheoran, Sheoran, and Poonia (2009), suggests that some indigenous plants have a high sensitivity and ability to accumulate heavy metals in soil. Hamzah, Kusuma, Utomo, and Guritno (2012) showed that weed crops, *Chromolaena odorata*, in addition to improve soil fertility, also act as a remediator plant. This plant is able to absorb Pb in leaves and roots, 55.56% and 44.44%, respectively. This suggests that wild plants are potential to be an accumulator plants.

Accumulator plants has many benefits, which is environmentally friendly, easy to implement, efficient and aesthetic, work on a wide variety of pollutants, and most importantly, do not need high cost (Zynda, 2001). Phytoremediation technology is underdeveloped in Indonesia. With the support of the rich biodiversity of plants and tropical climate of Indonesia, of course, the role of plants in controlling pollution needs to be studied and researched further, and applied in Indonesia.

Under these conditions, this research needs to be done to harness the potential of wild plants as plants Remediator, so the previously contaminated land can be used again as a healthy agricultural land. This study aims to find wild plants species that grow around the artisanal gold mining activities and has potency as remediator plant for heavy metal.

2. Materials and Methods

2.1. Study Site

Exploratory research of plant and taking tailings sample was carried out at the artisanal gold mine tailing, Pesanggaran, Banyuwangi district (Figure 1). Study sites geographically are located between 7 43'- 8 46' South Latitude and 113 53'- 114 38' East Longitude (The Indonesian Central Bureau of Statistics [BPS], 2012).

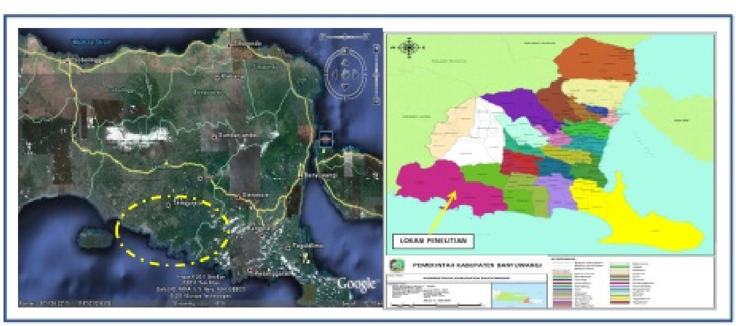

Figure 1. Map of Banyuwangi district and research study sites

Exploratory and wild plant species analysis was conducted in field, otherwise soil and heavy metal analysis was done at Agricultural Faculty Laboratory of Tribhuwana Tunggadewi University, Soil Department Laboratory of Agricultural Faculty of UPN "Veteran" East Java, and Soil Department Laboratory of Agricultural Faculty of Brawijaya University. This research was conduct started from Mei until August 2013

2.1.1. *Exploration Potency of Wild Plants as Plants Remediator*

Exploration was conducted directly in the field by doing vegetation analysis. Inventory of plant species was conducted in the tailings disposal sites and in the area around of gold mining. Samples were taken using a transect method. Observations were made on 9 plots measuring 200m^2. Transects were made perpendicular to each plot, and then on the left and right of the transects were made five plots each measuring 1m x 1m as a plot observations (Sambas, 2002).

The dominance of a species is determined from the relative frequency and relative density of the habitat. If a species is common and has a high density in a habitat compared with other species, the species is dominant and important in these habitats. Dominant species which are indicated by high value of Importance Value Index (IVI) will be developed as a remediator plants. Important Value Index (IVI) (Soerianegara & Indrawan, 2005; Kent & Coker, 1993) was calculated according to the following equation:

$$IVI = FR + KR$$

Where

IVI = Important Value Index. IVI is between 0 -200%, the greater the value of IVI of a species, the greater the role of the species in the community.

FR = Relative frequency of a species (%), determined by comparison of the frequency of a species by the number of frequencies of all species in a unit of land use. The highest relative frequency is 100%.

KR = Relative density of a species (%) was determined from the ratio of the density of a species at a density of all species in a unit of land use. The highest relative density is 100%.

2.1.2. *Soil and Plant Analysis*

Soil samples were taken at the tailings disposal locations around the amalgamation process. Samples which are taken are samples of the second stage separation process (cyanidisasi). The first separation process was not taken, because at the first process is still a little gold gained so the process was proceed with the second process (cyanidisasi).

Chemical analysis of soil include pH (H2O), soil organic matter (Walkey & Black, 1934), N-total (Kjedahl), P-total (Olsen), K-exchangeable, CEC (NH4OAc pH 7.0). While heavy metals which is analyzed consists of Mercury (Hg), Cyanide (Cn), Cadmium (Cd), Lead (Pb), Nickel (Ni), and arsenic (As) using AAS and CAA (Atomic Absorption Spectrometry and Cold Atomic Absorption). Results of analysis of soil and heavy metals will be the basis for determining the nutrient content and the level of heavy metal contamination. Heavy metal which exceeding the Threshold Limit Value (TLV) required (PP. No.. 18 of 1999) will be further investigated.

2.2. Data Analysis

Effects of treatment of the parameters were analyzed using analysis of variance (ANOVA) at the level of 5% and 1%. When the results of the analysis of variance showed significant difference, then followed by least significant difference test (LSD) at the 5% significance level (α = 0,05). The relationship of each variable was analyzed using regression and correlation.

3. Results and Discussion

3.1. Mapping of Research Sites

Research site is artisanal gold mining that have been abandoned by miners. The reason why miners left the gold mines i.e.: (a) mining area is not getting the gold as expected, (b) Safety reasons, due to the mining area is illegal mining so at all times raided by security forces, (c) socio-economic reasons, and other reasons that are not revealed.

The results showed that most of the agricultural land which is used as a tailings dump has been polluted. The Symptoms shown is a disturbance of the vegetative and generative plant growth in the tailings disposal area. According to Lu, Kruatrachue, Pokethitiyook, and Homyok (2004) environment which polluted by heavy metal will affect plant growth due to changes in reaction to heavy metal stress. However, plant growth will be back to normal after the plants began to adapt. At this stage the plant has vegetative growth in which there has been a division of meristematic cells. At this stage the plant has vegetative growth in which there has been a division of meristematic cells. Plants which began to adapt will have a green color and the leaves and stems began to flourish. The ability of the growth is related to the availability of nutrients contained in the waste (Palapa, 2009).

3.2. Characterization of Land Contaminated Tailing

Soil analysis showed that the soil had a pH of 7.9 (alkaline). Soil chemical characteristics such as soil organic carbon (0.1%), N-total (0.1%), available P (5.7 mg kg-1), K exchangeable (0.1 me/100g), and CEC (13, 0 me/100g) was classified as low to very low (Table 1).

Table 1. Chemical Characteristics of Land Contaminated Tailing

Nutrient Content	pH (H_2O)	C-org	N-total	P	K	KTK
		------- %------		mg kg^{-1}	--- me/100 g---	
	7,9	0,4	0,1	5,7	0,1	13,0
Heavy metal	Hg	Pb	Cn	Cd	Ni	As
		-------- mg kg^{-1} ---------				
	251,2	135,2	0,31	1,4	0,6	0,1

The soil samples collected were analyzed for their metal contents. It appears that metal concentration in different samples varies to a great extent from sample to sample.

Heavy metal content of the five elements of metal being analyzed, two of which exceed the threshold value (NAV). Heavy metals content of Hg and Pb is 251.2 mg kg^{-1} and 135.2 mg kg^{-1}, respectively. The high content of heavy metals is suspected not only come from the addition of chemicals in the amalgamation process that uses mercury as the main gold ore separator material, but also due to the reaction of some chemical elements contained in the raw material mining extractive.

Herman (2006) revealed that the mineralogy of the tailings consist of a variety of minerals such as silica, silicates of iron, magnesium, sodium, potassium, and sulfides. Of these minerals, sulfide was an active mineral, and when in contact with air will oxidized into acidic salts and liquid acid containing toxic metals such as As, Hg, Pb, and Cd that will contaminate and damage the environment.

The results showed that the soil heavy metal pollution in the study area is quite high, especially Hg and Pb (251.2 and 135.2). The high concentration of heavy metal pollution is related to the use of mercury (Hg) in the amalgamation process that pollutes the soil and surrounding environment. While high concentrations of Pb probably derived from rocks containing silica in contact with oxygen and oxidize (Herman, 2006; Hamzah, Kusuma, Utomo, & Guritno, 2012). It is associated with poor waste management processing in traditional gold mining so that pollute the environment. Another issue arising from mining activities is high soil pH, which is equal to 7.9. This figure shows that the soil in the study area is alkaline so it is required further management steps. High soil pH will cause immobilization of elements so that plants can not grow well. High soil pH also causes changes in plant metabolism which in turn can lead to declining crop yields. Some contaminants have time half average in long time and in other cases derivative chemicals are formed from the main soil pollutants.

3.3. Inventory Wild Plants Species as Remediator Plant

Inventory of wild plant species in the surrounding area of artisanal gold mining get at least 31 species of wild plants, six of them are grown predominantly i.e. *inica, Chromolaena odorata, Ageratum conyzoides, Amaranthus, spp., Sesbania grandiflora,* and *Momordica charantia.*This domination was shown by the high IVI value i.e. 22.27; 22.02; 15.20; 14.57; 13.97 and 12.49, respectively while the rest have IVI under 10. The high value of IVI, shows that the plant has the ability to live and be able to adapt to the surrounding environment (Soerianegara & Indrawan, 2005), and is thought to have accumulator characteristics. Plants will be categorized as an accumulator if it has character (i) capable of absorbing elements in the soil is higher than the other plants, (ii) is able to absorb large amounts of the elements at the roots and canopy, (iii) capable to translocate large amount of heavy metals from the roots to the canopy (Brown, Angle, Chaney, & Baker, 1995).

Identification results showed that the majority of wild plant populations derived from *Astaraceae* family, then family *Poaceae*, *Amarantaceae*, *Fabaceae* and *Cucurbiceae*. The same study been conducted in 2002 in the gold mining areas of West Java Pongkor by Sambas (2002), which gets as many as 64 species of indigenous plants, which consists of the family Amaranthaceae, Poaceae, Cyperaceae, Convolvulaceae, Asteraceae, and Scropulariaceae. Hamzah *et al*. (2012) who conducted similar research at artisanal gold mining - Lombok NTB, also found similar wild plants. Several of types have the same relatives, including *Astaraceae, Poaceae* and *Amaranthaceae* which are also found in the study sites. Plants that been categorized as Asteraceae family have potency as plants remediator (Sambas, 2002; Hamzah *et al.*, 2012).

In this study also found Ipomoae sp, but not dominant so it can not be used as an accumulator plant. However, Robinson *et al*. (2003) found that this species is able to accumulate cyanide in artisanal gold mining i.e. 35.70 mg kg^{-1}. Likewise Mikania cordata (Burm.f.) which are known are able to accumulate lead (Pb), up to 11.65 mg kg^{-1}, unfortunately this plant is not found dominant in the study area. This is due to differences in agroecosystems that affect the dominant plant species that are found in study area.

Williams and Currey (2002) found that some species of wild plants such as herbaceous annuals, shrubs and trees can be used as phytostabilization agent. Wild plants such as grasses can produce closures above ground quickly and reduce dispersion the dust of tailings. Shrubs and trees produce extensive canopy cover and produce deep roots to prevent erosion in the long term. In addition, shrubs or trees provide high nutrient to the grass while lowering water stress and improve soil physical properties (Tiedemann & Klemmedson, 2004).

Some plants may dominate the ecosystem due to natural selection, but the presence and influence of the less dominant species remain significant in shaping a sustainable ecosystem (Tilman *et al*., 2001). Absorption and accumulation of heavy metals by plants can be divided into three ongoing processes, (1) the metal uptake by roots, (2) translocation of metals from the roots to the other plant parts, and (3) metal localization of a particular cell to keep not inhibit metabolism. Key to the success of remediation of soil contaminated heavy metal is use tolerant plant species which have already selected (Mukhopadhyay & Maiti, 2010).

4. Conclusion and Suggestion

4.1. Conclusion

1. There are 6 species of wild plants that have potency as remediator plant which is shown with highest IVI. These plants are *Eleusine inica* (22.27), *Chromolaena odorata* (22.02), *Ageratum conyzoides* (15.20), *Amaranthus* spp. (14.57), *Sesbania grandiflora* (13.97) and *Momordica charantia* (12.49).
2. Tailings analysis showed that the soil in the artisanal gold mining area have a low level of fertility, and high of heavy metal contamination, especially Hg and Pb.

4.2. Suggestion

1. Wild plants which have potency as remediator plant has the highest value of importance value index because the ability to live and adapt is sufficiently high.
2. Soil contaminated tailing has a low fertility rate, as well as the high content of heavy metals, especially Hg and Pb so that it is needed comprehensive management by optimizing the use of local resources as organic matter inputs.

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