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Prospect of indigenous plant species for revegetation in the tailings area of ex community gold mine

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Abstract. *Ekyastuti W, Astiani D, Roslinda E. 2016. Prospect of indigenous plant species for revegetation in the tailings area of ex community gold mining. Biodiversitas 17: 764-768.* One of the reclamation activities in the tailings area of ex community gold mine is revegetation. The success of revegetation is strongly influenced by the selection of suitable plant species. The purpose of this research was to determine the prospects of indigenous plant species for revegetation in the tailings area of ex community gold mine. Research has been conducted at the tailings area of ex community gold mining in Menjalin subdistricts Landak District West Kalimantan, using an experiment method with randomized complete block design (RCBD). Used ss basic for blocking is the difference of tailings area age: 2 years old and 10 years old after mining activities. In both locations, seven indigenous plant species were planted, i.e: *Dillenia suffruticosa, Vitex pinnata*, *Archidendron pauciflorum*, *Anacardium occidentale*, *Shorea leprosula*, *Alstonia scholaris* and *Hevea brasiliensis*. The results showed that the seven indigenous plant species are tolerant to mercury and can grow well in the tailing areas of ex community gold mine of both 2-years and 10-years after mining. Five indigenous plant species use phytostabilization to remediate mercury in the plant tissue, while two others species use phytoextraction. Therefore, the prospect of using indigenous plant species for revegetation in tailings area of ex community gold mine is very well.

Keywords: Ex community gold mining, indigenous plant species, tailing

INTRODUCTION

In West Kalimantan, small-scale gold mining activities (community gold mining) can be found in almost all districts, with the exception of Pontianak. As a result, tailing areas of ex community gold mining are spread throughout the province. One of the districts in West Kalimantan with quite extensive tailings area is the district of Landak. Particularly in Menjalin Sub District of Landak, data from 2013 showed a vast tailings area of ex community gold mining of 3,209 hectares (Romana et al. 2013). Many of the community gold mining activities are still going on to date. Tailings area of ex community gold mining is a critical land that is barren, arid, nutrient poor, tends to be acidic, and contains heavy metal of mercury (Ekyastuti 2013). Such condition requires proper reclamation to allow the survival of living things around it.

Part of the activities for land reclamation in ex-gold mine is revegetation. Since tailings area of ex-gold mine has limitations as medium for planting, a successful revegetation would be quite challenging. However, these constraints could be minimized by improving the physical, chemical and biological of tailings, i.e: by adding organic matters such as compost, top soil, and inoculation of arbuscular mycorrhizal fungi (Ekamawanti and Ekyastuti 2010, Ekyastuti 2013; Ekyastuti et al. 2016a). Moreover, the success of revegetation is also strongly influenced by the suitable selection of plants. The characteristics of plants suitable for revegetation in the tailings area are: easy to grow, intolerant, catalytic and phytoremediator of pollutants (Setiadi 2003; Mansur 2010; Sarma 2011). This means that besides being able to grow well in the tailings area, the species should also be able to facilitate other species to grow in these places. Furthermore, as written by Setiadi (2003), the catalytic species grow rapidly, generating much litter that decompose quickly, produce fruits which could invite animals who play a role in dispersing seed, which in turn results in fast colonization of plants on the area. Some indigenous plant species are considered having such characteristics, as the indigenous plant species are more adaptable to local environment. Astiani (2016) stated forest degradation has caused the loss of more than 50% of important species, yet based on research results by Ekyastuti and Roslinda (2015) in Menjalin sub district, the availability of seedlings of indigenous plant species for revegetation are still very good. This is made possible because in the surrounding of tailings area in Menjalin sub district, we could still find some secondary forest with a healthy condition. Therefore, it is necessary to study the utilization of indigenous plant species in revegetation activities. In this case, the study is focused on the field (on the tailings area).

Previous research proved that the planting of four indigenous species using the media of tailings ex-gold mine in the greenhouse run well (Ekyastuti et al. 2016b). The study also revealed that planting collectively (together) a number of species in the same location was better than planting one species only. However, testing of planting has not been done in the field. Planting tests in the original areas is very necessary to prove that indigenous species can grow well in the tailings area of ex-community gold mine, which will then enable it for revegetation. This study is therefore aims to explore the prospects of indigenous species for revegetation on tailings area of ex-community gold mine through field tests.

MATERIALS AND METHODS

Research has been conducted at the tailings area of ex-community gold mine in Menjalin sub districts, using an experimental method with randomized complete block design (RCBD). Used as basic for blocking is the difference of tailings area age: 2 years old and 10 years old after mining activities. The location of tailings area of 2-year after mining is in Lamoanak village, and tailings area of 10-year after mining is in Sepahat village (Figure 1). The treatment in this study was the planting of seven indigenous species, namely: *Dillenia suffruticosa, Vitex pinnata, Archidendron pauciflorum, Anacardium occidentale, Shorea leprosula, Alstonia shcolaris* and *Hevea brasiliensis* in both sites. Planting was carried out on a planting hole of 40 cm x 40 cm, with holes of 40 cm deep each. In order to obtain the optimal conditions of planting medium, each hole was improved in its physical and chemical condition, using a mixture of top soil + compost 1: 1 (v / v) (Ekamawanti and Ekyastuti 2010; Ekyastuti 2013). Planting activity was carried out in the afternoon to avoid excessive evaporation. Planting activity is presented in Figure 2.

Analysis of variance was performed using the software program SAS 13. The data analyzed covered: percentage of plant growth, plant height increment (cm), and plant diameter increment (cm). Analysis of total mercury content in the roots, shoots and media (ppm) at the end of the study were conducted at the Laboratory of Baristand Pontianak, using standard SNI 06-6992.2 2004. The data would be used as baseline data to calculate: bioconcentration factor and translocation factor following the technique of Rabie (2005).

RESULTS AND DISCUSSION

The results showed that in both planting site, tailings area of 2-year after mining and 10-year after mining, the seven indigenous species planted could grow well and normal. No signs of mercury poisoning found on the plants. Results of observation and calculation are described separately below.

Percentage of plant growth

The mean of plant growth percentage at both sites are high, 91.42% at the tailings area of 10-year after mining (with a range between 80.00-97.60%) and 70.23% at the tailings area of 2-year after mining (with a range between 56.0-93.0%). Based on test results, percentage of plant growth at the tailings area of 10-year after mining was

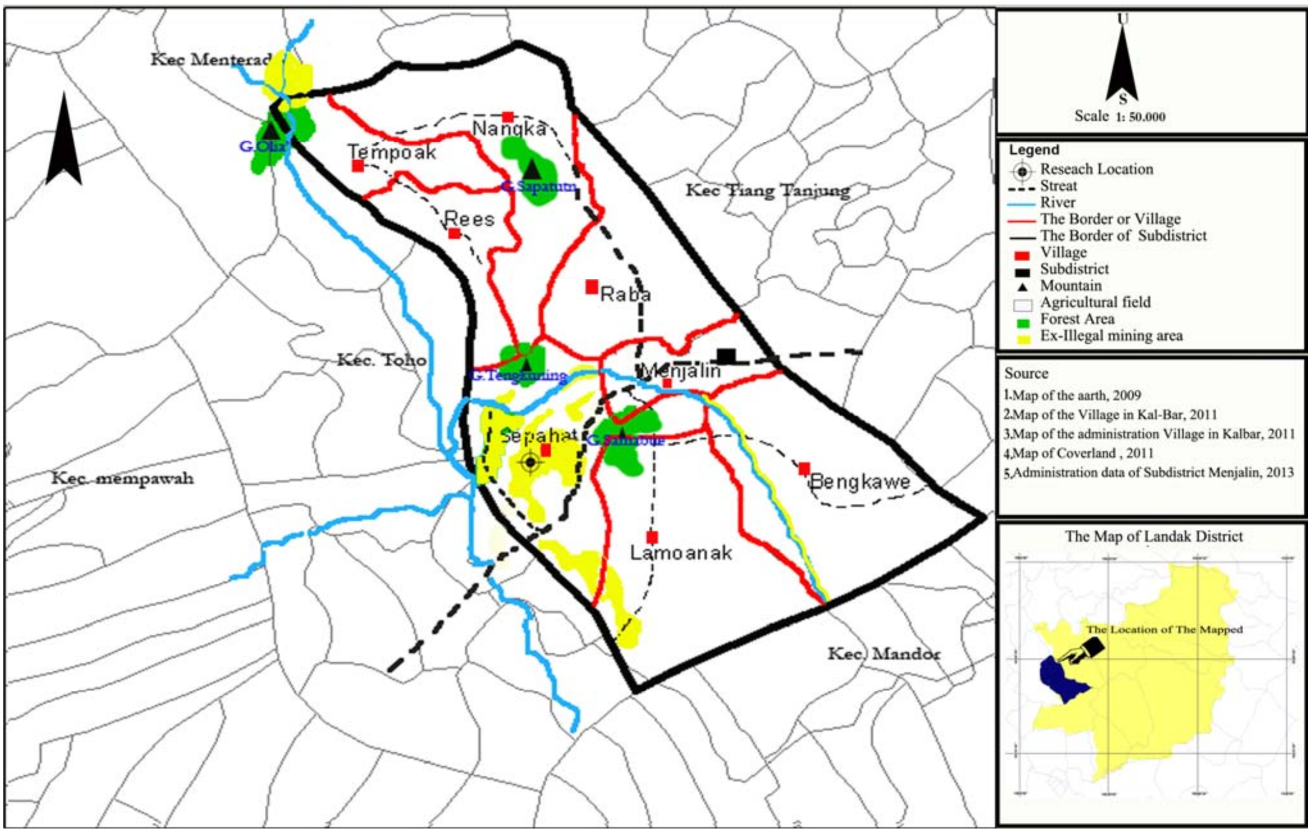

Figure 1. A map of the study site: Menjalin Sub district, Landak District, West Kalimantan, Indonesia. Map source: GPS data processing in the Laboratory of Forest Planning, Faculty of Forestry, Universitas Tanjungpura, Pontianak, Indonesia (2016)

Figure 2. Planting activities at tailing areas of ex community gold mining (A-C) transporting seedlings to the field and (D-F) planting activities

significantly higher than tailings area with the tailings area of 2-year after mining (Table 1). Meanwhile in each planting site, the growth percentage of seven indigenous species was not significantly different. However, there was a tendency that the percentage of plant growth in the tailings area of 2-year after mining slightly fluctuated (Figure 3).

Plant growth response

Plant growth responses in the field are measured through both their height and diameter, which were measured every month. The results showed that neither in tailings area of 2-year after mining nor 10-year after mining showed significant difference in average plant height and plant diameter increase (between seven indigenous species) (Table 2). Although insignificant, four indigenous species, *H. brasiliensis*, *A. pauciflorum*, *S. leprosula* and *V. pinnata,* showed the tendency of lower plant height and plant diameter increase in the tailings area of 2-year after mining compared to those in the tailings area of 10-year after mining (Figure 4). The other three indigenous species showed relatively similar increase. This is in line with the results of physical-chemical analysis of tailings. Physical-chemical conditions of tailings area of 10-year after mining had already begun to improve. Likewise, the content of mercury has declined from 0.5 ppm (tailings area of 2-year after mining) to 0.02 ppm (tailings area of 10-year after mining).

Bioconcentration factor (BF) and translocation factor (TF)

The result showed that the seven indigenous species have a bioconcentration factor > 1. This means that the accumulation of mercury generally occurs in the plant tissue, not in the media (Rabie 2005). It also means the seven indigenous plant species are tolerant to mercury. Based on the translocation factor, it is understood that five indigenous plant species accumulated mercury in the roots (TF < 1). The five indigenous species are: *A. occidentale*, *H. brasiliensis*, *A. pauciflorum*, *S. leprosula* and *V. pinnata*. Meanwhile, two other indigenous plant species, *A. scholaris* and *D. suffruticosa,* accumulated mercury in the shoots (TF > 1). According to Fulekar et al. (2009) and Sarma (2011) the process of mercury remediation is phytostabilization if TF < 1 and phytoextraction if TF > 1.

Tabel 1. DMRT of the percentage of plants growth

Tailing ages	The average percentage of plant growth
2 years after mining	70.23 a
10 years after mining	91.42 b

Table 2. Anova of increments of height and diameter

Treatments	Plants height increment	Plants diameter increment
A. scholaris	13.930 a	0.415 a
A. occidentale	10.550 a	0.305 a
D. suffruticosa	9.650 a	0.195 a
H. brasiliensis	14.320 a	0.245 a
A. pauciflorum	5.880 a	0.290 a
S. leprosula	4.730 a	0.205 a
V. pinnata	6.910 a	0.215 a
P-value	3.279	2.215
F-value	4.280	4.280

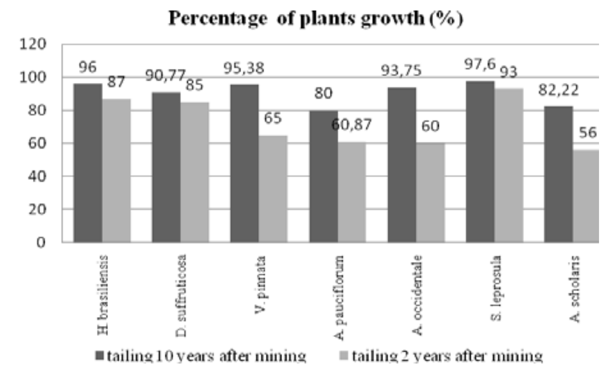

Figure 3. Percentage of plant growth in tailing areas

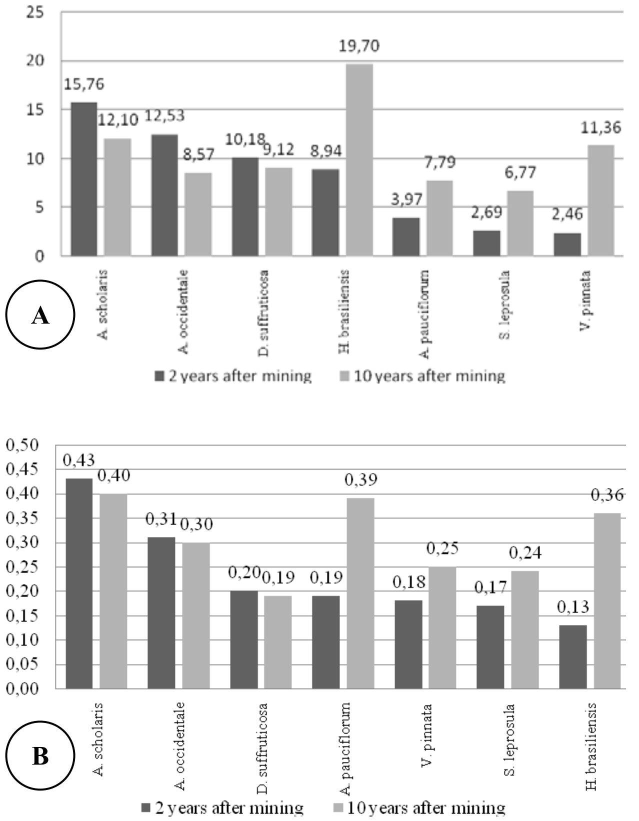

Figure 4. Average of incremets (cm) of (A) height and (B) diameter

Tabel 3. Bioconcentration Factor (BF) and Translocation Factor (TF)

Indigenous plant species	BF	TF
A. scholaris	45.0	1.3
A. occidentale	6.5	0.3
D. suffruticosa	15.5	3.0
H. brasiliensis	13.5	0.1
A. pauciflorum	11.0	0.1
S. leprosula	7.5	0.5
V. pinnata	40.0	0.6

Discussion

The percentage of plants growth at the tailings area of 10-year after mining is very high (91.42%), whereas at the tailings area of 2-year after mining is moderate (70.23%). The difference in percentage growth of plants is suspected due to the difference in tailings' fertility rate as the medium for growing plants. It is evident that based on the results of physical-chemical analysis, tailings area of 2-year after mining is worse than the tailings area of 10-year after mining. At the tailings area of 2-year after mining, we found a fairly high level of mercury (0.5 ppm), low macro nutrient content, low pH (acidic), low cation exchange capacity (CEC) and the soil texture was dominated by sand (89.6%). Fauziah research's results (2009) showed that the tailings area as plant medium is bad or unworthy. However, the condition could be improved by adding humic acid and compost. The opinion is echoed by Sembiring (2008) and Ekyastuti (2013), stating that the tailings area of less than 2-year after mining has not showed any improvement, physically and chemically. Therefore, it is not suitable for plants' growth.

Meanwhile, at the tailings area of 10-year after mining, the success of growing plants is affected by the improvement in tailings' physical-chemical conditions. Based on the analysis on tailings area of 10-year after mining, it is revealed that the nutrient availability has increased, along with normal pH, moderate level of cattion exchange capacity, and mercury content down to 0.02 ppm. Such condition would provide a much better site for plants' growth, so the percentage of plant growth will be very good. Some parts of the tailings area of 10-year after mining in Sepahat village have been used for cultivation of – not only timber – but also horticultural crops.

Based on the analysis, the mercury content in the tailings area is 0.02 ppm - 0.5 ppm. We found that the older the tailings, the lower the mercury content. On the other hand, based on the response of plant growth, the seven indigenous plant species can grow well not only at the tailings area of 10-year after mining, but also at tailings area of 2-year after mining. The conclusion proved by ANOVA is not significantly different. It also proves that the seven indigenous plant species are relatively tolerant to mercury. The results of this study (field study) is in line with previous studies conducted in the greenhouse (Ekyastuti et al. 2016). Such condition is achieved not only due to the physical-chemical improvement of tailings area, including lower mercury content, but also due to the selection of indigenous species, which are more adaptable to local environment compared to other exotic species (Adman et al. 2012). The results of this study are very useful to support plant breeding and preservation program of indigenous species (Uji 2007).

Based on data from bioconcentration factor, it is revealed that the planting of seven indigenous plant species in this study led to the accumulation of mercury in plant tissue instead of the planting medium, because the seventh has a value of FB> 1. The results showed further that the seven indigenous plant species are tolerant to mercury (Rabie 2005). While based on the value of translocation factor, the results are varied. Five indigenous plant species, *A. occidentale*, *H. brasiliensis*, *A. pauciflorum*, *S. leprosula* and *V. pinnata,* use phytostabilization to remediate mercury in the plant tissue. As for the other two species, *A. scholaris* and *D. suffruticosa,* use phytoextraction to remediate mercury in the plant tissue. In remediation process using phytostabilization, the mercury content is accumulated in the vacuole of roots, and not distributed to the leaves. Therefore, the photosynthesis process is not disturbed and the plants grow normally. Meanwhile, in the phytoextraction process, mercury is distributed to the leaves (Patra & Sharma 2000; Wang 2004). As a result, if the plant uses phytoextraction processbut the growth is still normal, it is suspected that mercury is stored in the vacuole of leaf, resulting in undisturbed photosynthesis process. However, the theory was not further examined in this study.

Based on the results of plant growth in the field, namely in the tailings area of 2-year after miningand 10-year after mining, it can be concluded that the prospects of using indigenous species as the selected plants for revegetation at the ex-community gold mine is very good. Furthermore, the improvement of physical-chemical properties of the tailings by adding compost and other beneficial microorganisms (in this case is arbuscular mycorrhizal fungi) is also important. In the future, these activities should also involve the communities surrounding the tailings of ex-gold mining to optimize the results.

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