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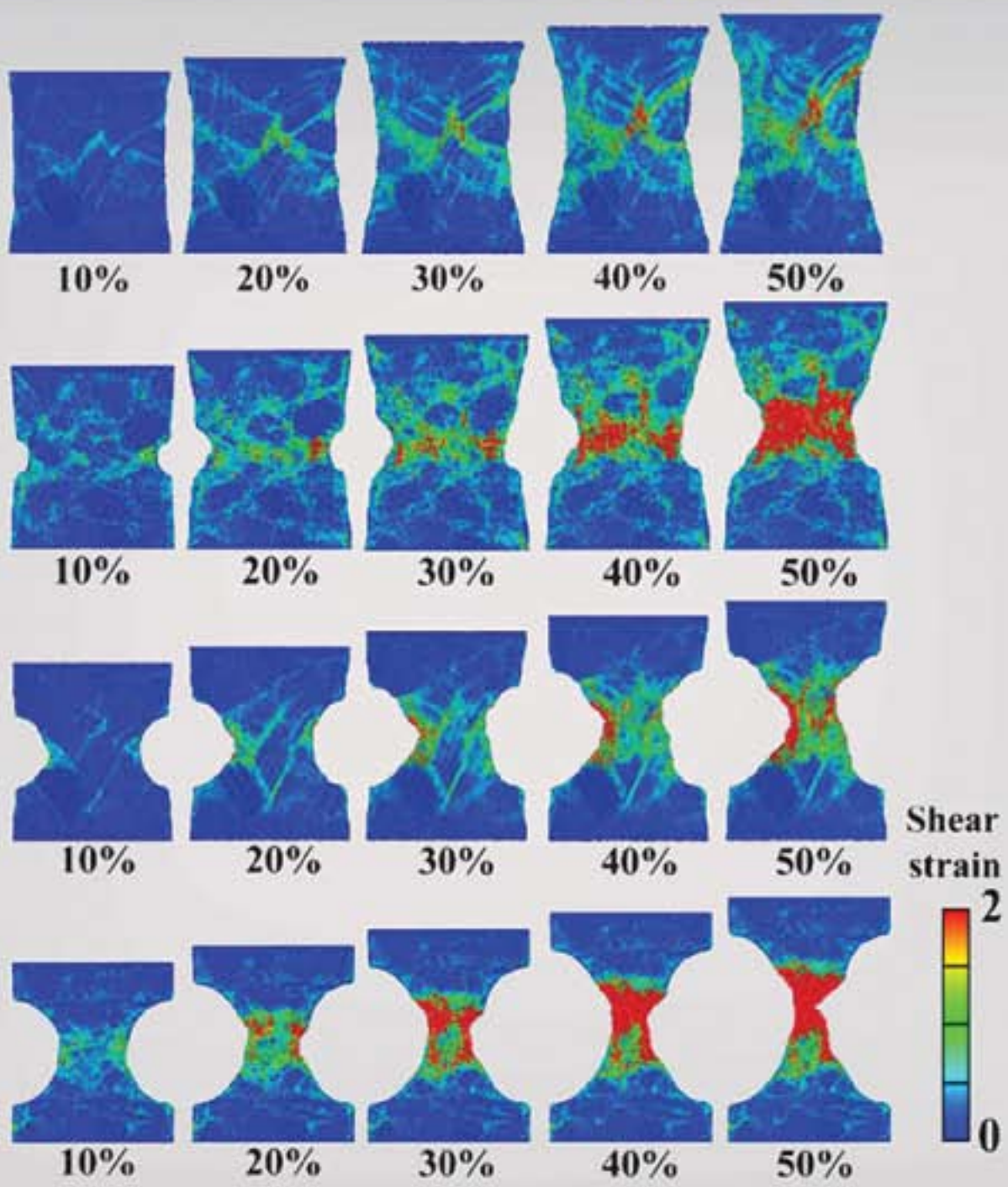

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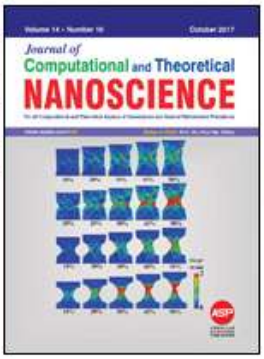

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Adaptation of Pioneer Plant at the Coal Mining Area in East Kalimantan Indonesia

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Environment quality decrease is one of the impact of coal mining activities in East Kalimantan. The land becomes barren and critical, making it difficult for plants to grow and adapt, therefore post-mining area needs to be rehabilitated to restore the soil of the land as an important factor in crop cultivation. Before being planted with local trees, the environmental conditions must be suitable for seedlings to be planted. One of the pioneer plants functions is to stabilize the post-mining environmental conditions. The objective of this study was to determine a pioneer species that have a well adapt to the post-coal mining environment in East Kalimantan. This study using completely randomized block design. The plot used a rectangular 30 × 25 meter plot of 15 plots for five pioneer tree species. Data collected were the plant life percentage, plant height, stem diameter and crown diameter. The study result showed that from the five species of pioneer plants there were three species has an optimal growth they are Alstonia scholaris, Homalanthus populneus and Croton argyratus. Based on the List Significance Difference test 5% level results shows the Alstonia scholaris and Croton argyratus life percentage is not significantly different with Homalanthus populneus, but it is very different from Macaranga gigantea and Trema tomentosa. Homalanthus populneus is the most adaptable pioneer species in the open area, its growing in the open post-mining area and from the forest with has intact condition. The genetic factors really affect the adaptation and growth of pioneer plants in post-mining areas.

Keywords: Adaptation, Pioneer Plant, Adaptation, Post-Mining, Coal.

RESEARCH ARTICLE

1. INTRODUCTION

East Kutai has many coal reserves. Since 1995 produced ± 15 million tons of coal per year and it has increased every year. The production target has increased to 50 million tons per year in the last five years [1]. In Indonesia coal mining activities is using opencast mining method which have a potential to change the physical, chemical and biological environment, such as landforms, soil and water conditions, and have an important effect on vegetation patterns [2–3]. Environmental quality decrease is one of the coal mining activities impact in East Kalimantan [4–5]. The land becomes barren and critical, therefore rehabilitation effort were needs to restore the soil potention as an essencial production factor especially in crop cultivation [6].

In East Kutai district East Kalimantan Province, land disturbed by PT Kaltim Prima Coal (KPC) mining activities will be rehabilitated [3]. That is means it will be returned to its natural and productive condition. After rehabilitation, it is necessary to plant more trees (re-vegetation). In the first three years after tree planting, the land condition will naturally suitable to plant a tropical trees (a local tree which only can grow well under protective plants (in-tolerant tree) [2]. It is important to note that the environmental balance in post-mining areas is change rapidly. In such locations the introduced species may not be able to adapt, it cannot grow and cannot develop properly it is being planted in areas where the ecological systems change due to mining exploitation [7].

There is 123 plant species in post mining areas in South Kalimantan, consist of 79 plants (Cyperaceae, Poaceae and Asteraceae), 10 lianes, bryophyte, 9 ferns, 10 shrubs and 14 tree species [8]. Some Poaceae, i.e., Paspalum conjugatum, Paspalum dilatatum, and Echinochloa colona are generally present among large stones, and rocky roads. Whereas Cyperaceae such as Fimbristylis miliaceae, Cyperus javanicus, Rhyncospora corymbosa and Scleria sumatrensis are most commonly found around ponds with subtle and moist substrate characteristics. Certain species of shrubs and trees are present at the site of

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the 7th month overburden disposal. For shurb the spesies such as Chromolaena odorata, Clibadium surinamense, Melastoma malabathricum, Trema micrantha, and Solanum torvum, and for tree species such as Ochroma pyramidale dan Homalanthus populifolius. This plant species can be used to accelerate the primary succession at post coal mining reclamation area. However, species selection is needed to avoid invasive species planting. Study results in East Kalimantanof was found 104 plant species at the reclamation site, which consisted of 76 tree species and 28 herbaceous species. Tree species consist of 35 locally planted species (e.g., Dryobalanops aromatica, Eusiderox-ylon zwageri, Macaranga gigantea), 25 non-local plant species planted, and 16 local species that grow spon-taneously (e.g., Leucaena glauca, Lansium domesticum, Shorea laevis). As comparison, 133 species were found in pre-mining sites, which consisted of 132 local tree species, one non-local tree species (Acacia mangium) and 52 herbaceous species [2].

This is the importance of various pioneer plant species adaptation research for the post coal mining rehabilitation area. Before the post mining land area planted by the local plant, the condition of the soil has to be suitable for the seed's life. One of the pioneer plant function is to stabilize in macro and micro ecosystem around. This study was determines pioneer species that can adapt to the post-coal mining environment in East Kalimantan.

2. EXPERIMENTAL DETAILS

The study was conducted at a mining location in East Kutai District in 2018 (Fig. 1). The tools used in this study are hoes, rulers, micro-calipers, machetes, scissors, stationery, while the materials used are from 5 selected pioneer plant species, namely Macaranga gigan-tea, Trema tomentosa, Alstonia scholaris, Croton argyratus and Homalanthus populneus (Fig. 2).

Other materials are used to support research is NPK fertilizer. The research starts by field orientation, seedling preparation, land preparation, planting and every month measurement. The data collected is the plant life per-centage, plant height, stem diameter and crown diameter. The seedlings planted are threemonthold seeds with uniform conditions, while preparing post mining that has been planted with cover crops and leguminous species. This study used in a completely randomized block design (RCBD). The plot used a rectangular plot of 30 × 25 meters in size as many as 15 plots for five pioneer trees species.

The data of plant species tested at post mining reclamation areas in East Kutai, were process to calculate the plant life percentages (%), stem diameter measurement results (cm), crown diameter measurement results (cm), plant height measurement results (cm), data analysis by ANOVA, and if the \results is significantly different, then to find out the best treatment, use a further test with the smallest real difference test (LSD).

3. RESULTS AND DISCUSSION

The plant life percentage at a month of the various pioneer species studied showed overall plants grow well. The aver-age life percentage at a month is 93.15%. The criteria of planting success are based on the following criteria; failed (<9%), low (10–39%), sufficient (40–69%) and good (70– 100%) [9]. Based on these criteria, all plants studied had a percentage of life with good criteria (>70%).

The result show that almost the whole plant can grow well at the three month age. This research was using suc-cess criteria [9]. So it can be found that the life percentage average is 92%, so based on the success criteria its life percentage is in good criteria. At six months ages the overall can grow well with the average life percentage of 86.58%, which is in good criteria. At 12 month age, the average of plant percentage is 78.70% and these plant grow well (70–100%) based on the plant success criteria.

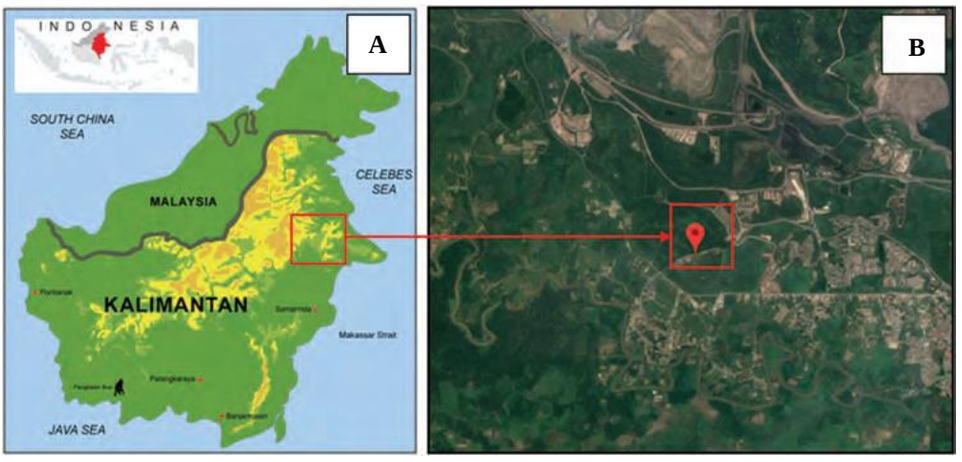

Fig. 1. (A) Research sites in East Kalimantan Province, Indonesia. (B) Post-mining area, East Kutai at 0 32 17.3 N and 117 29 39.1 E.

RESEARCH ARTICLE

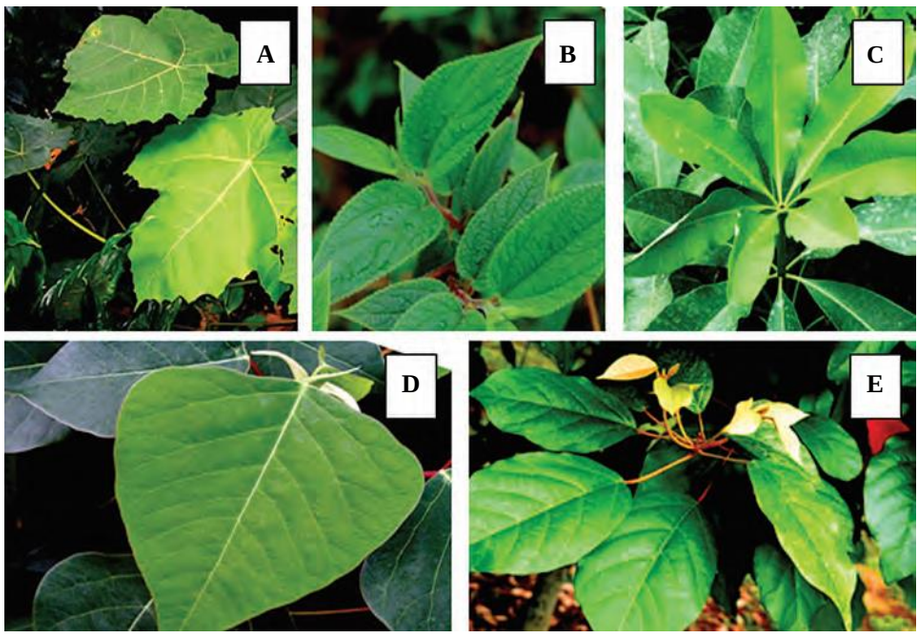

Fig. 2. (A) *Macaranga gigantea*, (B) Trema tomentosa, (C) Alstonia scholaris, (D) Croton argyratus and (E) Homalanthus populneus.

A plant with the best percentage of living conditions is Alstonia scholaris (97.50%). While the percentage of life from Macaranga gigantea (58.50%) and Trema tomentosa (65%).

Pioneer plants measurements recapitulation of one to 12 months of life percentage can be seen in Table I. Based on the 5% BNT test results showing Alstonia scholaris and Croton argyratus croton is not significantly different from Homalanthus populneus. But it is really different with Macaranga gigantea and Trema tomentosa.

A factors that cause the plants life difficulty or the low life percentage at the reclamation area according are the strength of soil aggregates or rock deposits transported from mining quarries so that soil aeration is very poor, soil pH is too high and alkaline soil conditions this does not support vegetation growth [10]. Physical, chemical and biological soil fertility rates are considered very low. In plants that are difficult to live, special treatment is needed, especially for endangered species, which can be conserved by *ex situ* conservation [11].

The measurements result of plant height tested at a month ages shown the average plant height has good height increase (40.97 cm). The best height-growth plant is Trema tomentosa (50.75 cm) and the lowest is Macaranga gigantea (30.25 cm). At three months age the plant are overall increased with the average plant height was 52.23 cm. The best plant with high growth is Homalanthus populneus (70.35 cm), while the lowest were Macaranga gigantea (25.00 cm). Some tested plants species experienced negative height growth (the average plant height reduced compared to the previous three months), i.e., Macaranga gigantea. It is suspected that there is a high decrease due to a pest or brackish animal disorder (Cervus sp) which eats plant leaves. At six months old it was shown that the overall height measurement results had a good height increase (94.85 cm). The best height-growth plant species is Homalanthus populneus (150.00 cm). While the lowest high-growth was Macaranga gigantea (35.40 cm). At 12 month age, the overall height is well increased (109.33 cm). The best high growth plant is Homalanthus populneus (120.05 cm), while the lowest is Macaranga gigantea (45.75 cm). The recapitulation of measurements result on tested plant height for one to 12 months can be seen in Table II. The analysis results of plant diversity indicate that there is a high variation of the tested species.

Table I. The average of life percentage(%) of pioneer tree species.

No	Tree species	1 month	3 month	6 month	12 month
1.	Alstonia scholaris	100.0	100.0	100.0	97.5[a]
2.	Croton argyratus	100.0	98.0	95.4	89.0[a]
3.	Homalanthus populneus	92.0	93.0	90.0	83.5[b]
4.	Macaranga gigantea	90.5	87.0	75.0	58.5[c]
5.	Trema tomentosa	83.0	82.0	72.5	65.0[c]

Note: a, b. c is a significant different of statistic result. The same alphabet shows there is no significant different, the same alphabet shows a significant different.

Table II. The average of pioneer species heigh (cm).

No	Tree species	1 month	3 month	6 month	12 month
1.	Alstonia scholaris	35.20	70.35	110.50	120.05
2.	Croton argyratus	33.50	40.15	80.20	110.50
3.	Homalanthus populneus	55.15	70.05	150.00	155.15
4.	Macaranga gigantea	30.25	25.00	35.40	45.75
5.	Trema tomentosa	50.75	55.60	98.15	115.20

RESEARCH ARTICLE

The average plant height in one year old based on Table II overall is good, except Macaranga gigantea species, the decline is suspected because of disturbance of animals (Cervus sp) which eat the leaves of plants. Even if these plants have good bud ability, but if the disturbance is in a high degree it caused the newly planted tree dies. In general at 12 months the plant height difference is due to the differences of plant genetic properties. The growth of plant height varies with the availability of resources, such as light, water, and nutrition [12]. In the natural environment, these resources do not have the same availability and can vary between regions and land types. Resources Availability also plays a role in the results of competition between the growth processes because these differences have a productivity impact. Post-mining re-vegetation was carried out using three-year old plant material taken from tree nurseries. Trees are planted with a narrow spacing. Plant species are usually native species to ensure that the high life percentage will eventually grow well. Important maintenance is carried out periodically irrigation, mixing topsoil with selected ash or overburden and fertilizer use which can accelerate re-vegetation [13].

The measurements result of one month old plant stem diameter were 0.52 cm with the lowest value was Macaranga gigantea (0.45 cm) and the highest was Homa-lanthus populneus (0.60 cm). At three months age the aver-age stem diameter is 0.99 cm with the lowest value was Macaranga gigantea (0.60 cm) and the highest in Homa-lanthus populneus (1.30 cm). At the age of six months, the average stem diameter is 1.66 cm and the lowest diameter is Macaranga gigantea (0.95 cm) and the highest diameter is in the type of Alstonia scholaris (2.30 cm). The measurements result of 12 month old plant shows that the average value of plant stem diameter is 1.89 cm, with the lowest diameter is Macaranga gigantea (1.15 cm) and the highest diameter is Homalanthus populneus (2.50 cm). Over the past 12 months generally the plants diameter grew continuously. The average growth recapitulation of stem diameter for 12 month study can be seen in Table III. The great plants growth are really influences by of soil chemical, soil nutrition, soil structure, soil texture, ger-mination, seedling growth and suitability with the air drainage.

Homalanthus populneus is a pioneer plant species that grows in logged-over forests, secondary forests and river-bank forests, in the lowlands to approximately 2000 meters above sea levels. Populalus homalanthus is only found in open places and sometimes grows in open parts of intact forest [14]. That's why as seen at Table III, the reason that is causes the average growth of stem diameter of Populneus homalanthus is faster compared to other tree species pioneer. Homalanthus populneus has a straight, rounded stem, sometimes bent and the base of the stem is enlarged if it grows in a high humidity place or in mountain forests. The trunk skin surface is slippery, dirty gray, and not cracked. It is natural propagation with seeds and shoots. The seedling height reaches 2.5 meters in a year with 10 cm stem cycle. But event thought it growth fast, it has not been much cultivated. As comparison in a mining area of Amazon, native species tree such as F. macrophylla, M. aff. fallax, P. pteroclada, P. pinnatum, and Z. longifolia show the best survival and growth in all locations and become the most suitable species to be used for rehabilitation and reclamation [15].

Table III. The average stem diameter of tree pioneer species (cm).

No	Tree species	1 month	3 month	6 month	12 month
1.	Alstonia scholaris	0.54	1.28	2.30	2.40
2.	Croton argyratus	0.50	0.70	1.25	1.65
3.	Homalanthus populneus	0.60	1.30	2.23	2.50
4.	Macaranga gigantea	0.45	0.60	0.95	1.15
5.	Trema tomentosa	0.50	1.10	1.58	1.75

The average results of canopy diameter measurements during the study as follows; The pioneer plants showed good growth of canopy diameter (i.e., Homalanthus populneus and Trema tomentosa. While the commercial pioneer tree species was Alstonia scholaris. Although the percentage of its life does not reach 70%, but the nature of Trema tomentosa has an ability to generative growth fast, it has begun to show flowers and fruit in a three month, and it is become a food source for wildlife. This plant species can be one of the considerations for land rehabilitation and reclamation in a high brackish animal population area, so the wildlife does not destroy other plants species. Post-mining re-vegetation is directed to land cover accelerating, plant growth accelerating, increasing species diversity, and conserving local species and supporting other important objectives [16]. Animal attacks should not be a serious threat, so an animal conservation area should be built around the reclamation area. Besides this area it can be developed as a habitat for many mammals such as orangutans, deer and birds. In the East Kalimantan Province Pongo pygmaeus is the largest species of non-human primate in Indonesia [17]. A similar case occurred in the South Kalimantan province. The Paringin coal mining area more than 16 years ago has become a suitable habitat for Nasalis larvatus monkey, proboscis monkeys, non-human primates which are endemic in Kalimantan [16].

The growth indicator of crown diameter is important to find out the land cover to create a microclimate. In addition, it can increase soil fertility and as an initial prepration for the primary forest species entry both from the Dipeterocarpaceae species and as a feed source for animals. This is in accordance with a study result which states that to evaluate plant growth in post-mining areas can be determined from the level of the canopy closure [18]. Local species have an adaptable canopy. The use of local plant species in the reclamation post coal mining areas activities will have a positive impact, it is impacting on biodiversity

conservation activities. It is helps to accelerate the succession process to be close to natural conditions, maintain the genetic availability of local plant species and increase the success of planting in the field [19].

4. CONCLUSIONS

Study of five pioneer plants species showed three species with optimal growth, i.e., Alstonia scholaris, Homalanthus populneus and Croton argyratus. Based on the LSD test result at 5% level, the life percentage of Alstonia scholaris and argyratus croton is not significantly different to Homalanthus populneus. But it is very different with Macaranga gigantea and Trema tomentosa. Homalanthus populneus is the most adaptable pioneer plant species in open places, it's grows in the open post-mining area and in a forest with still intact condition. In general, plant adaptation and growth is influence by land factors and the genetic characteristics of existing plants.

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References

1. Hilmawan, R., Yudaruddin, R. and Wahyuni, Y.S., 2016. Coal mining operations and its impact on sectoral and regional area: Evidence of East Kalimantan, Indonesia. *Journal of Indonesian Applied Eco-nomics, 6*(1), pp.22–42.
2. Komara, L.L., Choesin, D.N. and Syamsudin, T.S., 2016. Plant diver-sity after sixty years post coal mining in East Kalimantan, Indonesia. *Biodiversitas, 17*(2), pp.531–538.
3. Wardhana, W., 2008. *Evaluasi potensi tanah dan estimasi biomassa vegetasi di areal PT. Kaltim Prima Coal Sengata Kutai Timur*.Graduates, Mulawarman University.
4. Komara, L.L., 2017. *The Protozoan Function in Soil Carbon Cycleon Post Coal Mining Area*. Doctoral, Bandung Technology Institute.
5. Komara, L.L., Murtinah, V. and Arbain, A, 2018. Evaluation of Plant Species Composition After Thirteen Years Post Coal Mining Reha-bilitation in East Kutai District of East Kalimantan, Indonesia. *IOP Conference Series: Earth and Environmental Science*, Vol. 144.
6. Bariroh, N.R., Danial, D. and Gunawan, S.G., 2016. The Increase of Forage Productivity in Ex Coal Mining by Adding Fertilizer & Forage in East Kalimantan. *International Seminar on Livestock Pro-duction and Veterinary Technology*, Vol. 2016, pp.471–475.
7. Yusuf, M. and Arisoesilaningsih, E., 2017. Exotic Plant Species Attack Revegetation Plants in Post-Coal Mining Areas. *8th International Conference on Global Resource Conservation (ICGRC 2017)*,AIP Publishing.
8. Novianti, V., Choesin, D.N., Iskandar, D.T. and Suprayogo, D., 2017. Plant species from coal mine overburden dumping site in Satui, South Kalimantan, Indonesia. *Journal of Degraded and Mining Lands Management, 4*(4), pp.927–936.
9. Stein, R.A. and Ludwig, J., 1979. *Vegetation and Soil Pattern onan Chihuahuan Desert Bajada*. The University of Notre Dame,Vol. 101.
10. Kustiawan, W., 2001. Perkembangan Vegetasi dan Kondisi Tanah serta Revegetasi pada Lahan Bekas Galian Tambang Batubara di Kalimantan Timur. *Rimba Kalimantan, 6*(2), pp.20–31.
11. Barrance, A.J., 1997. Forest Genetic Resources in Central America: The Challenge of Conservation.Rural Development Forestry Network 21f, Sumer 1997. ODI, Portland House Stag Place, London SW 1E, 5DP, UK.
12. Buss, J., Stratechuk, K. and Pinno, B.D., 2018. Growth and competition among understory plants varies with reclamation soil and fertilization. *Ecological Processes, 7*(12), pp.2–8.
13. Pavloudakis, F. and Roumpos, C., 2004. Evaluation of land recla-mation and environmental protection strategies in open-pit lignite mines. *Advances in Mineral Resources Management and Environ-mental Geotechnology*, Hania 2004, Greece.
14. Zuhud, E.A.M., Siswoyo, S, Sandra, E., Hikmat, A. and Andhiyanto, E., 2013. *Buku acuan tumbuhan obat Indonesia*. Jakarta. Dian Rakyat.
15. Villacís, J., Casanoves, F., Hang, S., Keesstra, S. and Armas, C., 2016. Selection of forest species for the rehabilitation of disturbed soils in oil fields in the Ecuadorian Amazon. *Science of the Total Environment*, pp.566–567:761–770.
16. Soendjoto, M.A., Dharmono, D.,Fahrudin, F., Riefian, M.K. and Didik, T., 2014. Plant species richness after revegetation on the reclaimed coal mine land of PT adaro Indonesia, South Kalimantan. *JMHT, 20*(3), pp.150–158.
17. Mukhtar, A.S. and Heriyanto, N.M., 2012. Plant succession at ex coal mine area in East Kalimantan. *Penelitian Hutan dan Konservasi Alam, 9*(4), pp.341–350.
18. Rahmawaty, R, 2002. Restorasi Lahan Bekas Tambang Berdasarkan Kaidah Ekologi. in *UTARA*, edited by U. S., Medan, USU Digital Library.
19. Lestari, D.A., Fika, A.B., Fauziah,F. and Budiharta, S., 2019. Growth evaluation of native tree species planted on post coal mining reclamation site in East Kalimantan, Indonesia. *Biodiversitas, 20*, pp.134–143.