RECLAMATION LAND OF FORMER ZIRKON MINING FOR CARBON DIOXIDE ABSORPTION MEDIUM BY EUCALYPTUS PLANTS

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ABSTRACT

Eucalyptus plants have a promising potential to absorb carbon dioxide in the reclamation area of the former zircon mining area. Eucalyptus was chosen as a pioneer plant because it was easy and inexpensive to propagate, plant and maintain. Selection of land reclamation plants by looking at the characteristics of the land to be planted, such as information on the physical properties of the soil, soil chemistry, rainfall, wind, temperature, topography, pests, diseases and animals that exist around the reclamation site. Research results show that carbon dioxide uptake is significant in support of its growth.

Keywords*: reclamation land, eucalyptus, carbon dioxide, absorption*

INTRODUCTION

The use of Eucalyptus (Melaleuca sp.) as a former mining land reclamation plant on the condition of the sandy soil structure is considered suitable. The consideration according to Sudaryono (2010) Eucalyptus plants can be classified into plants that can survive in conditions that are less fertile, with a long dry climate, resistant to hot air temperatures. This plant can be found from the lowlands to an altitude of 400 m above sea level, can grow near the beach behind mangroves, with texture from clay to clay clay, at pH 4-7. Eucalyptus plants are ideal for growing in dry climates, with a maximum rainfall of 2000 mm per year with a minimum temperature of 22 ° C and a maximum temperature of 32 °C (3,4). Eucalyptus plants have a long biological cycle, fast growing, can thrive on soils with

good or bad draenase, with high salt or acid content, eucalyptus plants can be used as greening plants on land with a slope of less than 15%. According to Utumo (2012) Eucalyptus plants can also grow on infertile or barren land that does not require good growing conditions regarding the soil, can grow well on poor soil, so that it can be called a pioneer type. This tree sprouts easily from milestones, therefore although the forest is often damaged by fire, this tree will soon grow back.

Cultivating Eucalyptus members of the guava family (Myrtaceae) is quite easy. This plant is a formidable species, because it is able to grow in a variety of land conditions, ranging from rocky dry land with a pH above 7 to heavily textured lands with pH below 4 such as ex-mining land. Eucalyptus can also grow in both dry and wetlands. Eucalyptus can compete well with weeds and surrounding weeds in addition to rich organic matter (Ludang et al., 2007) so that maintenance costs are low.

Pioneer types require a lot of light and are able to grow on marginal land so that it is theoretically suitable for open mining land that is open and nutrient-poor and recommends to use eucalyptus vegetation types including local crops because it is easy to adapt to marginal local conditions. Good adaptability will reduce the risk of failure and provide a guarantee of good growth success rather than being imported from the outside. Besides the eucalyptus vegetation will be used as a reclamation plant, this plant will grow fast without requiring a high cost, it is relatively more effective in absorbing water and solar energy and carbon dioxide, because the acceleration of growth is closely related to the physiological metabolic process in photosynthesis.

Eucalyptus plant species produce relatively much litter, so it is expected to quickly decompose and can produce organic matter that forms soil aggregates and prevents erosion. The eucalyptus litter is expected to play a role in increasing soil moisture, improving physical, chemical and biological soil properties which can be used as a medium for growing various microorganisms so that the soil is rich in organic matter. In the root system, Eucalyptus is able to have a symbiosis with certain microbes where the roots also support the growth of trees, absorbents and at the same time transport water and minerals to plants.

Eucalyptus plant as a non-timber forest product commodity has quite promising potential. Utilization is in sandy soil in the reclamation area of the former zircon mining area. In this framework, it is necessary to study the potential of carbon dioxide uptake in eucalyptus plants of different ages for environmental carrying capacity.

REVEGETATION BY EUCALYPTUS PLANTS

The benefits

Eucalyptus plants have been widely used by the people of Indonesia for various purposes. Eucalyptus is a plant that has a variety of benefits and has long been used by the people of Indonesia as a material to overcome various kinds of health problems. Utilization of eucalyptus plants, has long been done by the people of Indonesia before the existence of technology. Eucalyptus leaves are used to reduce pain or swelling due to insect bites. Eucalyptus leaves are also extracted or dried to be used as stamina enhancing ingredients. In addition, eucalyptus plants at this time began to be widely planted around the yard as a mosquito repellent because of its distinctive aroma (Rosmawati, 2018).

Eucalyptus plants in West Kalimantan are also widely used by local communities, such as the bark of Eucalyptus can be used as a cover for cracks or holes in the boat so that it does not leak and the fruit can be used as herbal medicine or traditional medicines. In addition, this eucalyptus plant is one of the types of plants producing essential oils. Essential oils from the Eucalyptus plant can be obtained from refining eucalyptus leaves. This oil is commonly called Eucalyptus oil or in international trade is called cajeput oil. Eucalyptus Oil has many benefits, Eucalyptus oil produced from distillation of Eucalyptus leaves is efficacious as a skin scrub, insecticide and aroma therapy ingredients. The aroma of Eucalyptus oil is very distinctive and this oil gives a warm feeling when applied to the skin. Therefore, the biggest utilization of Eucalyptus oil is carried out in the pharmaceutical industry, specifically as an ingredient in skin scrubbing, as an insect repellent and as a body warmer. Furthermore, Eucalyptus oil also has many benefits as a liniment to reduce swelling and itching due to insect bites, toothaches, headaches, aches, muscle cramps, flatulence, bruises, to cough mixtures. A number of studies also prove, this plant has the efficacy of diaphoretic or sweating sweat, analgesic or pain reliever, disinfectant or germ killer, expectorant or decay of phlegm and antispasmodics or abdominal pain relievers (Rosmawati, 2018).

Carbon dioxide uptake

Plants have the ability to photosynthesize using carbon dioxide and water as raw material. Forests are an important carbon sink, forests are also a regulator of GHG. With the forest as one of the carbon sinks, carbon dioxide levels in the atmosphere will decrease. But the ability of forests as carbon sinks is diminishing. The reduced capability of the forest is a result of the decline in forest area caused by logging, fires, and conversion of forests to settlements, industries and the like (Sukmawati et al, 2015).

The presence of CO_2 in the atmosphere is part of the carbon cycle. Carbon can enter other pools through photosynthesis. Photosynthesis is the formation of carbohydrates ($C_6H_{12}O_6$) from atmospheric CO_2 gas and water molecules (H_2O) from the soil with the help of sunlight and chlorophyll. The results of photosynthesis will become biomass from plants. In addition to carbohydrates, photosynthesis also produces oxygen (O_2) which is released back into the atmosphere.

Pane et al (2016) carbohydrate metabolic activity related to the absorption of carbon dioxide by plants, this is related to the formation of carbohydrates in plants needing carbon dioxide as a raw material through photosynthesis with the following reactions: $6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$

The formation of 1 carbohydrate molecule based on the above photosynthesis reaction requires 6 molecules of carbon dioxide. Based on this the higher the carbohydrate mass in plant leaves, the higher the carbon dioxide used by the leaves.

Carbon dioxide absorption per unit time of each plant is different, depending on the type of plant itself, especially on the leaf morphology. In plants that can live in environments with low light intensity, the leaves will be larger, thinner, have larger stomata sizes, fewer leaf numbers, and greater intercellular space. Conversely, in environments with high light intensity, the leaves will be smaller, thicker, stomata small and many, also the number of leaves leafier. This is a response of plant adaptation to the environment to avoid damage to leaf chlorophyll. The rate of CO_2 absorption is also influenced by the age and location of the leaves. Chlorophyll increases with age and leaf area. When the leaves are still young, the ability of photosynthesis is relatively low and will continue to increase until the maximum size. After that the leaves will get older and yellow due to damaged chlorophyll. The leaves located in the inner canopy also have a low absorption rate, this is because the leaves do not get enough sunlight.

Potential leaf strands in absorbing carbon dioxide (CO_2) per hour shade plants from previous data will be obtained potential carbon dioxide uptake per leaf strand per hour for each type of shade plant. Through the carbon dioxide absorption potential data, it will be known whether the morphological character, namely the leaf surface area of each plant, has an influence with the carbon dioxide absorption potential per hour (Pane et al, 2016).

Pane et al (2016) each shade plant also showed a greater increase in carbohydrate mass at 12.00-17.00 WIB namely Angsana 27%, Eucalyptus 29.81% and Mahogany 35.82% compared to 05.00-12.00 WIB ie Angsana 6%, Eucalyptus 21.34% and Mahogany 7.36%. The formation of carbohydrates in the process of photosynthesis requires light as energy. The light used in this case is sunlight. Thus the increase in the intensity of sunlight that occurs during the day will also be followed by an increase in carbohydrate mass which results in an increase in carbon dioxide needs. The amount of increase in light intensity will be followed by

an increase in carbon dioxide uptake for carbohydrate metabolism in the photosynthesis reaction.

Tran et al (2015) in an article related to carbon stocks in southern Vietnam, describes their research in primary Melaleuca forests on sandy soils with a characteristic number of 2,330 plants per ha with average plant height of 14.69 m and in Melaleuca forests regeneration on sandy soil with a characteristic number of 10,950 plants per ha with an average plant height of 7.11 m then concluded that primary Melaleuca forest on sandy soil has a higher carbon density than regenerated Melaleuca forest, which is 275.98 tonC / ha compared 159.36 tonC / ha. In sandy soils, the number of plants grows per hectare and the topsoil contributes most significantly to carbon density.

Pane et al (2016) with an average leaf area of 62.00 cm^2 have CO_2 absorption / hour of 0.96 x10-3 g / cm^2 / hour with CO_2 / strands / hour absorption potential of 59.34 x10-3g / strands / hour. Rambaradellangga et al (2018) the ability of Eucalyptus plants to absorb CO_2 of 302.54 (kg / tree / year).

Revegetation of the former zircon mining areas

Revegetation is an effort to repair and restore damaged vegetation through planting and maintaining activities on land that has been used for forest use. Land in this case is land used for mining activities. It is also a kind of transferred land (Murhaini & Ludang, 2020), provision of greenspace (Susilowati et al., 2020), and plantation of fired land (Prasetyoko et al., 2020).

The reclamation program regulated in Minister of Energy and Mineral Resources Regulation number 7 of 2014 is revegetation activities, namely determining the type and number of plants that will be used for reclamation, plant spacing between trees and the area of land to be replanted.

The first stage of revegetation of mined land must be planted with fast-growing pioneer plants that are able to adapt quickly to soil conditions. These pioneering plants have the following requirements for reforestation or reclamation:

1. Has a function as a savior of land and water with growing requirements in accordance with the conditions of the location, both climate and soil
2. Has a function as land reclamation;
3. Has a wide and deep roots;
4. The results can be obtained in a not too long time;
5. If planted in areas that often rain must have the characteristic of evaporating water;
6. If planted for dry areas, plants must be selected which have difficult water vaporizing properties;
7. Growing fast and able to grow in less fertile areas;
8. Not competing in water and nutrient needs with staple crops;

9. Do not experience deciduous leaves in certain seasons;
10. Not become a host of diseases, resistant to wind and easily destroyed;
11. Plants have good economic prospects and can be utilized later on.

RESEARCH RESULTS

Carbon dioxide uptake in reclaimed land conditions

Hidayati et al (2013) titled Variation of Carbon dioxide (CO_2) Absorption in Tree Types in "Ecopark", Cibinong and their Relation to Potential Greenhouse Gas Mitigation shows that there are various variations in the rate of CO_2 assimilation between tree species. The overall CO_2 assimilation rate ranged from 2.86 to 16.45 μmolm-2s-1. The highest CO_2 absorption was Pometia pinnata (16.45 μmolm-2s-1), followed by Garcinia xanthochymus (11.40 μmolm-2s-1), Syzygium polyanthum (10.99 μmolm-2s-1), followed by Garcinia xanthochymus (11.40 μmolm-2s-1), Syzygium polyanthum (10.99 μmolm-2s-1), followed by Garcinia xanthochymus (11.40 μmolm-2s-1), Syzygium polyanthum (10.99 μmolm-2s-1), Syzygium polycepaliodes (10, 40 μmolm-2s-1) 89 μmolm-2s-1), and Palaquium obtusifolium (10.41 μmolm-2s-1). The transpiration rate was recorded between 1.29 μmolm-2s-1 (Maniltoa grandiflora) and 7.85 μmolm-2s-1 (Euphoria longan). The CO_2 assimilation rate is influenced by solar radiation and thus the quantum leaf (Q leaf), stomatal conductance, and leaf chlorophyll content. Tree species that have high CO_2 absorption characteristics and are efficient in maintaining water balance (low transpiration rate), are suitable for mitigating greenhouse gases.

Supriadi et al (2013) titled Estimating Carbon Reserves in the Mining Reclamation Area: Case Study of PT Newmont Nusa Tenggara. Estimated carbon stocks are divided into several carbon pools, namely tree biomass, poles and saplings, and plant biomass and litter. From the results of the study of carbon stocks in the PTNNT reclamation forest in 2001-2008 it was found that the total average carbon stock in the three reclamation activities locations (East Timbunan, Sejorong Timbunan and Tongoloka Timbunan) was 3,965.95 tons of carbon or 34.96 tons of carbon / hectare. In addition, the number of tons of carbon / hectare affected by plant growth is evidenced by the results of the calculation of carbon stocks / hectare in 2006, the highest compared to the previous year. This was also supported by the results of periodic monitoring conducted by PTNNT if the plant growth in the 2006 planting year was better than the previous year.

Sukmawati et al (2015) entitled The Absorption of Carbon Dioxide in Urban Forest Plants in Surabaya. The results of this study indicate that the highest CO_2 uptake is found in bintaro plants with a total CO_2 absorption of 7.661 mg / 50ml, so that bintaro is the most effective plant to absorb CO_2.

Pane et al (2016) titled Potential Carbon dioxide (CO_2) Absorption in the Shade Trees on Jalan Soekarno Hatta, Pekanbaru City. The sample trees are the most dominant trees in the green belt on the Soekarno Hatta Road in Pekanbaru. Trees used in this study were 27 trees, namely 9 angsana (Pterocarpus indicus Willd.), 9 mahoganies (Swietenia macrophylla King.) And 9 eucalyptuses (Melaleuca leucadendron L.). The results showed that angsana had the highest absorption potential of carbon dioxide compared to mahogany and eucalyptus on Jalan Soekarno Hatta in Pekanbaru.

Franklin et al (2017) titled Absorption of Greenhouse Gases (Greenhouse Gases) Green Line Vegetation on Jalan Sam Ratulangi Manado. Data obtained by survey, data analysis using ArcGis. From the research results obtained vegetation that has the highest CO_2 absorption is tamarind trees and corridors in the green path Sam Ratulangi 2 (District Wanea) planted by trees that absorb the most CO_2.

Pambudi et al (2017) titled Analysis of Plant Carbon dioxide (CO_2) Absorption in the Puyer Block of the Ranu Pani Region in the Bromo Tengger Semeru National Park (TNBTS) in 2016. The results showed a total biomass of 146.55 (tons / ha), 211 carbon content, 55 (tons / ha), carbon dioxide absorption 775.69 (tons / ha) and carbon content of 4.47 x 10-8. The highest CO_2 uptake was shown by the Macropanax dispermum (Blume.) O. Ktze tree because the plant dominated the Puyer block area with an Importance Value Index of 0.67.

Rambaradellangga et al (2018) titled Analysis of the Capability of Green Open Space in Reducing CO_2 and Air Temperature and Their Effects on the Comfort Levels of Universitas Brawijaya Campus. In the condition of the weekend / RTH has better air conditions than the condition of the weekday / working day, this is caused by the high mobility of motor vehicles. On weekday conditions, green space is still lacking to reduce the burden of CO_2 levels.

Fitrada et al (2020) titled The Potential of Urban Forest Vegetation in Reducing Carbon dioxide (CO_2) Emissions in Jambi City. The basal area of the vegetation of trees in each location was 72.72 m2 / ha for Bagan Pete urban forest, 25.45 m2 / ha in Muhammad Sabki city forest, and 5.12 m^2 / ha for Kenali pine forest. While the reduction of CO_2 from tree vegetation in urban forests at each location was 41,386 tons / ha / year, 14,482.93 tons / ha / year, 2,916.94 tons / ha / year. Based on this study, Bagan Pete urban forest has the highest potential of the three urban forests owned by the city of Jambi, and the total reduction in carbon dioxide emissions in the city of Jambi from the presence of existing urban forests is 58,785.87 tons / ha / year.

Some of these studies conclude that the ability of plants to absorb carbon dioxide (CO_2) per hour depends on the type, morphological characteristics of leaf surface area, measurement time (morning, afternoon and evening), and an increase in plant carbohydrate mass at 12.00- 17.00 WIB namely Angsana 27%,

Eucalyptus 29.81% and Mahogany 35.82% compared to 05.00-12.00 WIB namely angsana 6%, Eucalyptus 21.34% and Mahogany 7.36%.

Plants on reclamation land

Sittadew (2016) titled Mitigation of Degraded Land Due to Mining Through Revegetation. types of fast growing plants that are commonly used for revegetation are sea sengon (Paraserianthes falcataria), acacia (Acasia mangium, Acasia crassicarpa), Lamtoro (Leucaena glauca), turi (Sesbania grandiflora), gamal (Gliricidia sepium). In addition to fast-growing plants, local plants are also an option for revegetation. Successful revegetation will increase levels of organic matter and improve nutrient cycles and increase the amount and activity of microbes.

Hirfan (2016) titled Post-Mining Land Reclamation Strategy. For example, some of the reasons why forests were chosen for reclamation schemes could be because the slopes formed after the regrading process are still too steep for agricultural activities, the production of forest timber products is more profitable, forest plants may be planted only to meet aesthetic aspects, or land status requires that the former land the mine was replanted with forestry plants.

Setyowati et al (2017) entitled Study of Plant Revegetation Selection for the Success of Mine Reclamation Land. Tree species selection criteria for ex-mining land can be seen from: 1) Pioneering local species, 2) Fast growing but does not require high costs, 3) Produces a large litter and easily decomposed, 4) A good root system and capable of symbiosis or related reciprocity with certain microbes, 5) Stimulates the arrival of the seed carrier vector, 6) Easy and inexpensive in propagation, planting and maintenance. Successful revegetation depends on several things such as: planting preparation, plant maintenance and plant monitoring.

Oktaria (2017) titled Reclamation and Revegetation Policy of Former Mining (Case Study of Indonesian Coal Mining) form of post-mining activities (reclamation) on mining areas that are used no later than one month after there are no more mining business activities on disturbed land. In addition, it is also necessary to control post-mining land by combining land improvement, and selection of the right type of plants, namely with the criteria of local pioneer type fast growing, resistant to sun exposure, fast decomposition, good root system and symbiotic with certain microorganisms, easy and inexpensive in propagation, and plant monitoring.

Nugroho and Yassir (2017) titled Policy on the Success of Reclaiming Post Coal Mining Land in Indonesia. The results show that there are no regulations that meet all ecological restoration criteria. All regulations have included rehabilitation or reclamation obligations as well as evaluations but none of these regulations contain a ban on the use of invasive plants. The conclusion of this study is the regulation of post-mining rehabilitation and reclamation in Indonesia is not yet

fully in line with the concept of restoration ecology because it only contains some of the criteria and indicators of ecological restoration so that improvements are still needed so that post-mining land improvement and restoration can meet the concept of ecological restoration.

Andriani et al (2018) titled Pioneer Plant Types Found in the Former Cretaceous Land of the Banjaragung Village, Rengel District, Tuban Regency. This study obtained 18 types of pioneer plants that grew in the former limestone quarry land with the highest relative density was Tridax procumbens at 28.15% and the lowest relative density was Euphorbia hirta and Taraxacum mongolicum at 0.29%. While the highest relative frequency is Waltheria indica by 17.39%. The highest INP is Tridax procumbens at 41.20%.

Syachroni et al (2018) titled The Growth Power of Pioneer Plants in the Tin Mining Area in Bakam District, Bangka Belitung Province. The results showed that the types of plants that were able to live in the former tin mining area were Rubber with a percentage of life of 31.34%, Acacia (Acacia mangium Willd.) Of 33.64%, and Sengon (Falcataria moluccana) of 35.02%. Based on the results of the analysis of the research data it was concluded that the pioneer plants most suitable for reclamation of the Bangka tin mining area were the Sengon plant.

Karyati et al (2018) titled Soil Temperature and Humidity on Post Mining Revegetation Land at PT Adimitra Baratama Nusantara, East Kalimantan Province. The results showed that the highest soil temperatures at depths of 10 cm and 20 cm were 27.7ºC and 26.6ºC, respectively, at revegetation at 3 years old. While the lowest soil temperature in revegetation at 7 years old at a depth of 10 cm and 20 cm respectively was 26.1ºC and 24.9ºC. The highest soil moisture was 87.8% (at a depth of 10 cm) and 88.0% (at a depth of 20 cm) on revegetation land aged 7 years. Added, the lowest soil moisture at a depth of 10 cm (81.3%) and 20 cm (81.5%) is in the revegetation area at 3 years old. Differences in planting age affect microclimate fluctuations, including temperature and soil moisture at different soil depths.

Kamrullah et al (2019) entitled Evaluation of the Implementation of the Reclamation of Nickel Ore Mining in PT. Wijaya Inti Nusantara in Laeya Subdistrict, South Konawe that the success rate of reclamation is 73.8 with the medium category meaning that reclamation can be accepted but that reclamation improvement is still needed. WIN is an area of agricultural use of dry land food crops (dry fields) and the results of the analysis of the cost calculation of the reclamation plan of PT. WIN the second period of 2015-2019 covering an area of 8.58 hectares requires Rp. 3,291,882,543, - whereas planned by PT. WIN is Rp. 1,980,932,611

Huzeini et al (2019) titled Post-Mining Evaluation Study of PT. Ratu Samban Mining, Bengkulu Tengah Regency Bengkulu Province provides an overview of the final post-mining operations, evaluating the performance of PT. Ratu Samban Mining and provide post-mining recommendations. The data analysis method used

is the desk study method with the main data being the ESDM Minister Regulation number 7 in 2014. The results of the post-mining evaluation of PT. Ratu Samban Mining Based on Ministry of Energy and Mineral Resources Regulation No. 7 of 2014 it was found that the implementation of post-mining that has been realized gets a value of 28.57%. This means that it is worth ugly. To return the Mining Business Permit (IUP) to the Minister, governor, or regent / mayor based on the provisions of the legislation in force, then the post-mining program can be re-implemented for 5 years, so that the post-mining program can reach an adequate value of > 80.

Azim et al (2020) titled Reclamation Planning with revegetation of the Stockpile at PT. Allied Indo Coal Talawi District, Sawahlunto Municipality, West Sumatra Province. After land management is complete, cover crops will be planted. Furthermore, the revegetation process starts from irrigation, digging planting holes, planting, and maintaining. Based on calculations in the reclamation plan with revegetation, the direct costs for revegetation reclamation activities in the Stockpile at PT. Allied Indo Coal is IDR 804,921,900.00. and indirect costs are IDR 173,101,842.00. Then the total cost of reclamation and revegetation at that location is Rp 978,023,742.00.

Some of these studies conclude that fast-growing plant species as pioneer plants with growing and maintenance requirements that are still being able to absorb carbon for revegetation are sea sengon (Paraserianthes falcataria), acacia (Acasia mangium, Acasia crassicarpa), Lamtoro (Leucaena glauca), turi (turi) Sesbania grandiflora), gamal (Gliricidia sepium). In addition to fast-growing plants, local plants are also an option for revegetation. Successful revegetation will increase levels of organic matter and improve nutrient cycles and increase the amount and activity of microbes.

CONCLUSION

A moderate level of reclamation success rate means reclamation is acceptable but reclamation improvement is still needed. After land management is complete, cover crops will be planted. Furthermore, the revegetation process starts from irrigation, digging planting holes, planting, and maintaining. In addition to the technical aspects, direct costs for revegetation reclamation activities are crucial.

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