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Model of land treatment on plant growth in reclamation area of post-mining at PT Antang Gunung Meratus

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Abstract

The purpose of this study is to determine the appropriate land management model in the post-mining land reclamation field at PT Antang Gunung Meratus. Reclamation since 2012 has conducted 5 models of land treatment in the area to be planted: (1) clay stone; (2) clay stone dressing + compost + fertilizer; (3) topsoil compact; (4) topsoil compact dressing + compost + fertilizer; and (5) topsoil compact dressing + compost + fertilizer + mulch. The data of the plants studied during the data collection was Sengon buto (*Enterolobium cyclocarpum*). Measurements of plant diameter and height as well as soil sampling were performed on each soil treatment model. Assessment of quality of soil physical and chemical properties of laboratory test results referring to land assessment criteria by the Soil Research Center Staff (1983) in Hardjowigeno (2003). From the data analysis, there are two models of soil treatment that are higher than the five treatment models, namely the treatment models D and E. The soil pH conditions in the treatment model A are very acidic with a pH value of 4.59 and soil pH conditions in the E treatment model are categorized as normal (not acidic and not alkaline) with a pH value of 7.40. Result of soil chemical analysis on all model of soil treatment in less fertile category.

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Introduction

As a result of the physical changes of soil to the excavation and removal of rock layers in the mine area, it has an impact on changes in physical, chemical and biological conditions of the soil. The soil layer will become unprofitable, there is soil compaction due to the movement of machinery and mining equipment, nutrient deprivation due to erosion in the embankment area. In addition, changes in the landscape can affect groundwater and surface water, micro-climate change, disturbance to biological habitats of flora and fauna. The high rainfall can also dissolve the nutrients present on the soil surface and the occurrence of acid mine water due to oxidation between rocks with water causes the pH of water and soil to be low.

The slow process of planting crops in disturbed areas leads to a decrease in soil productivity, so that the soil will become barren. For that required an activity as an effort to preserve the environment in order to avoid further damage. Efforts are made to improve the ecosystem that has been disturbed is to re-arrange the land and by immediately replanting or called reclamation activities.

According to Latifah (2003), reclamation is the effort to repair (restore) damaged land as a result of mining business activities in order to function optimally in accordance with its ability. The steps undertaken in the recovery of former mine land starts from the arrangement of the land up to the formation of new ecosystem or new function of the land. Stages of activities in the implementation of reclamation, among others: (1) Arrangement of land, the activities undertaken to establish land (land scaping) with construction and plans that have been made with tiered system; (2) Erosion control by establishing a water control channel to be fixed at a predetermined point; (3) Soil management for vegetation can grow well by using top soil; (4) Replanting with fast-growing plant species; (5) Plant care which includes, fertilizing, weeding and weed cleaning. The target of reclamation is to return mining land to conditions similar to the condition prior to mining (ELAW, 2010).

The reclamation of former at PT Antang Gunung Meratus (AGM) mine land has cooperated with JIFPRO (Japan International Forestry and Promotion and Cooperation Center) since 2012. PT AGM is one of the companies used as project model for reclaimed ex-mining land by JIFPRO. To build forests on degraded land requires a strategy to increase success, in this case the JIFPRO program has applied some soil treatment and planting of some plant species to be used as trial species trial. Meanwhile, to overcome the lack of top soil, the JIFPRO project conducted several models of soil treatment on the area to be planted. Considering this, at the beginning of the project work, five (5) soil treatment models were created.

The purpose of this study is to determine the appropriate land treatment model in the reclaimed land of former mining land at PT AGM. The result of this research is expected to determine the most suitable soil treatment model in the implementation of reclamation of mine site.

Materials and methods

Materials

The tools used in this study consist of digital cameras, GPS and computers for data processing. The object of research is data of high increment and addition of diameter of *Enterolobium cyclocarpum* for five years and for five models.

Methods

The research was conducted in the reclamation area of former mining land of PT AGM in Ida Manggala Village, Sungai Raya SubDistrict, Hulu Sungai Selatan District of South Kalimantan, which has been previously designated as a special planting and research area by JIFPRO (Japan International Forestry and Promotion. The research area taken is on the first cooperation project area carried out on the former mining area of 5 ha. The planting of this research field has been conducted in 2012. The study was conducted for 5 months from June 2017 until October 2017. The data of the plants studied during the data collection was Sengon buto (*Enterolobium cyclocarpum*) of 225 trees with an initial height of 50cm.

These plant data were observed because this plant had the highest percentage of live (95%) during observation data (five years) of growth on the former mine compared to other plant species (Prawito, 2009). The planting distance of each plant is 3m x 3m with the size of the planting hole is 30cm x 30cm x 30cm (Rachman, 2008). The compost used in this research is cow dung as much as 1 kg per hole. Fertilizer used as much as 2 tablets per plant.

Mulch used is bark of wood *Melaleuca leucadendron*. Secondary data were obtained through literature studies and saw the annual working paper of annual measurements conducted for five year planting locations from 2013, 2014, 2015, 2016 and 2017 as well as other secondary data obtained from AMDAL documents, Reclamation Plan (RR) and Closing Plan Mine (RPT) of PT AGM. Considering this, at the beginning of the project work, five (5) soil treatment models were created: (1) clay stone; (2) clay stone dressing + compost + fertilizer; (3) topsoil compact; (4) topsoil compact dressing + compost + fertilizer; and (5) topsoil compact dressing + compost + fertilizer + mulch.

To find out the best soil treatment model at the research location, the measurement of diameter and height of the plants and soil sampling in each model of soil treatment. To know the suitability of soil condition where growth with soil condition of reclamation area was analyzed physical and chemical properties of soil. Soil sampling was conducted on five predetermined treatment areas. Soil sampling is assumed that the soil chemical conditions are the same in each soil treatment, then analyzed in the laboratory. Assessment of quality of soil physical and chemical properties of laboratory test results refer to land assessment criteria by the Soil Research Center Staff (1983) in Hardjowigeno (2003).

Results and discussion

The model of soil treatment used at the beginning of planting as many as five treatment models by planting a specific crop type.

1. Soil treatment model A (clay stone):

The model of soil treatment in model A is done by leveling the ground surface of clay (claystone) with heavy equipment which is also used as soil surface compactor. The slope of the ground level is set at around 4% so that no water gets stuck when it rains. After the ground level has been leveled, the planting hole is 30 x 30 x 30cm with 3 x 3 meter spacing. After the hole is formed then plant cultivation by spraying the soil around the hole.

2. Soil treatment model B (clay stone dressing + compost + fertilizer):

Soil treatment model in model B is done by leveling the ground surface of the former mine (clay stone) with heavy equipment which is also used as a compactor of the soil surface after compacted so the soil returned with a heavy equipment called ripper so that the area around the planting hole in a loose state.

The slope of the ground soil surface is set to about 4% so no water is trapped when it rains. After the surface is completed in leveling, then made a planting hole with size 30 x 30 x 30cm with a spacing of 3 x 3 meters. Before planting the planting hole included compost and added fertilizer NPK 2 tablets type of fertilizer slow release slow fertilizer (SRF). The use of SRF fertilizer is expected to control the speed of release of nutrient elements that are easily lost due to dissolve in water and evaporate.

3. Soil treatment model C (topsoil compact):

The soil treatment model C is carried out by the method normally used in the mining land reclamation process. After the overburden soil surface is flattened and compacted, the top surface of the soil is sprinkled with shoots of approximately 50 cm thick and the surface of the soil is compacted with heavy equipment with a slope of about 4%.

After the surface is completed in leveling, then made a planting hole with size 30 x 30 x 30cm with a spacing of 3 x 3 meters. After the planting hole is ready, then the planting of trees with soil shoot media that exist around the planting hole.

4. Soil treatment model D (topsoil compact dressing + compost + fertilizer):

The soil treatment model D is carried out by the method normally used in the mine land reclamation process. After the overburden soil surface is flattened and compacted, the top surface of the soil is sprinkled with shoots of approximately 50 cm thick and the surface of the soil is compacted with heavy equipment with a slope of about 4%. After the surface is fully compacted, the soil surface is heavier again. After this, then made a planting hole with size 30 x 30 x 30cm with a spacing of 3 x 3m. Before planting the planting hole included compost and added fertilizer NPK 2 tablets type of fertilizer slow release slow fertilizer (SRF). Use of SRF fertilizer is expected to control the speed of release of nutrient elements that are easily lost due to dissolve in water and evaporate.

5. Soil treatment model E (topsoil compact dressing + compost + fertilizer + mulch):

The soil treatment model E is carried out by the method normally used in the mine land reclamation process. After the overburden soil surface is flattened and compacted, the top surface of the soil is sprinkled with shoots of approximately 50 cm thick and the surface of the soil is compacted with heavy equipment with a slope of about 4%. After the surface is fully compacted, the soil surface is heavier again. After this, then made a planting hole with a size of 30 x 30 x 30cm with a spacing of 3 x 3 meters. Before planting the planting hole included compost and added fertilizer NPK 2 tablets type of fertilizer slow release slow fertilizer (SRF). The use of SRF fertilizer is expected to control the speed of release of nutrient elements that are easily lost due to dissolve in water and evaporate. In the vicinity of the plant is coated with mulch, which is expected to reduce the erosion around the plant, keep the soil moisture and resist the splash of dirt due to rain on the stems and leaves on the plant.

From the results of the average analysis of the high growth rate of *Enterolobium cyclocarpum* in Fig. 1 and the average growth diameter in Fig. 2 shows the growth rate every year. The highest increase and the highest diameter is in the third year, then there is a decrease. This is accordingly according to Wahyudi (2012) that the plants form an upside-down parabolic chart, ie slow at the beginning of growth, then rapidly and slowing again.

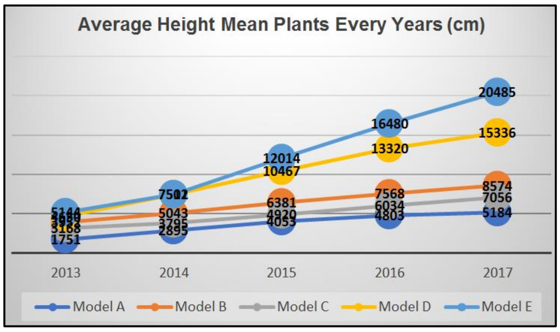

Fig. 1. Average height mean of *Enterolobium cyclocarpum* every years

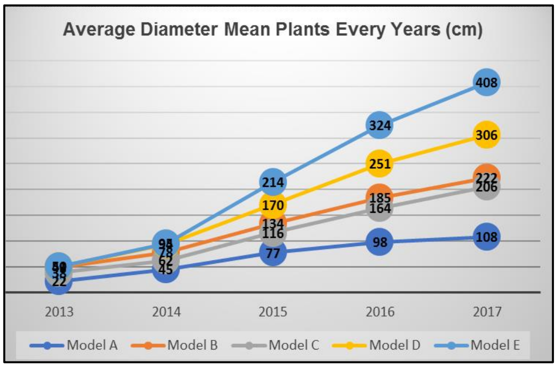

Fig. 2. Average diameter mean of *Enterolobium cyclocarpum* every years.

The highest plant growth is on soil treatment model E (topsoil compact dressing + compost + fertilizer + mulch). Wicaksono (2014) added that nutrient conditions in the soil and spacing also determine the rate of plant growth. Dina *et al.* (2013) stated that the application of fertilizer to the soil can have a good effect on soil nutrient content and can have good effect for the plant because macro nutrient contained in element N, P and K is needed for plant growth and development. According to (Joko & Basuki 2003), the use of mulch can modify the soil microenvironment, such as increasing the soil temperature, soil moisture, and soil organic matter content. The use of mulch also increases growth (plant height, stem circumference, dry weight of plant) and crop yield (fruit crop weight). Although the planting medium is a soil derived from top soil but has a low fertility rate.

Fertilization aims to improve soil fertility so that plants get enough nutrients to improve the quality and quantity of plant growth (Herdiana, 2007). Wu *et al.* (2010) stated that the use of fertilizers with low nitrogen content (0.034g N / kg of soil) is better than high nitrogen fertilizer (0.136g N / kg soil).

Top soil is lost due to tailings buried or submerged in puddles. In the former mining area, it looks like a small lake (shaped like a small lake), over burden, and taling (the rest of the washing material) in the form of swamp or dry land. Latifah (2003) indicates that over time, tailings deposits will form an expanded expanse of tailings. The results of Sitorus, (2008) suggest that the physical properties of the tailings are not easily changed with increasing time. Tailings aged 25 years have not match the original ground.

Normal soil profile is impaired due to dredging, stockpiling and heavy equipment compaction. This results in poor water and aeration systems that directly affect the phases and development of roots. The texture and structure of the soil become damaged so affect the capacity of the soil to hold water and nutrients.

The soil layer is not perfectly profiled, so it will have an effect on building a conducive plant growth. The influence of the wind is quite serious on the unstable soil surface, where the soil can be flown, covered by soil, grain fly and moved to an undesirable growing area. The materials used during mining will limit water infiltration, thereby reducing acid production and erosion. As a result of soil compaction causes the soil in the dry season to become solid and hard. In this heavily textured soil, the absorption of water into the soil is slow because the soil pores are so small that it can increase the rate of surface water flow which has an impact on increasing the rate of erosion. The hard and solid soil conditions are very heavy to be processed which indirectly affects the increase in labor requirements.

To observe the effect of soil chemistry on plant growth, soil analysis was done in the research area. Soil samples were taken each one on each model of soil treatment in the reclamation area of the former mining area of 5ha. Soil sample test results are presented in Table 1. Furthermore, the data is compared with the criteria in Table 2 (soil chemical evaluation criteria).

Table 1. Soil chemical analysis.

No	Parameter	Unit	Model A	Model B	Model C	Model D	Model E
1	pH H_2o	-	4,59	5,53	5,02	6,44	7,4
2	C	%	0,15	1,91	0,16	1,5	0,46
3	N	%	0,45	0,34	0,42	0,14	0,21
4	P_2o_5	mg/100g	9,9	22,08	30,46	32,43	53,97
5	K_2o	mg/100g	12,14	12,26	12,29	19,96	19,83
6	Ca-dd	me/100g	3,28	5,18	5,61	2,81	5,16
7	Mg-dd	me/100g	0,72	0,72	0,52	0,42	0,62
8	Na-dd	me/100g	0,45	0,45	0,29	0,23	0,22
9	K-dd	me/100g	0,07	0,1	0,04	0,29	0,18
10	KTK	me/100g	16,72	17,75	23,16	45,08	56,85
11	KB	%	10,02	11,55	27,91	22,35	34,86

Table 2. Soil chemical evaluation criteria.

Soil Properties	Very Low	Low	Medium	High	Very High
C (%)	< 1	1-2	2,01-3	3,01-5	>5
N (%)	< 0,1	0,1-0,2	0,21-0,25	0,51-0,75	>0,75
P	< 10	10-15	16-25	26-35	>35
K(me/100g)	< 0,1	0,1-0,2	0,3-0,5	0,6-1	>1
KTK(me/100g)	< 5	5-16	17-24	25-40	>40
KBK (%)	< 20	5-16	17-24	25-40	>40

1) Soil acidity (pH H_2O)

The soil reaction indicates the acidity or soil properties of the soil is assessed based on the concentration of H + and expressed in pH value (Judge *et al*, 1986 in Utami, 2009). In general, nutrients will be easily absorbed by plants if the soil pH is neutral, because at that value the nutrients are easily dissolved in water. In the treatment model A where the soil acidity value (pH: 4.59). Based on the soil assessment criteria in Hardjowigeno (1995), the soil samples from the treatment model A show the pH very sour or close to sour. If the acid soil is left in a sour state, the plant will lack P, because P will be bound to Al, otherwise the solubility of micro elements such as Fe, Mn, Zn, Cu and Co in soil will increase. Micro elements are needed by plants in small quantities. If the amount is too large it will endanger the plant (Hardjowigeno, 2003). For the B and C treatment model, the same result of the soil level in the slightly acidic catagothic pH (5,02-5,53), in the treatment model D and E soil acidity value of pH equal to (6,44-7,40) with neutral categories (not sour and not alkalis),

2) C- Organic

The content of organic C and N of the fifth overall soil samples is also relatively low (Fig. 3). Kasno (2009) states that the provision of organic materials in the long term can increase soil pH. Organic C sources in the five treatments include very low to low category. The treatment model was very low in treatment model A (0.15), treatment C (0.16) and treatment E (0,46) <1,00 while in model B (1,91) and D (1,50) at low level , 00 - 2.00).

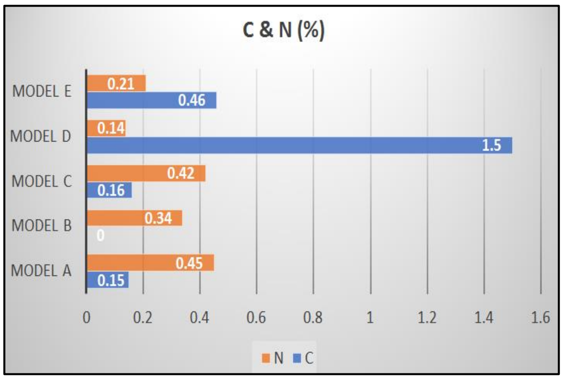

Fig. 3. C & N result every model.

Soil organic matter is formed from living soil consisting of flora and fauna, as well as rooting of decomposed and modified plants (Susanto, 2005). Chemically the plant remnants consist of 44% C, 40% O, 8% H and 8% minerals (Hanafiah, 2005). Remains of undecomposed plants by soil microbes will precipitate and increase the organic content of soil C. The high Organic C content and low total N cause the C / N ratio to be high. Hanafiah (2005) mentioned that the C / N ratio less than 20 indicates the occurrence of nitrogen mineralization, whereas if greater than 30 occur nitrogen immobilization. Natural forest soils have a C / N ratio lower than 20 which means enough nitrogen is available in the soil to be absorbed by plants.

3) Potassium (K)

In sandy soils with low CEC and low K reserves (Fig. 4), sour soils that have been degraded further, paddy land with 2: 1 clay mineral species (montmorillonite), soil with ratio (Ca + Mg) / K in high solution, and wetland with drainage bad often lack of K (De Datta, 1981; Dobermann and Fairhurst, 2000). Potassium deficiency causes: (1) leafy brownish edges with orange blotches especially on old leaves, dwarfed plants and drooping leaves, (2) frequent falls due to high N / K ratio, leaf senescence (4) unhealthy root growth (many rotting roots due to loss of oxidation power, so nutrient uptake is disrupted), and (5) plants are susceptible to disease such as blast, rotted stem, and leaf spot; especially when N fertilization is excessive. The results of soil chemical analysis showed that potassium content at the study sites of treatment model A (12,14), B (12,26), C (12,29), D (19,96) and E (19,83) in category low (10 - 20).

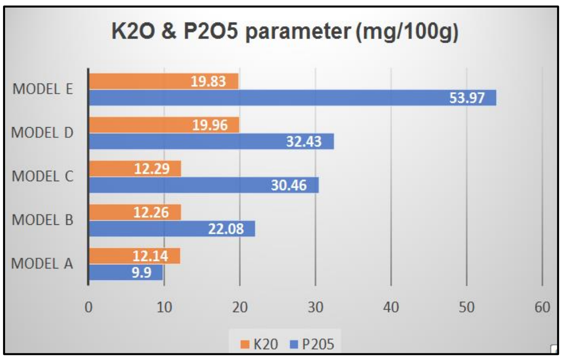

Fig. 4. K_2O and P_2O_5 result every model.

4) Phosphate content (P_2O_5)

Phosphate content (P_2O_5) in treatment model A was 9.90 with very low category, on treatment B, C and D (22,08; 30,46 and 32,43) with low category (Fig. 4). Based on the low phosphate content of the plant will lack phosphate resulting in rooting system, leaves, the formation of branching is reduced resulting in death. According to Winangun's (2009) statement that phosphorus deficiency resulted in the root system being dwarfed, the color of the leaves became dull, grayish green and red pigment appeared on the leaf base, and the formation of little branches and fruit was reduced. While in the treatment model E, the phosphorus content of 53.97 with high category. Phosphorus is an important component of compounds for energy transfer (ATP and other nucleoproteins), for genetic information systems (DNA and RNA), for cell membranes (phospholipids), and phosphoproteins (Gardneretal, 1991; Lambersetal, 2018).

5) Cation Exchange Capacity

Cation Exchange Capacity (CEC) of a soil is a capability of soil caloid to absorb and exchange cations (Hakim *et al*, 1986 in Utami, 2009). The cation exchange capacity (CEC) is a chemical property very closely related to soil fertility. Soil with high organic content or high clay content has a higher CEC value than soils with low organic matter or sandy soil (Hardjowigeno, 2003), the higher the CEC value, the more fertile the soil. Soil chemistry analysis in five treatment models showed that soil fertility level in treatment model A was low (16,72) at Fig. 5, in treatment model B and C was medium (17,75 - 23,16). In the treatment model D is at high soil fertility level (45.08) whereas in soil treatment model E soil fertility level is very high (56,85)> 40.

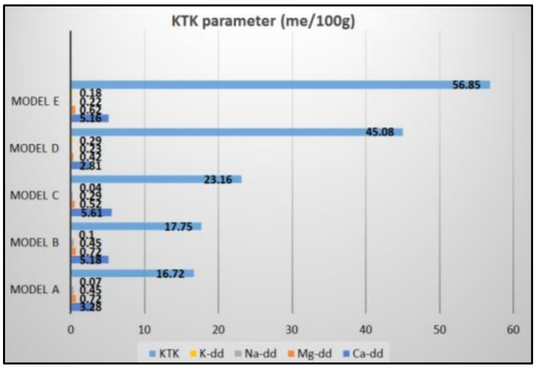

Fig. 5. KTK every models.

6) Saturation Bases (KB)

Low base saturation of the soil, dominated by acidic cations such as Al and H. In accordance with the Arabic statement, Zaibabun and Royani (2012), that if too much acid cation Al can cause toxic to plants. Result of soil chemical analysis showed that in treatment model A (10,02), treatment B (11,55) <20 with very low category. While treatment C (27,91), treatment D (22,35) and treatment of E (34,86) with low category (20 - 35) (Fig. 6).

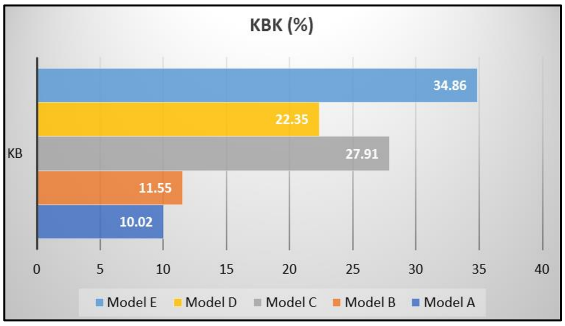

Fig. 6. KBK every models.

The chemical condition of the former mining area shows that soil fertility, soil acidity (pH) and the presence of nutrients in the soil are low, while the presence of heavy metal minerals is high, due to the solution of metal sulphide. Nutrient conditions such as low N and P elements, acid or alkaline soil reactions are a major problem. low soil pH resulted in decreased supply of food substances such as P, K, Mg and Ca which resulted in quite harmful to high soil temperatures. The erosion of top soil and litter layer as a carbon source to support potential soil microbial survival is one of the major causes of declining population and soil microbial activity that is important in the provision of nutrients and indirectly affecting plant life. Low soil microbial activity due to the influence of various microbial environmental factors, such as decreasing soil pH, soil moisture, organic matter content, soil holding power to water and soil structure.

Conclusion

From data analysis, there are two models of soil treatment which is higher than the five treatment models, that is D treatment model (top soil, compost, fertilizer) and E treatment (top soil, compost, fertilizer and mulch). The soil pH conditions in treatment model A were very acidic with a pH value of 4.59 and soil pH conditions in the E treatment model were categorized as normal (not acidic and non alkaline) with a pH value of 7.40. Result of soil chemical analysis on all model of soil treatment in categorize less fertile.

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