The effect of ameliorant application in abundance of soil microbiology on coal mine reclamation land at Muaro Jambi Regency of Jambi Province

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Abstract. Efforts to restore the environmental conditions of ex-coal mine land through reclamation can be monitored through land quality indicators. Soil quality is a soil condition that describes the soil as healthy, which has good physical, chemical and biological properties of soil, and high productivity in a sustainable manner. The quality of soil in biology is largely determined by the number of micro-bodies in the soil (especially fungi, actinomycetes, and bacteria). This aim of this study is to describe changes in soil quality from the abundance of several types of soil microorganisms after the application of ameliorant and re-vegetation on coal mine land in Muaro Jambi Regency, Jambi Province. This activity was carried out in the coal mine reclamation land that had been reclaimed / stockpiled at PT Gea Lestari, Tanjung Pauh Village, Mestong District, Muaro Jambi Regency from January to December 2016. The study design used was Randomized Block Design with treatment factors: 10 tons of manure/ha and manure 10 tons/ha + mycorrhizae 30 g/plant. Each treatment was repeated 3 times. The plants used are corn, soybeans, Setaria and ground cover plants (leguminosae) among conservation plants. Samples obtained from 3 replications were composite for biology analysis of the soil. The results of the biological analysis of the soil obtained various results both at the initial conditions of the soil at the study site and after the results of the assessment. The initial conditions of the land indicate that the reclamation land of former coal mines has a diversity of soil microorganisms, namely cellulotic fungi, cellulotic bacteria, mycorrhizae, propargules fungi and heterotrophic aerobic bacteria and has C-mic activity. Re-vegetation on reclaimed land of ex-coal mines shows indicators of macro-fauna and microorganism life that increase in number and activity.

1. Introduction
Mining activities are part of economic activities that utilize natural resources and are expected to guarantee life in the future. One of the activities in utilizing natural resources is coal mining activities. Coal mining provided large regional revenues, but on the other hand these activities cause severe environmental damage such as opening of vegetation closure in the land clearing process. Furthermore, the excavation process causes loss of nutrients and soil organic matter contents, topographic and landscape changes, water and soil pollutions [1]. Meanwhile, physical problems that often arise are sandy soil structures and fairly high surface temperature [2]. Soil damage due to the use
of heavy equipment makes the soil more dense and this will cause a decrease in porosity and soil drainage. Based on its biological problems, this is closely related to the microbial life of land dwellers.

Ex-mining land that has extreme physical conditions such as that does not allow the growing conditions for soil microbes [3]. Even though according to [4] soil microorganisms have a function as a nutrients resources, organic matter decomposers and organic mineralization, spur plant growth, biological agents controlling plant pests and diseases, influence the physical and chemical properties of soil.

The rehabilitation and reclamation process are being made to reduce the increment of critical and unused land due to the open mining process. Reclamation activities are the activities that are expected to restore land to its original conditions. Reclamation is aimed to improve or organize the utilization of disturbed land as a result of mining business activities, so that it can function and be efficient according to its designation. Reclamation of ex-mining land is not only an effort to improve post-mining environmental conditions, but also to produce a good ecosystem environment and striving to be better than the initial hue, carried out by considering the potential of the remaining minerals [5].

According to [6] practices reclamation that is usually carried out to improve the quality of the ex-coal mining reclamation land fertility are compost utilization, NPK fertilizing and lime amelioration to improve soil fertility, vegetative mulch utilization and bench terraces or mounds formation to reduce erosion, acid mine management handling with lime or wetland methods. Furthermore it is said that biological fertility involves microbiological activity in the soil carried out by various micro/mesofauna-/flora. Various parameters of soil physical and chemical properties cannot describe the soil quality changing after reclamation.

Efforts to restore the environmental conditions of ex-coal mine land through reclamation can be monitored through land quality indicators. Land quality is a soil condition that describes the soil as healthy, which has good physical, chemical and biological properties of soil, and high productivity in a sustainability. The soil biology quality is largely determined by the number of microorganism in the soil (especially fungi, actinomycetes and bacteria). Microorganisms decompose organic matter, release nutrients in the form available to plants, and degrade toxic residues so as not to endanger plants. About 15% of organic matter consists of microbial cells [7] [8]. The number and type of microorganisms that are abundant in the soil can be an indication that the soil is fertile, with an indicator of the sufficient organic matter in the soil, appropriate temperature, sufficient availability water and supporting ecological conditions of the soil [9]. This paper aims to describe changes in soil quality from several types of soil microorganisms abundance after the ameliorant application and re-vegetation on ex-coal mine land in Muaro Jambi Regency, Jambi Province.

2. Materials and Methods

2.1. Time and location of activities
This activity was carried out on the ex-coal mine land that had been reclaimed at PT Gea Lestari, Tanjung Pauh Village, Mestong District, Muaro Jambi Regency from January to December 2016.

2.2. Materials and tools
The materials used in this activity are corn plant seeds, soybean seed, animal feed seeds, leguminous seeds, manure, NPK fertilizer, pesticides, dolomite, and liquid organic fertilizer. Tools used in activities are: office stationery (ATK), hoes, tugal tools, hand sprayers, buckets and bailers.

2.3. Procedure

2.3.1. Plotting and land preparation
Plotting is done before planting to border corn, animal feed and legume plants with conservation plants which was planted by the coal company. Dolomite is given on the land with a dose of 1000
kg/ha or according to the analysis of soil pH 1 week before planting. Manure is given on the day before planting with a dose of 10 tons / ha by being stocked on the area.

2.3.2. Planting and maintenance
Plants planted are corn, Setaria and leguminosae between conservation plants. Corn is planted directly with a spacing of 20 x 60 cm. Soybeans are planted directly with a spacing of 40 x 15 cm. Fertilizers used are NPK fertilizers with doses according to the results of soil analysis. Setaria are planted with a spacing of 50 x 50 cm and given NPK fertilizers at doses according to the results of soil analysis. Leguminosae is planted between conservation plants and NPK fertilizer is given according to the results of soil analysis.

2.3.3. Soil sampling and analysis
Soil biological data obtained by taking disturbed soil samples are then analyzed in the laboratory. The total plate count method is used to analyze the number of cellulolytic bacteria, the number of heterotrophic bacteria, the number of fungi, the number of mycorrhizae and the number of cellulolytic fungi. Soil samples were carried out before planting and after harvest. Each treatment is composite and then analyzed in the laboratory.

2.3.4. Method
The research design used was a randomized block design with treatment factors:
P1 = 10 tons of manure/ha
P2 = 10 tons/ha manure + mycorrhizae 30 g/plant
Each treatment was repeated 3 times. The plants used are food crops (corn and soybeans), animal feed plants (Setaria) and ground cover plants (leguminosae) among conservation plants. Samples obtained from 3 replications were composite for soil biology analysis.

The parameters observed are number of cellulolytic bacteria, number of heterotrophic bacteria, number of fungi, number of mycorrhizae, number of cellolytic fungi, C-microbes in soil and soil respiration.

3. Result & Discussion

3.1. Overview of Study Sites
PT Gea Lestari is located in Tanjung Pauh Village KM 32, Mestong Subdistrict, Muaro Jambi Regency, which geographically lies between 103°28'12.93” - 103°29'17.00” and 1°47'00.00” - 1°50'08.76” coordinates. This location is on the edge of the provincial road, the main route Tempino - Bulian with reclamation land location is about 1 km from the main road. This location has a tropical climate with an average temperature of 32°C. Rainfall based on BMKG evenly throughout the year 192 days for a year or 16 days/month with an average of 186 mm/day [10].

From the results of the soil analysis it can be concluded that the level of fertility of the reclamation land is very low - very low. The macro nutrient content (N, P and K) is very low in the upper layer and the lower layer unless available - K. Soil reaction was acid and cation exchange capacity was low - very low. Ameliorant technology is needed to improve soil fertility so that re-vegetation can succeed. The addition of organic material is absolutely necessary to increase the organic C content, CEC and the capacity to hold water to restore soil fertility in this reclamation area. In addition, macro nutrient fertilizer (N, P, K) is also needed at high doses, especially for productive plants.

Furthermore, it is said that the topography of ex-coal mine area of PT Gea Lestari which has been reclaimed is generally hilly with slopes> 8% except in the excavated area which is closed on average flat, undulating and sloping. The physical properties of soil are: mixed color soil, unstructured or solid (massif), fine texture to very fine dominant clay. Drainage is not good and it often shows stagnant water resistance (water does not easily seep into the soil). The average soil water content is 19.77% and the average density of contents is 1.37 g/cm³.
3.2. Abundance of soil microbiology before and after ameliorant applications

Land is an ecosystem that contains various types of microbes with different morphology and physiological properties. The number of each microbial group varies greatly, some of which only consist of several individuals, some of which amount to millions per g of land. The number of microbes affects the chemical and physical properties of the soil and plant growth. By knowing the amount and microbial activity in a soil, it can be known whether the soil is fertile or not because a high microbial population indicates adequate food / energy supply, the appropriate temperature, adequate water availability, and soil ecological conditions that support microbial development.

The biological analysis of the ex-coal mine land showed various results, both in the initial conditions of the soil at the study site and after the results of the assessment. The initial conditions of the land indicate that the ex-coal mine reclamation land has a diversity of soil microorganisms, namely cellulotic fungi, cellulotic bacteria, mycorrhizae, propragu fungus and heterotrophic aerobic bacteria and has C-mic activity.

Cellulotic microorganisms are microorganisms that are involved in the decomposition of organic matter, both bacteria and fungi. Heterotrof bacteria are a group of bacteria that use C-organic as a carbon source and its growth energy source [11] is a cleaning bacteria that can decompose organic waste. Table 1 presents an abundance of numbers of anaerobic heterotrophic bacteria and bacteria before ameliorant application and after ameliorant and applications.

Table 1. Number of types of soil bacteria on coal mine reclamation land before and after amelioration.

| No | Commodities       | Ameliorant            | Number of cellulotic bacteria (CFU/g soil) | Number of aerob heterotroph bacteria (CFU/ g soil) |
|----|-------------------|-----------------------|-------------------------------------------|--------------------------------------------------|
| 1  | Before assessment | -                     | 5.00 x 10^2                               | 8.23 x 10^9                                      |
| 2  | Corn              | Manure                | Not measurable                            | 1.07 x 10^10                                     |
| 3  | Corn              | manure + mycorrhizae  | Not measurable                            | 6.73 x 10^8                                      |
| 4  | Soybean           | Manure                | Not measurable                            | 5.23 x 10^10                                     |
| 5  | Soybean           | manure + mycorrhizae  | Not measurable                            | 2.09 x 10^10                                     |
| 6  | Legume            | Manure                | Not measurable                            | 1.33 x 10^10                                     |
| 7  | Legume            | manure + mycorrhizae  | Not measurable                            | 2.57 x 10^10                                     |
| 8  | Setaria           | Manure                | 1.20 x 10^3                               | 2.97 x 10^10                                     |

The number of cellulotic bacteria in the initial conditions was 500 CFU/g of soil, which become not detected in maize, soybean and legume crops, both in the application of fertilizers and in mycorrhiza. Whereas, there was an increase in number of cellulotic bacteria on Setaria. It is showed that the application of manure affects the number of cellulotic bacteria. It is suspected that bacteria help un-matured manure decomposition.

The number of heterotrophic aerobic bacteria in the initial conditions was 8.23 x 10^9 and increased in all commodities of manure application and manure + mycorrhiza application. Increased population of heterotrophic bacteria that occurs after ameliorant application because this group of bacteria is able to utilize organic compounds contained in manure as a growth source of carbon. Most of these organic compounds are used as energy sources and are burned in the respiration process into CO_2 while most of the others with nitrogen elements will function as one of the elements in the formation of protoplasmic cells, especially cell wall formation [12].

The total number of fungi in the soil after treatment application decreased compared to the initial condition. It is assumed that fungi are used as an energy source for decomposition of manure in the
soil which may still have parts that have not been completely decomposed. The number of cellulotic fungi has a similar trend except in legume plantations which is increased in manure application but decreased in manure + mycorrhizae application. The number of fungi and cellulolytic fungi is presented in Table 2.

**Table 2.** Number of types of fungi on coal mine reclamation land before and after ameliorant.

| No | Commodities | Ameliorant      | The number of fungi (propagul/g soil) | The number of cellulotic fungi propagul/g soil |
|----|-------------|-----------------|--------------------------------------|---------------------------------------------|
| 1  | Before assessment | -              | 2.7 x 10^6                            | 3.03 x 10^4                                 |
| 2  | Corn        | Manure          | 1.78 x 10^6                           | Tnd                                        |
| 3  | Corn        | manure + mycorrhizae | 3.00 x 10^4 | Tnd                                        |
| 4  | Soybean     | Manure          | 1.40 x 10^6                           | Tnd                                        |
| 5  | Soybean     | manure + mycorrhizae | 3.50 x 10^4 | Tnd                                        |
| 6  | Legume      | Manure          | 2.50 x 10^4                           | 1.70 x 10^6                                |
| 7  | Legume      | manure + mycorrhizae | 8.13 x 10^3 | 1.80 x 10^3                                |
| 8  | Setaria     | Manure          | 4.17 x 10^4                           | 2.20 x 10^5                                |

Figure 1 shows the number of mycorrhizae has increased in application of manure + mycorrhizae in all plants, whereas the number of mycorrhizae has decreased in manure application. The increase in the number of mycorrhizae due to the application of mycorrhiza is very reasonable because there will be an increase in the number of mycorrhizae around the roots. Arbuscular mycorrhizal fungus can increase nutrient uptake of N, P, K in the soil so that it can fulfilled plant nutrient needs. The roots of plants symbiosis with arbuscular mycorrhizal fungi are more efficient in absorbing water and nutrients compared to plant roots that are not symbiosis with arbuscular mycorrhizal fungi [13]. The number of mycorrhizae in the manure application decreased. It was thought that manure contained antagonistic elements against mycorrhizae.

Arbuscular mycorrhizal fungi can be found in almost all ecosystems, including acidic land and alkalin, as well as ex-coal mine land. Arbuscular mycorrhizal fungi can be associated with almost 90% of plant species. The diversity of Arbuscular mycorrhizal fungi spores always changes with changes in observation time, host type and salinity level [14].

From the results of [15] the presence of arbuscular mycorrhiza on ex-mining land in Sumatra has different spore densities in each region. In the ex-coal mine in Jambi Province, the density of natural spores before trapping was carried out only 5 spores/50g soil and after trapping for 4 months 89 spores/50g. In ex-coal mine area of Tanjung Enim South Sumatra the abundance obtained from the age of the mine land after landfill of 0 years to 19 years and the host source of inoculum or dominant vegetation found mycorrhiza showed differences in species. Arbuscular mycorrhizal abundance in acidic dry land in acidic dry land Central Lampung is very diverse. The highest number of spores is obtained from soil containing pH 5.15.
Figure 1. The number of mycorrhiza before and after ameliorant application.

Carbon microorganism is the amount of biomass of microorganisms in the soil which is one indicator of soil fertility because the soil containing various microorganisms shows that the soil has a good fertility rate [16]. Soil C-microbial levels are relatively small compared to C-soil as a whole, but soil microbes play an important role in the sustainability of nutrient cycles. The researchers determine microbial biomass in relation to its important role in storing nutrients and energy [17] one of the structures and stability of the soil, ecological markers, and pool of nutrients as a reserve of nutrients [18]. The C-mic after ameliorant application increases compared to the initial conditions of the land. This is contradictory to other results which tend to decrease except mycorrhiza. It is suspected that this increase in C-mic indicates the presence of other microorganism activity which is not observed in the parameters, due to the presence of manure. Manure contains a variety of microorganisms because decomposers are added from animal feces and in decomposition. The highest activity is in legume cropping which is seen from its development indeed covers almost the entire surface of the land (Figure 2).

Figure 2 also presents soil respiration before and after ameliorant application and harvested. Soil respiration is one of indicator of microbial activity in the soil. In the process of respiration there is the use of O$_2$ and the release of CO$_2$, so that the respiration rate can be determined by measuring the O$_2$ used by soil microbes. Soil respiration rates are determined by the level of CO$_2$ evolution. The evolution of soil CO$_2$ results from the decomposition of organic matter. Thus, the level of respiration is an indicator of the level of decomposition of organic matter that occurs at certain intervals [19].

The higher the value of respiration of microorganisms, the higher the microorganism producing CO$_2$. The activity of high soil microorganisms means that the production of CO$_2$ in the soil is also high. Factors that influence the activity of soil microorganisms are soil pH, soil organic matter, cation exchange capacity and total microorganisms. If the soil pH is acidic, organic matter in the soil is low, the soil cation exchange capacity is low and the total soil microorganism is small, the soil microorganism activity decreases. Acid soil pH decreases the activity of microorganisms. Organic matter as a food supply or energy that is small in the soil will reduce the activity of microorganisms. The lower the value of cation exchange capacity, the soil is infertile and makes microorganism activity decrease. The higher the total microorganism and the greater the amount of organic matter in the soil, the higher the respiration of microorganisms. The high activity of microorganisms is related to the large population of microorganisms and organic matter as an energy source. The low value of
respiration due to poor recovery of vegetation which causes the recovery of organic matter that is slightly on the ground [20].

Figure 3. Microbial activity and soil respiration on coal mine reclamation land before and after amelioration

4. Conclusions
The results of biological analysis of the soil obtained various results both in the initial conditions of the soil at the study site and after the results of the assessment. The initial conditions of the land indicate that the reclamation land of ex-coal mines has a diversity of soil microorganisms, namely cellulotic fungi, cellulotic bacteria, mycorrhizae, proragul fungi and heterotrophic aerobic bacteria and has C-mic activity. Revegetation on reclaimed land of ex-coal mines shows indicators of microorganism life that increase in number and activity.

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