Utilization of *Tephrosia vogelii* in post-mining land reclamation

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Abstract. Reclamation is an effort to repair the damaged mining sector to provide optimal benefits. This review article aims to propose a natural product technology approach to the reclamation of post-coal mining land by increasing the content of soil organic matter so that the post-mining land becomes fertile and can be used for agricultural land. The method used is an observation and literature study. Literature searches were using them ScienceDirect, Scopus, PubMed, and Google Scholar databases. Land-use change of post-mining site to agricultural land provides prospective economic value to the community. However, the land quality of the post-mining area should be improved before food crop production. *Tephrosia vogelii* is a member of the Papilionoideae subfamily is important for land revegetation. They can fertilize the soil because of mutualistic symbiosis with the bacteria Rhizobium sp. which is capable to fix nitrogen in the soil and hence provide available nitrogen. Thus, the use of post-mining land as agriculture can improve the economy and sustainability as well as protect life and the environment with natural product technology.

1. Introduction

Land requirements are increasing with the increase of population. Likewise, land problems increasing with more intensive mining. A lot of lands have been neglected and degraded after mining activities. Before changing land use of mining area to another use, especially agriculture, rehabilitation of post-mining land is required. The mining sector in Indonesia contributes to forest destruction up to 10%, now 2 million hectares per year are destructed [1]. The forest vegetations are often intended for revegetation and further reclamation of post-mine land used since mining land is usually located in the forest [2]. After land reclamation and rehabilitation, the post-mining land can be used for agriculture, ecotourism, settlements or wetlands.

In carrying out post-mining land reclamation, things that need to be considered and carried out in rehabilitating/reclaiming post-mining land are the impact of changes from mining activities, land reconstruction, revegetation, prevention of acid mine drainage, drainage arrangements, and post-mining land use [3].
Returning the land to its initial conditions takes a long time, due to damaged soil components and low organic matter content causing low activity and microbial population [4]. The selection of plants that are suitable for land conditions is one of the determinants of reclamation success. Plants that are often chosen for soil revegetation on post-mining areas are usually planted with Leguminosae-Gamal (*Gliricidia sepium*) and sengon (*Albizia chinensis*) [5]. However, the selection of plants must be in accordance with the conditions of the post-mining land.

The genus *Tephrosia* belongs to the family Leguminosae or Fabaceae and the sub-family Papilionoideae. According to Polhill, et al. [6], which are shrubs, herbs, and trees. The genus *Tephrosia* is known to have the ability to fertilize the soil because it can symbiotic mutualism with the bacteria Rhizobium sp. which can fix nitrogen in the soil, as reported by Harborne [7]. *Tephrosia* is discovered all through tropics and subtropics. *Tephrosia vogelii* is one of the *Tephrosia* species. In West Java, this species is known as pig nut or *kacang babi*, as reported by Susanto [8]. This plant is known as a woody herb with branching stems that are downy white or brown, or a small tree with green leaves, spirally arranged and dense, ranging from 0.5-4 m in height. This study aims to propose a natural product technology approach to the reclamation of post-coal mining land with an increase in the content of soil organic matter so that the post-mining land becomes fertile and can be used for agricultural land.

2. Method

The type of data used by the author in this study is primary data by making observations and observations, while secondary data is data obtained from journals, documentation books, and other references related to the study of revegetation plant selection for the success of reclamation of post-mining land. The collected data is then analyzed using descriptive analysis methods. The descriptive analysis method is a research method that is carried out by describing the facts that are later followed by analysis, and providing adequate understanding and explanation. Literature searches were using the ScienceDirect, Scopus, PubMed, and Google Scholar [9]. The research data is then presented systematically, starting from the criteria for selecting tree species for post-mining land, revegetation plant types based on historical land use and describing examples of post-mining land reclamation, especially coal mining, which has been widely practiced by large companies engaged in mining in Indonesia, and using other keywords that are natural product technology, *Tephrosia vogelii*, soil organic matter, fixing nitrogen by *Rhizobium* sp., fertile agricultural land.

3. Results and discussion

3.1. Characteristics of post-mining area

Many activities in coal mining can damage structure, texture, porosity and bulk density as important soil physical characteristics for plant growth. Each phase in this process is believed to be associated with different sets of environmental damage covering physical, chemical and biological effects to mining land. The ex-mining area could be classified as degraded land, referring to the land that loses its natural productivity due to a decrease in land quality, from the point of view of agriculture land usage. The degraded land of the post-mining area comprises the deterioration of the physical and chemical properties of the soil, a drastic species reduction in some flora, fauna and soil microorganisms. The poor land quality causes the decline in soil fertility and leads to a more compacted structure, which physically affects its capability of performing penetration, a condition which is unfavorable for the plant to grow. For this purpose, it is critical in restoring mined lands to repair the soil quality through a reclamation process, or even to improve the land productivity after surface mining. As an important part to remediate the land degradation, there are many methods of reclamation, such as revegetation, and improving land quality by using fertilizer to increase essential nutrients and reach the optimum of pH levels by adding an appropriate amount of lime based on the soil type and intended pH, as well as the use of microbes for soil rejuvenation. The objective of the treatments is to enhance soil health and quality [10].
The chemical characteristics of the soils such as pH, organic matter, exchangeable bases, effective cation exchange capacity, and exchange acidity are found to be conducive to rice production and other agricultural crops; the soil quality can be improved by farmers and therefore soil cannot be permanent limitations for rehabilitation of post-mining area [11].

3.2. Land revegetation
The definition of the post-mining is an activity planned, systematic, and continue after the end of the part or all mining activities to restore the function of the natural environment and social tasks according to the local conditions in the mining area [12]. This is in accordance to Mining Law No. 3/2020 has been enacted to amend the Mining Law No. 4/2009. The law paved the way for several changes, including matters relating to the determination of mining areas, centralization of authority and mining business licensing, including reclamation and post-mining [13]. Government Regulation No. 78 of 2010 regarding Reclamation and Mine Closures (GR 78/2010) [14]. Minister of Mining Regulation No.1827/K/30/MEM/2018 Year 2018 concerning Guidelines for Implementing Good Mining Engineering Rules (Appendix V and VI) [15].

Post-mining land actually has the opportunity to be used as agricultural areas to meet food needs and overcome post-mining environmental problems. Agricultural technology innovation interventions are believed to be able to improve the physical, chemical, and soil's biological properties, allowing it to be used as an ideal medium for agricultural cultivation. Apart from the biophysical aspects, reclamation efforts should also consider the socio-economic aspects of the community, such as land ownership status, farmer knowledge and skills, and farming cost feasibility. As a result, it is critical to develop and operationalize the reclamation of post-mining land for agricultural use [16].

The problem in post-mining land is low productivity due to poor physical and chemical properties of the soil, due to low water absorption, large porosity, infertile soil due to the pH of the soil that is too acidic. In addition, low nitrogen and phosphorus, cation exchange capacity (CEC) in the soil, and low alkaline (K, Ca, Mg, and Na) and Al, in addition to the soil's high concentration of heavy metals and toxic compounds. Many ways can be done to repair the damage caused by mining, one of them is the Legum Cover Crop (LCC) which can live on damaged soil and the incorporation of organic compounds capable of improving the physical and chemical properties of the post-mining soil. Plant roots will grow if the soil has appropriate air and circulation. Good circulation will occur if the soil has a loose consistency and the soil structure has developed [17].

Soils with high organic matter content generally have loose consistency. Dense and hard soil due to loads from heavy equipment will greatly reduce the air infiltration rate, the amount of air and air in the soil, and of course inhibit the growth of plant roots. It is recognized that applying high doses of organic matter or compost to the soil or planting holes to increase soil looseness is often difficult to meet due to materials. Therefore, the use of organic material substitute compounds, such as humic compounds can be done. Chemical fertility is related to the availability of nutrients and the optimum level of soil acidity for plant growth. To increase the success of revegetation, topsoil is often sprinkled with a thickness of 50 – 100 cm over the post-mining land that has been laid out with the assumption that the topsoil is chemically and physically fertile. The topsoil for reclamation is very infertile soil, as reflected by the very low organic matter content with the damaged soil structure making it easy to compact [18].

The improvement the chemical fertility of topsoil can be done by combining the use of compost and basic fertilizers that are commonly used. The humic acid compounds as a substitute for compost have significantly improved the performance of ground cover crops. Chemical fertility in soil with acidic pH is strongly influenced by the presence of toxic elements for plant growth caused by the oxidation of sulfide derivative compounds, such as pyrite. Sulfur can be toxic to plants. Sulfur dioxide in the atmosphere in any sizable concentration kills plants [19]. The chemical properties of soil containing sulfide minerals can be identified by measuring the pH in H2O2 [20]. In very acidic environmental conditions, heavy metals in overburden or tailings will be more easily dissolved and carried away by surface runoff, thereby contaminating surface water and subsurface water. In such
conditions, plants cannot grow optimally. Biological fertility is influenced by microbiological activity in the soil carried out by various micro/mesofauna/-flora [21].

3.3. *Tephrosia vogelii* (*T. vogelii*) for land revegetation
Legum cover crop plants on post-mining land reclamation are useful for protecting soil from erosion damage and for producing large amounts of organic matter, this Leguminosae plant has roots that can improve soil physical and chemical properties and able to absorb heavy metals on post-mining land, one of the Leguminosae plants that are often used is *T. vogelii*. In addition to the use of cover crop legumes, to increase soil fertility, it is necessary to add organic material, organic matter is a very important material in creating soil fertility, both in terms of physics, chemistry, and soil biology, so that plants can produce secondary metabolites [22]. Organic matter is an excellent aggregate stabilizer. Part of the soil's cation exchange capacity (CEC) comes from organic matter [17].

*Tephrosia vogelii* is a leguminous plant that grows a lot in Africa, there are bacteria *Rhizobium japonicum* that live in a symbiotic mutualism in its roots that can improve the nitrogen content in the soil. *Tephrosia* can improve soil fertility, like firewood, as an insecticide. Besides that, it is also used as a medicine for skin diseases and intestinal worms. Leaves of this plant contain rotenone one of the toxic compounds to fish and ruminants [23].

![Figure 1. Root nodules of Tephrosia vogelii [23].](image1)

![Figure 2. Tephrosia vogelii [24].](image2)

*Tephrosia vogelii* is a shrub, grows in savanna, grasslands, forest edges and shrubs, deserts, and empty fields and can grow in acid soils, with the presence of nodules this plant can fix nitrogen from the environment and release it slowly in the soil where so that this plant can grow on poor soil and is not susceptible to disease because of the content of chemical compounds that cause plants to survive
even in a bad environment. One of these compounds is tephrosine which makes this plant resistant to termites [22][25].

The root arrangement of *T. vogelii* is generally very good, the root growth is straight into the soil and has many branch roots, at the root nodules containing the bacterium *R. japonicum*, which can bind N from the air which is then used to fertilize land [7]. Good pH tolerance as a condition for growing *T. vogelii* plants, which is between 5 - 6.5, grows well on various types of soil, especially Andosol soil with good drainage and soil aeration. *T. vogelii* can grow well in places with a temperature range of 12-27 °C, in places that are open and with rainfall of 850-2,650 mm3 per month. Therefore *T. vogelii* is mostly grown in areas with a sea level of 2,100 m [23].

*Tephrosia vogelii* can be used as a crop plant for sustainable agriculture because the plant can reduce the use of pesticides, herbicides, and fertilizers [26], even this plant can withstand raindrops that fall directly and reduce the speed of water flow on the soil surface, restraining the rate of erosion, soil, adding soil organic matter produced from the remains of leaves, stems, and roots, carrying out transpiration so that it can withstand evaporation from the soil directly [27], increasing soil fertility where this plant has root nodules resulting from the symbiosis of plant roots with *Rhizobium* bacteria that can bind nutrients N from the air so that it can be available for farming [7].

*Tephrosia vogelii* can suppress weed growth because it has allelopathic properties. This is very beneficial in terms of crop cultivation because it can reduce the cost of chemical weed control and indirectly creates sustainable agriculture. Another advantage of this *T. vogelii* plant is that it can suppress or reduce diseases caused by fungi or bacteria the same as *Cassia grandis* [28][29]. Post-mining land reclamation methods can be updated and developed with information system technology with Structured Query Language (SQL) for the manufacture of artificial intelligence [30] and linked to an Internet of Things (IOT) based website that is connected to sensors and soil fertility measurement tools, water control, weed control, pest and disease control, thereby increasing capability, accuracy with the use of more diverse types of parameters [31].

4. Conclusions

*Tephrosia vogelii* which is one of the leguminous plants has advantages in helping post-mining land reclamation in terms of increasing soil fertility, controlling water, controlling weeds, controlling pests, diseases and creating sustainable agriculture.

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