Effectivity of Signal Grass (*Brachiaria decumbens*) Enrich with Microorganism to Absorb Heavy Metals (Pb)

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Introduction

Forest destruction, or deforestation, is four-pronged; it affects the biological, physical, chemical and social environments [1]. When a forest is destroyed, many organisms lose their habitats, climate regime is altered with the loss of carbon sequestering organisms, the consequent soil erosion affects the availability of soil nutrients, and the loss of habitat may also lead to the displacement of the indigenous people whose livelihood depends much on the forest.

Depletion of soil nutrients due to soil erosion is a serious consequence as it affects food security (availability, quality, quantity, access, utilization and stability). Hence, the replenishment of soil nutrients is of equal importance and a priority for human survival.

When left alone, nature may be able to fend for itself. However, the slow natural recovery process may not be able to cope with the rate of forest destruction, particularly the intrusion of heavy metals into the soil. Thus, some forms of soil intervention regime is necessary.

Like other fertile soils, the soils in Java, Bangka, Papua, Sulawesi, and East Nusa Tenggara islands are rich in minerals and nutrients that benefits many organisms [2,3,4,5,6]. However, due to improper management, human development activities had polluted these fertile lands.

Soil pollution, either intentional or unintentional, is the introduction of substances into the soil resulting in soil disturbances or damages by changing its initial condition [7]. These human activities causing soil pollution include mining and industrial development that introduce wastes and pollutants into the soil, water and air.

Heavy metals are one type of these soil pollutants. Naturally, soil contains the elements Si, Al, Fe, Ca, Na, K, and Mg derived from the weathering of parent

Source: Dani Yudi Trisna SEAMEO BIOTROP

materials [8]. The excessive presence of metals affects the soil properties and impacts the ecosystem balance. Contaminated soil can decrease soil quality, resulting in unhealthy soil and ultimately, in soil inability to support plant life. One of the heavy metal pollutants is lead (Pb). This metallic element can come from industrial waste and improper mining activities such as excessive use of agricultural and hazardous materials (B3), which can seep into the soil through air currents and settle in the soil layers. Lead waste in high amounts can be toxic and can endanger the health of plants, animals and humans. Based on its toxicity, Pb is a heavy metal classified under the highly toxic category.

As pollutants, heavy metals are difficult to remove naturally from the ecosystems. Hence, soil or chemical burning is necessary but this activity requires high costs and poses potential damage to the environment. Consequently, eco-friendly alternatives need to be carried out. One

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biological alternative to alleviate the impact of pollutant substances is soil remediation which involves the improvement of contaminated land using bioremediation and phytoremediation [9].

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Bioremediation is carried out by utilizing the role of microorganisms in restoring contaminated soil [10]. Microorganisms are the first life forms that were highly adaptive to rapid changes brought about by critical environmental conditions. Microbes are everywhere and they literally impact the entire biosphere; starting from their major role in regulating biogeochemical cycles, extreme environmental conditions such as frozen environments, acid lakes, hydrothermal vents, and deep ocean floors, to the small intestines of animals [10]. Meanwhile, phytoremediation involves the use of symbiotic plants with microbes that have great potential to remedy contaminated soil [11].

Signal Grass Enrichment (*Brachiaria decumbens*)

Biological approaches using microorganisms and heavy metal resistant plants are a possible solution that is economical and environment-friendly in overcoming soil pollution by heavy metals, one of which is through enrichment planting with Signal grass (*Brachiaria decumbens*). In the efforts to improve the environment, researchers in Indonesia have tested several grass species in their abilities as phytoremediation agents such as *Chrysopongon zizanoides* L., *Scirpus grossus*, *Brachiaria humidicola, Eleusine indica, Paspalum notatum, Setaria splendida*, and *Panicum maximum* Jacq. However, Signal grass' potential as a phytoremediation agent in post-coal mining soil contaminated with Pb has not yet been reported.

Therefore, this study tried to determine the phytoremediation ability of Signal grass planted on ex-coal mine soil after enrichment by *Claroideoglomus etunicatum* and *Bacillus subtilis*. Available information about plants as phytoremediation agents are deemed necessary to help restore the fertility and productivity of post-mining soil.

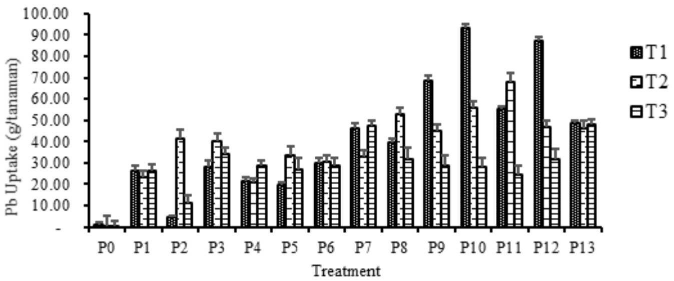

Figure 1. Comparison of Pb metal uptake in Signal Grass after 12 weeks of treatment from left to right: T1 = teak garden soil media, T2 = ex-mining soil media, T3 = ex-mining soil media, P0 = no treatment, P1 = 100% NPK, P2= 100% dolomite, P3= 50% NPK + 50% dolomite, P4= *C. etunicatum*, P5= *Bacillus* sp., P6 = *C. etunicatum + Bacillus subtilis*, P7= 50% NPK + *C. etunicatum*, P8 = NPK 50% + *Bacillus subtilis*, P9= NPK 50% + *C. etunicatum + Bacillus subtilis*, P10= Dolomite 50% + *C. etunicatum*, P11 = Dolomite 50% + *Bacillus subtilis*, P12= Dolomite 50% + *C. etunicatum + Bacillus subtilis*, P13 = 50% NPK + 50% dolomite + *C. etunicatum + Bacillus subtilis*.

Source: Dani Yudi Trisna SEAMEO BIOTROP

The soil sample is the post-mining soil in the form of revegetation soil (T2) and overburden (T3) obtained from Bukit Asam, coal mining company, while the land for comparison is teak garden soil (T1) which was taken from SEAMEO BIOTROP teak gardens. Signal Grass enriched with *C. etunicatum* and *Bacillus* sp. (P4, P5, P6, P7, P8, P9, P10, P11, P12, P13) showing phytoremediation abilities, had absorbed large amounts of Pb pollutant compared to control (P0) and unenriched Signal grasses (P1, P2, P3) without damaging plant growth. The highest Pb pollutant absorption value in Signal grass enriched with *C. etunicatum* and *Bacillus subtilis* reached 93 g/plant. Phytoremediation ability arises because *C. etunicatum* and *Bacillus subtilis* help in increasing the total dry biomass of the plant, thereby increasing the metal uptake ability of the plant (Figure 1).

Before being treated, the Signal grass did not show phytoremediation abilities, but after being enriched with C. etunicatum and Bacillus subtilis it manifested phytoremediation capacity. The plants absorb the metal Pb pollutant in large quantities (93 g/plant). As such, research becomes really useful in supporting activities that help protect, restore, and promote the sustainable use of the earth's ecosystem, that sustainably manage the forests, that combat desertification, that revoke land degradation rights and eventually, implement biodiversity conservation.

Future Research Innovation Connectivity

This information on post-mining land resource management technology, particularly using plant as potential agents of phytoremediation and microorganisms as bioremediation agents are needed to guide policy formulation, decision making and implementation. This relates to the mission of Indonesia and other countries to stop deforestation during the decade 2021-2030 particularly, the agreement on the climate-related Summit (COP26) in Glasgow [12]. In addition, the research were carried out to support the international agreement of the UN Global Goals or the Sustainable Development Goals (SDGs) # 15 "Mining and Life on Land" [13] where the research activities were aimed to help promote sustainable forests and other terrestrial ecosystems by addressing human-induced land degradation.

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