Utilization of Compost as ameliorant in a Nickel post mining soil

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Abstract. Southeast Sulawaesi is one of the nickel producing regions. Nickel mining activities in addition to positive impacts can also have negative impacts such as decrease of soil and increased accumulation of heavy metals in the soil. Therefore, couple solutions are needed to improve the quality of nickel mining soil, one of those is by providing soil amendments. The material that used in this research is compost. Compost fertilizer contains humic acid which has cation exchange ability so that it can be useful for remediating the nickel post-mining area. The research used a complete randomized design method by variating the ratio of compost to nickel post-mining soil. The method steps consisting of (1) Analysis of post-mining soil sample (2) Analysis of compost-mixed mining soil sample. The results showed that the best treatment was the 17% addition of compost to nickel post-mining sample which characterized by changes in soil characteristics, such as pH value 6.68 to 7.17 (neutral); C-organic content 2.01% to 3.69% (high); N-total 0.19% to 0.21% (moderate); P₂O₅ 21.77 mg/100g to 25.03 mg/100g (moderate); K₂O 15.13 to 17.77 (low); and nickel content of 1194.66 ppm to 988.86 ppm. Despite a decrease of nickel content in the soil, its level is still hazardous in term of human health.

1. Introduction
Mining activity owns both advantage and disadvantage. One of the disadvantage of mining process might be observed in nickel mining [1]. Once producing nickel ore, nickel mining activities also reduce a soil fertility quality by physically, biologically and chemically. In addition, this activities can also increase the accumulation of heavy metals in the soil [2].

The decrease of soil fertility is caused by excavation and removal of top soil during mining activities. The lost of top soil is the reduction of fertile part that contains abundant nutrients for plants. Removal of rock lead to the accumulation of waste that could be potential to cause erosion [3]. It is necessary to remediate the environmental conditions of the post mining land, so that the land can function and become more efficient in term of its purpose. One of breakthroughts that would be worthwhile according to that issue is reclamation activities [4]. Such effort which can be utilized to enhance a quality of post mining land is by treating it with compost.

Compost is afforded from organic waste, for example market organic waste, agricultural / plantation waste. Compost can increase the soil chemical content due to its macro nutrients content such as N, P, K, Ca, Mg and S along with its micro nutrients content such as Fe, Mn, B, Zn, Mo, and Cl [5]. [6], reveals that organic materials that have been broken down into compost contain fulvic acid, humic acid and humin. Reportedly, humic acid is able to react with trace metals by forming a bond to metals in the soil [7]. This is caused by the humic compound which has an aromatic carbon framework and a functional group containing oxygen atoms [8]. Humic acid functional groups containing oxygen atoms such as -OH and -COOH, which are the most reactive groups to associate with cations [9].
Compost can induce the mineral weathering process, protect the soil from damage caused by erosion and reduce the activity of harmful soil microorganisms especially in nickel mining areas. In addition, the mineral content in compost is able to exchange with metal ions in the soil [10]. According to [11] Compost can be used to lower the high concentrations of nickel due to the humus content of the compost.

Due to the importance of using compost in improving soil quality, a research was conducted concerning compost application on the former nickel mining soil. This research was objected to afford an optimal dose to improve soil quality.

2. Materials and methods

2.1. Sampling
Nickel mining soil sample (collected from sub-district Amonggedo, Konawe Regency, Southeast Sulawesi). Compost (afforded from fermented market organic waste with the addition of EM-4, Effective Microorganisms-4)

2.2. Analysis and Soil Analysis
Analysis of compost and post mining soil, including: determination of the acidity level (pH), moisture content, C-organic, N-total, P as P$_2$O$_5$, K as K$_2$O. For post mining land, the total nickel content is also determined.

2.3. Research design
The dosage of compost added to nickel mining soil media. The soil was added with compost with various concentrations of compost (0; 9; 13; 17%).

3. Results and discussion
The value of acidity of the nickel mining soil before adding compost is 6.68. The increase in pH value is affected by an intensive soil weathering process which increase the release of alkalis which also plays a role in increasing the pH of post mining land [12]. Meanwhile, compost has a pH value of 7.12. The result of mixing mining soil sample with compost reveals that the average pH value has been appropriate with the quality standards of the Soil Research Center [13], which is $> 6.6$ (Table 1). The result shows that the best treatment is the 17% addition of compost to the soil. The tendency of increase of the soil pH is caused by the organic matter have undergone the decomposition process, resulting in a ligand exchange reaction with organic anions, especially humic and fulvic acids with free –OH ions. This process lead to the increase of the number of OH ions in the soil solution [1]

C-organic in soil functions for plant growth [14]. The C-organic content in the post mining soil before adding the compost was 2.01%. According to the soil research center (2009) the level of C-organic content is inappropriate (C-organik ≥3). The low levels of soil organic matter in post nickel mining areas are associated with the fact that the soil has been mixed with over burden [15]. According to [16] the part of the land surface which has been r-covered by latest top soil generally has a less ideal chemical and physical properties. The highest C-organic soil content was afforded in addition of 17% compost to the former nickel mine, from the initial condition 2.01% to 3.68% (Table 1). Based on [17], the addition of organic fertilizers can enhance the soil C-organic content.

The nitrogen content of the post mining soil before addition of compost is 0.19%. According to the quality standard of Soil Research Center [13], the nitrogent content is inappropriate (standard ≥ 0.21). The low nitrogen concentration is due to the absence of vegetation so that the land is highly uncovered, which causes the nitrogen content in the soil is easily evaporate as N$_2$ into the atmosphere [18].The highest nitrogen content was recorded from the soil added by 9% compost, which was 0.224% (Table 1). According to the quality standard of Soil Research Center [13] the nitrogen content has been appropriate. The increase of nitrogen content is affected by the organic matter which have undergone a decomposition process [14].

The role of P in the soil serves to transport metabolic energy in plants and stimulate root growth and enlarge cell tissue [19]. P$_2$O$_5$ content on the post nickel mining before added by compost was about 21/77 mg/100 g (Table 1). According to the quality standard of Soil Research Center [13], the P$_2$O$_5$ content was appropriate (≥ 21). The availability of phosphate was presumed that it was affected by the
presence some of minerals such as apatite \((\text{CaF(PO}_4)_3)\) and vanadinite \((\text{Pb}_5\text{Cl(PO}_4)_3)\) found in nickel mining soil [20]. The highest value of phosphate content was recorded at the addition of 17% compost, which was about 33.57 mg / 100g (Table 1). The increase of phosphate value was presumed that induced by organic matter that has reacted with the soil hence Al substance in the soil solution became inactive. So that embedding phosphate can be reduced and the availability of phosphate in the soil increases [21].

The \(\text{K}_2\text{O}\) content in the former nickel mining soil was 15.13 mg / 100 g (Table 6). According to the quality standard of the Soil Research Center [13], the \(\text{K}_2\text{O}\) content is inapropriate \((≥21)\). The low availability of potassium is due to soil compaction caused by tools and low soil porosity [18]. According to [22] the low availability of potassium in the soil is also influenced by the amount of mineral reserves and the rate of weathering. The highest potassium content of sample in the addition of 17% compost was 17.77 mg / 100 g (Table 6). Based on the quality standards of the Soil Research Institute [13], the value is inapropriate yet. The low increase in the value of potassium was presumed to be affected by the organic substance in the post mining soil sample decomposed incompletely. This is associated with the slow decomposition reaction of organic matter. Therefore, the enhancement of available nutrient ions such as \(\text{K}^+\) produced from organic matter is reduced [17].

| Addition of ameliorant (compost) | Acidity (%) | Organic C (%) | N total (%) | \(\text{P}_2\text{O}_5\) (mg / 100g) | \(\text{K}_2\text{O}\) (mg / 100g) | Nickel (ppm) |
|-------------------------------|------------|---------------|----------|---------------------|----------------|------|
| 0%                            | 6.68       | 2.01          | 0.19     | 21.77               | 15.13          | 1194.66 |
| 9%                            | 7.10       | 2.29          | 0.224    | 22.74               | 15.74          | 1072.24 |
| 13%                           | 7.14       | 2.65          | 0.220    | 23.78               | 16.70          | 1044.12 |
| 17%                           | 7.17       | 3.69          | 0.21     | 25.03               | 17.77          | 988.86  |

The addition of 17% compost to post mining soil can reduce nickel content from the initial condition, 1194.66 ppm to 988.86 ppm (Table 7). When compared to the Soil Research Center [13], these levels are inapropriate to the standards\((≤20\) ppm). Nickel metal can be absorbed by compost component because in the soil organic matter can form a complex compounds with heavy metal cations and micro element cations.

4. Conclusion
Based on the research conducted, the following conclusions were obtained:
• Characteristics of the chemical properties of nickel mining: pH 6.68; C-organic 2.01%; N-total 0.19%; \(\text{P}_2\text{O}_5\) 21.77 mg / 100 g; \(\text{K}_2\text{O}\) 15.13 mg / 100 g and Nickel1194.66 ppm.
• The addition of compost was able to increase C-organic, N-total and \(\text{P}_2\text{O}_5\) content of nickel mining land, as well as reducing nickel content from 1194.66 ppm to 988.86 ppm.

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