Remediation of Remains Place Gold Mining Land Using Boiler Ash and Sludge from Palm Oil Liquid Waste Processing

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Abstract. The activity of placer gold mining has ruined the ecosystem by disturbing the upper soil layers, contaminating waterways, and leading to sedimentation downstream. This study is being carried out in order to improve soil quality in Tanoh Mirah Village, Sungai Mas Subdistrict, West Aceh Regency, Aceh Province, Indonesia. The main objective is to explore the impact of applying boiler ash and sludge from the palm oil liquid waste processing on enhancing the fertility of soil in areas previously used for mining activites. Infertile soil samples from the remains mining site were treated with a specific composition of boiler ash and sludge, placed in 5 kg plastic containers, and stored for 15 days. Subsequently, soil pH, accessible phosphorus (P), organic carbon (C), total nitrogen (N), and exchangeable potassium (K) analyses were performed. The research findings demonstrate that after the remediation treatment, soil quality improved significantly. The soil's organic carbon content increased from 0.42% to 2.92% after applying 1,500 grams of sludge. The total nitrogen level increased from 0.02%. to 0.2% after treated with 1,500 grams of sludge, and 500 grams of boiler ash. The phosphorus content of the soil increased up to 123.13 mg/kg from original condition of 1.3 mg/kg, when 1,500 grams of boiler ash were added. In summary, boiler ash and sludge remain from the palm oil industry's waste processing activities have the potential to be used for enhacing the quality of soil damaged by placer gold mining processes.

Keywords: Placer Gold, Upper Soil, Boiler Ash, sludge.

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1. Introduction

Mining Operations carried out by the community around river stream and in nearby residential areas have shifted the community's cultural traditions from agriculture to small-scale mining. The activities exhibit environmental, health, and social implications. Alluvial gold resources can be mined more easily with less expensive machinery. Alluvial gold mining, additionally referred to a placer gold mining, can ovvur on land, resulting in bare soil and ponds that harm the soil's structure and composition. Stating that mining operations can degrade surface water quality, distrupt aquatic ecosystems, and possibly lead to biodiversity loss. During the rainy season, the mining activity can accelerate river flow and cause flooding. Due to the removal of nutrient-rich upper soil layers, prior gold mining areas are nutrient-poor resulting in exceedingly poor soil fertility (Isnaniarti et.al, 2018; O and J, 2017).

Rehabiliting prior mining ares necessitates a process of improving soil quality known as remediation. Many studies have reported using organic compounds from sludge to treat palm oil liquid waste in order to repair affected land. Sludge treatment has been proven to improve Ultisol soil pH, organic carbon content (C), and accessible phosphorus (P). By appliying liquid waste improves soil pH, organic matter content, total nitrogen (N), accessible phosphorous (P), and exchangeable potassium (K) and magnesium (Mg). Sludge treatment can improve soil fertility (Pandapotan et. al, 2017).

Sludge produced by palm oil wastewater treatment process contains essential nutrients with the ability to improve soil. Several nutrients can be found are nitrogen, phosphorus and potassium (Awere et. al, 2020). Using sludge from palm oil to fertilize plants may provide a nutrient supply that is sufficiently absorbed for rice crop growth, The sludge's nitrogen molecule contributes to chlorophyll production and photosynthesis. The study has not yet used the utilization of boiler ash, which is high in inorganic nutrients (Ezward et. al, 2019). Besides sludge, boiler ash containing SiO_2, CaO, and K_2O can be used in soil remediation processes. The mineral concentration of boiler ash is affected by geological factors, fertilizers, soil chemistry and cultivation methods (Pachana et. al, 2021; Suparyanto and Rosad , 2020).

Via this study, the author blended sludge from a palm oil and boiler ash with barren soil sampes from placer gold mining activities to improve soil quality in Tanoh Mirah Village, Sungai Mas Subdistrict, West Aceh Regency, Aceh Province, Indonesia. The objective of this study was to investigate whether this material composition affected the pH, accessible phosphorus (P), organic carbon (C), total nitrogen (N), and exchangeable potassium (K) values in the soil. There have been no reports on the simultaneous use of sludge and boiler ash, to the best of our knowledge based on a review of the literature. Furthermore, this combination has not been applied to the soil media of former mining regions at the research site, notably in Tanoh Mirah Village, Sungai Mas Subdistrict, West Aceh Regency, Aceh Province, Indonesia.

2. Methodology

2.1 Materials

Soil samples from a former placer gold mining area in Tanoh Mirah Village, Sungai Mas Subdistrict, West Aceh Regency, Aceh Province were used extensively. Boiler ash and sludge were obtained from PT. Karya Tanah Subur's Palm Kernel Shell (PKS) plant at Padang Sikabu, Kaway XVI Subdistrict, West Aceh Regency.

2.2. Remediation Procedure

Soil samples were collected on-site from the former placer gold mining site using sampling equipment. 5 kg of soil was combined with boiler ash and sludge from the processing of liquid waste from a palm oil plant. Table 1 details the composition of each ingredient in each sample. All samples were then placed in plastic pots and placed inside a

greenhouse 2.5 × 3.5 meter. The structure of the greenhouse was composed of wooden templates, and the walls were covered with 200-micron UV plastic.

Table 1. Composition of additional remediation materials

Sample	Composition (gr)		
	Soil	Boiler ash	Sludge
A	5000	1,000	-
B	5000	-	1,000
C	5000	500	1,500
D	5000	1,000	1,000
E	5000	1,500	500

2.3. Analysis of Soil Nutrients Changes

Soil samples were analyzed after 15 days of storage in the greenhouse to determine changes in the physical and chemical properties of the soil. During the 15-day period of soil arrangement inside the greenhouse, the samples were watered with 1 liter of water every 3 days.

The pH of the soil was measured in situ with a DEMETRA PAT.193478 E.M. System Soil Tester (Japan). The Walkey and Black method were used to determine the organic carbon content. The total nitrogen concentration was determined using the Imana Method, which involved homogenizing 1 gram of the sample with 10 ml of 1 N $K_2Cr_2O_7$ and 20 ml of concentrated H_2SO_4. The mixture was subsequently diluted with 100 mL of distilled water and 5 mL of H_3PO_4. Titrated the sample with 1 N Fe_2SO_4 solution until the color turned to green. The Kjeldahl method was also used to determine the total nitrogen content. This included titrating 0.02 N HCl into a soil sample that had previously been treated with 20 cc of NaOH-$Na_2S_2O_3$ solution using a nitrogen catalyst.

The Bray II method was used to determine the phosphorus concentration. 2.5 grams of soil sample were combined with 25 mL of the Bray and Kurt I extractor in this procedure. The absorbance of the extract from the sample solution was then measured using a spectrophotometer at a wavelength of 693 nm. Cation exchange capacity (CEC) was also measured at pH 7.0 using the NH_4OAc buffer solution technique. This entails assessing the soil's ability to retain and exchange positively charged ions (cations), specifically ammonium ions, at a specified pH level.

3. Results and Discussion

3.1. The Effects of Boiler Ash and Sludge Composition on Soil pH

The pH of the soil influences soil biogeochemical processes and is regarded as a significant soil parameter that regulates the biological, chemical, and physical aspects of the soil, hence influencing plant growth. The pH levels vary from 4.1 to 4.4 under control settings (no remedial treatment). This is due to the lack of vegetation at the former open-pit mining site, where the mineral soil contains pyrite (FeS_2). Acid mine drainage is triggered by the contamination of the soil with oxygen, water, and microbes (Li. et.al, 2016). There is an increasing in pH in remediated soil samples, ranging from 4.8 to 5.3. Despite the pH of the soil is raised as a result of remediation, it remains acidic (Suparyanto and Rosad , 2020).

3.2. The Effects of Boiler Ash and Sludge Composition on Soil Organic Carbon Content

The remediation process increases the highest soil organic carbon content significantly (as shown in Fig. 1). The organic carbon content of the soil was 0.42% before remediation,

but it increased to 2.92% when 1,500 grams of sludge were applied. The sludge is a deposit that forms in the wastewater treatment plant's anaerobic pond and contains 5.52% organic carbon. Soil organic carbon is an important source of plant nutrition because it influences mineral solubility, CEC, and soil pH. Soil organic carbon acts as a proxy for organic matter when plant nutrients such as nitrogen, phosphorus, and sulfur are released. Because of decreased soil microbial activity, soils with minimal organic matter tend to lack plant nutrients (Mng'ong'o. et. al, 2021).

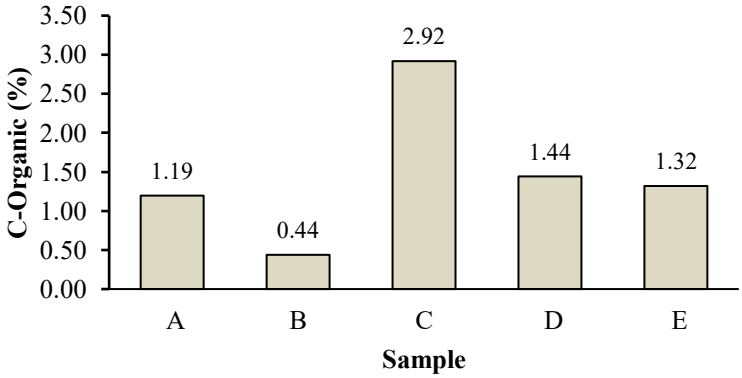

Figure 1. Profile of changes in soil organic carbon content

3.2. The Effects of Boiler Ash and Sludge Composition on total- N content of the soil

Nitrogen is essential for plant growth, and a lack of this element can lead to a decrease in agricultural output (Mng'ong'o. et. al, 2021). Before the restoration operation, the total nitrogen concentration of the soil was 0.02%. This value increased to 0.2% after treatment with 500 grams of boiler ash and 1,500 grams of sludge, respectively (Figure 2). The increase is related to the sludge's total nitrogen level of 0.18% (Pandapotan et. al, 2017).

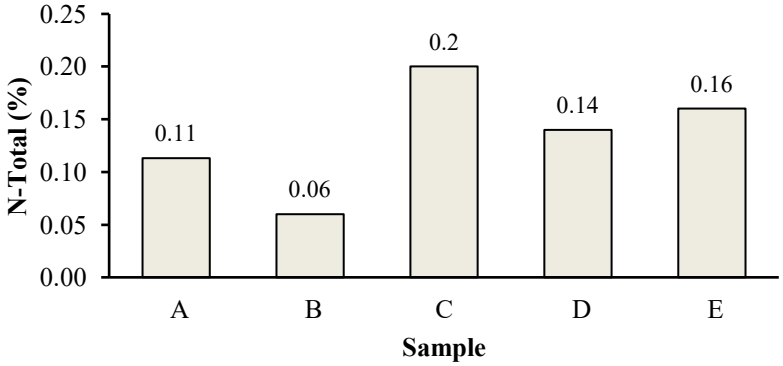

Figure 2. Nitrogen Concentration after remediation

3.3. The Effects of Boiler Ash and Sludge Composition on Phosphor content of the soil

Figure 3 depicts the variances in phosphorus content in soil for each varied sample condition. After remediation, the phosphorus concentration in treatment A, which included the addition of 1,500 grams of boiler ash, reached 123.13 mg/kg. Prior to remediation, the sample's phosphorus concentration was only 1.3 mg/kg. The addition of boiler ash to a soil sample can raise its phosphorus level. The increase in accessible phosphorus is proportional

to the increase in pH. The higher the pH value, the less metals are soluble in the soil, lowering phosphorus binding to soil metals. As a result of the high solubility of aluminum (Al), iron (Fe), and manganese (Mn), phosphorus is liberated and becomes accessible in the soil. Boiler ash has a K_2O content of 2.74% (Suparyanto and Rosadi , 2020).

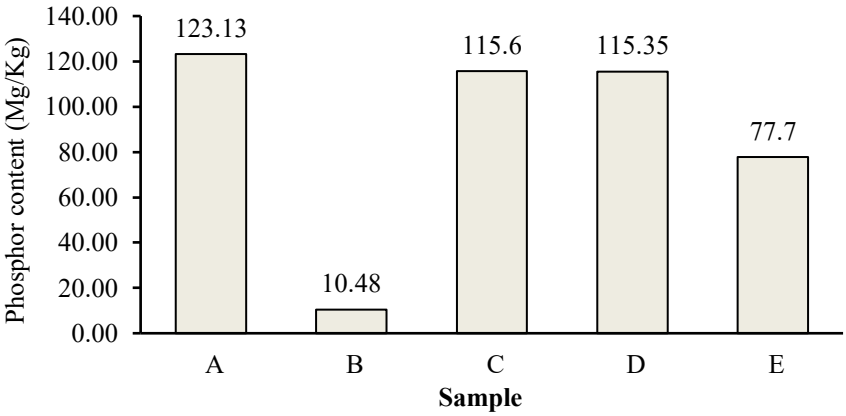

Figure 3. Phosphorus Concentration after remediation

3.4. The Effects of Boiler Ash and Sludge Composition on CEC of The Soil

The ability of soil to retain positively charged ions is an important soil characteristic that determines soil structure stability, nutrient availability, and soil pH. Organic matter can improve the soil's ability to absorb both cations and anions. Soils with a high organic matter content have a greater capacity for cation exchange, allowing them to bind more cations such as calcium (Ca) or potassium (K) (Najmuddin. et. al, 2018).

The CEC value before remediation of the soil sample in this study was 17.20 cmol/kg. This value increased to 25.2 cmol/kg after remediation with the addition of 1,500 grams of boiler ash and 500 grams of sludge (Figure 4). The application of boiler ash can enhance the soil's exchange capacity for potassium (K) (Suparyanto and Rosad, 2020).

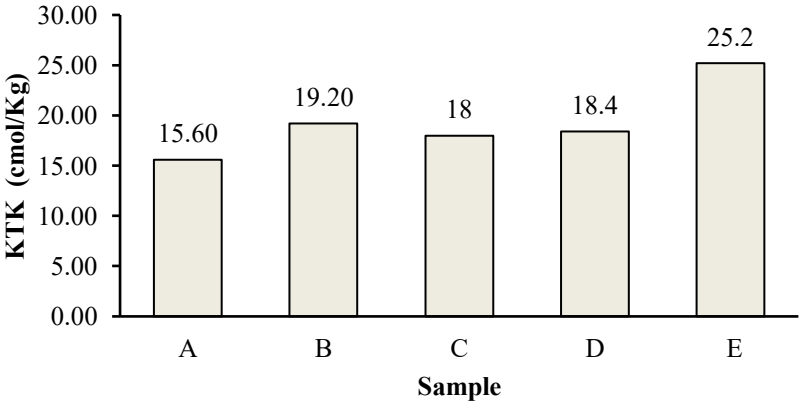

Figure 4. Cation Exchange Capacity after remediation

Conclusion

The soil on the village's traditional placer gold mining site has degraded, with nutrient values of 0.42% organic carbon (C-organic), 0.016% total nitrogen (N-total), 1.3 mg/kg phosphorus, and 17.2 soil CEC. Potential materials for remediating the damaged soil include boiler ash and sludge from the palm oil wastewater treatment plant. The optimum composition of boiler ash and sludge was added, and the soil nutritional conditions were successfully restored. After applying 1,500 grams of sludge, the soil's organic carbon content increased to 2.92%. Following treatment with 500 grams of boiler ash and 1,500 grams of sludge, the total nitrogen level increased to 0.2%. Similarly, the soil cation exchange capacity and phosphorus content rose. The phosphorus content of the soil increased to 123.13 mg/kg when 1,500 grams of boiler ash were added. Meanwhile, after remediation using 1,500 grams of boiler ash and 500 grams of sludge, the soil CEC reached 25.2 cmol/kg.

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