East Asian Journal of Multidisciplinary Research (EAJMR)
Vol. 4, No. 9, 2025: 4727 - 4736

Effect of Compost and NPK Fertilizer on Mercury (Hg) Absorption by Vetiver (*Vetiveria zizanioides* L.) on Gold *Tailings* Media in Seloto Village, Taliwang District, West Sumbawa Regency

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A R T I C L E I N F O

Keywords: Compost, NPK Fertilizer, Mercury, Vetiver, Gold Tailings

Received : 12, August
Revised : 20, September
Accepted: 25, September

A B S T R A C T

This study aims to determine the effect of compost and NPK fertilizer on the ability of vetiver grass (*Vetiveria zizanioides*) to absorb mercury (Hg) from gold tailings media. The research was conducted at the University of Mataram from May 21 to July 22, 2025, using a factorial group Random Design with two factors: the dose of compost (0, 57, and 113 grams) and the dose of NPK fertilizer (0, 1.1, and 1.9 grams). The results of the study showed that the lack of influence of NPK fertilizer on the absorption of mercury by vetiver grasses. This study shows that compost is effective, but NPK is not significant. This opens up questions about why NPK doesn't work, whether there are other factors inhibiting it, or whether there are other types of fertilizers that are more effective under similar conditions. This gap points to the need for further research to understand the interactions between chemical fertilizers and phytoremediation, particularly in the context of mercury uptake.

INTRODUCTION

Seloto Village in Taliwang District, West Sumbawa Regency has gold mining potential. Gold mines in general face serious environmental problems. Gold mine waste is called tailings. Tailings contain Mercury (Hg) and other highly toxic heavy metals (Legiarsi, Khairuddin, and Yamin 2022). Other characteristics of tailings are physically and chemically unsuitable for plant growth, high porosity, unstable soil structure, poor in nutrients and organic matter (Setyaningrum, 2022)

Results of chemical analysis of tailings samples conducted using INAA and TD-ICPMS methods. It shows that the mineral content in tailings is dominated by seven elements that are usually found in tailings in large quantities and concentrations. These elements are Hg, Au, Cu, Pb, Zn, As and Fe. Based on the results of the analysis, it is known that the Hg content in all samples is still high, which ranges from 78 – 828 ppm. The mercury in tailings does not come from mineral rocks, but is added in the process of gold amalgam. This high Hg content indicates that the tailings are very dangerous and must be managed before being released to landfills. The interesting thing is that the gold content in tailings is also still high and is still economical to be extracted again (Nazmi, 2011).

Efforts to reduce mercury levels and the success of rekalamation accumulated in the soil are one of them using indicator crops or cultivated crops that can function as phytoremedies. Some types of plants that can be used for phytoremediation include sunflowers (*Helianthus annuus* L.) and vetiver (*Vetiveria zizanioides*). Hg absorption by sunflower plants (Helianthus annuus L.). Cultivation of sunflowers and vetivers for 8 weeks with Hg absorption rates of 0.0005 mg/kg and 0.00999mg/kg significantly affected the Hg absorption capacity of the soil (Rifaldi, Isrun, and Khaliq 2022).

The success of land reclamation dominated by tailings can be increased through revegetation using vetiver plants (*Vetiveria zizanioides*). Tailings that are poor in nutrients make vetiver require a better growing medium, so the addition of compost and NPK fertilizer is needed. The combination of compost, NPK fertilizer and vetiver is effective for restoring tailings land. Compost improves the structure of tailings soil, increases aggregates and absorbs mercury. NPK fertilizer provides essential nutrients for vetivers to thrive in unproductive media. Vetiver phytostabilizes by binding mercury to its roots. to reduce the negative impact of tailings and restore land ecosystems.

Based on this background, this research aims to:

a. Analyze the effect of compost on the ability of vetiver grass to absorb mercury from gold tailings media.
b. Analyze the effect of NPK fertilizer on the efficiency of mercury absorption by vetiver grasses.
c. Analyze the interaction between compost and NPK fertilizer on mercury absorption by vetiver grasses.

THEORETICAL REVIEW

Compost and Fertilizer

Compost is the result of fermentation of organic materials such as pruning plant leaves, vegetables, fruits, organic waste, livestock manure and other materials (Agustrina et al., 2023). Compost can be used as a natural fertilizer and restorer of soil nutrients that may be lost during harvest and due to erosion (Aryantha, 2010) in (Agustrina et al., 2023). The results of applying compost as a stimulant to vetiver plants are able to improve the phytoremediation process (Triastuti, 2009).

NPK fertilizer is a fertilizer that provides essential nutrients that are needed for the growth of seedlings (Adinugraha 2012). Composting together with NPK fertilizer can increase the absorption of Nitrogen (N) by 3.52%, while the application of compost and NPK fertilizer independently can increase the available nitrogen, generative growth (plant height and number of saplings per clump) and plant yield (Kaya 2013).

Tailings and Mercury

Tailings are mining wastes including gold, silver, copper and other minerals (Herliana et al., 2020). Tailings from gold processing generally have a low pH and organic matter content and are poor in nutrients N, P and K, in addition to containing low pH, tailings also contain harmful mercury (Syofiani & Oktabriana, 2017; Widianti et al., 2024).

Mercury (Hg) is one of the most toxic elements among heavy metals and when exposed to high concentrations it will result in permanent brain and kidney damage (Yulis, 2018). Mercury is harmful when it enters food webs in the form of methyl mercury (Danasla et al., 2024).

Vetiver plant (Vetiveria zizanioides)

According to Dwityaningsih et al. (2019), vetiver can absorb heavy metals such as lead (Pb) and dadmium (Cd) inside plants. This ability is an effective solution to prevent heavy metal compounds from spreading and polluting the environment. This plant is suitable for reducing mercury (Hg) pollution. Vetiver plants (*V. zizanioides*) can be developed along mining areas as well as phytoremediation. Mercury (Hg) contained in soil is reduced (Bayani 2022).

METHODOLOGY

This research was carried out in the greenhouse of the Forestry Study Program, Faculty of Agriculture, University of Mataram, from May 21 to July 22, 2025. Soil samples (tailings) were taken from Seloto Village, Taliwang District, West Sumbawa Regency. This study used a factorial Group Random Design (RAK) with two factors: compost dose (K) with three levels (K1: 0 grams, K2: 57 grams and K3: 113 grams) and NPK fertilizer dose (N) with three levels (N1: 0 grams, N2: 1.1 grams and N3: 1.9 grams). The combination of these two factors resulted in 9 treatments that were repeated 3 times, making a total of 27 experimental units. Each experimental unit uses 1 kg of tailings soil in a polybag measuring 20x20 cm and planted with one vetiver seedling. Seedlings are

prepared by separating from the hump and taking one stem that has fresh and green leaves. Measurement of mercury (Hg) levels in soil and plant samples was carried out at the Soil Chemistry Laboratory, Faculty of Agriculture, University of Mataram, using an Atomic Absorption Spectrophotometry (AAS) tool with the F-732-S model. Mercury analysis is carried out twice, namely before planting and at the end of the harvest period. The parameters observed included the percentage of live plants, plant height, root length and mercury levels. The data obtained was analyzed using variance analysis (ANOVA) at a significance level of 5%, and if there was a significant difference, followed by Duncan's follow-up test.

RESULTS

The results of variance analysis (ANOVA) showed the effect of applying compost and NPK fertilizer on several observed parameters. The recapitulation of the results of the variance analysis can be seen in Table 1.

Table 1. Recapitulation of Variance Analysis Results

Parameters	Treatment		
	Compost	NPK	Compost x NPK
Percentage of Life	0.475tn	0.825tn	0.402tn
Plant Height	0.062tn	0,030*	0,045*
Root Length	0.621tn	0.180tn	0.061tn
Mercury	0,013*	0.933tn	-

The values listed in the table are significant numbers. The * sign indicates that the treatment has a significant effect on the 95% confidence level with a significance value (α) < 0.05, while tn indicates that the treatment has no significant effect on the 95% confidence level with a significance value (α) > 0.05.

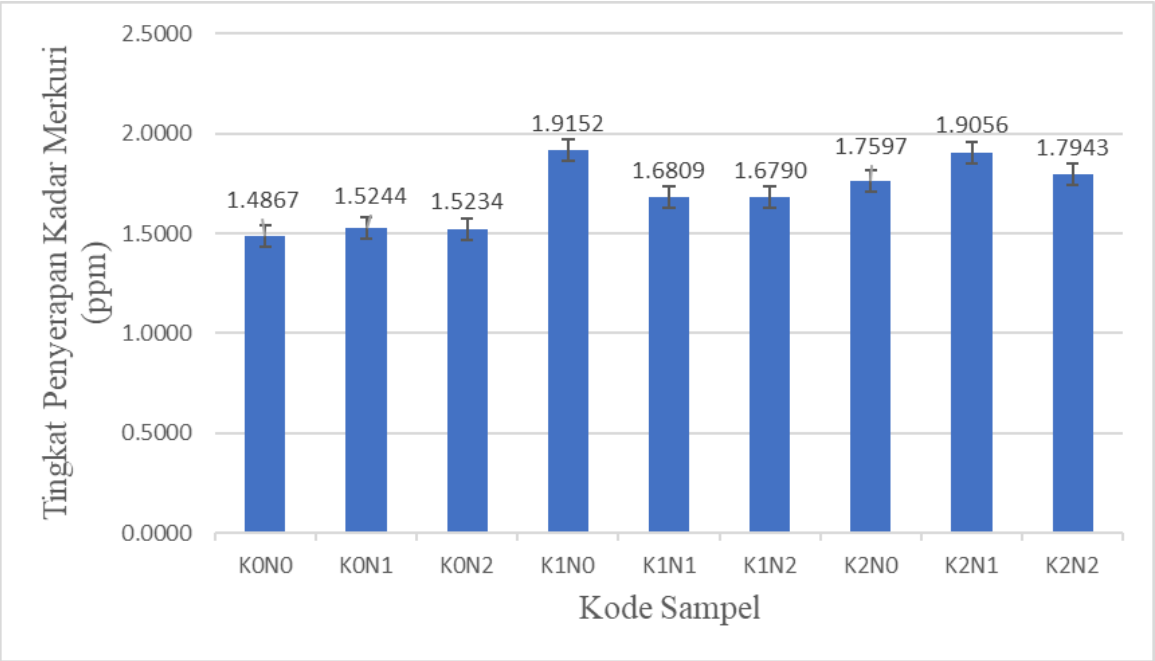

Figure 1. Graph of Absorption Rate of Mekuri (Hg)

DISCUSSION

Percentage of Living Plants

The application of compost and NPK fertilizer did not have a significant effect on the percentage of vetiver plant life. The significance values (Sig.) for compost (0.475), NPK (0.825) and its interactions (0.402) were all greater than 0.05, suggesting that there was no significant effect of the treatment. The variation seen in the percentage of live plants was influenced more by random factors (errors) in the experiment than by the dose treatment of the fertilizer applied. This can be explained by the very high natural resistance of vetiver to extreme environmental conditions. The plant is able to survive in dry, wet, sandy soils and even soils with high salinity, so the application of additional fertilizers is not the main determining factor for its survival (Alfi et al., 2024).

Plant Height (Vetiveria zizanioides)

ANOVA analysis showed that compost had no significant effect individually (Sig. = 0.062), This means that the variation in plant height has not been noticeable in the short term due to composting, while NPK fertilizer had a very significant effect on plant height (Sig. = 0.030), shows that the application of inorganic fertilizers has a direct and real effect on the vegetative growth of plants, especially plant height. The results of Duncan's further test showed that the NPK (N1) dose treatment of 1.1 grams was significantly different from the control treatment (N0) without fertilizer. However, N1 is not significantly different from the N2 treatment (1.9 grams). This indicates that a dose of 1.1 grams of NPK is optimal enough to increase the height of vetiver plants, and an increase in dosage of up to 1.9 grams does not provide a statistically significant difference in results. Based on the results of this study, NPK fertilizer plays an important role in increasing vetiver growth. This statement is in line with the theory put forward by

(Ayu et al., 2019) which states that the content of nitrogen, phosphorus, and potassium in fertilizers is the key to successful cultivation.

Interaction between compost and fertilizer NPK also showed a significant effect (Sig. = 0.045), proving the synergistic effect of the two fertilizers. The results of Duncan's further test showed that K0N1 (0gr Compost, 1.1gr NPK) was significantly different from K0N0 (0gr Compost, 0gr NPK) but not significantly different from K0N2 (0gr Compost, 1.9gr NPK), K1N0 (57gr Compost, 0gr NPK), K1N1 (57gr Compost, 1.1gr NPK), K1N2 (57gr Compost, 1.9gr NPK), K2N0 (113gr Compost, 0gr NPK), K2N1 (113gr Compost, 1.1gr NPK), K2N2 (113gr Compost, 1.9gr NPK). These results are in line with the theory Wasis and Nurulita, (2024) that the nitrogen, phosphorus and potassium content in NPK fertilizers is essential for vegetative growth. A short observation time (28 days) may not be enough for compost to have a real impact on vegetative growth.

Plant Root Length

Based on variance analysis (ANOVA), the use of compost, NPK fertilizer and the interaction of the two showed no significant effect on plant root length. The significance value for all treatments was greater than 0.05 (compost = 0.621, NPK = 0.180 and interaction = 0.061). This suggests that the treatment applied is not strong enough to significantly promote root growth. According to Laviendi & Ginting (2017) says that a combination of compost and fertilizer NPK did not show significant effects on various plant growth parameters, including root length. This condition occurs because the compost used is not fully mature and the application time is not enough.

Mercury (Hg) Analysis

The result of the analysis of mercury levels in tailings soil before treatment was 1.9847 ppm. The results of the analysis of the absorption rate of mercury levels by vetiver plants showed that the dose of compost had a significant influence on the absorption of mercury (Hg) by vetiver plants (Sig. = 0.013 < 0.05). Duncan's further test results showed that the K1 treatment (57 grams of compost) had a significant difference with the control treatment (K0), but did not show a significant difference with the K2 treatment (113 grams of compost). The dose of NPK fertilizer had no significant effect on mercury absorption (Sig. = 0.933 > 0.05). The use of compost in general increases the accumulation of mercury in plant tissues, with treatment of 57 grams of compost (K1) showing the highest rate of mercury absorption. Compost plays an important role in binding and inactivating mercury in the soil through its organic matter content (Mirdat, Patadungan, and Isrun 2013). On the other hand, without compost or with fertilizer NPK alone, the rate of mercury absorption tends to be low. These results are reinforced by other studies indicating that the absorption of mercury (Hg) in grass can be increased through the application of organic matter (Siahaan et al., 2014). In line with that (Putra, Syekhfani and Kusumarini 2018) also explains that the nutrients contained in compost not only promote plant growth, but also play an important role in accelerating how heavy metals are absorbed by plant tissues, but also play a role in increasing the speed of the process of absorption of heavy metals into plant tissues.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions for this study:

1. Composting had a significant effect on the absorption of mercury (Hg) by vetiver plants with the lowest absorption in the treatment without compost and NPK (K0N0) of 1.4867ppm and the highest in the treatment of 57 grams of compost and without NPK (K1N0) of 1.9152ppm.
2. NPK fertilizer has no effect on mercury absorption.
3. Compost, NPK fertilizer and intraction both have no effect on the plant's survival percentage and root length, but NPK fertilizer and intraction have a significant effect on plant height

Suggestions for Advanced Research:

1. Extend the observation period by more than 28 days to observe the long-term effects of the treatment.
2. Perform soil pH checking before seeding.
3. Conducting further research to determine the optimal dose of compost and NPK fertilizer that can maximize mercury absorption, because a dose of 57 grams of compost has had a real effect.

FURTHER STUDY

Practical recommendations for the community and the mining industry regarding the application of gold tailings phytoremediation:

1. Focus compost as the primary soil amendment. A dose of 57 grams per 1 kg of tailings soil (equivalent to K2 treatment) has been shown to be effective, instead of focusing on NPK fertilizers for mercury absorption purposes. NPK fertilizers can be used to promote vegetative growth of plants, such as plant height, but not for mercury absorption.
2. Plant vetiver grass (*V. zizanioides*) in areas contaminated with tailings. The plant has high resistance and is effective for phytoremediation. Vetiver is able to bind mercury to its roots, helping to reduce the negative impact of tailings and restore the land's ecosystem.
3. Strategic Combination: Although NPK does not directly affect Hg absorption, its interaction with compost can have a synergistic effect on plant growth. Adding NPKs can help increase plant height, which may indirectly support biomass and overall phytoremediation capabilities.
4. Tailings are particularly dangerous because they contain mercury (Hg) and other toxic heavy metals. Before being released to landfills, tailings must be well managed, and the application of phytoremediation using vetiver and compost is one way to do this.

ACKNOWLEDGMENT

The author would like to thank Mrs. Dr. Endah Wahyuningsih, S.Hut., MP. and Mr. Dr. Indriyatno, S.Hut., MP., as the supervisor who has provided direction and guidance during the preparation of this thesis.

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