Mercury Accumulation in Sweet Potato Plants: Effect of Gold Mine Tailing Contamination and Compost Amendment

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The effect of compost on mercury content in sweet potatoes grown on soil contaminated by mine tailings was investigated in this study. In a completely randomized factorial design with three repetitions, the sweet potato MZ119 clone was planted on soil with a mixture of tailings at a ratio of 0%, 30%, 50%, 70%, and 100% (w/w) and compost amendment (0 g/pot, 250 g/pot, 500 g/pot, and 750 g/pot). An increase in the tailing contamination ratio led to an increase in mercury accumulation in sweet potatoes. In contrast, an increase in compost dosage reduced mercury accumulation. Compost doses of 500 and 750 g/pot were most effective in reducing mercury accumulation in sweet potatoes. The mercury concentration in sweet potato tubers ranged from 0.153 to 0.802 mg/kg, which is above the threshold required for crops set by the WHO/FAO and other international standards. However, sweet potato plants exhibited a high mercury accumulation potential for mercury phytoremediation purposes, as they can accumulate mercury up to 18.15 mg/kg in their leaves.

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INTRODUCTION

Indonesia has many gold mining locations. Gold mining activities in Indonesia are generally carried out by mining companies (medium or large) or communities known as artisanal and small-scale gold mining (ASGM). Small-scale gold mining activities are generally carried out by communities using simple equipment in locations that are uneconomical for mining companies to exploit.

One of the ASGM areas in Indonesia is in Kertajaya Village, Simpenan District, Sukabumi Regency, Province of West Java. The processing of gold ore carried out at artisanal and small-scale gold mining in Kertajaya Village leaves behind waste called tailings. Tailings are waste resulting from the process of grinding mining rock (ore) to extract valuable minerals. Tailings contain heavy metals and have low fertility, physical, chemical, and biological properties (Susilowati *et al*. 2019). Tailing leftovers from gold ore processing in Kertajaya Village are generally thrown into rivers or gardens, collected in holding ponds, or stored in sacks.

Mercury amalgamation is a common method used by artisanal gold miners in Kertajaya Village, Sukabumi Regency, to extract gold ore deposits. The tailing waste generated by this process is typically dumped on farmland that is used to grow food crops such as sweet potatoes. The gold mine tailings still contain heavy metals, including mercury (Hg), cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn), which can accumulate in plants and harm human or animal consumption through the food chain. Even in low amounts, heavy metals, including arsenic (As), cadmium (Cd), lead (Pb), chromium (Cr), and mercury (Hg), are thought to be highly hazardous to unintended living things (Di *et al*. 2023).

Sweet potatoes are a widely consumed food crop that is a member of the Convolvulaceae family. Sweet potatoes, cassava, potatoes, yams, and aroids are all food roots, and tuber crops are key cultivated staple energy sources, second only to cereals, in tropical parts around the world (Chandrasekara and Josheph Kumar 2016). In various studies, plants of the Convolvulaceae family, such as sweet potato, are metal accumulators. According to Zhou *et al.* (2016), sweet potatoes absorb more metals (Pb, Cd, and As) from polluted soil than white radishes and carrots. Sweet potatoes with fibrous roots can adapt to areas with a lack of fertility and less soil porosity (Ngailo *et al.* 2016). This means that the plant is very suitable for use in ASGM areas with poor soil properties. The gold mine tailings have low acidity and poor physical and chemical properties. Sand materials usually dominate them, along with silty materials with low organic matter and low cation exchange capacity (Taberima *et al.* 2020). These properties are less supportive of plant growth, and high mercury levels are potentially accumulating in the edible parts of food crops.

Organic fertilizers such as compost have been shown to improve soil physical and chemical qualities, increase biological biodiversity, and lower metal bioavailability (Montiel-Rozas *et al.* 2015). Total N, available P, exchangeable K, Ca, Mg, accessible S, Zn, and B, and the amount of organic matter in the soil were all significantly boosted with the addition of cow dung (Zaman *et al.* 2017). It was found that the application of sewage sludge compost with higher nitrogen concentrations led to a reduction in the bioavailability of heavy metals relative to lower nitrogen levels (Yu *et al.* 2022).

Low-to-moderate application levels of well-matured compost with high humic content are expected to decrease mercury concentrations in sweet potato tubers by immobilizing mercury in stable organic complexes and by promoting plant growth that dilutes mercury in the harvested biomass. According to Caraballo-Laza *et al*. (2025), the mercury mass balance indicated a decrease in the total mercury content in the initial biomass over the composting. Adding composted organic matter to soil decreased the transfer of mercury into plant tissues compared to soil without compost, according to a controlled study using *Phaseolus vulgaris* (common bean). According to Restrepo-Sánchez *et al.* (2015), this suggests a barrier or immobilization effect on the availability of mercury to roots.

According to FAO/WHO and the National Agency for Drug and Food Control (Indonesian FDA), the permissible limit of mercury in vegetables is 0.03 mg/kg. Mercury, arsenic, lead, chromium, and cadmium have been the most prominent heavy metals that have caused human poisoning (Abd Elnabi *et al.* 2023). This study aimed to investigate the effect of gold-mined tailing contamination and compost on mercury accumulation in sweet potatoes.

EXPERIMENTAL

Sampling Location

Artisanal and small-scale gold mining in Kertajaya Village is located in Simpenan District, Sukabumi Regency, Province of West Java (Fig. 1). The area lies within the geographical coordinates of -7.101638 latitude and 106.573462 E longitude and has an average elevation of 750 m above sea level. The location experiences a tropical climate, receiving an annual rainfall of about 400 mm, with the wetter periods occurring from September to December. There is a mean minimum temperature of 17 °C and a mean maximum temperature of 32 °C. The concentration of mercury (Hg) in the Jampang gold mining area, Sukabumi, has been shown to be high, posing a serious environmental problem, particularly in the river, where significant Hg levels (up to 0.2180 mg/L) have been discovered, which can pollute both water and soil (Widodo 2008).

Fig. 1. Sampling location

The mineralization process and hydrothermal alteration process of this area are closely related to the formation of gold deposits. This process is closely related to the process of magmatism. In Indonesia, magmatism has occurred since the pre-tertiary period until now, with different periods of magmatism, and it has produced different hydrothermal deposits. One of the hydrothermal deposits that is often found in Indonesia is a low-sulfidation epithermal deposit.

Ore mineral deposits in epithermal deposits are related to the filling of hydrothermal solutions in the form of silica solutions, which fill the fractures produced by extensional structures. One of the epithermal deposits found in Indonesia is in the West Java area, which is located on the Sunda-Banda continental arc. This volcanic arc was formed in the Cenozoic age. The continental arc located in West Java produces two magmatism belts, namely an old magmatism belt of Eocene-Early Miocene age and a young magmatism belt of Miocene-Pliocene age, which produces Miocene Old Sunda

Banda Arc mineralization (Cijulang, Arinem, Cibaliung, and Ciemas mineralization) and the Younger Sunda Banda Arc mineralization of Pliocene Pleistocene age (Pongkor, Cirotan, and Cikidang mineralization).

Materials

Soil and tailing samples were collected from sites known to have substantial ASGM activities. Five spots were purposively selected, and soil samples were collected within a depth of 0 to 25 cm using a stainless-steel soil auger and trowel. The recovered tailings and topsoil were sieved through a 2-mm sieve following a seven-day air-drying period for chemical analyses. The analysis parameters carried out include mercury and water content, C-organic, total N, total P, and cation exchange capacity (CEC). The cow dung came from the Ciparanje experimental facility at Padjadjaran University in Indonesia. Orange-fleshed sweet potato MZ119 clones were utilized in this experiment. Maulana *et al.* (2020) reported that the MZ119 genotype of sweet potatoes was stable and produced a good yield.

Pot Experiment Design

The pot experiment was carried out in a greenhouse at Ciparanje experimental farm, Faculty of Agriculture, Padjadjaran University, Indonesia, using a completely randomized factorial design. The first factor was the gold tailing ratio, which has five levels (0% or no tailing, 30%, 50%, 70%, and 100% (w/w) tailing), and the second factor was compost doses, which have four rates (0 g/pot, 250 g/pot, 500 g/pot, or 750 g/pot) with one application at the beginning of the experiment. Each treatment combination was given three times. In each pot, 10 kg of gold mine tailings mixed with soil and compost were used to plant sweet potatoes, as displayed in Table 1. The planting media was watered often to keep its moisture level at 60% of its water field capacity. Six weeks following planting, all plants received a fertilizer (NPK) application at a rate of 5 g/pot. The plants were harvested 18 weeks after being sown.

Table 1. Treatment Combinations Used for the Study

Tailing, S	Compost, C (g/pot)			
(% w/w)	C_0 (0)	C_1 (250)	C_2 (500)	C_3 (750)
S_0 (100% soil)	S_0C_0	S_0C_1	S_0C_2	S_0C_3
S_1 (30% tailing)	S_1C_0	S_1C_1	S_1C_2	S_1C_3
S_2 (50% tailing)	S_2C_0	S_2C_1	S_2C_2	S_2C_3
S_3 (70 % tailing)	S_3C_0	S_3C_1	S_3C_2	S_3C_3
S_4 (100% tailing)	S_4C_0	S_4C_1	S_4C_2	S_4C_3

Mercury Accumulation in Plants

The total amount of mercury in the dry weight of harvested plants is used to calculate the concentrations of mercury. Concentration of mercury means the amount of mercury per unit dry weight of plant material. It is usually expressed as mg Hg per kg dry weight (mg kg^{-1} DW) or sometimes μg g^{-1} DW. All plants were divided into tuber, fibrous root, tendrils, and leaf, cleansed with water, and weighed (fresh and dry weights). The harvested plants were reduced in size and dried in the oven for 48 h at 80 °C using aluminum foil to prevent mercury from evaporating into the free air. Sweet potato shoot and root samples that had been dried out were first reduced to a powder using a mortar and pestle and a mixer grinder for metals analysis.

$$Hg\ concentration = \frac{total\ Hg\ in\ roots/shoots/tubers}{dry\ weight\ of\ that\ plant\ part} \quad (1)$$

Samples of tailings, soils, and plants (0.5 g) were digested with an HNO_3-$HClO_4$-HF (5:5:1) acid mixture and diluted up to 25 mL with deionized water (Shentu *et al.* 2008). The concentration of mercury was evaluated using a Cold Vapor Atomic Absorption Spectrometer (CV-AAS), Agilent Flame and Graphite Furnace Duo System. The mixed-acid digestion (HNO_3–$HClO_4$–HF) is regarded as a proficient technique for the analysis of tailings, soils, and plant tissues, as it significantly improves the nearly complete decomposition of both silicate and organic matrices, thereby facilitating a reliable total mercury quantification across heterogeneous samples. The determination of mercury employing cold vapor atomic absorption spectroscopy (CV-AAS) is a comprehensively validated, highly selective, and sensitive technique. The reliability of the data was reinforced through meticulous calibration verification, the use of reagent blanks, the application of certified reference materials, evaluations of spike recoveries, and the carrying out of replicate analyses, all contributing to satisfactory accuracy and precision.

The total concentration of mercury in plant tissue was divided by the total amount of the target metal in the soil to determine the bioconcentration factor (BCF) of heavy metals (HM) from soil to plant. The BCF > 1 indicates the hyperaccumulator plant of heavy metal absorption (Benavides *et al.* 2021). The capacity of the plants to accumulate and transport mercury can be determined using the translocation factor (TF) (Kabata-Pendias and Pendias 2001). The TF > 1 means the hyperaccumulator plants of heavy metal absorption (Liu *et al.* 2020). Both the BCF and TF formulas were calculated as follows:

$$BCF = \frac{HMs\ in\ the\ leaves\ (mg/kg)}{HMs\ in\ the\ soil\ \ (mg/kg)} \quad (2)$$

$$TF = \frac{HMs\ in\ the\ leaves\ (mg/kg)}{HMs\ in\ the\ roots\ \ (mg/kg)} \quad (3)$$

Statistical Analysis

The statistical analysis of variance (ANOVA) and computation of the mean and standard deviation of all the data were performed using SPSS 26.0. Duncan multiple range tests (DMRT) were used to determine whether there were significant changes in metal accumulation between plant parts. Data were square root transformed (x + 0.5) before ANOVA analysis.

RESULTS

Tailing, Soil, and Compost Characteristics

The characteristics of gold mine tailing, soil, and compost used in this study are presented in Table 2. The tailings were found to have an acidic pH of 3.65 with low C and N organic matter content of 0.87% and 0.09%, respectively. The concentration of mercury in the tailing was 46.70 mg/kg, which was quite high compared to the permissible level of 0.3 mg/kg in soil, and in sediments 0.2 mg/kg (FAO/WHO 2001).

The soil used was an Inceptisols soil (subgroup Fluvaquentic). The soil used has a clay loam texture with low soil fertility. The soil was acidic (pH 5.44), below the range of optimum pH for sweet potato growth (pH 6.7~7.2) (Ragonezi *et al.* 2022). Contents of C-organic (2.47%) and CEC (19.27%) were moderate, total N was low (0.18%), P-Olsen was very low (2.87 ppm), and high K-available 48.13 mg K_2O/100 g.

Table 2. Characteristics of Gold Mine Tailing, Soil, and Compost Used for the Study

Characteristics	Tailing	Soil	Compost
pH	3.65	5.44	7.5
C-organic %	0.87	2.47	30.45
N %	0.09	0.18	2.18
P_2O_5 ppm P	11.97	2.87	10.19
K_2O mg/100 g	17.19	48.13	0.91%
CEC Cmol(+)/kg	21.92	19.27	
Texture		Clay loam	
Mercury (mg/kg)	46.70		

The compost used in this research is a suitable organic amendment due to its alkaline pH (7.5), high organic matter content (30.4%), and noticeable levels of N, P, and K (2.18, 10.19, and 0.91%). When applied to growing media, it can enhance soil fertility, increase cation exchange capacity, buffer soil acidity, and potentially reduce the mobility and bioavailability of heavy metals.

Mercury Accumulation

Tuber

The research results showed that sweet potatoes planted at a tailings contamination ratio of 70% and 100% did not produce tubers. This study revealed the interaction effect between gold mine tailings and compost amendment on mercury accumulation in sweet potatoes (tuber). Gold accumulation in sweet potato tubers has a strong correlation with mercury accumulation. Duncan's test results on the effect of the tailings-soil ratio treatment and compost dose on the pH of the planting medium are presented in Table 3.

Table 3. Effect of Gold Tailing and Compost on Mercury Accumulation (Mg/Kg) in Sweet Potato Tuber

Tailing, S (% w/w)	Compost, C (g/pot)			
	C_0 (0)	C_1 (250)	C_2 (500)	C_3 (750)
s_0 (100% Soil)	0.23 aC	0.25 aB	0.22 aC	0.15 bB
s_1 (30% tailing)	0.44 bB	0.59 aA	0.57 aA	0.56 aA
s_2 (50% tailing)	0.80 aA	0.58 bA	0.44 cB	0.52 bcA
s_3 (70 % tailing)	nt	nt	nt	nt
s_4 (100% tailing)	nt	nt	nt	nt

Note: Numbers followed by the same letter are not significantly different based on the Duncan test, level 5%. Lowercase letters are vertical (column), and capital letters are horizontal (row)

The research results show that the tailings ratio treatment S_2 (50% tailings) combined with compost (C_0) produced an increase in the mercury accumulation that was not significantly different from S_1C_2 (30% soil+500 g/pot compost) and S_1C_3 (30% soil+750 g/pot compost).

Fibrous roots

No significant effects were found for the interaction between gold mine tailings and compost amendment on mercury accumulation in sweet potato fibrous roots. Duncan's test results show the independent influence of the ratio of tailings in soil and compost dosage on mercury concentration in fibrous roots, as presented in Table 4.

Table 4. Effect of Gold Tailing and Compost on Mercury Accumulation (mg/kg) in Sweet Potato Root (Fibrous)

Treatments	Hg Content (mg/kg Dry Weight)
Gold tailing, S (% w/w)	
s_0 (100% Soil)	0.68 c
s_1 (30% Tailing)	1.75 b
s_2 (50% tailing)	5.98 a
s_3 (70 % tailing)	6.66 a
s_4 (100% tailing)	5.68 a
Compost, C (g/pot)	
c0 (0)	5.57 a
c1 (250)	4.56 ab
c2 (500)	3.18 c
c3 (750)	3.29 bc

The independent levels of gold tailings addition S4 (100% tailings), S3 (70% tailings), and S2 (50% tailings) produced no significant differences in mercury concentration in fibrous roots. Meanwhile, a higher compost dosage resulted in a lower accumulation of mercury in the fibrous root part of the sweet potato. The compost dosage of 250 g/pot and without compost showed no significant difference in mercury accumulation in fibrous roots.

Tendrils

The study showed a significant interaction between gold mine tailings and compost amendment in their effect on mercury content in sweet potato tendrils (Table 5). There was no significant difference between 30% gold tailing combined with 0 g/pot or 250 g/pot cow dung amendment on the accumulation of mercury in tendrils.

Table 5. Effect of Gold Tailing and Compost on Mercury Accumulation (mg/kg) in Sweet Potato Tendrils

Tailing, S (% w/w)	Compost, C (g/pot)			
	C_0(0)	C_1(250)	C_2(500)	C_3(750)
s_0 (100% Soil)	0.01 bC	0.001 bD	0.10 aD	0.11 aC
s_1 (30% Tailing)	0.16 aC	0.17 aCD	0.15 aD	0.15 aC
s_2 (50% Tailing)	1.02 aB	1.09 aBC	1.28 aC	0.49 aC
s_3 (70 % Tailing)	0.78 cB	2.80 bcB	8.72 aA	5.98 bA
s_4(100% Tailing)	2.88 bA	5.67 aA	5.91 aB	2.90 bB

Note: Numbers followed by the same letter are not significantly different based on the test Duncan level 5%. Lowercase letters are vertical (column), and capital letters are horizontal (row)

Leaves

The study revealed a significant interaction between gold mine tailings and compost amendment on mercury content in sweet potato leaves (Table 6). A higher amount of gold tailing contamination resulted in a higher accumulation of mercury in the leaf part of the sweet potato. Data in Table 6 showed that sweet potatoes growing on 100% gold tailing combined with all doses of compost generated the highest mercury content in the leaf, which was 10.62 to 18.15 mg/kg dry weight, or increased 5 to 15 times that of the control (100% soil).

Table 6. Effect of Gold Mine Tailing and Compost on Mercury Accumulation (mg/kg) in Sweet Potato Leaves

Tailing, S (% w/w)	Compost, C (g/pot)			
	C_0(0)	C_1(250)	C_2(500)	C_3(750)
s_0 (100% Soil)	2.14 aC	1.77 abC	1.55 bC	0.99 bcD
s_1 (30% Tailing)	7.56 aAB	9.29 aAB	2.96 bC	2.96 bC
s_2 (50% Tailing)	10.88 aA	8.85 aAB	2.39 bC	9.55 aB
s_3 (70 % Tailing)	5.54 aB	5.49 aB	11.71 aB	9.07 aB
s_4 (100% Tailing)	10.62 aA	12.57 aA	18.15 aA	17.86 aA

Note: Numbers followed by the same letter are not significantly different based on the test Duncan level 5%. Lowercase letters are vertical (column), and capital letters are horizontal (row)

Bioconcentration factor and translocation factor

The sweet potato's bioconcentration factor (BCF) and translocation factor (TF) values on treatment growth media are described in Fig. 2. The BCF measures the accumulation of mercury in the sweet potato exposed to the tailings.

The investigation produced Hg BCF values that were more than 1 on treatment of S_4C_0 and S_4C_1. The results demonstrated that adding more compost to soil contaminated with gold tailings reduced the BCF values for mercury. The value of BCF declined as soil contamination by gold tailings increased. The study's findings showed that the TF value of Hg was greater than 1 in various treatments, except for S_1C_0, S_1C_1, and S_0C_0. It was supposed that compost affects Hg translocation to the shoot.

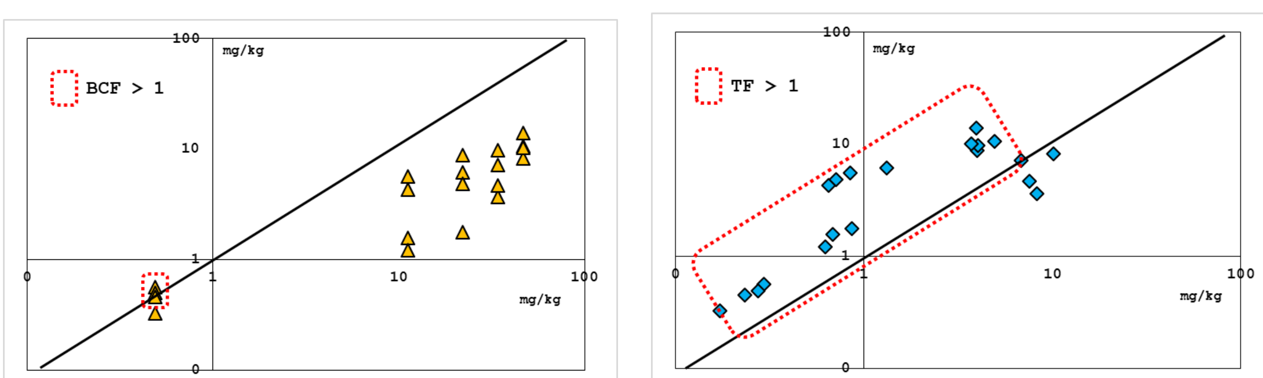

Fig. 2. BCF and TF of mercury in sweet potato

DISCUSSION

The findings of this study indicate that an increase in the ratio of soil contamination from gold mine tailings causes poor plant development and decreased dry biomass of sweet potatoes. Tailings from gold mining have a fine-grained structure, low cohesive capacity, high hydraulic conductivity, and weak aggregation (Vega *et al*. 2004). The low dry-weight biomass of sweet potatoes was caused by the gold mine tailings' low pH, high heavy metal content, and poor physical-chemical characteristics. Gold tailings and soils are acidic mainly due to oxidation of sulfide minerals (especially pyrite, FeS_2), which generate sulfuric acid**,** combined with leaching of basic cations (Ca, Mg, K, Na) under intense weathering and rainfall. In tailings this process is intensified by crushing, exposure to oxygen, and residual processing chemicals, leading to acid mine drainage conditions (Evangelou 1995; Lottermoser 2010; Weil and Brady 2017). Acidic soils commonly develop from parent materials poor in base-forming cations (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) and rich in silica and acidic minerals, such as quartz-rich sands, granitic and rhyolitic rocks, sandstone, shale, and strongly weathered volcanic ash, where prolonged weathering and leaching remove basic cations and leave acidic residues dominated by Al and Fe oxides (Schaetzl and Anderson 2005; Buol *et al.* 2011; Weil and Brady 2017).

Mercury contamination substantially compromises plants' uptake and utilization of nutrients, resulting in adverse physiological and biochemical alterations. The presence of mercury in both soil and atmospheric environments influences numerous metabolic pathways, culminating in diminished growth and modified nutrient profiles in vegetative organisms. Mercury exposure is associated with a reduction in photosynthetic rates, which manifests as chlorosis and a pale yellow hue in foliar structures (Chakraborty and Choudhury 2023). The accumulation of mercury predominantly transpires within the root system, with restricted translocation to aerial parts, thereby impacting the overall distribution of nutrients (Su *et al*. 2009). Plants cultivated in soils contaminated with mercury demonstrate diminished nutrient availability, which may intensify malnutrition among populations dependent on these agricultural products (Khan *et al*. 2015).

Mercury accumulation in sweet potatoes is influenced by gold mine tailing pollution of the soil and compost addition, either jointly or separately. The plants' mercury concentration was reduced as the compost amendment was increased. Heavy metals become strongly bonded to organic compounds when organic waste such as compost are applied, making heavy metals like mercury inaccessible to the plant (Kabata-Pendias and Pendias 2011).

Mercury phytoaccumulation can be significantly dependent on the species variation of plants and the site-specific effect of the environment (Falandysz *et al*. 2001). The highest concentrations of mercury are generally reported in the roots of plants (Zhong *et al*. 2018). However, Antoniadis *et al*. (2017) observed higher mercury concentrations in the leaves of lettuce compared to the roots.

According to Pelcová *et al*. (2021), root vegetables (carrot and beetroot) accumulate mercury mainly in the secondary roots (fibrous) rather than in the storage root and leaf. The same result was observed by Falandysz *et al*. (2001), who found higher mercury concentrations in leaf vegetables compared to root vegetables and fruit vegetables. Faster transpiration rates of leaf vegetables have been explained compared to non-leaf vegetables (Luo *et al*. 2011).

The pH of the soil is lowered by contamination from gold mine tailings. Chen *et al.* (2006) stated that pH affects the amount of metal that accumulates in plants. The amount of dissolved organic matter in the solution, pH, and metal loading on soil sorbents all affect the solubility of the metal (Weng *et al*. 2002). Plant type parameters, metal element properties, and soil qualities (pH, cation exchange capacity, clay content, and organic matter) all affect metal accumulation by plants (Tlustoš *et al*. 2011). Due to the organic amendment's potential to convert available forms of heavy metals into unavailable forms, such as carbonates, organic compounds, or metal oxides, it can reduce the bioavailability of heavy metals in soil (Wei *et al*. 2012). Metal solubility can be enhanced by root H^+ ion secretion, which acidifies the rhizosphere. According to Zayed *et al*. (1998), the bioconcentration factor describes how well a plant can absorb heavy metals based on the concentration of those metals in the surrounding medium. According to the TF value findings, the sweet potato's shoots had higher quantities of mercury than its roots. From a categorization perspective, TF > 1 shows that the plant translocates metals from the root to the shoots. Plants use the low mobility of metals from the root section to the shoot as a mechanism to counteract metal toxicity (Badr *et al*. 2012).

Compost generally increases or buffers soil pH, especially in acidic soils, because it contains basic cations (Ca^{2+}, Mg^{2+}, K^+, Na^+), carbonate and bicarbonate compounds, and functional groups (carboxyl and phenolic) that can neutralize H^+ and Al^{3+} ions in the soil solution. During decomposition, compost also promotes microbial activity that reduces aluminum toxicity and enhances cation exchange capacity (CEC), leading to a more stable and less acidic soil environment. However, the magnitude of pH change depends on the initial soil pH, compost pH, application rate, and degree of compost maturity (Whalen *et al*. 2000; Stevenson 1994; Haynes and Mokolobate 2001).

Based on the present results, phytoremediation using the sweet potato plant would rely on harvesting and removing the above-ground biomass (leaves and vines), which accumulated the highest mercury levels, while excluding tubers due to growth suppression and food safety concerns. The harvested biomass should be transported to a controlled, non-agricultural facility (a licensed hazardous-waste landfill or a controlled incineration or stabilization site) to prevent mercury re-entry into the environment or the food chain.

The results revealed that mercury concentrations in all sweet potato tuber (edible part) samples exceeded the permissible limits for food set by FAO/WHO (0.1 mg/kg) and the European Union (0.03 mg/kg), indicating a high potential exposure risk to humans. This is in accordance with previous studies by Mahmud *et al*. (2020) and Hindersah *et al*. (2018), who reported the elevated accumulation of mercury above international regulatory limits in vegetables and other plants growing in the vicinity of ASGM.

The utilization of compost in soils contaminated with mercury should be regarded simply as a strategy for environmental remediation aimed at improving the immobilization of mercury or the efficacy of phytoremediation, with the sweet potato plant identified as a viable candidate species for the extraction of mercury from tailings and polluted soils to mitigate environmental pollution in areas affected by artisanal small-scale gold mining (ASGM).

CONCLUSIONS

1. The research findings indicated a significant influence of gold mine tailing contamination and compost amendment on the accumulation of mercury (Hg) in various parts of sweet potato plants.

2. There was an interaction between gold mine tailings and compost on Hg accumulation in the sweet potato parts (tuber, tendrils, and leaf) except fibrous roots.
3. The application of compost was able to decrease Hg concentration in sweet potato (TF > 1).
4. The results of this study have highlighted differences in the absorption levels of mercury by different treatments of gold mine tailings and compost amendment doses. The order of accumulation of mercury in the sweet potato plant parts is leaf > tendrils > fibrous root > tuber.
5. Sweet potatoes can be used to remediate heavy metals in polluted soils through accumulation in the above-ground parts (leaves and vines). However, the tubers produced under such conditions are not suitable for human consumption.
6. This suggests that phytoremediation using the sweet potato plant would likely rely primarily on above-ground biomass (leaves and vines) rather than tubers, with the crop managed not for food production but as a leaf-harvest phytoextractor.

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