

## LITERATURE STUDY OF THE ABILITY OF FRAGRANT ROOTS (*Vetiveria zizanioides*) AND SUNFLOWERS (*Helianthus Annuus*) ON THE PHYTOREMEDIATION OF LEAD-TAINTED SOIL (Pb)

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| ARTICLE INFO                                                                    | ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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| <b>Received:</b> 03-02-2022                                                     | Lead pollution is a serious problem because of its wide distribution as a result of residential, agricultural, and industrial activities. Lead is a heavy metal that can cause various health problems due to its high toxicity. The high level of lead pollution needs to be overcome to reduce the impact of the risk of lead toxicity, one of which is phytoremediation. The ability of vetiver and sunflower in the phytoremediation process of lead has been reported by various literature. 40 kinds of literature were used as data sources. A literature review by making identification and classification based on the variables and parameters that will be reviewed from several articles that discuss the same topic using a synthetic matrix. Both plants have hyperaccumulator properties in absorbing heavy metals. The highest accumulation of Pb was in the roots up to 5500 mg kg <sup>-1</sup> , while sunflowers accumulated Pb up to 1450 mg kg <sup>-1</sup> . The accumulation of Pb was influenced by soil type, nutrient abundance, rhizobacteria, and chelating agents. The toxicity of highly contaminated metals did not significantly affect the growth of vetiver but only slightly decreased parameters. Sunflower response to stress caused by Pb varies depending on variety, soil type, metal type, dose, and duration of metal exposure. |
| <b>Accepted:</b> 13-02-2022                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Published:</b> 20-02-2022                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Keywords:</b> : Phytoremediasi, Heavy metal, V. zizanioides, H. annuus, Lead |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

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### INTRODUCTION

Soil pollution appears in the environment primarily as a result of anthropogenic activities. Direct disposal of industrial waste into the soil, accidental chemical spills, use of agricultural chemicals (pesticides) into the soil, percolation of contaminated surface water to subsurface layers, or improper disposal of waste are examples of causing soil pollution of various pollutants. (Mirsal, 2004). The greatest human concern about the toxicity or accumulation of heavy metals is directed at young children. A young child's body and central nervous system thrive and any exposure to Pb, even PB levels in the blood as low as 10 µg/dL (0.1 ppm), can cause long-term health problems in many organ systems and mental and physical disorders. (Succuro, 2010).

Extraction or immobilization by physical and chemical processes is not economically feasible to recover heavy metal contamination in large areas of land and is often recommended only for small areas requiring complete and rapid decontamination. (Martins, Liduino, Oliveira, & Sérvulo, 2014).

Other methods, such as soil washing, have detrimental effects on biological activity, soil structure, and fertility, and may require a significant budget for their implementation (Butcher, 2009).

Phytoremediation is an environmentally friendly, practical, economically viable, aesthetically beautiful, and highly acceptable technique. (Wuana & Okieimen, 2011). Phytoremediation is a developing technology that can potentially address the problem of contaminated agricultural soil or areas more polluted by urban or industrial activities. Three main strategies exist today to extract inorganic substances from the soil using plants (1) using natural hyperaccumulators; (2) increased uptake of elements of high biomass species with chemical additions to soil and plants; and (3) phytoovolatilization of the elements, which often involves changing chemical forms within plants before evaporation into the atmosphere (McGrath, Zhao, & Lombi, 2002).

Phytoremediation of Pb-contaminated soil includes two different strategies: phytostabilization and photo extraction. Phyto stabilization is the utilization of plants and soil fertilizers to reduce the intrinsic danger of Pb-polluted soil by reducing the availability of Pb biodiversity in the soil. (Cunningham, Berti, & Huang, 1995). Phyto extract is the use of plants to remove Pb from contaminated soil. Through the continuous planting of selected plant species in Nt-contaminated locations, the soil can eventually be decontaminated. Because planting and harvesting crops is a relatively inexpensive process compared to traditional engineering practices that rely on intensive manipulation of soil, Phytoextracts can provide an attractive alternative to cleaning nt-contaminated soil. (Huang, Chen, Berti, & Cunningham, 1997).

Fragrant roots and sunflowers can accumulate a wide variety of heavy metals. The accumulated heavy metals are transported to parts of the plant. The study aims to determine the ability to accumulate lead by fragrant roots and sunflowers in lead-polluted soils. Measures the effect of nutrient addition on the accumulated ability of fragrant roots and sunflowers. Determine the influence of environmental conditions on the accumulated ability of fragrant roots and sunflowers.

## METHODS

The research method is a reference in research so that it can be carried out by what has been planned. This literature study discusses the ability of vetiver zizanioides and *Helianthus annuus* plants that are affected by the addition of nutrients to reduce contaminants, variations in the concentration of lead metal waste in the soil using phytoremediation methods in various environmental conditions. The research framework is used in formulating research ideas, conducting supporting literature searches, literature studies, literature data processing, discussion of literature data, and conclusion withdrawal. Variables used in the literature study are plant type, lead concentration in soil, lead accumulation in plants, the addition of nutrients, and the influence of environmental conditions on the ability of accumulation of fragrant roots and sunflowers.

The parameters studied are the content of plant parts, plant morphology (height of plants and the number of leaves), the accumulation rate of lead, pH, temperature, humidity, and the presence of microorganisms supporting the process of phytoremediation. The literature study that will be conducted includes a review of 50 pieces of literature, including 10 case studies that occur in certain regions. Review articles by making identification and classification based on the elements to be reviewed from several articles that cover almost the same topic.

The data obtained is then integrated into the results of literary analysis based on the similarities and differences of each literature and make conclusions based on the similarities and differences of each literature in the form of collective conclusions from several kinds of the literature analyzed.

## RESULTS AND DISCUSSION

### A. Mekanisme Fitoremediasi oleh Tanaman

The most important aspect of the phytostabilization method is the transformation of excessive toxic compounds (mercury-containing compounds) into less toxic forms. However, the potential release of these hazardous and toxic materials into the atmosphere is a disadvantage. Contaminants can be removed from plants by transpiration or evaporation. As is well known, water

is brought from the roots to the leaves with the help of the vascular system. Therefore, contaminants are released into the air through evaporation or evaporation.

The process of taking a Pb from the soil by root is largely determined by plant factors, and different plant species have different properties in the absorption and distribution of Pb. Some are root accumulators, store Pb in roots, transport slightly to the top of the soil, and others shoot accumulators, store more Pb in shoots.

The mobilization of Pb metals into plants is influenced by plant transpiration factors. Transpiration is the evaporation of water on the surface of the mesophyll cells of corals in the leaves, followed by the loss of moisture through the stomata. If the transpiration rate increases, then the rate of water absorption by the roots also increases. Factors that affect the rate of transpiration also affect the absorption of water by plants. Transpiration rate is influenced by several factors, including:

1. Temperature: Faster evaporation and diffusion at higher temperatures.
2. Moisture: The diffusion of water vapor out of the leaves slows down if the leaves are already surrounded by moist air.
3. Wind speed: Moving air removes water vapor, increasing the rate of diffusion of water vapor from the leaves
1. Light intensity: Stomata open wider to allow more carbon dioxide into the leaves for photosynthesis.

Translocation factors indicate the ability of plants to translocate pollutants from the roots to the aerial parts of the plant; It is calculated as the ratio of the concentration of pollutants at the top of the plant to the concentration of pollutants at the roots. Bioconcentration factors (BCF) indicate the efficacy of plants to accumulate pollutants in their tissues. BCF is calculated as the ratio of the concentration of pollutants in plants to the concentration of pollutants in the soil. Calculations of bioconcentration factors (BCF) and translocation factors (TF) are performed to assess whether plants can be categorized as accumulators, as follows :

$$BCF = \frac{\text{Konsentrasi polutan pada tumbuhan}}{\text{Konsentrasi polutan pada media}}$$

$$TF = \frac{\text{Konsentrasi polutan pada bagian atas tumbuhan}}{\text{Konsentrasi polutan bagian akar}}$$

## B. Fragrant Root Ability in Lead Phytoremediation

Fragrant roots are tall (1–2 m) grasses, fast-growing, perennial, with long (3–4 m), massive, and complex root systems, that can penetrate deeper layers of soil (Pichai & Mudulodu, 2001) due to their unique morphological, physiological and ecological characteristics, such as their large and deep rooting system and its tolerance to a variety of adverse climatic and edaphic conditions.

Fragrant roots have been shown to tolerate high concentrations of various heavy metals with no effect on growth and development (Roongtanakiat & Chairaj, 2002). Previous studies have shown the ability of fragrant roots to accumulate up to  $19,800 \pm 2400$  and  $3350 \pm 66$  mg Pb kg<sup>-1</sup> of dry weight in root tissue and shoots, respectively; without symptoms of phytotoxic such as growth retardation and chlorosis, under hydroponic regulatory conditions. Fragrant roots meet the requirements of accumulator plants with advantages such as rapid growth, high biomass, extensive root system, ease of harvesting, and ability to accumulate high concentrations of Pb in harvestable parts.

Fragrant roots meet the specifications for a Pb accumulator given by (Shahid et al., 2012) based on the concentration of budding tissue. Phytoremediation is unlikely to be a viable technology unless the basic biochemical mechanisms that control Pb absorption and detoxification are well done by fragrant roots. The addition of substances such as EDTA and antioxidants can increase the uptake rate of fragrant roots against lead, so many studies use these substances in research to find out how much influence the substance has in the process of phytoremediation.

Literature shows the ability of fragrant roots in accumulating lead using plant abilities, additive addition, as well as a symbiosis with microorganisms (bacteria, algae, and fungi).

(Roongtanakiat & Chairroj, 2002) It is suggested that fragrant root technology could be used appropriately in former landfills to remove heavy metals and land reclamation. Research conducted by (Andra, Datta, Reddy, Saminathan, & Sarkar, 2011) revealed the complex formation between phytochelatin in fragrant roots, Pb, and Ethylenediaminetetraacetic acid (EDTA). The formation of this complex is hypothesized to produce lead tolerance in fragrant roots. Studies have also revealed that the chelant-bound lead form is less harmful and easily absorbed by plants. Danh et. Al. (2009) propose that even though fragrant roots are not as strong as some different species in substantial metal absorption, fragrance roots are highly resistant to soil conditions and harsh weather makes fragrant roots a viable option for planting in contaminated locations. All these unique attributes, make fragrant roots a suitable plant for phytoremediation purposes. For the reclamation of polluted soil, the top of the fragrant roots can be harvested periodically without replanting. The preferred point of view of fragrant roots is that it is not considered toxic waste after harvesting. Fragrant roots can be safely utilized for bioenergy generation, compost, or even as materials for craftwork (Roongtanakiat 2009). Rotkittikhun et. al. (2010) observed that Pb can increase the content of fragrant root oil. Planting fragrant roots in tin mining zones could be an ideal candidate for the reclamation of Pb. EDTA contaminated soil can induce Pb accumulation in fragrant roots.

For soil repair using fragrant roots, abiotic strangulation is the dominant factor affecting plant performance. Plants are always faced with abiotic stress, and they have developed strategies to deal with adverse conditions. The survival of plants depends on their ability to adjust growth, development, and physiology to escape (or reduce) stress.

The following is a graph of accumulated concentrations on fragrant roots based on the literature studied. :

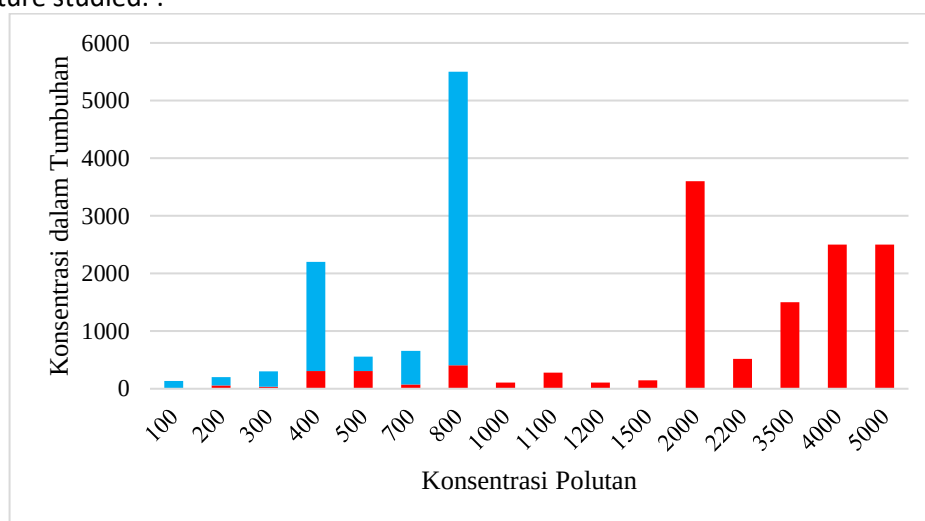


Figure 1. Graph of Concentration of Lead Accumulation by Fragrant Roots  
Accumulated concentrations of Pb at fragrant roots at various concentrations of pollutants have a value range between 5-5500 mg kg<sup>-1</sup>.

### C. Effect of Nutrients and Environmental Conditions on Fragrant Roots

Based on research by Kumar & Nikhil (2016) algae, manure and inorganic fertilizers have a real effect on the dry weight of shoots and roots as well as the number of stems. NPK fertilizer is more efficient than organic fertilizers in providing N, P, and K in the short term, while compost has the advantage of supplying other macro and micronutrients that are not contained in NPK fertilizer in the long term or slow-release to nature.

The application of N fertilizer significantly reduces the toxic effects of Pb and Zn on fragrant roots. Under a low supply of P and N, fragrant roots secrete a variety of organic acids in the roots more than *Typha latifolia* (Wu, et. al., 2012).

This suggests that fragrant roots are more efficient at dissolving nutrients with more root exudates during nutritional deficiencies. Nutrients are important for stress tolerance, and the supply of nutrients can also be increased by fungi and mycorrhizal-related bacteria.

Although the beneficial effects of microbial interaction with fragrant roots on phytoremediation have been widely reported, mechanisms for achieving benefits are rarely adequately illustrated. Based on Chen et.al. (2020), the role of microbes in influencing the performance of fragrant roots in soil remediation can be attributed to

1. Changes in the availability of nutrients and metals,
2. Increased tolerance of plant-stress left through physical and/or biochemical protection,
3. Encourage plant growth due to bacterial-induced hormones, and
4. Helps the absorption of plant nutrients.

Based on research conducted by Truong (1999), Yang et. al. (2003), Chiu et. al. (2006), Anning & Akoto (2018), Danh et. al. (2011), fragrant roots can live well on former mining land. This indicates good survival ability in environmental conditions with low nutrients and high levels of pollutants. Danh's research (2011) shows that in muddy soil conditions (alkaline soil conditions), Shu's research (2003) also shows the ability to survive good fragrant roots in acidic conditions in processing mine acid drainage.

Fragrant roots can tolerate extreme drought and wind conditions. Its rigid and upright stems can survive in deep streams of water. Fragrant roots are also resistant to fire, frost, traffic, and heavy grazing pressure, as new roots grow from underground crowns.

#### **D. Sunflower Ability in Lead Phytoremediation**

Sunflowers can clean up soil contaminated with Cd and Pb through different phytoremediation mechanisms. According to (Nasser et.al 2014) technologies for metal phytoremediation include:

1. Phyto stabilization: Paralyzes heavy metals in the rhizosphere, so that it does not dissolve or enter the plant shoots,
2. Phytoextracts: The use of plants to remove metals from the soil and to transport and concentrate them in above-ground biomass; then heavy metals are removed from the site when the plant is harvested, or
3. Phytoovolatilization: Uses plants to pick up contaminating heavy metals and translocate them into shoots, where they can be evaporated

Roots are the main pathway through which heavy metals gain access to sunflowers. The absorption of heavy metals by sunflowers varies with soil properties and sunflower cultivars. The concentration of heavy metals in soil solutions is the most important factor responsible for the absorption of heavy metals by plants.

It has been reported that sunflowers undergo hyperaccumulation of several heavy metals simultaneously in conditions of mixed metal contamination (Cutright et al., 2010). The time of exposure also greatly affects the absorption of metals by sunflowers. It has been reported that the accumulation of Pb and Zn in sunflower species (*Tithonia diversifolia* and *H. annuus*) peaked at 4 weeks after planting in contaminated soil of 400 mg kg<sup>-1</sup> Pb and Zn, compared to 6 and 8 weeks. The translocation factor, the ratio of the concentration of metals at shoots to those at the roots, is greater than 1 for both metals, which indicates the photo potency of this species of sunflower (Adesodun et al., 2010). Similarly, sunflowers absorb Cd, Pb, and Zn in buds for up to 8 weeks after planting, and then metal absorption decreases over time (Chae et al., 2014). In contrast, the concentration of Cd and Cu on sunflower shoots and roots increased significantly with increased duration of exposure (0, 3, 7, 10, and 16 days) to metal strangulation (Groppa et al., 2007). Overall,

the type of metal and the timing of exposure are the most important factors in the phytoremediation of contaminated soil using sunflower plants.

Although sunflowers have the potential as a Pb metal hyperaccumulator, there are some effects experienced by plants caused by exposure to Pb on the soil. The presence of Pb in the soil leads to a significant decrease in the concentration of chlorophyll in sunflower leaves. Excessive Pb decreases chlorophyll concentration, O<sub>2</sub> evaluation rate of photosynthesis, and photosystem II efficiency, although the photosynthesis system is not damaged (Kastori et al., 1998). The presence of metals affects the exudation of organic acids, which play a role in changing the pH of the rhizosphere and redox potential, and the response varies with the metal species and time.

Stomata resistance also increased significantly after lead application. The effects of Pb ions cause inhibition at the intensity of photosynthesis and photosystems. This inhibition is thought to result from a secondary/indirect effect of lead rather than a direct effect, i.e. distortion of the ultra-chloroplast structure due to lead's affinity for N and S protein ligands and inadequate concentrations of carbon dioxide in stomata closure. In a study conducted by Wińska-Krysiak et. (2015), inhibition of photosynthesis was observed only 24 hours after the treatment of Pb. No prolonged inhibition of photosynthesis may be associated with efficient stress defense mechanisms induced after the first period of exposure. However, this happens because the exposure period is too short or the dose applied is too low to cause permanent damage to metabolic processes in plants. Decreased transpiration leads to a reduction in the intensity of water absorption and limits the absorption of metal ions from the substrate, which is a stress avoidance mechanism.

Here is figure 2 in the form of a graph of the accumulation of metals Pb by sunflowers obtained from the literature that has been studied :

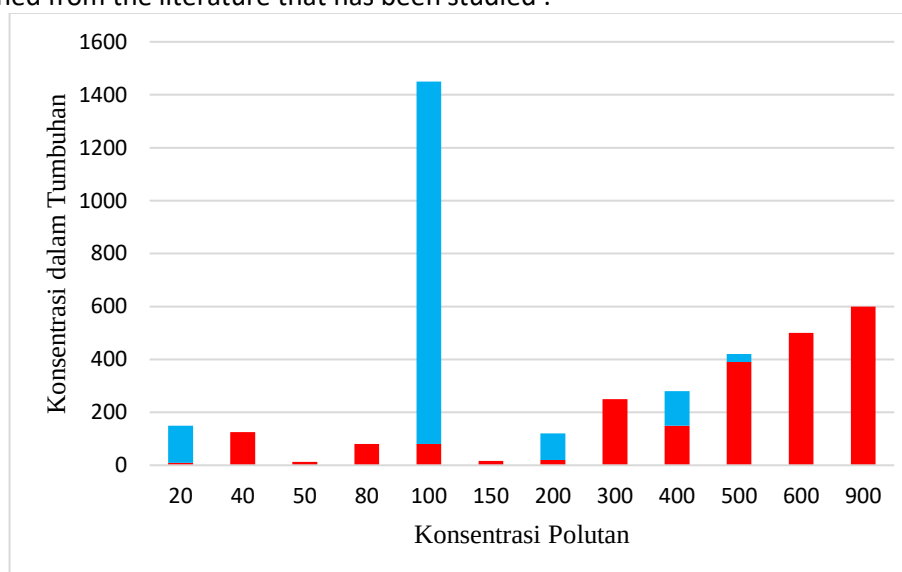


Figure 2. Graph of Concentration of Lead Accumulation by Sunflowers

The accumulation of Pb metal by sunflowers is in the range of 2.3-1450 mg kg<sup>-1</sup>. Differences in the range of Pb metal accumulation capabilities in both fragrant roots and sunflowers are caused by differences in the concentration of pollutants, nutrients in the soil, soil type, exposure time, plant age, absence of supporting microorganisms, and the addition of related substances.

#### E. Effect of Nutrients and Environmental Conditions on Sunflowers

Heavy metals can cause deficiency of essential mineral nutrients in plants due to impaired uptake by plants. However, some studies report a reversal in the toxicity of heavy metals in plants following optimal application of mineral nutrients (Pankovic et al., 2000; Rizwan et al., 2016; Zaccheo et al., 2006).  $\text{NH}_4\text{NO}_3$  applications in the field increase Cd extraction, while applications  $(\text{NH}_4)_2\text{SO}_4$  increase Zn and Pb uptake by tested sunflower cultivars (Nehnevajova et al., 2005). Inoculation with lead-tolerant rhizobacteria performed by Saleem et.al. (2018) increased the length of shoots too (15.27%) in comparison to plants that grew at the same level of mental stress

without inoculation. Research conducted by Saleem et.al (2018) also showed that inoculation with lead-tolerant bacteria increased the superoxide content of dismutase by 26%, glutathione reductase by 24%, and sunflower proline content in lead contamination. This illustrates that the special form of N plays an important role in reducing the toxicity of metals in sunflowers. The addition of soluble and insoluble Pb into the soil decreases the concentration of Pb on the part of the sunflower and increases the dry weight of the stems, leaves, and roots (Park et al., 2012). Case application increases sunflower growth and metal absorption.

EDTA application decreases plant growth while *G. mosseae* increases plant growth and absorption of Pb by sunflowers compared to EDTA treatment and control (Jarrah et al., 2014). Janmohammadi et. al. (2013), reported that inoculation with plant growth-driving rhizobacteria promotes ascorbatidid peroxide, catalase, superoxide dismutase, glutathione reductase, and protein content in plants in lead contamination compared to uninoculated plants grown in lead contamination because it increases the antioxidant activity of enzymes. Inoculation with lead-tolerant bacteria reduces the MDA content in plants which may be due to rhizobacteria stimulation effects on plant defense mechanisms.

#### **F. Effect of Kelat on Fragrant Roots and Sunflowers**

The success of phytoremediation can be enhanced by the application of chelating agents in growth media. EDTA can induce the accumulation of Pb in fragrant roots. Most of the increase in lead uptake after kelat treatment can be explained as the effect of increased solubility of Pb (Lai and Chen, 2004). It is well known that metal solubility and bioavailability can be improved with the application of synthetic related i.e. EDTA, HEDTA, NTA, and citric acid to the soil (Gupta, 2007). The effect of heat on metal absorption may also be related to different absorption mechanisms of the metal in question.

In the presence of EDTA, the formation of the metal-EDTA complex affects almost all of the steps mentioned above in the entry of metals into the roots of the plant. First, EDTA facilitates the diffusion of metals to plant roots by:

1. The desorption of the metal from the soil further increases its concentration in the soil solution; and with
2. Lowers the apparent diffusion coefficient of metals under the form of metal-EDTA (Degryse et al., 2006).

Second, because of the neutral charge, the metal-EDTA complex is not obstructed or bound by carboxyl groups or polysaccharides of rizoderm cell surfaces. In this way, EDTA causes the metal to enter directly into the roots of the plant (Shahid et al., 2012).

The application of EDTA dissolves large amounts of lead from the soil which then diffuses down its concentration gradient into the plant roots and can be absorbed by mass flow. The accumulation of lead in parts of the plant correlates with the formation of the Pb-EDTA complex and this complex is the main form of lead absorbed and translocated by the plant. Once absorbed by the roots, lead localization is greater in the roots than in other parts of the plant. Lead moves mainly into the root apoplast and thus radially crosses the cortex and accumulates near the endodermis. The endodermis acts as a partial barrier to lead movement between the roots and shoots. This may partly explain reports of higher lead accumulation in the roots compared to shoots on fragrant roots.

A large number of slating agents have been used to mobilize heavy metals in the soil and increase their absorption by metal-tolerant plants. Ethylenediaminetetraacetic acid (EDTA) has been widely used to increase metal solubility, complexation, and uptake by sunflowers. The addition of EDTA increases the concentration of toxic metals (Cd, Ni, Pb, Cu, Fe, and Zn) in sunflower roots grown in compost soil, but does not increase the concentration of such metals in mud-containing soils (Liphadzi and Kirkham, 2006). The addition of EDTA in mixed metal contamination conditions increases the uptake of Cd, Pb, and Ni by sunflowers and decreases the dry weight of plants compared to controls (Eissa et al., 2014).

Research by Jarrah et. al. (2014) showed that the treatment of AMF and EDTA led to an increase in the translocation of Pb from root to shoot and its accumulation in the air. Solhi et. Al. (2005) shows that the absorption of Pb by the root is done inactively, while capillary roots can absorb Pb and store it in the cell wall to some extent. The application of EDTA increases the concentration of Pb at the top of the sunflower but decreases total metal uptake at higher EDTA concentrations, possibly due to a decrease in the growth rate of the plant. In contrast, citric acid is inefficient in increasing the absorption of metals by plants which may be due to the rapid mineralization of citric acid and high soil buffering capacity (Lesage et al., 2005). Similarly, low doses (0.1 g kg<sup>-1</sup>) of EDTA are more effective in increasing the Phyto extracted metal by sunflowers than citric acid by the same dose.

The effect of EDTA on Phytoextracts varies with the availability of nutrient growth media and plant density. For example, Pb is more likely to be mobilized by EDTA at moderate nutrient levels than at low or high nutrient levels (Lin et al., 2009). Liphadzi et. Al. (2003) states that the high density of plants and the right dose of EDTA are the most important factors in facilitating the photo extraction of metals by sunflower plants.

Different additive combinations may be an effective strategy to reduce the toxic effects of heavy metals on sunflowers and increase metal extraction by plants. For example, the application of gibberellic acid and compressed sludge either single-handedly or in combination increases growth and biomass while lowering the concentration of heavy metals in different parts of the sunflower compared to controls.

#### G. Influence of Soil Type on Pb Accumulation by Plants

Soil type affects the ability to accumulate heavy metals by plants. According to (Nowack et. al., 2006; Saifullah et. al., 2010, Shahid et. al., 2013) soil type has organic content, soil texture, pH, carbonate, competing ions, groundwater holding capacity, biological and microbial conditions, soil redox potential, different soil buffering capacities. This causes plant development, the diversity of rhizobacteria, and the uptake of Pb metals by plants to vary.

Vo and Le's (2009) research shows that fragrant roots grown on soils with higher nutrients have a better ability to accumulate Pb metals than soils with lower nutrients such as clay.

Fragrant roots grown on former mining soil with the addition of nutrients (Yang et.al., 2003; Danh et. al., 2011) and sandy soil (Gravand et. al., 2020; Bahraminia et. Al. 2015) has a higher yield of metal accumulation in plants. The former mine soil has a high Pb metal content and extreme soil conditions, fragrant roots also have good life defense mechanisms such as exudate production that makes fragrant roots can tolerate Pb ions entering the plant so that Pb uptake increases. Sandy soil has a high level of porosity, this is supported by fragrant roots that have lush fiber roots that make the cruising power of fragrant roots in the soil wide. The linkage of these two supports the process of phytostabilization and phytoaccumulation of Pb metal by fragrant roots.

Types of soil that have a high sand content such as sandy soil (Nasser et. al., 2014), sandy clay (Saleem et. al., 2018), clay sand (Adedosun et. al., 2009), and muddy sand soil (Usman & Mohamed 2009) show high PB phytoaccumulation results in sunflowers. Arias et. al. (2014) with a mixture of peat soil, forest soil, silt, and perlite also produces an accumulation of Pb up to 1400 mg kg<sup>-1</sup>. This suggests that soil porosity affects the cruising power of roots in the soil which can increase the absorption area of Pb metal.

In certain soil types, plant recommendations that can be used for metal phytoremediation of Pb can be seen in table 1.

Table 1. Plant Recommendations on Certain Soil Types

| No. | Land Type                   | Plant Recommendations         |
|-----|-----------------------------|-------------------------------|
| 1.  | Clay                        | Fragrant roots                |
| 2.  | Former mining land          | Fragrant roots and sunflowers |
| 3.  | Former <i>landfill</i> land | Fragrant roots and sunflowers |
| 4.  | Chalky sand land            | Sunflower                     |



|    |                  |                               |
|----|------------------|-------------------------------|
| 5. | Plantation land  | Sunflower                     |
| 6. | Farmland         | Fragrant roots and sunflowers |
| 7. | Sedimentary soil | Fragrant roots and sunflowers |
| 8. | Industrial land  | Fragrant roots                |
| 9. | Peat soil        | Fragrant roots                |

#### H. Potential of Crops in Land Reclamation of Mines and Former Landfills

Mining fields and former landfills generally contain an assortment of heavy metals including Pb. Fragrant roots and sunflowers can accumulate a wide variety of heavy metals. This makes both plants have potential in the process of reclaiming mining land and landfill. The ability of both plants in accumulating heavy metals can be combined based on cruising power and root depth. Fragrant roots can penetrate the inner soil layer, while sunflowers accumulate heavy metals in layers near the surface of the soil.

The addition of nutrients such as compost, inorganic fertilizers, and mudslides can increase the mechanism of absorption of heavy metals by plants in former mines and landfills (Truong, 1999; Which et. al., 2003; Chiu et. al., 2006; Danh et. al., 2011). The addition of nutrients also affects the abundance of rhizobacteria microorganisms that support the growth and accumulation of Metals Pb. The addition of additives such as EDTA helps the remediation process in mobilizing and translocation of Pb in plants.

Initial treatment of mining and landfill lands such as soil smelting to increase soil porosity helps plant roots in covering larger and deeper land areas.

#### CONCLUSION

Based on the results of the research that has been discussed, the literature's conclusions show that fragrant roots and sunflowers are grown in soil contaminated with heavy metals have the potential to reduce contaminants through Phytoextracts. The accumulation of Pb metal at the fragrant root is mostly in the roots of the plant, while sunflowers are at the top of the plant. Nutrients are essential for both plants to accelerate growth rates, increase dry weight and stress tolerance. The application of nutrients significantly reduces the toxic effects of Pb on fragrant roots. Whereas in sunflowers, certain forms of nitrogen (NH<sub>3</sub>-, NH<sub>4</sub>NO<sub>3</sub>) play an important role in reducing the toxicity of Pb metals in sunflowers. Fragrant roots have a high survival ability in extreme edaphic environmental conditions making them an option that can be applied in a variety of environmental conditions. Sunflowers need supportive environmental conditions. AMF, the right lasting substances, and nutrient levels can increase the ability of sunflowers to accumulate Pb metal.

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