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# Phytoremediation of zinc polluted soil using sunflower *(Helianthus annuus* L.)

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## ABSTRACT

This study aimed at assessing the ability of sunflower to remediate zinc (Zn) impacted soils and the partitioning factors of Zn in soil-plants interactions. The research method used ex situ experiments using teddy bear sunflower seeds with 8 different treatments for each. This began with the preparation of the sample soil media on garden soil, and the seeding of sunflower seeds. This research was carried out for six months starting in August - December 2020, with *Helianthus annuus* plants with variations of the Zn. Various concentrations of Zn were applied, ranging from 50 ppm to 350 ppm. Laboratory analysis of Zn was carried out using the Atomic Absorption Spectrophotometry (AAS) method. The research results have revealed that roots have the ability to translocate more Zn than shoots, which suggests a phytoremediation mechanism. Sunflower plants are able to translocate Zn, which proves it reliable for phytoremediation of Zn-polluted soil.

**KEYWORDS:** Zinc, polluted soil, sunflower, phytoremediation

## INTRODUCTION

Environmental pollution is one of the big problems found in almost every region. In general, the biggest source of environmental pollution comes from industrial activity waste. Most industrial waste is liquid waste that enters and pollutes the ground through water. Generally, liquid waste contains dangerous chemicals that can threaten human health and damage the environment and the balance of the ecosystem in it.

Increasing the concentration of heavy metals in the environment can have serious effects on all forms of life. For human symptoms of heavy metal toxicity can include heart, liver, cancer, disorders and nervous system damage. For plants metal poisoning can cause root shortening, leaf loss, chlorosis, and nutritional deficiencies (Adji *et al*., 2008). Heavy metals that are generally contained in industrial waste include lead (Pb), mercury (Hg), cadmium (Cd), arsenicum (As) and chromium (Cr) (Prasasti *et al*., 2006). Heavy metal contamination in the environment needs to be handled properly to reduce its toxicity. The handling method requires high costs because it is difficult to separate the toxicity from the environment (Kurniawan *et al*., 2016). However, biological activity is believed to be an alternative method to detoxify polluted environments (Samudro and Mangkoedihardjo, 2020) as well as reduce heavy metal contamination (Dhokpande, 2013).

Phytoremediation uses various types of plants to remove, stabilize, or destroy contaminants and metals in soil and groundwater (Appenroth, 2010). Sunflower (*Helianthus annuus L*) has the ability to grow quickly and has the ability to produce very high biomass and is easy to harvest (Noviardi & Damanhuri, 2015). Sunflower is also a plant that has several benefits, including as an ingredient in making soap, wax, varnish, paint and lubricants and it is classified as a hyper accumulator plant that is tolerant of contaminants. And from several studies from several countries, sunflower has the ability to reduce heavy metals such as lead (Pb), nickel (Ni), Cadnium (Cd), and Zinc (Zn) well (Zalewska & Nogalska, 2014). The previous studies demonstrated that sunflower shows high tolerance to heavy metals (Pilon-Smits, 2005; Chirakkara & Reddy, 2015; Govarthanan *et al*., 2018). Therefore, this study aims at assessing the ability of sunflower to remediate zinc impacted soils and the partitioning factors of zinc in soil-plants interactions.

## METHODS

### General

The research method used ex situ experiments using teddy bear sunflower seeds with 8 different treatments for each. This began with the preparation of the sample soil media on garden soil, and the seeding of sunflower seeds. This research was carried out for six months starting in August - December 2020, with *Helianthus annuus* plants with variations of the heavy metal Zinc (Zn). Various concentrations were applied, ranging from 50 ppm to 350 ppm. Laboratory analysis of Zn was

carried out using the Atomic Absorption Spectrophotometry (AAS) method.

### Preparation

The soil sampling used in this study came from the planted soil without fertilizers taken from the flower market. Because the soil contains little water (alkaline), the soil is dried in the sun and then weighed to be put into the available plastic polybags, each about 3 kg for a 25cm polybag.

The pollutant used was Zinc Chloride (ZnCl2) powder, which was obtained from Giga Kimia Tangerang through online purchases.

Sunflower plant seeds obtained through online purchases are a local variety of teddy bears. The land used for planting the crops was previously dried and watered after being put in a small polybag for a nursery. In this process the sun seeds are soaked overnight. This is to help the sprouts grow faster. In addition, other materials needed in this manufacture are gloves and a small spoon.

### Experiments

Experimental tests were based on soil, obtained from the flower garden, which was tested for the initial presence of zinc, prior to planting sunflower and the addition of pollutants. Soil samples will be identified and carried out 4 treatments, namely one pre-treatment before the nursery is carried out to determine the availability of zinc concentration and to allow the presence of fertilizer content at the beginning of the garden soil, and 3 subsequent treatments which will only be analyzed for the presence of zinc content. Just do it at the stage after the nursery, namely when the plants are 4 weeks old, namely the fourth week, the eighth week and the twelfth week. The implementation stage of planting and observation were carried out in the backyard of university campus, i.e. ITS block D International Dormitory, Jl. Teknik Industri, Keputih Surabaya. The experimental conditions followed the directions for plant research (Mangkoedihardjo and Samudro, 2014).

## RESULTS AND DISCUSSION

### Garden Soil Characteristics

The analysis of the structure of the planting soil is loose soil with a dark brown color, and it can be felt that the soil has a soft structure and is easily destroyed and is not mixed with gravel or rocks. The results of the initial analysis for the presence of zinc metal is provided in Table 1.

The initial test on the planting soil showed that there was a difference in zinc metal at each sampling with a different zinc concentration. In this condition, the planted land has not been added with pollutants. The results of the analysis of heavy metal zinc in the planting soil, the largest range was 22.49 mg/kg.

### Soil Characteristics Test Before Treatment

The soil characteristics analyzed before the research treatment were carried out were the total concentration of zinc content in the planting soil (E0 - E6) and allowed the presence of other chemical and physical substances such as NPK fertilizer as shown in Table 2. This is the initial soil test as the basis for further treatment.

### Soil Polluted with Zinc

Zinc polluted soil was prepared by giving ZnCl2 solution with a concentration of 100 ppm and 200 ppm Zn (Zalewska & Nogalska, 2014). ZnCl2 solution was obtained from mixing ZnCl2 powder with aquadest. The ZnCl2 solution was then poured into each sampling except for the side of E0 where the E0 sampling function as a fixed value or control variable. The samples to be analyzed for the presence of the next 6 polybags of Zn with a concentration of Zn 50 ppm - Zn 350 ppm Table 3).

In the above treatment, it was known that the amount of Zn treatment content is different from the Zn concentration in the soil. The highest concentration of Zn levels was found in treatment E6, namely 363.01 ppm. Planting sunflower seeds is carried out in the late afternoon when the outside temperature begins to decline and is not too hot. Also do the watering so that the soil becomes a valley and makes it easier for the sun seeds to have room to grow quickly. watering is carried out two or three times a day morning and evening.

### Nursery for Sunflower Seeds

Planting sunflower seeds is carried out in the late afternoon when the outside temperature begins to decline and is not

Table 1: Zinc content in the test garden soil

| No | Code | Analysis results | |
|---|---|---|---|
| | | Content | Unit |
| 1. | E0 | 18.15±008 | mg/kg |
| 2. | E1 | 18.38±0.01 | mg/kg |
| 3. | E2 | 17.66±00.5 | mg/kg |
| 4. | E3 | 14.88±006 | mg/kg |
| 5 | E4 | 22.49±0.01 | mg/kg |
| 6. | E5 | 13.42+0.01 | mg/kg |
| 7. | E6 | 6.35±0.00 | mg/kg |

Table 2: Soil Characteristics Before Treatment

| Materials | Content | Unit |
|---|---|---|
| Clay (solid, tough and odorless) | 42.34 | % |
| Dust | 35.26 | % |
| Sand | 22.40 | % |
| Zn | 111.33 | Ppm |
| N | 1.31 | Ppm |
| P | 28.86 | Ppm |
| K | 5.27 | ppm |

Table 3: Soil polluted with zinc

| Treatment | E0 | E1 | E2 | E3 | E4 | E5 | E6 |
|---|---|---|---|---|---|---|---|
| Soil Zn (ppm) | 50.01 | 112.06 | 141.05 | 202.01 | 222.09 | 302.11 | 363.01 |

too hot. Also do the watering so that the soil becomes a valley and makes it easier for the sun seeds to have room to grow quickly. watering is carried out two or three times a day (morning and evening). And placed in an open room without the sun. In this state the seed that is sown grows and does not wither or dry out during the growing process, and still gets a little sun under the roof of the building. The seeds can be seen that the seeds grow quickly in 2 days (Figure 1). On the second day the shoots began to grow and the leaves were not clearly visible and on the 4th day there were also shoots and some leaves appeared.

### Soil Zinc Content After Treatment with Sunflower Plants

Testing the concentration of Zn in the soil in this study was carried out 3 times, namely at week 4, week 8 and week 12. The following is the effect of Zn concentration on the soil at week four and eight which are presented in Table 4, where at this treatment stage has a different concentration from the previous treatment, namely the time before planting the plants are acclimatized and developed for several weeks.

Table 4: Soil zinc content after treatment with plants

| Treatment code | Zn Concentration (ppm) In week 4 | Zn Concentration (ppm) In week 8 |
|---|---|---|
| E0 | 50.01 | 50.01 |
| E1 | 82.06 | 69.05 |
| E2 | 121.05 | 98.01 |
| E3 | 182.01 | 153.03 |
| E4 | 222.09 | 202.01 |
| E5 | 283.11 | 210.06 |
| E6 | 310.01 | 257.16 |

In this treatment, the concentration of zinc metal experienced a decrease in absorption capacity and increased differently due to soil contamination (50 ppm Zn to 350 ppm Zn). Overall, the sunflower treatment had a higher Zn concentration than the sunflower-free treatment.

### Partitioning Zinc of Soil-plants

To determine the accumulation of zinc metal in sunflowers, it was done by calculating the metal concentration in soil, roots and leaves. The ratio between the metal concentration in the roots/leaves and the concentration in the soil is known as the bioconcentration factor (BCF). BCF in leaves and roots was calculated to determine the concentration of metals in leaves and roots from the environment (MacFarlane *et al*., 2003; MacFarlane *et al*., 2007). In addition, the translocation factor (TF) is used to assess whether a plant can be categorized as an accumulator (Mellem, 2012). TF value was calculated to determine the transfer of metal accumulation from roots to shoots. The two partition factors are formulated as follows (MacFarlane *et al*., 2003):

$$BCF = [Zn](leaf + stem + root)/[Zn](soil)$$

$$TF = [Zn](leaf + stem)/[Zn](root)$$

The analysis of the amount of BCF and TF of zinc by sunflower plants is presented in Table 5.

From the analysis, it can be seen that the leaves and roots absorb more Zn than the stem, and the highest absorption rate occurred in the E6 treatment where the roots were 69.03 ppm

**Figure 1:** The process of growing sunflower plants

Table 5: BCF and TF of zinc by sunflower plants

| Treatment Partitioning factors | E1 | E2 | E3 | E4 | E5 | E6 |
|---|---|---|---|---|---|---|
| BCF | 4.23 | 3 | 5.04 | 3.89 | 3.32 | 3.33 |
| TF | 1.91 | 1.31 | 0.95 | 0.92 | 0.9 | 0.95 |

and leaves 33.45 ppm. And the lowest absorption occurred in the E1 treatment with 16.33 ppm roots and 12.14 ppm leaves. In the analysis results, there are different results in each observed case. According to Shanker *et al*. (2005) heavy metals are mostly absorbed in the roots of the leaves and stems. The amount of Zn absorption in plants is also caused because the roots have a system of stopping metal transport to the leaves.

## CONCLUSION

Roots have the ability to translocate more heavy metals than shoots, with the presence of zinc accumulation in the roots and stems and leaves, indicating a phytoremediation mechanism. In accordance with the analysis of this research, it can be concluded that sunflower is able to translocate zinc metal. Thus, sunflower plants proved to be reliable for phytoremediation of zinc-polluted soil.

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