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# Phytoremediation Ability of Ornamental Plants *Celosia argantea* L. and *Mirabilis jalappa* L. in Plumbum (Pb) Contaminated Soil

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**Abstract**

Plumbum or lead is a type of heavy metal that is dangerous if it has exceeded the threshold of 0.07 µg/g based on the National Standardization Agency SNI 2004. This type of heavy metal is found in nature such as in soil, water, and air. The purpose of the study was to determine the phytoremediation ability of two types of ornamental plants, namely *Celosia argentea* L. and *Mirabilis jalappa* L., against Plumbum (Pb) metal in soil. The growth parameters observed consisted of plant height, plant stem diameter, number of leaves, leaf length, and leaf width. The ICP-MS (Inductively coupled plasma-mass spectrometry) was used to analyze the plumbum (Pb) content in soil and plants. The results ofinitial soil analysis prior to the plant planting process (phytoremediation) were 103.17 µg/g which had exceeded the predetermined threshold. The result of the analysis after phytoremediation of *Celosia argentea* L. showed plumbum (Pb) content of 49.685 µg/g in soil and 1,9548 µg/g in plants. Similarly, the analysis of Ph content after phytoremediation of Mirabilis jalappa L. was 47.802 µg/g in soil and 5.3077 µg/g in plants. Based on biomass calculation of *Celosia argentea* L. and *Mirabilis jalappa* L., the obtained Plumbum (Pb) content was 18.84% and 27.85%, respectively. The percentage of Pb removal of *Celosia argentea* L. was 51.842%, while *Mirabilis jalappa* L. was 53.667%. The efficiency of Pb absorption of *Celosia argentea* L. and *Mirabilis jalappa* L. was 1.895% and 5.145%, respectively. In conclusion, Ornamental plants *Celosia argentea* L., and *Mirabilis jalappa* L., are able to act as phytoremediation agents for Plumbum (Pb) metal that pollutes the soil as evidenced by the decrease in Pb levels in the soil after the phytoremediation process.

**Keywords**: Plumbum (Pb), Phytoremediation, *Celosia argentea* L., *Mirabilis jalappa* L.

## INTRODUCTION

Heavy metals are elements that are difficult to degrade. Hence, waste containing heavy metals discharged directly into the environment will cause accumulation in soil and water. Some examples of heavy metals that usually pollute the environment are Plumbum (Pb), Hydrargyrum (Hg), Cuprum (Cu), Cadmium (Cd), Arsenic (Ar), Chromium (Cr), Nickel (Ni), and Ferrum (Fe) (Putra & Mairizki, 2020). Heavy metals usually cause special effects on living things which include humans, animals, and plants. All heavy metals can be toxic and can poison the body of living things, but some of these metals are still needed by living things in small amounts, if these needs are not met, it can be fatal to the survival of every living thing (Irhamni *et al*., 2017).

Plumbum (Pb), which in Indonesian is known as black tin or lead, is one of the non-essential and toxic heavy metals that is very dangerous because it can cause poisoning and death if it exceeds the threshold. The accumulation of lead in the body can cause fatigue, anaemia, as well as compromising the function of kidney, nervous system, circulatory system, and reducing reproductive quality (Sofyan *et al*., 2020). The toxicity of this metal is very high at the acute and chronic levels. However, acute toxicity of this metal is rarely found in the wider community, but along with increased exposure to lead in the environment it is very likely to occur (Handriyani *et al*., 2020). If lead metal enters the food chain, it can cause biological magnification. Based on the National Standardisation Agency SNI 2004, the threshold value for sediment/soil is 0.07 μg/g.

Environmental pollution by heavy metals is a very important problem to solve because it can endanger the survival of living things. One of the alternatives that can be done in reducing the content of lead metal (Pb) in the environment is through the process of phytoremediation, which utilises plants as absorbent, trapping and accumulating agents of heavy metals. However, the success of phytoremediation is determined by several things including plant species, climate, and waste conditions. According to Borolla *et al* (2019), all plants have the ability to absorb metals in varying amounts. Thus, not all plants can be categorised as hyperaccumulator plants. Plants that can be categorised as hyperaccumulator are plants that meet certain requirements, i.e. being able to produce high biomass in a short period of time, easy to cultivate, easy to harvest, and can live in extreme areas.

The use of ornamental plant *Celosia argentea* L. and *Mirabilis jalappa* L. in the study is because both types of plants are hyperaccumulator plants. The soil sampling was carried out at Tamangapa Antang Makassar Landfill because the landfill accumulated heavy metals from inorganic waste. The purpose of this study is to determine the phytoremediation ability of two types of ornamental plants, namely *Celosia argentea* L. and *Mirabilis jalappa* L. against Plumbum (Pb) metal in soil.

## RESEARCH METHODS

This study was conducted to determine the ability of ornamental plants *Celosia argantea* L. and *Mirabilis jalappa* L. to absorb plumbum (Pb) metal in soil. The tool used to measure Pb metal content in soil and plants is ICP-MS (Inductively Coepled Plasma-Mass Spetrometry) which can detect elements at pg/ml concentration levels. The materials used include seeds of ornamental plants of *Celosia argantea* L. and *Mirabilis jalappa* L., various chemicals including HNO3, HClO4, distilled water, and soil from Tamangapa Antang Makassar landfill (Juhriah and Alam, 2016).

Soil Pb metal content was analysed before and after the study. The soil was taken from the Tamangapa Antang Makassar landfill, cleaned from rocks and other impurities, then homogenised and sampled for analysis using ICP-MS. Seedlings of *Celosia argantea* L. and *Mirabilis jalappa* L. that had been sown previously and were 4 weeks old were selected for similar phenotypic appearance (roots, stems and leaves). Soil that had been analysed for Pb content was put into 5 kg planterbags and used to plant each ornamental plant, which in each planterbag consisted of 3 plants with 3 repetitions. Maintenance and observation of plant growth were carried out for 12 weeks. The parameters observed consisted of plant height, plant stem diameter, number of leaves, length, width of plant leaves and calculation of plant biomass, Pb removal, and Pb absorption efficiency. The analysis of Pb content in ornamental *Celosia argantea* L. and *Mirabilis jalappa* L. was measured at the end of the study with the steps, namely the plants were uprooted and washed thoroughly using water to remove dirt, dried for 30 minutes, then cut into small pieces and the preparation process was carried out to produce a sample in the form of a solution and then analysed using ICP-MS. Soil that has been used to grow plants is also analysed using ICP-MS by means of filter results connected to a hose that connects to the ICP-MS tool, after which the Plumbum (Pb) metal reading is conducted.

The Pb metal data of soil and plant samples read by ICP-MS were entered into a formula with a blank value for Pb metal of 0.041 µg/mL to obtain the conversion value of Pb metal content in soil and plant samples. The formula is as follows:

$$\sum \text{result} = \frac{\frac{\sum \text{Tool result} - \sum \text{blanko } (\mu g/mL)}{1000} \text{ x Final volume of sample (mL)}}{\text{gram sample}}$$

The following are the calculation formulas for plant biomass, Pb removal, and Pb metal absorption efficiency:

a. $\text{Biomass } (\%) = \frac{\text{Dry weight(gr)}}{\text{Wet weight(gr)}} \text{ x } 100$

b. $\text{Pb removal } (\%) = \frac{\text{Final metal content } (\mu g/g)}{\text{Initial metal content } (\mu g/g)} \text{ x } 100$

c. $\text{Absorption efficiancy } (\%) = \frac{\text{Plant metal } (\mu g/g)}{\text{Initial metal soil} (\mu g/g)} \text{ x } 100$

## RESULTS AND DISCUSSION

Phytoremediation plants that have been planted are treated and observed for 12 weeks. The plants were placed in an open space exposed to sunlight. In the 12th week, the plants were uprooted, then the soil and plants were analysed using ICP-MS. The use of ornamental plant of *Celosia argantea* L. and *Mirabilis jalappa* L. as phytoremediation agents can reduce the levels of Pb metal that pollute the soil. Plant growth observations made every 7 days for 12 weeks for each parameter consisting of plant height, plant stem diameter, number of leaves, leaf length, and plant leaf width are presented in Table 1.

**Table. 1** Growth Parameters of *Celosia argantea* L. and *Mirabilis jalappa* L. in Tamangapa Antang Makassar Landfill Soil Polluted with Plumbum (Pb) Metal

| No | Type of Plant | Plant height (Cm) | Stem diameter (Cm) | Leaf lenght (Cm) | Leaf widht (Cm) |
|---|---|---|---|---|---|
| 1 | *Celosia argentea* L. | 57,22 | 1,10 | 16,75 | 8,01 |
| 2 | *Mirabilis jalappa* L. | 29,88 | 1,01 | 12,55 | 8,23 |

Based on Table 1, it is known that in the parameters of plant height, stem diameter, and leaf length, the ornamental plant *Celosia argantea* L. is superior to *Mirabilis jalappa* L.. Meanwhile, in the parameter of leaf width, the ornamental plant of *Mirabilis jalappa* L. is slightly wider than the leaves of *Celosia argantea* L. The results of the calculation of the number of leaves of both types of ornamental plants are presented in Table 2.

**Table 2 .** Number of Leaves of Celosia argantea L. and Mirabilis jalappa L. in Tamangapa Antang Makassar Landfill Soil Polluted with Plumbum (Pb) Metal

| No | Type of Plant | Number of leaves |
|---|---|---|
| 1 | *Celosia argentea* L. | 57,22 |
| 2 | *Mirabilis jalappa* L. | 29,88 |

Table 2 shows that in the parameter of the number of leaves, *Mirabilis jalappa* L. has more leaves than *Celosia argentea L.* Based on the research that has been done, it is known that the two types of ornamental plants used can grow well even though the soil media used to grow the plants has been polluted by heavy metals such as Plumbum (Pb).

The results of the analysis of heavy metal Pb using ICP-MS in the soil are: 103.17 µg/g. This value has exceeded the sediment/soil threshold based on the National Standardisation Agency SNI 2004, which is 0.07 µg/g. Based on the research, it is known that the soil has been contaminated with lead (Pb). Soil is an important component in life because it is a place for plants to grow as producers that produce products for consumption by living things, both humans and animals. Pb metal pollution that occurs can pose a danger to the health of living things if not immediately addressed. The content of heavy metals in the soil greatly affects the heavy metal content of plants that grow on it, unless there is an interaction between the metals so that there are obstacles to the absorption of these metals by plants (Darmono, 1995 in Fitrianah & Permana, 2019)

According to Irhamni (2017), heavy metal accumulation depends on the following factors, including:

1. Plant nature, such as species, growth speed, root size and depth, evaporation rate, and nutrient requirements for metabolism.
2. Soil factors, such as pH, organic matter content and nature, nutrient status, soil type, clay mineral content, and the amount of metal ions such as phosphate, sulphate.
3. Environmental and management variables, such as temperature, humidity, sunlight, rainfall, fertilisation, etc.

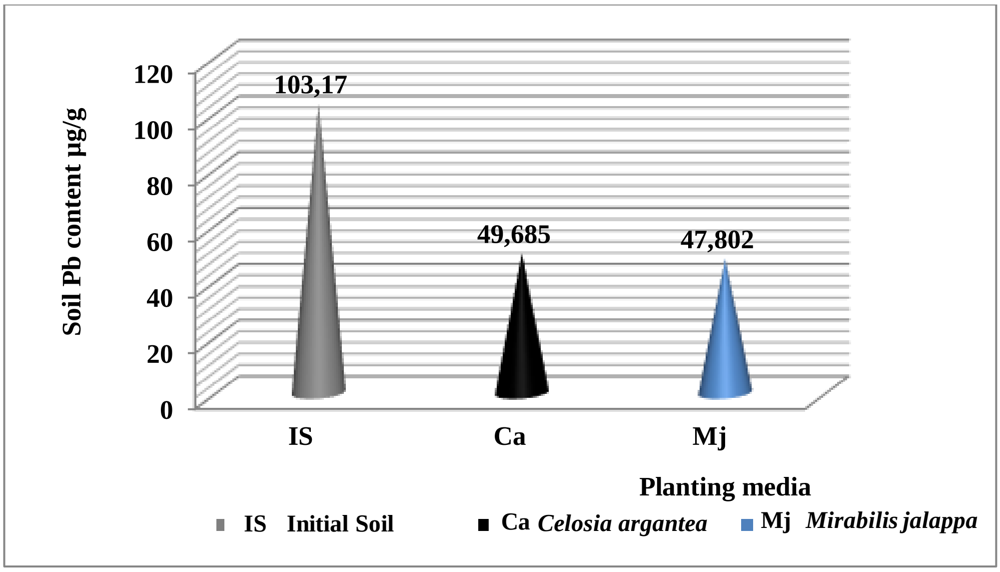


**Figure 1**. Plumbum (Pb) Metal Content Before and After Phytoremediation *with Celosia argentea* L., and *Mirabilis jalappa* L. Plants in Soil

Based on Figure 1, it is known that the ornamental plants of *Celosia argentea L.* and *Mirabilis jalappa* L. are able to absorb Pb metal content in the soil based on the results of analysis using ICP-MS. The heavy metal content of plumbum (Pb) in the soil during the initial analysis was 103.10 µg/g and after the final analysis, the metal content of plumbum (Pb) in the soil was reduced by half from the initial analysis results. According to ( Khopkar (1990) in Widaningrum *et al* 2007), the contact time between metal ions and absorbents greatly affects the absorption. The longer the contact time, the absorption will also increase until a certain time reach a maximum and after that it will go back down.

According to Aprilia & Purwani (2013), the absorption of heavy metal Pb in the soil occurs through two ways, namely the absorption of roots and leaves (stomata). Absorption through the roots occurs if Pb in the soil is in dissolved form. Meanwhile, absorption through the leaves occurs if Pb particles in the air fall on the leaf surface and are absorbed through the stomata to other tissues. The absorption of Pb from soil and air is influenced by various environmental factors and plant species. Plants that grow in environments with high metal levels will contain high concentrations of metals.

Heavy metal accumulation depends on several factors including the nature of the plant (type, size, root depth, growth speed, transpiration rate, and nutrient requirements for metabolism). Soil factors (pH, organic matter content and nature, nutrient status, soil type, clay mineral content, and amount of metal ions and certain anions such as phosphate, sulphate) and environmental variables (temperature, humidity, sunlight, rainfall, fertilisation, and management). Until now, Pb heavy metals have not been known for certain benefits for living things. Hence, they are categorised as non-essential heavy metals (Irhamni *et al*., 2017).

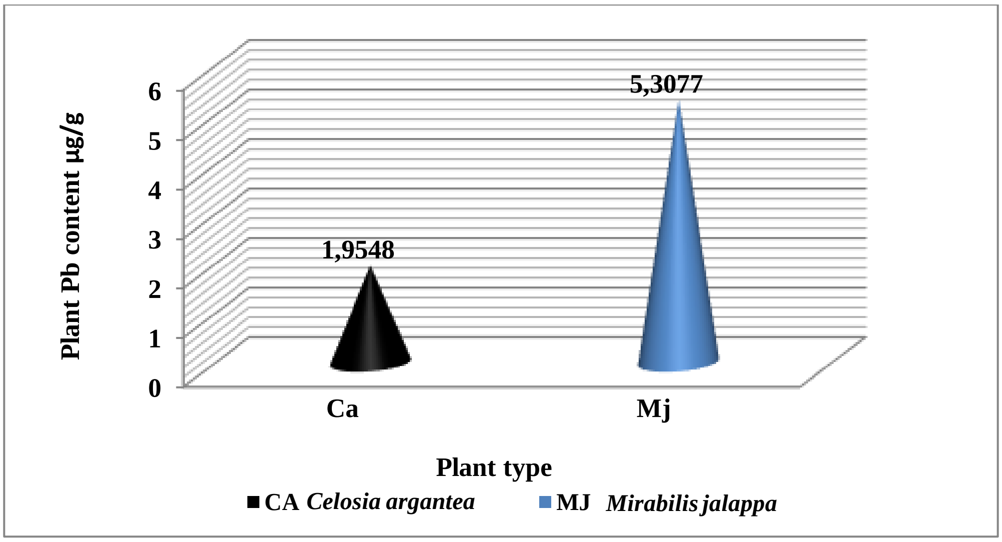


**Figure 2**. Plumbum (Pb) Metal Content in Plants After Phytoremediation with Celosia argentea L., and *Mirabilis jalappa* L. Plants, in Soil

Based on Figure 2, it is known that *Mirabilis jalappa* L. ornamental plants absorbs more metal content than the *Celosia argentea* L. Sahara (2022), states that the success of the phytoremediation process of a plant depends on its ability to concentrate heavy metals in the soil without showing signs of toxicity. Plants are good indicators of environmental quality and directly affect air, soil and water quality. The use of phytoremediation can improve environmental quality because phytoremediation can change the chemical structure of heavy metals into non-toxic forms.

Recently, phytoremediation techniques have developed very rapidly. The development of phytoremediation technology has made the presence of metal hyperaccumulator plants a very important component. Hyperaccumulator plants are able to accumulate heavy metals at concentrations 100 times better than normal plants, because normal plants experience metal poisoning and decreased production, while hyperaccumulator plants do not. This occurs due to differences in physiological and biochemical processes, as well as the expression of genes that control the absorption, accumulation, and tolerance of plants to metals (Hidayati, 2013).

Based on the results of the study, it is known that each ornamental flower plant is able to absorb more than 50% of the heavy metal content of Plumbum (Pb) from the results of the initial analysis that has been carried out, which is 103.17 µg/g. In *Celosia argentea L.* ornamental plants obtained 49.685 µg/g in soil and 1,9548 µg/g in plants. In *Mirabilis jalappa* L. ornamental plants obtained 47.802 µg/g in soil and 5.3077 µg/g in plants. According to Widyasari (2021), plants absorb and transmit contaminants (heavy metals) by plants in the form of solutions decomposed as harmless substances and then released into the atmosphere.

Sahara (2022), states that the rate of metal absorption by plants is different for each type of plant. Each pollutant can be harmful at different concentrations and each plant species responds differently to each pollutant. Some factors that affect plant damage include plant species, physical characteristics of leaves, plant age, pollutant concentration, length of the pollution process, and pollution time period. Plant absorption of heavy metals is influenced by plant growth and environmental conditions.

Calculations of plant biomass, Pb removal, and Pb absorption efficiency are presented in the following table.

**Table 3.** Plant biomass, Pb removal, and Pb absorption efficiency

| No | Type of plant | Wet weight (gr) | Dry weight (gr) | Plant biomass (%) |
|---|---|---|---|---|
| 1 | *Celosia argantea* L. | 104.33 | 19.66 | 18,84 |
| 2 | *Mirabilis jalappa* L. | 73 | 20.33 | 27,85 |
| **No** | **Type of plant** | **Initial metal (µg/g)** | **Final metal (µg/g)** | **Pb removal (%)** |
| 1 | *Celosia argantea* L. | 103.17 | 53,485 | 51,842 |
| 2 | *Mirabilis jalappa* L. | 103.17 | 55,368 | 53,667 |
| **No** | **Type of plant** | **Plant metal (µg/g)** | **Soil metal (µg/g)** | **Pb absorption efficiency (%)** |
| 1 | *Celosia argantea* L. | 1.9548 | 103,17 | 1,895 |
| 2 | *Mirabilis jalappa* L. | 5.3077 | 103,17 | 5,145 |

Table 3 shows the calculation of plant biomass, Pb removal, and Pb absorption efficiency. In each calculation, *Mirabilis jalappa* L. is higher than *Celosia argantea* L.. Plant biomass is one of the factors that affect the ability of plants to absorb heavy metals. According to Caroline & Moa (2019), heavy metal content in growing media (soil) can inhibit plant growth. Plants can accumulate large amounts of metals but their growth is very slow or their biomass is low. Based on research conducted by (Noviardhi & Damanhuri (2015), which used a different type of plant, namely sunflower Helianthus annuus L., it was found that the plant was able to grow quickly and produce high biomass.

## CONCLUSION

*Celosia argentea* L. and *Mirabilis jalappa* L. ornamental plants are able to grow well in an environment that has been polluted with plumbum (Pb) and are able to absorb the metal content in the soil. The plumbum (Pb) content before the plant planting process (phytoremediation) was 103.17 µg/g. The results of the analysis after the phytoremediation process, namely, in *Celosia argentea L.* flower ornamental plants obtained 49.685 µg/g in soil and 1.9548 µg/g in plants, while in *Mirabilis jalappa* L. flower ornamental plants obtained 47.802 µg/g in soil and 5.3077 µg/g in plants. Both types of flower ornamental plants used in the phytoremediation process are able to absorb Plumbum (Pb) metal in the soil without showing signs of toxicity in plants. Calculation of the biomass of *Celosia argentea* L. and *Mirabilis jalapa* L. ornamental plants, obtained 18.84% and 27.85%, respectively. Pb removal of *Celosia argentea* L. and *Mirabilis jalapa* L. ornamental plants were 51,842% and 53,667%, respectively. Pb absorption efficiency of *Celosia argentea* L. and *Mirabilis jalapa* L. were 1.895% and 5.145%, respectively.

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