Phytoremediation of Lead Contaminated Soils using *Cordyline fruicosa (L)*

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Abstract. Phytoremediation is an eco-friendly and low cost potential strategy for cleaning up of heavy metals from contaminated soils. Selection of promising plant is an important approach for successful phytoremediation. In this study the role of *Cordyline fruicosa (L)* plants as a potential phytoremediator to soils contaminated with lead (Pb) was investigated. Pot culture experiments using *Cordyline fruicosa (L)* with different level of lead 250, 500 and 750 mg Pb kg-1 soil. The growth parameter biomass root and leaf, Pb accumulation in plant and photosynthetic pigment content were measured after 40 days. The results showed that the increase lead concentrations caused a reduction in most growth parameter and photosynthetic pigment content. On the other hand the lead accumulation in root and leaf was increased by increasing lead concentrations.
Keywords: **phytoremediation; lead; *Cordyline fruicosa (L)***

1 Introduction

Environmental pollution is a condition that occurs because changes in environmental conditions damage and harm the lives of humans, animals and plants due to contaminants. This is one of them as a result of human activities, resulting in the environment not functioning as before. Contamination of soil and waters is caused by many causes including industrial waste, mining waste, fertilizer and pesticide residues.

Lead is the second toxic heavy metal after arsenic [1] for plants, animals, microbes and humans [2]. Lead is a non-essential element in the metabolic process and can become toxic to kill the organism when it is absorbed. Lead is a major contaminant because its spread extends throughout the environment [3] lead mobility can enlarged through food chain mechanisms accumulation in water poses and soil risks to organism and environment [4].

Recovery needs to be done so that polluted land can be reused for various activities safely. The decrease in heavy metals content such as Pb metal is still using physical-chemical methods that require expensive equipment and monitoring systems. So that it is necessary to find alternative processing that is easy, inexpensive, and effective in its application [5]. Phytoremediation is a method that uses plants to remove, move, stabilize or destroy pollutants in the form of both organic and inorganic compounds. The basis of phytoremediation is the ability of plants to accumulate metal or organic compounds according to the characteristics of the plants used [6,7,8,9,]. The mechanism of accumulation in plants which is related to metal exposure in contaminated soil is phytoextraction, phytostabilization, fitovolatilization, fitodegradation and rhizofiltration

The advantages of using plants in improving the polluted environment include effectiveness in reducing contaminants, can be applied to large areas, easily monitored and treated, applicable to various contaminants, with photosynthesis, solar energy is used for cleaning activities, improving air and water quality around the phytoremediation area in addition it can improve the aesthetics of contaminated land and low costs [10], efficient [11,12] environmentally friendly and more economical [5,13,14]. Plants are easily monitored to ensure growth, not destructive because they use natural organisms [15]. Phytoremediation can provide habitat for animals, support biodiversity, and help accelerate the recovery of ecosystems that were previously disturbed by human activities [16,17,18]. The weakness of phytoremediation is in terms of time it takes longer and it is also possible to enter into the food chain through the animal's consumption of the plant

Ornamental plants must have beautiful shapes, colors and patterns. This is not only flowers that can be

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used as decoration, but also leaves, fruit, stems and even specific scents that make it special. Ornamental plants are used for landscaping and are widely distributed in urban and suburban environments such as parks, interior homes and offices, public parks, roadside. Ornamental plants in urban areas can be applied as prevention of pollution and can also beautify the environment, this is an advantage of ornamental plants as phytoremediation compared to other plants. [19,20]. Ecological functions of ornamental plants are capable of absorbing carbon dioxide and producing oxygen. In addition there are several plants that are able to absorb toxic pollutants in the air, water and soil. Expanding and increasing green space in urban areas Low carbon development efforts. The aim of this research is to analyze the growth, Pb absorption and phytoremidiation potential of *Cordyline fruicosa* (L) plants .

2 Material and method

2.1 Soil preparation

The land used is taken from the garden in the Kalisegoro village, Gunungpati sub-district. Then the ground is drained and sieved. Analysis of soil characterization in table 1

Table 1. Soil physical and chemical characteristics

No	Parameters	
1	Soil texture	
	Sand	4.92%
	Silt	59.71%
	Clay	44.37%
2	pH H2O	5.21
	pH KCL	4,73
3	C-organic	1.15%
4	N-Kjeldahl	0.17%
5	P2O5HCL 25%	80.12 mg/100g
6	K2OHCL 25%	24.53 mg/100g
7	CEC	15.41 cmol(+)kg^{-1}
8	Permeability	2.35 cm/jam
9	water content	10.25%
10	Soil volume	1.12 gcm^{-3}
11	specific gravity	2.05 gcm^{-3}

2.2 Plant growth

Cordyline fruicosa plants were obtained from ornamental plants in Bandungan sub-district with criteria for plant height of 20-30 cm, leaves of 5-8. *Cordyline fruicosa* in a plant in a plastic pot with a diameter of 20 cm containing 1000 g of soil on each pot. The Pb application is given after adaptation 3 weeks. Pb (NO3) 2 is mixed with pot soil per 1000 g of soil with a concentration of 0, 250mg / kg, 500mb / kg and 750 mg / kg. Each of them has four replications

2.3 Measurement of plant growth

Plants were harvested after 40 days of exposure to Pb are then measured by the fresh weight of the roots and leaves. The sample was dried in a 70^0C oven for 3 days and measured the dry weight of the roots and leaves.

2.4 Measurement of photosynthetic pigment

Fresh leaves of 0.5 grams were pounded with mortal then added 10 mL of 80% acetone. The absorbance of the extracts at 645nm, 663nm and 470 nm for photosynthetic pigment were recorded by UV-Vis spectrophotometer (lamda 25 Perkin Elmer) and photosynthetic pigment unit in mg/g. FW

2.5 Lead content in plant and translocation factor

Preparation of dry sample in furnace at 500^0C for 4 hours until it becomes ashes. After cold the sample was destroyed with HNO3, 65% and HCL 37% with a ratio of 4:1. Determinations of Lead were carried out on Perkin Elmer atomic absorption spectrophotometer Analyst 400. Operated at 217 nm

TF = metal concentration in tissue /metal concentrations in root ....(1)

2.6 Statistical analysis

Data were analyzed by ANOVA and LSD further tests to determine biomass, Pb content in plants, photosynthesis pigment in each treatment. All Statistical analyses processing was carried out by IBM SPSS statistic 23.0

3 RESULTS

3.1 Effect of lead concentrations on biomass

The effect of different concentration of lead treatment on biomass root and leaf are depicted in Table 2.

Table 2. Effects of treatment concentration on the biomass of *Cordyline fruicosa* plants

Pb	Biomass (mg/plant)	
($mg.kg^{-1}$)	Root	Leaf
0	917.350 a ± 8.82	838.616 a± 16.84
250	811.622 b± 23.76	791.158 b± 10.73
500	799.775 b± 14.78	767.807 b± 19.47
750	736.973 c± 22.41	702.798 c± 19.99

The value in the same row follow with the different letter is significantly different $P < 0.05$ Lead treatment affects the biomass of both root and leaf plants ($P <0.05$). Increased lead concentration is followed by decreasing plant biomass. All treatments were significantly different from controls but lead concentration of 250 mg. kg-1 was no different from 500 mg.kg-1 both in roots and leaves

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3.2 Effect of Lead on photosynthetic pigment contents

The higher the lead concentration, the photosynthesis pigment content of chlorophyll a, chlorophyll b, total chlorophyll and carotenoids decreases (fig.1). ANOVA test results that lead has an effect on photosynthetic pigment content (P <0.05).

3.3 Lead accumulation within the plant tissues

The accumulation of lead content in *Cordyline fruicosa* depends on the concentration of lead in the growth medium. Analysis of variance showed (fig.2). That lead concentration in different plant tissues is significantly different (P <0.05).

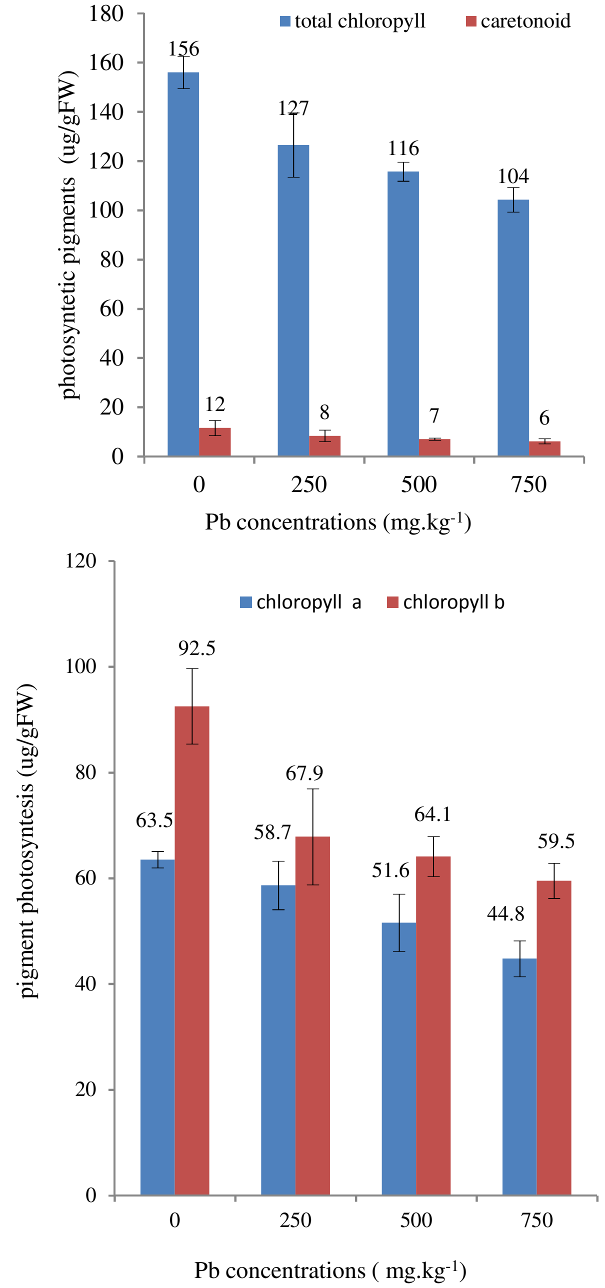

Fig.1. Effect of lead on photosynthetic pigment

Translocation factors at lead concentration (mgkg-1) 250, 500 and 750 at 0.612, 0.459 and 0.312. The accumulation of lead content in roots is higher than leaf tissue. The translocation factor in the study was less than 1.

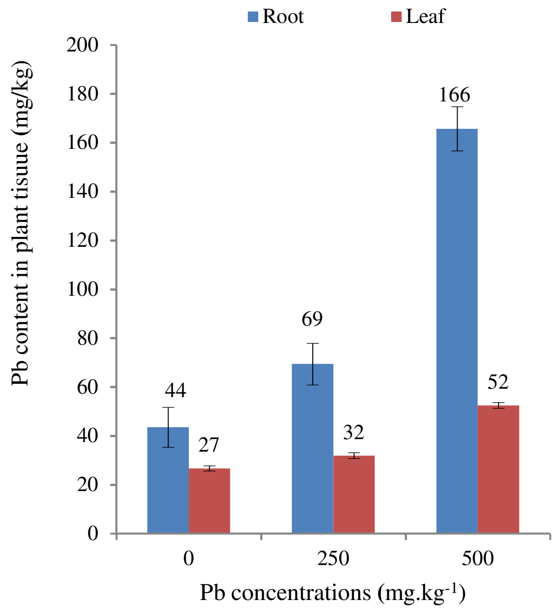

Fig 2. Lead accumulation within the plant tissues

4 Discussions

In this study that application of lead inhibits the growth of *Cordyline frucosa* plants. Plants absorb Pb and accumulate in plant tissues because they are not metabolized [21]) which will affect metabolic activity. As in this study root and leaf biomass decreases with increasing lead concentration. The main effect of lead poisoning on plants is inhibition of root growth, because it inhibits cell division that occurs at the root tip. This shows that Pb inhibits cell division at the roots of several plant species, including *Triticuma estivum* [22], Zea mays L. [23]), *Pisum sativum* [24], and *Sedum alfredii* [25], decrease in root length and dry weight due to lead toxicity. Decreased photosynthetic pigment content because lead inhibits chlorophyll synthesis by interfering with the absorption of important photosynthetic pigment elements, such as Mg and Fe [26]. Photosynthetic organs are also damaged because chlorophyllase activity is limited under abundance of lead, also causes an increase in chlorophyll destruction in this condition chlorophyll a which is more influential than chlorophyll b [27] Photosynthetic organs are also damaged because chlorophyllase activity is limited under abundance of lead, also causes an increase in chlorophyll destruction in this condition chlorophyll a which is more influential than chlorophyll b [27].

Lead accumulation in roots is higher than leaves in *Cordyline fruicosa* plants with TF <1. Lead is very low in solubility, and has low translocation power from roots to other plant organs [28] Lead acts as mobility in the process of absorption of metals from the roots of plants to the leaves to form complex compounds [29] following the flow of transpiration to the upper part of the plant through the tissues mainly through the xylem vessels and subsequently carried throughout plant parts by phloem where metals are stored in vacuoles. so that it will be carried to the plant tissue.

5 Conclusion

In conclusion, that *Cordyline fruicosa* (L) accumulates lead at roots higher than leaves. *Cordyline fruicosa* (L) conditions needed for cleaning contaminated lead soil. Thus, there is an excellent space to use these ornamental plants to remedy Pb around highways or industries and parks. The ecological function of ornamental plants is able to absorb carbon dioxide and produce oxygen. Expanding and increasing green space in urban areas Low carbon development efforts

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