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The Ability of *Dracaena marginata* var. *tricolor*, *Gratophyllum pictum*, and *Pedilanthus tithymaloides* as Lead Absorbents in the Air

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Abstract: Lead pollution in the air is dangerous for living because toxic and carcinogenic. *Dracaena marginata* var. *tricolor, Gratophyllum pictum,* and *Pedilanthus tithymaloides* are plants that are often found on the roadside of Sidoarjo city and are often exposed to lead. This research aims to determine the ability of *D. marginata* var. *tricolor, G. pictum,* and *P. tithymaloides* as lead absorbents in the air and the relationship between lead content with plant chlorophyll content. This research is observational. Leaf sampling was carried out at 3 points in 3 locations, namely Buduran Street, Pahlawan Street, and Cemengkalang Street Sidoarjo. The lead content parameter was measured using *Atomic Absorption Spectrophotometry* and chlorophyll content was measured using Spectrophotometer. Data analysis using ANOVA test followed by Duncan test and quantitative descriptive. The result showed that *D. marginata* var. *tricolor, G. pictum,* and *P. tithymaloides* have the ability as lead absorbents in the air. The highest to the lowest lead content were *G. pictum* 0.225±0.005 mg/L, *D. marginata* var. *tricolor* 0.087±0.006 mg/L, and *P. tithymaloides* 0.033±0.022 mg/L. The highest to the lowest chlorophyll content were *G. pictum* 13.707±5.028 mg/L, *D. marginata* var. *tricolor* 11.851±4.659 mg/L, and *P. tithymaloides* 11.391±4.256 mg/L. There was no significant effect of lead content on plant chlorophyll content.

Key words: Chlorophyll content, *D. marginata* var. *tricolor*, *G. pictum*, lead content, *P. tithymaloides*.

Introduction

Sidoarjo is a suburban area located in East Java and ranks third in the largest number of vehicles after Surabaya and Malang (Priyambodo, 2018). The number of vehicles in Sidoarjo has increased every year. In 2018 the number of vehicles is 1,088,298 units, in 2019 1,750,447 units, and in 2020 1,822,092 units (Sidoarjo Regency Police, 2021). Because of the increase in the number of vehicles, it has the potential to contribute pollutants to the air. One of these pollutants is lead (Gusnita, 2012).

Lead is a soft and elastic metal usually used as raw material and a gasoline fuel mixture to increase the octane (Fahruddin et al., 2020). Lead has nonbiodegradable properties that can trigger cancer and mutations. In plants, lead can cause chlorosis and inhibit the formation of chlorophyll. The mechanism of plants in absorbing lead occurs passively (Santoso, 2013). The physiological response of plants to adapt for the lead entry can be amelioration, neutralising Pb ion in the cytoplasm, immobilisation, compartmentalisation of metals ion in vacuoles, and chelation lead with a production of metal chelating peptides (Fascavitri et al., 2018).

The special characteristics of plants that have high potential as lead absorbents are having wide and oval leaf (Azizah and Rachmadiarti, 2018), cuticle leaf,

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thick leaf, do not fall easily, have a rough and downy leaf surface, scaly leaf, jagged leaf edges, sticky leaf surface, needle-shaped, wrinkled leaf surface, have a fairly large stem diameter, and ribbon shape leaf (Fascavitri et al., 2018). Plant stature also affects lead absorption. Shrub stature can absorb gaseous pollutants such as formaldehyde, benzene, and nitrogen oxides (Yudha et al., 2013).

D. marginata var. *tricolor, G. pictum,* and *P. tithymaloides* are plants that are often found in the traffic area of Sidoarjo. *D. marginata* var. *tricolor* is a shrub stature plant, ribbon-like and elongated leaf shape, and has a cuticle. *G. pictum* is a shrub stature plant that has an oval leaf shape cuticle, and rugosus (wrinkled) leaf surface type. *P. tithymaloides* is a shrub stature plant, that has an oval leaf shape and cuticle. Based on that characteristic, it was concluded that the three plants have the ability for lead absorbents from the air.

In the context of high Pb pollution along with the increasing number of motorised vehicles and there is little similar research about the ability of Pb absorption in different plants in Sidoarjo, Indonesia, so it is necessary to conduct research to know the ability of Pb absorption by *D. marginata* var. *tricolor*, *G. pictum*, and *P. tithymaloides* and their effect on chlorophyll content in Sidoarjo, Indonesia. Site selection is based on the wide distribution of these plants in this location.

Materials and Methods

Place and Time of Research

This research is observational. The research was carried out in July-December 2021. Leaf samples were taken from 3 locations in Sidoarjo, Indonesia (Figure 1) with average daily traffic from the highest to the lowest, namely Buduran Street (164,622 units), Pahlawan Street (84,174 units), and Cemengkalang Street (84,120 units). Measurement of environmental physical-chemical factors was carried out at 3 points at each location. Parameters measured included soil temperature, soil moisture, air temperature, air humidity, soil pH, and light intensity.

Research Procedure

Analysis of Lead Content

Sample preparation: This analysis was carried out at the Physical Chemistry Laboratory, Department of Chemistry, FMIPA UNESA using the dry destruction method. About 3.5 grams of leaf samples were weighed using an analytical balance, then placed in a porcelain dish, labeled, and incubated for 3 hours at 800°C. The sample that has been kilned is put into a beaker glass and added 1 mL of concentrated HNO_3 and 10 mL of aquademin. Next, the sample was stirred until well

Figure 1: Sampling locations (Source: Google maps, 2021); Note: 1 = Buduran Street (-7.424480, 112.723403); 2 = Pahlawan Street (-7.4483896, 112.7031341); 3 = Cemengkalang Street (-7.4418832, 112.6839519).

mixed and filtered using filter paper. Thereafter, the sample was prepared to be analysed using the AAS method.

Production standard metal solutions: The standard solution was made by making a standard solution of 100 ppm Pb from 1000 ppm Pb mother liquor. The step is to take 10 mL of 1000 ppm Pb mother liquor and then put it in a beaker glass. Add distilled water until the mark and then homogenise. The next step is to make a 10 ppm Pb solution from a 100 ppm Pb solution with the same method as making a 100 ppm Pb solution from a 1000 ppm Pb main solution.

Production calibration curves: The calibration curve of Pb was made by diluting 10 ppm Pb solution to obtain a concentration of 0-3 ppm.

Sample measurement: Each solution measured its absorbance value with AAS PERKIN ELMER AAnalyst 100 using a Pb cathode lamp. Sample measurement was carried out by Pb Content Test Method SNI Number 06.698945 of 2005 and the calculation of lead content is carried out based on the formula:

$$Cy' = \left(Cy \times \frac{V}{W} \right) \times 100$$

where

Cy' = Pb content absorbed by leaves (µg/g)
Cy = Measurable Pb content on AAS (mg/L)
V = Volume of solution dilution (L)
W = Dry weight of leaf biomass (g)
1000 = Convert mg to µg/g

Analysis of Chlorophyll Content

This analysis was carried out at the Physiology Laboratory, Department of Biology, FMIPA UNESA with the first step weighing 0.5 grams of leaf plant samples and then mashing it using mortar and pestle. Next, add 50 mL of 95% alcohol. Later, the filtered leaf sample using filter paper to obtain 50 mL of filtrate. The filtrate was then put into a cuvette and the chlorophyll content was measured using MAPADA V-1100D Spectrophotometer with 649 nm and 665 nm wavelength. Furthermore, record the absorbance value of the solution and then calculate with the formula of Wintermans and de Mots as follows:

- Chlorophyll a: 13.7 × OD665–5.76OD649 (mg/L)
- Chlorophyll b: 25.8 × OD649–7.7OD665 (mg/L)
- Total Chlorophyll: 20.0 × OD649+6.1OD665(mg/L)

Analysis of Leaf Surface Area

Leaf surface area measurements were carried out at the Department of Biology, FMIPA UNESA using Leaf Meter ADC AM350.

Data Analysis

Data showing the ability of *D. marginata* var. *tricolor, G. pictum,* and *P. tithymaloides* as lead absorbents and leaf chlorophyll content were analysed using statistical tests in the form of ANOVA test, followed by the Duncan test. Data related to the relationship between lead content and plant chlorophyll content, leaf surface area, also environmental physical and chemical factors were analysed quantitatively.

Results and Discussion

Lead is a very toxic heavy metal and the second most toxic metal after Arsenic (As). One of the lead sources in the air comes from motor vehicle fumes. Emissions produced from these motorised vehicles are composed of carbon monoxide (CO), sulphur (S), nitrogen oxide (NOx), hydrocarbons (HC), and lead (Pb). Several main compounds of lead (Pb) found in motor vehicle exhaust are PbBrCL.2PbO, $PbCl_2$, PbBrCl, Pb(OH)Cl, $PbBr_2$, and $PbCO_3$.2PbO. Lead can be absorbed from the environment into the plant body through leaves (Gusnita, 2012), stems, and roots. The mechanism of lead absorption by plants occurs passively. Plants slowly absorb lead from the air through the stomata located in the upper epidermis layer, that accumulates between the gaps in the palisade tissue or sponge tissue, leading to reaction through various pathways (Santoso, 2013). Because lead (Pb) particles are insoluble in water, Pb in leaf tissues get trapped in the intercellular spaces around the stomata. Gas that has been contaminated with lead will enter the leaf tissue through stomata holes located above the surface of the epidermis. Through these stomata holes, pollutants dissolve with water in the surface leaf cells (Rachmadiarti et al., 2019).

Each plant has a different ability to absorb lead. This can happen due to internal and external factors. Internal factors include plant morphology (plant stature, shape, size, type, leaf surface area, trichomes, also the number and size of stomata). While external factors include environmental factors around the plant, frequent exposure to pollutants and pollutant content. Based on the research that has been done, the Duncan test of lead content in the leaves in 3 locations (Table 1) showed that there were differences in lead content of each plant at location 1 with locations 2 and 3 but there was no difference between locations 2 and 3. *G. pictum* had the highest lead content compared to *D. marginata* var. *tricolor* and *P. tithymaloides* because of its morphological characteristics (Table 5), such as shrub stature plant, rugosus (wrinkled) leaf surface type, cuticle leaf, etc. This is in line with Yudha et al. (2013) that plants with shrub stature can absorb pollutants such as lead. Lead is optimally distributed in plants with shrub stature because lead is part of PM10 with a size of 10 µm. Plants that are effective in absorbing lead is having wrinkled leaf surfaces (Nurhikmah et al., 2015) and have cuticle leaves (Rachmadiarti et al., 2019).

Table 1: The average of lead content in the leaves of *D. marginata* var. *tricolor*, *G. pictum*, and *P. tithymaloides* at three different research sites

Plant name	*Average lead content (mg/L)*		
	1	*2*	*3*
D. marginata var. *tricolor*	0.246± 0.010 bB	0.005± 0.004 bA	0.012± 0.005 bA
G. pictum	0.645± 0.008 cB	0.023± 0.004 cA	0.007± 0.005 cA
P. tithymaloides	0.084± 0.060 aB	0.006± 0.004 aA	0.011± 0.004 aA

Notes: Notation: Numbers followed by different notations in rows and columns show significantly different results based on the Duncan test with a test level of 0.05. 1 = Buduran Street (with 3 repetition points), 2 = Pahlawan Street (with 3 repetition points), 3 = Cemengkalang Street (with 3 repetition points)

Location 1 (Buduran Street) is the location with the highest lead absorption compared to other locations. This is in line with the higher average daily traffic volume on Buduran Street, which is 164,622 units compared to Pahlawan Street at 84,174 units and Cemengkalang Street at 84,120 units (Sidoarjo Regency Police, 2021). The greater the average daily traffic volume on the road, the more sources of Pb are produced by motorised vehicles. This causes *D. marginata* var. *tricolor, G. pictum,* and *P. tithymaloides* that grew around Buduran Street to have higher lead content than other streets because the higher the lead concentration in the air, the higher the rate of lead absorption by plants.

Excessive lead emissions in the air can affect the structure and physiology of a plant, such as a decrease in growth, productivity, and even death in plants. The lead pollutant absorbed by plants can interfere the chlorophyll biosynthesis due to the inhibition of the enzymes photo chlorophyllide, porphobilinogenase, and ALAD which are known to play a role in chlorophyll biogenesis (Rachmadiarti et al., 2019). ALAD acts as a catalyst in the formation of porphobilinogen and when lead pollutant enters the plant, ALAD activity will be inhibited because the pollutant binds to the SH enzyme, then causing a decrease in chlorophyll production in plants (Ulfah et al., 2017). In addition to disrupting enzyme performance, the entry of lead pollutants in plants can reduce the number of stroma and grana, replace the position of Mg and Fe as materials for the structure of chloroplasts, and cause degradation of chlorophyll molecules into Phenophitin and Mg^{2+}. The Mg^{2+} molecule will be replaced with two H atoms which then change the structure, and characteristics of the light spectrum of chlorophyll and can reduce chlorophyll levels if exposed for a long time (Nas and Ali, 2018). On the other hand exposure to Pb in plants causes competition between pollutants and Fe to bind to porphyrin compounds. The inhibition that occurs in Fe-foripin which is the precursor for forming Mg-porifins will cause a decrease in chlorophyll content in plants (Ulfah et al., 2017). The greater the pollutant level of lead absorbed by plants, the greater the potential for damage to leaves such as necrosis and chlorosis.

The Duncan test for chlorophyll content showed that the differences in chlorophyll content between 3 plants in 3 locations were not significantly different (Table 2), so it can be seen that the absorption of lead did not affect chlorophyll content in the plant. This is further clarified in Table 3 that there was no significant effect of lead content on plant chlorophyll content. The higher the lead content, the higher the chlorophyll content and vice versa so this indicates that the plant has been able to adapt to lead exposure and can be the air lead absorbent. Plants that have the potential as lead absorbents can accumulate lead in large quantities but do not show symptoms of poisoning, and changes in chlorophyll content (Alamsyah and Rachmadiarti, 2020). This is also supported by research that Tabebuya has the potential to absorb lead in the leaves but the presence of lead does not affect the chlorophyll content of Tabebuya (Rachmadiarti et al., 2021). Plant physiological response to lead exposure, namely amelioration, neutralising pollutants in the cytoplasm, metal ion compartmentalisation mechanism, immobilisation, production of metal chelating peptides (phytochelatins and metallothioneins). Also another mechanism owned by plants to remove lead from the environment is phytoremediation which is divided into 7 techniques: phytoextraction, rhizofiltration, phytostabilisation, phytodegradation, phytovolatilisation,

Table 2: The average of chlorophyll content in the leaves of *D. marginata* var. *tricolor*, *G. pictum*, and *P. tithymaloides* at three different research sites

Plant name	*Average chlorophyll content (mg/L)*		
	1	*2*	*3*
D. marginata var. *tricolor*	6.714± 1.749 aAB	19.429± 9.457 aB	8.602± 2.770 aA
G. pictum	13.062± 4.240 aAB	19.187± 8.893 aB	8.872± 1.951 aA
P. tithymaloides	15.603± 6.427 aAB	9.698± 4.431 aB	8.872± 1.910 aA

Notes: Notation: Numbers followed by different notations in rows and columns show that the results are not significantly different based on the Duncan test with a test level of 0.05. 1= Buduran Street (with 3 repetition points), 2= Pahlawan Street (with 3 repetition points), 3= Cemengkalang Street (with 3 repetition points)

Table 3: The relationship of lead content absorbed by *D. marginata* var. *tricolor*, *G. pictum*, and *P. tithymaloides* with plant chlorophyll content

Plant name	*Average overall lead content (mg/L)*	*Average overall chlorophyll content (mg/L)*
D. marginata var. *tricolor*	0.087±0.006	11.581±4.659
G. pictum	0.225±0.005	13.707±5.028
P. tithymaloides	0.033±0.022	11.391±4.256

phytotransformation, and absorption of various volatile organic materials (Fascavitri et al., 2018).

The leaf surface area can affect the absorption of lead in the air. The larger the leaf surface area, the greater the plant's ability to absorb lead in the air (Azizah and Rachmadiarti, 2018). Measurement of the plant's leaf surface in 3 locations (Table 4) showed that the highest to the lowest plants' leaf surface areas are found in *D. marginata* var. *tricolor, G. pictum,* and *P. tithymaloides. G. pictum* has a lower average leaf surface area than *D. marginata* var. *tricolor* but has a higher ability to absorb lead. This can happen because the morphology of the *G. pictum* leaf is more supportive in lead absorption, namely wrinkled leaf surface (rugosus) and wider leaf size. This is in line with Nurhikmah et al. (2015), which led to the finding that a wrinkled leaf surface has a higher lead absorption ability than a smooth and flat-leaf surface and is supported by research that *W. trilobata* has a wider leaf size than *S. oleina*; therefore, *W. trilobata* can absorb more lead pollutants than *S. oleina* (Rachmadiarti et al., 2019).

Lead (Pb) entered the plants not only influenced by the plant species itself but also strongly influenced by environmental factors (Kumar et al., 2020). The result of environmental physical and chemical factors measurement (Table 6) showed that soil moisture values ranged from 7 to 10% RH and air humidity ranged from 52.3 to 68%. High humidity indicates the amount of water vapour contained. This caused the rate of transpiration to be slow (Yuniantara and Kuntjoro, 2020). High humidity is inversely proportional to temperature. The higher the temperature, the higher the lead content in the air (Melsandi et al., 2020). In this research, the soil temperature was between 28 and 29°C and the air temperature ranged from 32.3 to 39°C. Both of these temperatures are still classified as optimal temperatures for plant growth. This is in line with Azizah and Rachmadiarti (2018) that the optimal temperature for growth is in the range of 30-40°C. With an optimal temperature, it can support the performance of the stomata to open, making it easier for Pb to enter the plant tissue along with the air.

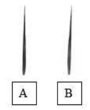
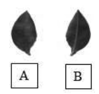
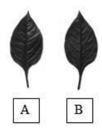
The degree of acidity (pH) is the most important factor that can regulate the ability to absorb lead in plants. Under acidic soil conditions, Pb is aqueous with the formula $Pb(H_2O_6)^{+2}$, whereas, under alkaline soil conditions, Pb forms aqueous complexes with hydroxyl ions (OH^-) (Levin et al., 2019). When pH 3-5 the absorption process is dominated, while at close to neutral pH (pH 6-7) the precipitation process is dominated (Zulfiqar et al., 2019). In this research, the soil pH is 7-7.5 and was classified as close to neutral pH. Even though the pH conditions were close to neutral, the three plants are still able to absorb lead so it could be seen that the plants can adapt well. In this research, the light intensity ranges from 1082 to 4321 lux which is classified as low intensity. The low intensity with a value of < 32,000 lux can cause a decrease in

Table 4: The average leaf surface area of *D. marginata* var. *tricolor*, *G. pictum*, and *P. tithymaloides* at three different research sites

Plant name	*Average leaf surface area (cm^2)*		
	1	*2*	*3*
D. marginata var. *tricolor*	12.309±1.002	8.182±0.142	8.327±0.096
G. pictum	4.495±0.341	4.643±0.465	4.600±0.293
P. tithymaloides	3.555±0.087	3.796±0.034	4.342±0.013

Description: 1 = Buduran Street (with 3 repetition points), 2 = Pahlawan Street (with 3 repetition points), 3 = Cemengkalang Street (with 3 repetition points)

Table 5: Leaf surface type of *D. marginata* var. *tricolor*, *G. pictum*, and *P. tithymaloides*

Plant name	*Leaf surface type*	*Characteristic features*	*Picture*
D. marginata var. *tricolor*	Laevis (smooth), nitidus (shiny)	Ribbon-like and elongated leaf shape, tapered leaf tips, parallel leaf bone, flat leaf edge, parchment-like leaf flesh	
G. pictum	Rugosus (wrinkled)	Oval leaf shape, tapered leaf tip and base, pinnate leaf bone, wavy leaf edge, soft-thin leaf flesh	
P. tithymaloides	Glaber (bald)	Oval leaf shape, pointed leaf tip, tapered leaf base, pinnate leaf bone, wavy leaf edge, soft-thin leaf flesh	

Description: A. Upper leaf surface, B. Lower leaf surface

Table 6: Environmental physical and chemical factors of *D. marginata* var. *tricolor*, *G. pictum*, and *P. tithymaloides* at three research sites

Plant name	*Location*	*Soil moisture (%RH)*	*Soil temperature (°C)*	*Soil pH*	*Air humidity (%)*	*Air temperature (°C)*	*Light intensity (Lux)*
D. marginata var. *tricolor*	1	7	29	7	68	36	3829
	2	7	28	7	59.6	32.3	1786
	3	10	28	7.5	54.3	34	2397
G. pictum	1	7.3	29	7	62	33	3487
	2	8	28	7	59.6	32.3	4106
	3	10	28	7.1	56	32	1818
P. tithymaloides	1	7.3	28	7.3	64	38	4321
	2	9.3	28	7	47.3	39	1082
	3	10	28	7	52.3	34	2493

photosynthetic performance, causing leaf stomata to close and lead pollutants in the air cannot absorb into the plant (Alamsyah and Rachmadiarti, 2020). Even under low light intensity conditions, the plants are still able to absorb lead and produce chlorophyll, so it can be interpreted that the plant has adapted to the condition of the surrounding environment that is polluted with lead.

Conclusion

From this research, we can conclude that *Dracaena marginata* var. *tricolor, Gratophyllum pictum,* and *Pedilanthus tithymaloides* have the ability to absorb lead in the air. The highest to the lowest lead content was found in *G. pictum* 0.225±0.005 mg/L, *D. marginata* var. *tricolor* 0.087±0.006 mg/L, and *P. tithymaloides* 0.033±0.022 mg/L. The highest to the lowest chlorophyll content was found in *G. pictum* at 13.707±5.028 mg/L, followed by *D. marginata* var. *tricolor* 11.581±4.659 mg/L, and *P. tithymaloides* 11.391±4.256 mg/L. There was no significant effect of lead content on plant chlorophyll content.

Suggestion

This research can be used as a reference to public and environmental practitioners regarding the application of *D. marginata* var. *tricolor*, *G. pictum*, and *P. tithymaloides* as lead absorbents. The result of this research also can be implemented as a strategy to reduce the lead content in the air.

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