The Potential of Tabebuya as Phytoremediator of Lead (Pb) in Atmosphere

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Abstract Lead (Pb) is one of the heavy metals that causes pollution in ecosystems, heavy metal Pb can cause disturbances to humans, including plants and animals. In Indonesia, especially in Surabaya, Tabebuya grows on main roads as a shade tree as well as an ornamental plant; This plant can be exposed to Pb metal, among others, from motor vehicle exhaust. This study aimed to determine the levels of Pb in Tabebuya and to study chlorophyll in the leaves. Pb levels in plant leaves were measured using an atomic absorption spectrophotometer (AAS), and chlorophyll levels using a spectrophotometer. Data in the form of Pb and chlorophyll levels at various locations were analyzed by analysis of variance (Anova). The results showed that the location of plant species affected the content of Pb metal and there is no effect of chlorophyll content in the leaves. The results also showed that the absorption of lead (Pb) content by the tabebuia 0.25-0.44 ppm and content of chlorophyll 12.89-14. 94. Lead (Pb) content do not affect the amount of leave chlorophyll produced and the plant had capabilities in absorbing lead like pollutants (Pb).

Keywords : Tabebuya, atomic absorption spectrophotometer, ANOVA

1 Introduction

Heavy metals (Pb, Cd, Zn, Fe) are the main pollutants released into the atmosphere [1]. Pb is one of three heavy metals (Pb, Hg, Cd) which are dangerous when contaminating organisms, whether it be plants, animals, as well as humans. Sources of these pollutants, among others, come from the fumes of motorized vehicles that use gasoline. Research [2] in Indonesia showed that Pb levels in PM-2.5 and PM-10 in several cities were still relatively high. Pb concentrations in the sampling locations of Tangerang, Jakarta, and Surabaya were higher than other cities. Pb levels according to quality standards, namely 2μg/Nm3 per 24 hours [3]. Therefore, it is necessary to make efforts to reduce Pb levels in the air. Syzygium oleina, Wedelia trilobata is able to absorb Pb [4]. One way to improve air quality is by utilizing plants through a phytoremediation process. Phytoremediation can be interpreted as controlling air pollution with technology that is cost-effective, energy-efficient, and environmentally friendly. In phytoremediation, plant organs and microbes present in the phyllosphere and rhizosphere interact with each other to overcome polluted air [5]. [6] reported that leaves associated with microbes that can reduce air pollutants, example Azalea leaves associated with Pseudomonas putida that can reduce volatile organic compounds [7], yellow lupine plant leaves together with endophytic Burkholderia cepacia for reduce toluene [8], and poplar leaf associated with Methylobacterium sp. that can reduce xenobiotic compounds [9].

Leaf and stem surfaces are known to absorb pollutants. Hence, microbe especially bacteria that live on this surface, called phyllospheric bacteria, have an important role. Part of the adsorbed pollutant also finds its way into the plant, creating (mainly) high-flowering leaf endophytes. Phylospheric and endophytic bacteria are known to be able to detoxify some pollutants through three steps i.e., degradation, transformation, and sequestration processes. Furthermore, rainfall can cause the flow of pollutants into the soil just below the plants. Pollutants contaminate soil and bacteria around plant roots (rhizosphere). This is the main role of plants in reducing air pollutants. This ability will also affect the chlorophyll content and growth.

Plants that can be used for this function, including the Tabebuya genus Handroanthus. Handroanthus chrysotrichus is a species of the family Bignoniaceae [10]. HabititusTabebuyain the form of shrubs or trees with a height ranging from 5-50 m depending on the species. The leaves are in pairs crossed or complex with the number of leaf sheets between 3-7 sheets.

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Taking into account the importance of the role of Pb in polluting the air and the prediction that Tabebuya can reduce Pb levels in the air, it is necessary to investigate the potential of this plant, so the objectives of this study were 1) to analyze the Pb levels in Tabebuya leaves, 2) to analyze the chlorophyll content in Tabebuya leaves. It is not known that Tabebuya is not only a shade plant and ornamental plant, it also maintains an ecological function, namely absorbing Pb in the air. In addition, research related to this phytoremediator has not been widely disclosed.

2 Materials and Methods

2.1 Stage 1: Tabebuya Sampling

The focus of this study is passive biomonitoring using plants in the study area, in the city of Surabaya. Tabebuya samples were collected from three different places, namely Jalan Diponegoro, Jalan Darmo, and Jalan Ir Soekarno. This selection is based on the presence of vegetation and traffic density. At each station, Tabebuya leaves were taken from three trees. On each tree, leaves are taken from the third branch from the base, then leaves are made for various purposes.

2.2 Stage 2: Sample Analysis

2.2.1 Pb Analysis

Lead level in leaves was measured using PerkinElmer Atomic Absorption Spectrophotometry (AAS) by Medtech, Waltham, Massachusetts, United State. Each sample leaf was weighed 2 g, then placed in 800°C furnace for 3 hours. The sample was then added 2 mL HNO3 and 10 mL demineralized aqua. Solution was then filtered and analyzed its absorbance using AAS. Lead content was measured using the standardized Pb Level Test Method SNI No. 06-698945 of 2005. The following was the formula was used to calculate Pb level:

\[
Cy' = (Cy \times V/W) \times 1000
\]

In which:
- \(Cy'\) = lead (Pb) content in leaves (µg/g)
- \(Cy\) = measured concentration (mg/L)
- \(V\) = dilution volume (L)
- \(W\) = leaf dry weight (g)
- 1000 = base conversion of mg to g

2.2.2 Chlorophyll Analysis

Leaf chlorophyll level was examined using MAPADA V-1100D visible spectrophotometers by Shanghai Mapada Instruments Co., Ltd, Shanghai, China at wavelengths of 665 and 649 nm. Extract was made of each sample leaf. From each sample, 0.5 g of leaf was macerated with 50 mL 96% alcohol until leaf color dissolved. Solution was filtered with filter paper and chlorophyll level was examined from filtrate based on level of optical density (OD). Calculation level between chlorophyll a, chlorophyll b, and total chlorophyll are using the formula of Wintermans and de Mots [8].

2.3 Data Analysis

Data from the research in the form of Pb levels in leaves, and chlorophyll levels in leaves at various locations were analyzed by Anova.

3 Results and Discussion

Table 1 shows the Pb content in Tabebuya leaves at various sampling locations. Meanwhile, Table 2 shows the chlorophyll content in Tabebuya leaves at various sampling locations.

| Area          | Mean of Pb (ppm) | Standard Deviation |
|---------------|------------------|--------------------|
| Diponegoro Street | 0.25            | 0.05a              |
| Darmo Street  | 0.26             | 0.08a              |
| Soekarno Street | 0.44            | 0.04b              |

Table 2. ANOVA result of location Tabebuya with Pb content in the leaves.

| Source       | Dependent variable | Sign |
|--------------|--------------------|------|
| Location     | Pb Content         | 0.02 |

Table 3. Chlorophyll content in the leaves Tabebuya. (n=3)

| Area          | Mean of Chlorophyll | Standard Deviation |
|---------------|---------------------|--------------------|
| Diponegoro Street | 13.18            | 1.89               |
| Darmo Street  | 12.89              | 2.96               |
| Ir Soekarno Street | 14.94           | 4.99               |

Table 4. ANOVA result of location Tabebuya with chlorophyll content in the leaves.

| Source       | Dependent variable | Sign |
|--------------|--------------------|------|
| Location     | Chlorophyll Content | 0.75 |

Table 5. Abiotic Factor

| Area          | Air Humidity | Air Temperature | Light Intensity (lux) |
|---------------|--------------|-----------------|-----------------------|
| Diponegoro Street | 58.33±1.154701 | 32.3±0.01 | 8266.67±12 12.32 |
| Darmo Street  | 54.66±1.154701 | 34.5±0.01 | 7313.33 704.65 |
| Ir Soekarno Street | 48.66±2.886751 | 36.00±0.0 | 6762.33±3004.78 |

Table 2, the results of ANOVA analysis for Pb content in leaves from various locations, showed that the location affected the Pb metal content in the leaves.
The stomata gap and settle in it, and accumulate between the gaps in the palisade tissue. Based on the National Ambient Air Quality Standards (NAAQS), the standard of Pb content in the air was equal to 0.15 g/m³ while the Pb content in Surabaya for particular matter (PM2.5-10) was 0.27 g/m³. However, the quality standard established by the Indonesian Government Regulation 41 in 1999 for Pb was 2 g/m² (24 hours) or 1 g/m³ (12 hours). This is also related with physical and chemical environmental factors. Table 5 show that air humidity of 48.66-58.33% is included in the humid air category, air temperature ranges between 32.01-36.00°C including optimum temperature to maximum. This is also supported by environmental physical and chemical factors. According to Dewanti (2012) The optimum temperature value ranges from 30°C while the maximum temperature is 40°C. The light intensity value obtained is 6762.33-8266.67 Lux which is classified as low intensity, this is because the optimum value of light intensity ranges from ±32,000 Lux according [15], the higher the light intensity and temperature, the higher the photosynthesis process. So it can be said that the physical and chemical factors of the environment are still in good condition so they can support the Tabebuya plant growth process. Judging from the potential of plants to absorb lead (Pb) and leaf chlorophyll content. And it is expected to be more effectively used as an absorbent of lead (Pb) in the air, so that it can be used to reduce pollution.

Conclusion for this research show that the location of plants affected the level of Pb heavy metal in leaves, but the location of plants did not affect the chlorophyll level in of leaves.

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