

The Role Of Plants In Controlling Air Quality: Case Study Of Jakarta

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Abstract: Jakarta City has been experiencing disturbance in air quality lately due to high pollution, which has exceeded the amount of threshold allowed. Data obtained shows that 70 – 80% of air pollution in the city is caused by moving sources originating from vehicles, which emits hydrocarbon and lead. Polycyclic Aromatic Hydrocarbons (PAH) is one of the aromatic hydrocarbon compounds with the ability to cause cancer, while lead is allegedly able to reduce IQ levels of children up to 5 (five) years. Therefore, considering the health hazards caused by these pollutants, it is essential to reduce its spread in the environment. One outstanding technique used to achieve this is planting with the subsystems of urban ecosystems, which is often seen as a decorative element of landscape, with aesthetic dominating this role. Living things, especially trees, are bio-indicators, known to be capable of reducing air pollution, both in the form of gas and particles while responding differently to the environment. Plants response to an environment is ameliorated or treated, with a balance to the metabolic system in a potentially toxic concentration condition. This study shows plants ability to absorb particles through leaves, thereby, making it able to take up roles in controlling air quality in urban areas and as a bioindicator of air pollution. It was carried out experimentally using a *simple random sampling* method with the analysis unit in the form of leaves from beautiful Mahogany and Fiddle-leaf Fig trees, while the wet destruction method (*Wet Methods*).

Keywords: Absorb and Adsorb, Bioindicator, Hydrocarbon and Lead, Role of plants , Environmental health, Ficus Tree Sp, Mahoni Tree sp

1. INTRODUCTION

Air pollution caused by moving and non-moving sources is a problem associated with environmental health. It is a condition where the air contains one or more chemicals in high concentration, thereby causing disturbance to humans, animals, plants, property, and the environment as a whole [1]. Air is an essential factor for life, therefore, a decrease in its quality due to pollution has various impacts depending on the types of pollutants, its concentration, and the environmental condition. Studies show that the level of emissions is increasing at the intersection area because many vehicles tend to stop, or traffic jams occur [2]. However, there are low temporal fluctuations in air pollutant concentrations during daytime with an increase at night till early in the morning [3]. This is because the pollutants in the form of air particles settle due to lower temperature change, with its characteristics soluble in water [4]. According to the air quality index (AQI) in 2018, the annual average concentration of PM 2.5 in Jakarta city was 42.42 micrograms per cubic meter, and 57.66 on January 1 – June 4, 2019, therefore, its air quality was ascertained low[5]. However, the Central Bureau of Statistics, stated that the primary source of poor air quality is moving vehicles, increased annually by 35%/year [6]. Therefore, to reduce this exposure rate, it is necessary to have trees that function as absorbers and adsorbers of air pollutants produced by motor vehicles.

2 THE ROLE OF PLANTS

2.1 Absorbing and adsorbing the pollutants

The pollutants based on physical and chemical characteristics are stable and labile. The absorbing process in plants is carried out due to the movement of the stoma or leaf mouth, and the adsorption by trichomes (spines or leaf hair). Stable pollutants with a smaller diameter (PM₁₀) are absorbed and accumulated during the opening and closing process of the stoma thereby, providing the old leaves with heavy metal contents. Furthermore, accumulation occurs due to the operation of plant resistance mechanisms against environmental toxicity [7]. Pollutants with diameters larger than PM₁₀ are adsorbed in the outer structure of the leaves which are the trichomes (hair or leaf spines). Those attached to the

trichomes are washed when exposed to water and deposited on the ground in such a way that the concentration is sometimes stable at the roots than in the leaves [4]. Several studies state that street trees tend to absorb materials containing lead and carbon, with the Angsana tree (*Pterocarpus indicus*) Co absorption rate amounting to 6.2 tons/year [8]. It also absorbs Pb (Lead) as much as 220.8µg/g, while that of the Glodogan tree (*Polyaltea longifolia*) is 208.2 µg/g [9]. Other trees, which cover crops trees such as Elephant grass (*Axonopus cupresus*) also absorb pollutants in the form of lead, which ranges between 1.12 – 12.38 µg/g [10]. In addition to Angsana and Glodogan trees, Mahoni and Fiddle-leaf Fig (*Ficus*) are also known to absorb pollutants containing lead and PAH. The leaves of the *Ficus* tree are greater in absorbing lead compared to the Mahoni tree, while the old and young leaves of the *Ficus* tree absorbed more lead with a greater amount of PAH [11]. These conditions show that the trees, especially the ones located on the street with crowded traffic, should be pruned as often as possible for the accelerated growth of young leaf to grow and help in the control of air quality in urban areas.

2.2 Bioindicator

One way to monitor air pollution is by using plants. Their vegetative organs have an important function as bioindicators in leaves which are historically composed of several cells and tissues. The epidermis is an example of cells that protects weak and easily damaged tissues. It consists of stomata (leaf mouths) and additional structures massively known as trichomes (hair or leaf spines). In woody plants, stomata are only found on the leaf surface, while in herbaceous, they are found on both young twigs, and stems. The ability of plants to reduce pollutant materials is technically influenced by its architectural structure, planting patterns, characteristics of the pollutant source, and non-technical aspects, which include anatomy, physiology, and taxonomy [4]. Some experiments previously carried out show that leaves with wider and rough surfaces, have a high effectiveness value in adsorbing particles [11]. This also affects the sensitivity level of each plant to adapt to the environment and its ability to absorb and accumulate heavy metals, thereby making it the most sensitive bioindicators pollution [12]. The tolerance limit for heavy metals in the human's body is 100 – 120 ug/dl, and 1000 ppm

($\mu\text{g/g}$) in plants [13].

2.3. Mahoni and Fiddle-leaf Fig (Ficus) Trees

Mahoni and Ficus are the most widely used plants as greening trees in various areas of DKI Jakarta. Since the colonial times, the mahoni tree have been used as road trees, as seen in old parks in Jakarta such as Suropati Park, in contrast to Ficus, which was only planted in DKI around the 70s. Mahoni and Ficus are road trees that easily grow in infertile and unfavorable environments. They are in accordance with the criteria of plants used as shade, in absorbing pollution, breaking down wind, and conservation (storing water). Criteria for plants used as air pollution absorbers include [4]:

- Has a deep, strong root, and is not easy to collapse.
- Able to grow in many physical disorders.
- Able to grow in any type of soil condition.
- Does not need intensive care
- Fast growth
- Has low evapotranspiration

Architecturally Mahoni trees have the following characteristics:

Mahoni Tree Morphology:

- It is a big tree
- Height can reach 35-40 m
- Maximum tree diameter of 125 cm.
- Has taproots

Tree Distribution:

- Derived from the West Indies
- Its distribution includes Sri Lanka, India, Sarawak and Fiji
- Entered Indonesia in 1872 through India
- Grew rapidly on Java from 1892-1902 and till now.

Distribution of Mahoni Trees:

- Grow wild in Thick Forest
- On the beach or brackish sand
- On the edge of the road as a protective tree

Benefits of Mahoni Tree:

- Reduces air pollution by 47% -69%
- Protective tree
- Air filter trees and catchments
- The leaves are responsible for absorbing pollutants around it.
- When it rains, its roots bind falling water, thereby, making it a water reserve.

Properties of trees:

- Can survive in arid land.
- Tree wood has a high economic value.
- Its tree bark is used for coloring clothes
- Tree sap can be used as raw material for glue
- Leaves of trees are used for animal feed.
- Mahogany tree seeds are used as vegetable pesticides, on Cabbage plants.

While the Ficus tree has the following characteristics:

Morphology of the Ficus Tree

- Is a tree with a taproot root.
- Grows under any conditions.

- Has a tree height of 20-30 m.
- Woody stems with cylindrical shapes.
- The root of the tree hangs from the stem.
- The leaves of the tree are single leaves..
- The length of leaves is around 10-15 cm, width of 5-7 cm.
- Has a hanging root which it uses to absorb air
- Its roots are strong to support the body.
- Head like a tree
- Single leaf type

Distribution:

- Tropical plants.
- Grows in the highlands and lowlands
- Original trees from Asia, Malaysia, Australia and several other Pacific regions.
- Fast tree growth to various locations in Indonesia
- Tree wood is used for various products

Properties of trees:

- Survives in arid land.
- Tree wood has a high economic value.
- Leaves of trees for animal feed.

Mahoni (*Swietenia mahagoni*) and Fiddle-leaf Fig (*Ficus Pandurata*) are trees widely planted in streets in Jakarta City. Mahoni leaves have a smooth surface and are small, while Ficus leaves are hairy and wide. However, both are long-lived plants capable of existing till the age of 50. Architecturally, it has an irregular canopy, and histology leaves with stomata only on the lower surface amounting to approximately 335/mm², while that of the Ficus tree which is approximately 200/mm² is found at its lower part [11].

3 HYDROCARBON AND LEAD

Hydrocarbons are aromatic compounds consisting of carbon and hydrogen atoms one of which is Polycyclic Aromatic Hydrocarbons (PAH). Its derivatives are in the form of stable substances, with a high boiling point, lighter density, insoluble in water, flammable, and carcinogenic [14]. Lead is a heavy metal that is soft and slightly soluble in water. However, at high temperature or in the presence of light, it breaks down into heavy metal and organic substances and is emitted into the air as lead salt.

4 ENVIRONMENTAL HEALTH

Jakarta, the country's capital city, continues to grow in all fields. Its development in an increasingly complex city has various impacts on environmental health. Elements such as clean water, air, and green open space are getting more limited due to pollution. Adequate management of the health of the urban environment is carried out through a node theory approach, as seen in the picture below. The four nodes are as follows [15]:

1. Node A is a source of various diseases and poisons both from nature and human with the potential to cause public or environmental health problems.
2. Node B is an intermediary medium, in the form of environmental components such as air, water, soil, food, drinks, insects, or vectors.
3. Node C shows a group of people in a healthy condition and exposed to various components of the environment that are at risk of entering the body, such as in blood, fat,

etc.

- Node D impacts on health experienced by healthy, vague, subclinical, or acute humans.

Node theory is used as a platform in identifying and anticipating the impacts.



Fig. 1. Node theory simul

5. RESULTS OF THE STUDY

5.1 The Research Method

The level of pollutants that were successfully absorbed and adsorbed by the leaves is determined by analyzing young and old leaves in the upper, middle, and lower parts. This study was conducted experimentally using the *simple random sampling* method. The measurement was carried out on Jalan Hangtuah Raya, Kyai Maja and Sisingamangaraja Kebayoran Baru, South Jakarta. It utilized *High Volume Dust Sampler* (HVDS), analyzed using *Atomic Absorption Spectrophotometer* (AAS), and *Gas Chromatography* (GS) instruments using the wet destruction method. The wet destruction method is the process of reforming organic metals using both single, mixed, and strong acids with an oxidizing agent to produce free inorganic metals [4].

5.2 Results of the Study

The analysis results show that Ficus and Mahoni leaves absorb and adsorb pollutants. The absorption of lead by the Ficus leaf (25.5 ppm) was greater than Mahoni (22.5 ppm) [4]. The Ficus tree has an appropriate branching and leaf mass, thereby, making it easy to capture more lead. In addition, heavy metals have a greater density than air. Therefore, their presence tends to be above the surface and the spread of lead close to the source. Ficus tree has a lower height than the Mahoni tree. It absorbs more lead because its leaves have a position closer to pollutant sources. Besides, its shape resembles a hairy cup which causes it to keep much more water, thereby making it moister and the preferred medium. The absorption of PAH by Mahoni leaves (0.40 ppm) is greater than Ficus (0.31 ppm) [4]. Mahoni leaves have the shape of a sickle and are slippery therefore, water quickly falls to the surface of the ground, resulting in the leaves drying faster. This condition, therefore, makes this non-polar medium the preferred technique used by PAH[4]. The description above shows that trees are needed to control air quality diversity and

strata due to the different behavior of each pollutant. The figure below shows the physical forms of leaves of Ficus and Mahoni trees and their planting proposal.



Fig. 2. Leaves of Mahoni tree (*Swietenia mahagoni*)



Fig. 3. Leaves of Fiddle-leaf Fig Tree (*Ficus pandurata*)



Fig. 4. Fiddle-leaf Fig tree (*Ficus pandurata*)



Fig. 5. Mahoni tree (*Swietenia mahagoni*)

6. CONCLUSION

All along, plants have only been seen as a decorative element with the domination of the its aesthetic region. However, various studies on its role in controlling air quality in urban areas have been carried out, which shows its ability to absorb and adsorb air pollutants in the form of particles. The responsiveness of plants to pollutants is carried out in various ways, and the species which are highly resistant to toxins are found to experience more than one response in overcoming environmental conditions. Leaves are important organs of plants with an important function and capable of being used as a bioindicator to the environment. The absorption and adsorption of pollutants in leaves are not only influenced by the shape of leaf morphology but also by its behavior. Water-soluble lead is known to be absorbed by the leaves of Fiddle-leaf fig tree (*Ficus pandurata*), which has wide leaf and resembles a cup, thereby, making it wet. While the leaves of the Mahoni tree with a smaller and smoother surface easily drain water, thereby, making the drier condition of the leaves the preferred medium by PAH. Plant are arranged in a structured way, thereby making it able to absorb both gas and particle pollutants. Therefore, environmental management is carried out using the health node approach. Also pollutant sources in the environment (node B), is prevented or reduced using trees with high responsiveness to pollutants entering the human body (node C).

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