Six tree species physiological responses to air pollution in Pulogadung Industrial Estate, East Jakarta, Indonesia and Universitas Indonesia Campus, Depok, Indonesia

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ABSTRACT

Air pollution is a global issue that has a harmful impact on living things and the environment. It is commonly recognized that bioremediation, including the use of tree plants, helps reduce air pollution. Tree plants can respond physically to air pollution. The value of the air pollution tolerance index (APTI) can be used to determine the physiological response. Based on APTI values, this study seeks to determine the tolerance levels and physiological response differences of six tree plant species (*Mangifera indica*, *Pterocarpus indicus*, *Cerbera odollam*, *Pometia pinnata*, *Syzygium myrtifolium*, and *Swietenia macrophylla*) in Pulogadung Industrial Estate, East Jakarta and Universitas Indonesia (UI) Campus, Depok. Environmental factors and APTI values with relative water content parameters, leaf extract pH, ascorbic acid content, and total chlorophyll content were measured in six kinds of tree plants at both research sites. The maximum APTI score in the Pulogadung Industrial Estate was 9.79 0.13, indicating that *Mangifera indica* plants are air pollution tolerant. Meanwhile, *Pterocarpus indicus* is classified as sensitive to air pollution, with the lowest APTI score of 6.59 0.18 at the UI Campus, Depok. The APTI test results revealed that tolerant species had high relative water content (RWC) values and ascorbic acid concentration, whereas sensitive species had low RWC values and poor total chlorophyll content.

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1. INTRODUCTION

Air pollution is a global issue that affects human and other living creatures' health, ecosystem health, climate, visibility, and man-made materials [1]. In Indonesia, motor vehicle emissions account for 60-70% of air pollution, industrial emissions account for 10-15%, and home activity emissions, rubbish burning, and forest fires account for the remainder [2]. According to the Ministry of Environment and Forests, gasoline-powered automobiles emit 70% carbon monoxide (CO), 100% lead (Pb), 60% hydrocarbons (HC), and 60% nitrogen oxides (NOx) [3]. In addition to emissions from motor vehicles, industrial operations contribute to greenhouse gas emissions through the combustion of fossil fuels and chemical processes in the manufacture of materials [4].

Bioremediation is one method that can be utilized to lessen atmospheric pollution. Plants, also known as phytoremediators, are one type of organism that can lower the amount of pollutants in the environment [5]. Plants play an important part in the monitoring and maintenance of the balance of ecosystems in the nutrient and gas cycle. In addition, plants provide leaves as an area of absorption and accumulation of air pollutants, which helps to reduce the overall levels of air pollution in the environment [6]. Changes in a plant's physiology and biochemistry can be brought on by the introduction of contaminants into its tissue [7], [8].

The air pollution tolerance index shows that some plant species can survive in polluted environments (APTI). The index is used to assess plant tolerance to air pollution [9]. Manjunath and Reddy [10] define ascorbic acid content, total chlorophyll content, relative water content, and leaf extract pH as APTI parameters. It is critical to understand how plants are classified as tolerant or sensitive because sensitive plant species can be used as bioindicators and tolerant plant species can act as a sink for air pollutants [11].

APTI research has been widely conducted in several countries, including India, in industrial and roadside areas [12]. One APTI study in industrial estates as a polluting site and control site in Bengaluru, India found no significant difference in APTI values in either location. All plant species are vulnerable to air pollution [10]. Meanwhile, APTI research in Indonesia, conducted in the industrial area of PT Krakatau Industrial Estate Cilegon (KIEC), Cilegon, Banten as a polluted site and a citizen's house as a control site, reveals a very significant difference in tolerance levels between *Polyalthia fragrans* and *Swietenia mahagoni*. *Polyalthia fragrans* was discovered to be a sensitive species, whereas *Swietenia mahagoni* is air pollutant tolerant [13]. Meanwhile, the results of an APTI study in Sidoarjo revealed that polluted locations had higher APTI *Pterocarpus indicus* and *Syzygium oleana* values than control locations. Because plants grow in areas near highways, it is suspected that they can defend against air pollution, which is supported by physiological parameters such as pH, ascorbic acid, water content, or high chlorophyll [14].

DKI Jakarta Province has one of the industrial areas in East Jakarta, namely Pulogadung Industrial Estate, which is managed by PT Jakarta Industrial Estate Pulogadung (JIEP) and has a land area of 500.00 ha. Green Campus refers to the Universitas Indonesia (UI) Campus, Depok, West Java. It is known that up to 75% of the campus area of 320 ha is used as a green area in the form of an urban forest. The function of trees planted along the roadside as a form of greening and shade is used in the Pulogadung Industrial Estate in East Jakarta and the UI Campus, Depok. Six tree plant species are common at both sites, including *Mangifera indica, Pterocarpus indicus, Cerbera odollam, Pometia pinnata, Syzygium myrtifolium*, and *Swietenia macrophylla*.

Pulogadung Industrial Estate in East Jakarta is one of the areas known to be heavily polluted by pollutants emitted by both motor vehicles and factories. Unlike the industrial area, UI Campus, Depok has a larger greening area than the industrial area. Because of these differences, the two were chosen as the location of the comparison. The purpose of this study was to determine the tolerance levels and physiological response differences of six tree plant species (*Mangifera indica*, *Pterocarpus indicus*, *Cerbera odollam, Pometia pinnata, Syzygium myrtifolium*, and *Swietenia macrophylla*) in the Pulogadung Industrial Estate in East Jakarta and the UI Campus, Depok against air pollution checks based on APTI values. Because the Pulogadung Industrial Estate is more likely to be polluted, plants in that area are expected to have a higher APTI value. The study's findings, in the form of APTI values, are expected to serve as the foundation for considering the selection of tree plant species to reduce the impact of air pollution in an environment.

2. RESEARCH METHOD

2.1. Study area and period

The study took environmental data and sampling of six species of tree plants was conducted in two different locations. The first location is in the Pulogadung Industrial Estate managed by PT. JIEP, East Jakarta, see Figure 1. The second location is on the Outer Ring Road of UI Campus, Depok (directions from FKM UI to FMIPA UI), see Figure 2. Soil pH measurement and test of physiological parameters of APTI were conducted in the Laboratory of the Department of Biology, Faculty of Mathematics and Natural Sciences University of Indonesia (FMIPA UI). The study was conducted for 2 months, starting from October–November 2021.

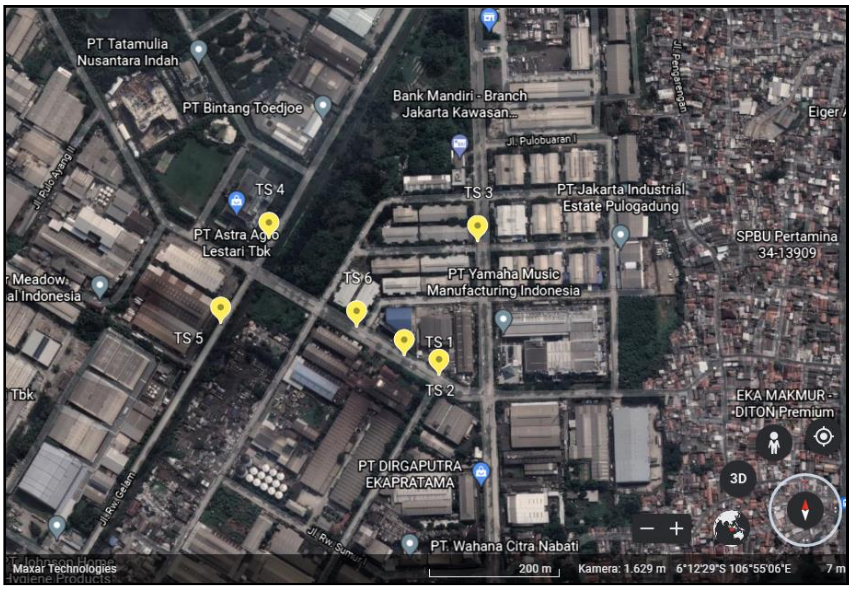

Figure 1. The study location at Pulogadung Industrial Estate, East Jakarta with six sampling points

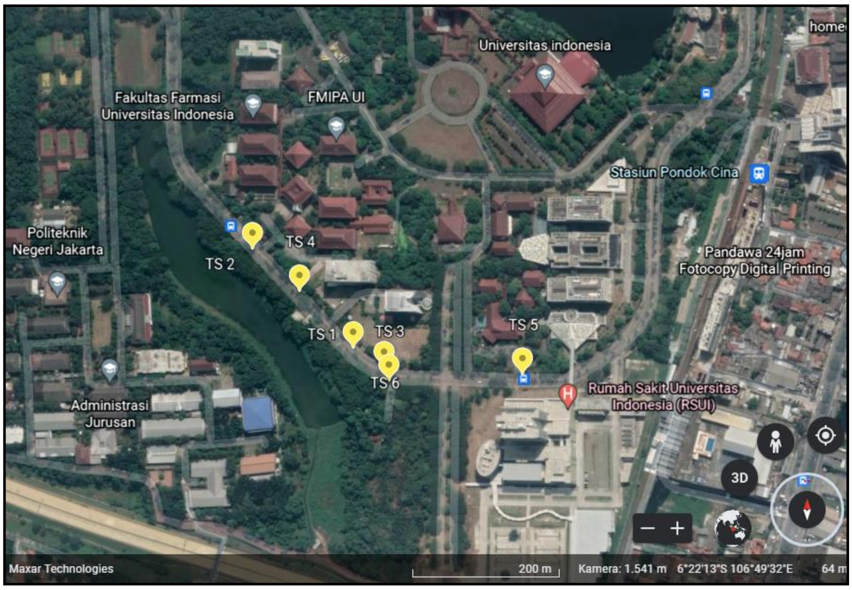

Figure 2. The study location in outer ring road of UI Campus, Depok with six sampling points

2.2. Environmental data retrieval

Measurements of temperature and relative humidity of the air are measured in both locations using a hygrometer in October (from the day of sampling) to November 2021 in the morning around 07.00-08.00 WIB. Air pollutant data from October to November 2021 in the morning at 07.00 WIB, noon at 12.00 WIB, and afternoon at 17.00 WIB obtained from the ISPUnet application developed by The Ministry of Environment and Forestry.

2.3. Plant collection and preparation of extract

Fresh leaf samples were taken from 6 species found in both locations, namely *Mangifera indica*, *Pterocarpus indicus*, *Cerbera odollam*, *Pometia pinnata*, *Syzygium myrtifolium*, and *Swietenia macrophylla*. Each species consists of 1 individual and collected as many as three samples (3 different branches). Leaf samples were taken from trees with a height of at least 1.5 m above ground and have been on site for two years [15]. In addition, the leaves face directly the sun and the road passed by motor vehicles [16]. The sample leaves are then put in a zip lock, labeled, and stored in a cool box filled with ice gel.

Leaf samples are taken to the laboratory, directly cleaned with a wet foam sponge, and then dried with a dry foam sponge. Next, the leaves are weighed according to the required weight on each test. The weighed leaves are then folded into aluminum foil and put in a zip lock, then stored in a freezer at −20 °C. The leaves used for the relative water content (RWC) test and the leaf extract pH are directly worked on.

2.4. Soil pH measurement

Soil composite samples were taken from a depth of 0–15 cm using a spoon of three repetitions at the study site (three different sampling points in the same location). Soil samples are taken to the laboratory and then filtered using a 2 mm mesh sieve. The filtered soil sample is dredged on A4 paper for further pH measurements. The pH measurement is done by mixing a soil sample with distilled water with a weight ratio (of 1:2.5). The pH of the mixture is measured using a digital pH meter. The pH measurement is performed for the entire sample replay [17].

2.5. Biochemical parameters

2.5.1. Relative water content (RWC)

RWC measurements were carried out using the method by [8] with modifications to the weight of fresh leaves and the temperature of the oven used. A total of 5 g of prepared leaves are used as fresh weight. Next, the leaves are soaked with distilled water for 24 hours. After that, the leaves are dried again using a dry foam sponge and re-weighed to gain a turgid weight. Sample the leaves in turgid conditions, then stored them in an envelope that has been labeled to be dried using the oven at a temperature of 60 °C until it gets a constant dry weight.

2.5.2. Leaf extract pH

The method of determining the pH of leaf extract in plants is based on methods conducted by [18] with modifications to the use of digital pH meters. A total of 5 g of samples of prepared leaves are ground with a pestle and mortar and added 50 mL of distilled water was until homogeneous. The homogenate is filtered using filter paper into a 100 mL Erlenmeyer flask. Next, the extract of the filter is transferred into a 100 mL beaker glass and measured with a digital pH meter. PH examination of sample extract is also carried out using universal pH indicator paper as confirmation.

2.5.3. Ascorbic acid content

The method of determining the content of ascorbic acid in plants is based on the volumetric analysis method [19]. Before making a sample solution, a blank solution is made in advance for titration. The blank solution is made by titrating 5 mL of standard solution (working solution) that has been added with 10 mL of oxalic acid 4% with dye solution until the color of the solution in the Erlenmeyer flask becomes exactly pink and obtained V_1.

The sample solution is made by grounding 0.5 g of leaf samples with a pestle and mortar while adding 100 mL of oxalic acid 4% using a pipette, then homogenized using a stirring rod. Next, the extraction results are put into a 15 mL centrifugation tube and centrifuged at a speed of 2500 rpm for 3 minutes. After that, the supernatant is picked up as much as 5 mL and then poured into an Erlenmeyer flask 100 mL, and added with 10 mL of oxalic acid 4%. Next, the sample solution is titrated with a dye solution until the color of the sample solution in Erlenmeyer becomes exactly pink and is obtained as a V_2 value.

2.5.4. Total chlorophyll content

The method of determining the total chlorophyll content in plants is based on methods from [10]. A total of 0.5 g of leaf samples are ground with a pestle and mortar and added 10 mL of 80% acetone was until homogeneous. The extraction results are taken using a pipette and then put into a 15 mL centrifugation tube and then centrifuged at a speed of 2500 rpm for 3 minutes. After that, the supernatant is picked up and put into a 10 mL measuring cup to be measured as the final volume of the supernatant. After the volume is recorded, the supernatant is picked back and inserted into the cuvette for absorption value measurements with a spectrophotometer at wavelengths of 645 nm and 663 nm.

2.6. Data analysis

The entire fresh weight, turgid weight, and dry weight of the leaf sample are then included in the RWC calculation formula by [8] as (1).

$$RWC = \frac{FW-DW}{TW-DW} \times 100 \quad (1)$$

Where the FW value indicates the fresh weight of the leaves (g), the TW indicates the turgid weight of the leaves (g), and DW indicates the dry weight of the leaves (g).

The value of the volume of the blank titration and the sample read on the burette is then entered into the calculation formula of ascorbic acid (mg/100 g sample) according to [19] as (2).

$$Ascorbic\ acid\ \left(\frac{mg}{100\ g\ sample}\right) = \frac{0.5\ mg}{V_1 mL} \times \frac{V_2}{5\ mL} \times \frac{100\ mL}{Sample\ weight} \times 100 \tag{2}$$

Where the V_1 value indicates the volume of the blank (mL) and V_2 indicates the volume of the sample (mL).

The value of the final volume of supernatant and the absorbance value read on the spectrophotometer are then entered into the total chlorophyll calculation formula according to [20] as (3).

$$Chlorophyll\ a\left(\frac{mg}{g}\right) = (12.7\ D_{663} - 2.69\ D_{645}) \times \frac{V}{1000 \times W}$$
$$Chlorophyll\ b\left(\frac{mg}{g}\right) = (22.9\ D_{645} - 4.68\ D_{663}) \times \frac{V}{1000 \times W}$$
$$Total\ Chlorophyll\ \left(\frac{mg}{g}\right) = Chlorophyll\ a + chlorophyll\ b; (20.2\ D_{645} + 8.02\ \ D_{645}) \tag{3}$$

Where the D_{645} value indicates the absorbance value at a wavelength of 645 nm, D_{663} indicates the absorbance value at a wavelength of 663 nm, V indicates the final volume of supernatant (mL), and W indicates the weight of the leaf (g).

All the values of the four parameters are entered into the APTI index calculation formula according to [21] as (4).

$$APTI = \frac{A(T+P)+R}{10} \tag{4}$$

Where A indicates ascorbic acid (mg/100 g sample), T indicates total chlorophyll (mg/g), P indicates leaf extract pH, and R indicates relative water content (%). Furthermore, six plant species were categorized as tree plants with sensitive or tolerant category values to air pollution based on APTI index values, see Table 1. All data were analyzed by looking at the height difference and low results of three times the measurement of all APTI tests from the same individual in six species of tree plants in Pulogadung Industrial Estate, East Jakarta and UI Campus, Depok.

Table 1. Categorization of sensitivity/tolerance of tree plants to air pollution based on APTI [22]

APTI value	Category
APTI>mean APTI + SD	Tolerant
mean APTI<APTI<mean APTI + SD	Moderately tolerant
mean APTI−SD<APTI<mean APTI	Intermediate
APTI<mean APTI−SD	Sensitive

3. RESULTS AND DISCUSSION

3.1. Environmental conditions at two research sites and their effect on tree plant physiological

3.1.1. Air temperature and relative humidity

The results of measurements of the temperature and relative humidity of the air in Pulogadung Industrial Estate, East Jakarta show fluctuating air temperature figures. The highest air temperature occurred in the 4th week (November 17, 2021) which was 32.9 °C and the lowest in the 3rd week (November 10, 2021) was 26.4 °C. The relative humidity of the air from the 3rd week tends to decrease and reach the lowest relative humidity in the 5th week (November 24, 2021) which is 47% as shown in Table 2.

The results of the measurement of the temperature and relative humidity of the air at UI Campus, Depok showed the lowest air temperature figure of 28.6 °C in the 1st week (October 28, 2021) and differently on the last day of measurement (November 25, 2021) showed the highest temperature figure of 34.3 °C. In addition, the highest relative humidity occurred in week 1 at 67% and the lowest in week 5 was 42% as shown in Table 2.

Table 2. Air temperature and relative humidity in Pulogadung Industrial Estate, East Jakarta and UI Campus, Depok for five weeks the end of October to the end of November 2021 at 07.00-08.00 WIB

Week-	Air temperature (°C)		Relative humidity (%)	
	Pulogadung Industrial Estate	UI Campus, Depok	Pulogadung Industrial Estate	UI Campus, Depok
1	28.8	28.6	64	67
2	31.5	29.4	64	59
3	26.4	30.1	57	57
4	32.9	29.6	53	50
5	29.6	34.3	47	42

Based on observations for five weeks (October-November 2021), Pulogadung Industrial Estate, East Jakarta has an average air temperature that tends to be higher than at UI Campus, Depok. This is due to the geographical and meteorological conditions of the two different locations. In addition, the existence of factory activities and the number of vehicles passing through Pulogadung Industrial Estate, East Jakarta is higher so the air temperature in the environment also increases. Plants in both locations belong to high-level plants with tree habitus. High-level plants belong to the mesophile category, i.e. can live at optimum temperatures between 10 °C and 30 °C [23]. Thus, six species of tree plants in both locations can live and adapt to environmental temperatures with that category.

Relative humidity and air temperature affect the rate of transpiration of plants. Very high relative humidity can reduce the rate of plant transpiration [23]. It is known that the relative humidity figures in Pulogadung Industrial Estate, East Jakarta and UI Campus, Depok for five weeks have a value that does not differ much, which is in the range of 40-70%. In general, the relative humidity of air in Indonesia is higher, ranging from 70-90%. Thus, six species of tree plants in both locations can carry out the transpiration process normally under these conditions of relative humidity.

3.1.2. Soil pH

The average soil pH at both research sites shows that the soil pH in Pulogadung Industrial Estate is higher compared to the UI Campus, Depok. Pulogadung Industrial Estate, East Jakarta has an average pH value of 8.46 ± 0.17 which means that the land in the location is alkaline. Meanwhile, UI Campus, Depok has acidic soil with an average pH value of 6.00 ± 0.49 as shown in Table 3.

Table 3. Soil pH and soil pH average on the roadside Pulogadung Industrial Estate, East Jakarta and UI Campus, Depok

Location (site-)	pH	
	Pulogadung Industrial Estate	UI Campus, Depok
1	8.59	6.56
2	8.27	5.66
3	8.51	5.79
Soil pH average	8.46 ± 0.17	6.00 ± 0.49

The concentration of hydrogen ions (pH) is an important property in the soil, as it affects the growth of plant roots and the presence of soil microorganisms. Good root growth can occur in slightly acidic soils with a pH value between 5.5 and 6.5. In addition, soil pH also determines the availability of nutrients in the soil [24]. It is known that the pH of the soil in Pulogadung Industrial Estate, East Jakarta has alkaline soil while the soil at UI Campus, Depok is acidic. This indicates that the nature of the soil at UI Campus, Depok is better to support the life and physiological processes of tree plants.

3.1.3. Air pollutants

The results of the average calculation in October 2021 showed that there was a difference in pollutant numbers between Jakarta and Depok. The highest $PM_{2.5}$ figure is in Jakarta at 82, while the lowest $PM_{2.5}$ number is in Depok at 25. PM_{10} and gaseous pollutants such as CO, HC, NO_2, O_3, and SO_2 in both locations are in the range of 0-50 as shown in Table 4. $PM_{2.5}$ index figures in Jakarta have a value in the range of 51-100 indicating that air quality in Jakarta belongs to the moderate category. Unlike Depok which belongs to the category of good air quality with pollutant numbers in the range of 0-50 as shown in Table 5.

In contrast, the results of the average calculation in November 2021 showed that the highest $PM_{2.5}$ number was in Depok at 67, while the $PM_{2.5}$ number in Jakarta had a value of 54. Similar to the data in the previous month, PM_{10} and gaseous pollutants such as CO, HC, NO_2, O_3, and SO_2 in both locations were in the range of 0-50 (Table 4). $PM_{2.5}$ index figures in both locations in the range of 51-100 indicate moderate air quality in November 2021 (Table 5).

Table 4. Average total pollutant figures at Jakarta and Depok stations in ISPUnet application in October and November 2021 at 07.00, 12.00, and 17.00 WIB

Pollutants	Average total pollutant concentration			
	October 2021		November 2021	
	Jakarta	Depok	Jakarta	Depok
$PM_{2.5}$	82	25	54	67
PM_{10}	39	39	23	26
CO	17	7	29	24
HC	0	0	23	8
NO_2	29	0	13	18
O_3	8	0	2	5
SO_2	7	22	3	13

Table 5. Categorization of air pollutant index figures in ISPUnet applications with references to ISPUnet (2021)

Air pollutant index	Air quality
0-50	Good
51-100	Moderate
101-200	Unhealthy
201-300	Very unhealthy
≥301	Hazardous

Pollutants in the air such as SO_2, NO_2, CO, HC, and PM significantly affect the biochemical and physiological processes of plants in Pulogadung Industrial Estate, East Jakarta and UI Campus, Depok. Pollutants such as SO_2 and NO_2 that enter the leaves through stomata can interfere with the process of photosynthesis in plants. Some other cases found that plants exposed to SO_2 will experience stomata closure. CO is also known to have some effects, one of which can damage plant cell membranes [25].

3.2. APTI biochemical parameter value of six tree plant species at two research sites

3.2.1. Relative water content (RWC) value

Figure 3 shows the average value of APTI biochemical parameter of six tree plant species at Pulogadung Industrial Estate, East Jakarta and UI Campus, Depok. Based on the analysis of RWC results according to species trends, it is known that *Mangifera indica* plants have the highest RWC value. According to location trends, plants in Pulogadung Industrial Estate, East Jakarta have a higher RWC value than plants at UI Campus, Depok. *Mangifera indica* species in Pulogadung Industrial Estate, East Jakarta has the highest RWC value of 96.95% ± 0.86. Meanwhile, the highest RWC value at UI Campus, Depok is found in the species *Cerbera odollam* with a value of 86.92% ± 4.97 as shown in Figure 3(a).

High RWC in plants indicates that the plant is resistant to drought. High RWC also indicates the ability of the cell membrane to maintain its physiological balance from the stress of air pollution [9]. Pollutants can induce increased permeability in cells causing water loss and dissolved nutrients, resulting in senescence in the leaves. Thus, plants with high RWC under polluted conditions may tend to be tolerant to air pollution [21].

3.2.2. Leaf extract pH value

Based on the analysis of the leaf extract pH results according to species trends, it is known that the *Cerbera odollam* plant has the highest pH value of leaf extract. According to location trends, plants in Pulogadung Industrial Estate, East Jakarta have a higher pH value of leaf extract than plants at UI Campus, Depok. The *Cerbera odollam* species in Pulogadung Industrial Estate, East Jakarta has the highest pH value of leaf extract, which is 7.32 ± 0.52. Then, *Cerbera odollam* at UI Campus, Depok has a higher pH value of leaf extract which is 7.66 ± 0.33 as shown in Figure 3(b).

The process of photosynthesis on the leaves will be disrupted if a plant has a low pH. Plant leaf extracts that have acidic pH will be more susceptible to pollutant contamination, while leaf extracts pH with a value of about 7 tend to be more tolerant to pollutants [9]. The presence of acidic pollutants will cause a decrease in pH and it is known that low pH is more abundant in sensitive plants than tolerant. Thus, plants with high pH levels of leaf extract under polluted conditions can increase the level of tolerance of these plants to air pollution [21].

3.2.3. Ascorbic acid content value

Based on the analysis of ascorbic acid content results according to species trends, it is known that *Mangifera indica* plants have the highest value of ascorbic acid content. According to location trends, plants in Pulogadung Industrial Estate, East Jakarta have a higher value of ascorbic acid content than plants at UI Campus, Depok. The species *Syzygium myrtifolium* in Pulogadung Industrial Estate, East Jakarta has the highest content of ascorbic acid worth 0.15 mg/100 g sample ± 0.00. Unlike at UI Campus, Depok, the highest ascorbic acid content worth 0.16 mg/100 g sample ± 0.07 owned by *Mangifera indica* plant as shown in Figure 3(c).

Ascorbic acid acts as a powerful reducing agent to prevent oxidation, namely the formation of oxidant compounds that are toxic to plants. Ascorbic acid plays an important role in protecting chlorophyll from being damaged by hydrogen peroxide (H_2O_2) compounds. Plants that have a high content of ascorbic acid indicate that the plant is tolerant. Conversely, the low content of ascorbic acid indicates that the plant is sensitive to air pollution [9].

3.2.4. Total chlorophyll content value

Based on the analysis of the results of total chlorophyll content according to species trends, it is known that *Pometia pinnata* plants have the highest total chlorophyll content value. According to location trends, plant species at UI Campus, Depok have a higher total chlorophyll content value than plants in Pulogadung Industrial Estate, East Jakarta. Tree plants in Pulogadung Industrial Estate, East Jakarta with the highest total chlorophyll value of 1.18 mg/g ± 0.15 is *Swietenia macrophylla*. Unlike at UI Campus, Depok, *Pometia pinnata* plants have the highest total chlorophyll content value of 1.27 mg/g ± 0.05 as shown in Figure 3(d).

Plants in stressful conditions of air pollutants will cause changes in the structure of chlorophyll, which leads to morphological, physiological, and biochemical changes in plants. Air pollutant compounds can interfere with or degrade chlorophyll synthesis in the leaves. High total chlorophyll levels in plants indicate that the plant is tolerant to air pollution [9].

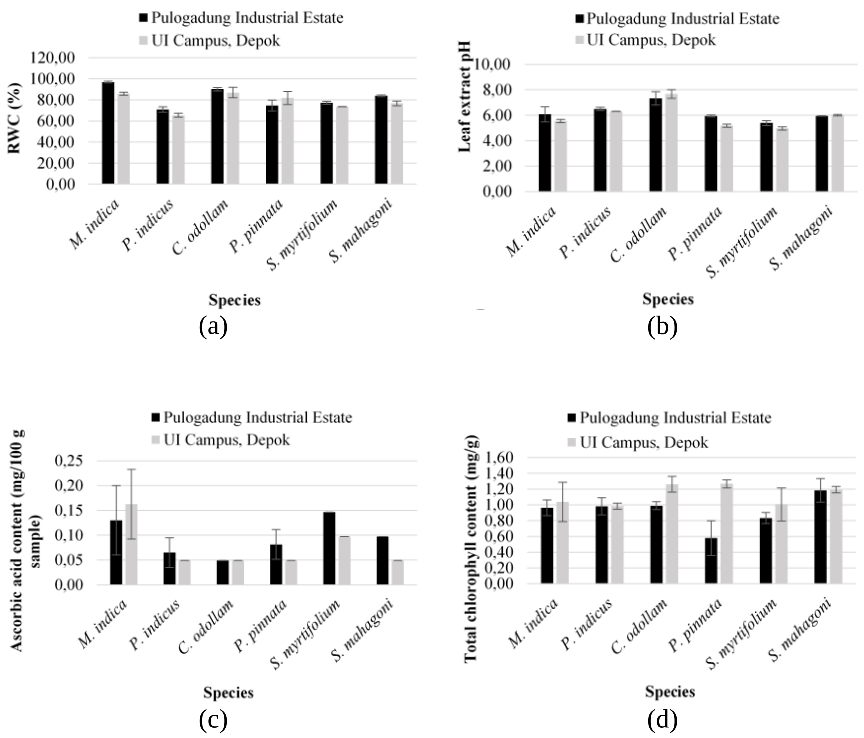

Figure 3. The average value of APTI biochemical parameter of six tree plant species at Pulogadung Industrial Estate, East Jakarta and UI Campus, Depok (a) RWC, (b) leaf extract pH, (c) ascorbic acid content, and (d) total chlorophyll content

3.3. Physiological response of six tree plant species to air pollution based on APTI values

Based on the categorization of tree plant tolerance to air pollution described by Thakar and Mishra [22], it is known that *Mangifera indica* species in both locations fall into the category of plants tolerant to air pollution. Meanwhile, *Pterocarpus indicus* species in both locations fall into the category of plants sensitive to air pollution. In addition, *Syzygium myrtifolium* in both locations falls into the category of intermediate-tolerant plants to air pollution as shown in Table 6.

Based on the analysis of APTI results according to species trends, it is known that *Mangifera indica* plants (category: tolerant) have the highest APTI value, while the species with the lowest APTI is *Pterocarpus indicus* (category: sensitive). According to location trends, plant species in Pulogadung Industrial Estate have a higher APTI value than plants at UI Campus, Depok. However, it was also observed that the *Pometia pinnata* plant at UI Campus, Depok has a higher APTI value compared to Pulogadung Industrial Estate, East Jakarta as shown in Table 6.

Table 6. Average total pollutant figures at Jakarta and Depok stations in ISPUnet application in October and November 2021 at 07.00, 12.00, and 17.00 WIB

Species name	APTI		Category	
	Pulogadung Industrial Estate	UI Campus, Depok	Pulogadung Industrial Estate	UI Campus, Depok
Mangifera indica	9.79 ± 0.13	8.70 ± 0.09	T	T
Pterocarpus indicus	7.14 ± 0.25	6.59 ± 0.18	S	S
Cerbera odollam	9.05 ± 0.15	8.74 ± 0.50	MT	T
Pometia pinnata	7.52 ± 0.51	8.21 ± 0.63	I	MT
Syzygium myrtifolium	7.81 ± 0.15	7.41 ± 0.02	I	I
Swietenia macrophylla	8.47 ± 0.08	7.71 ± 0.22	MT	I

Note: Mean (number of samples = 3) ± standard deviation; S: sensitive; I: intermediate; MT: moderately tolerant; T: tolerant

Each plant species has a different response to air pollution. Some species are tolerant and sensitive to air pollution. The category of tolerant or sensitive plants can be determined by APTI physiological parameters namely RWC, leaf extract pH, ascorbic acid content, and total chlorophyll content [26]. Determination of plants into tolerant or sensitive categories needs to be done because sensitive plant species can be used as bioindicators and tolerant plant species can act as sinks for air pollutants [11].

The *Mangifera indica* plant has the highest RWC value and ascorbic acid content among other species. It is known that the content of ascorbic acid is related to the leaf extract's pH value. Plants with a low leaf extract pH value, generally have a high content of ascorbic acid. Plants that have a high value of ascorbic acid tend to be tolerant to air pollution [9]. It has been reported that *Mangifera indica* can be utilized as a bio-accumulator plant [27]. Bio-accumulator plants are plants that can accumulate air pollutants such as aerosols, dust, and gas molecules into leaf tissue [28].

The *Pterocarpus indicus* plant has the lowest total RWC and total chlorophyll values among other species. It has been reported that plants under the stress conditions of air pollution will experience a decrease in chlorophyll levels in the leaves [9]. In addition, *Pterocarpus indicus* has a fairly high pH value of leaf extract, especially in Pulogadung Industrial Estate. Sensitive plants generally have a higher pH value of leaf extract than tolerant plants. This is based on research that states the pH content of *P. indicus* leaf extract in polluted areas is higher than that of unpolluted areas [29].

4. CONCLUSION

To conclude, APTI test results of six species of tree plants in Pulogadung Industrial Estate and UI Campus, Depok, *Mangifera indica* plants belong to the category of tolerant to air pollution and *Pterocarpus indicus* belongs to the category of sensitive to air pollution and the results of APTI test of six species of tree plants in Pulogadung Industrial Estate and UI Campus, Depok showed that tolerant species have high RWC values and high ascorbic acid content, while sensitive species have low RWC values and low total chlorophyll content. Thus, the study showed that *Mangifera indica* is more likely effective for reducing air pollution in the environment. Further, APTI research is needed using more tree plant species so that the results of APTI value in a location are more accurate and can be drawn in their entirety.

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