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Effectiveness of Angsana (*Pterocarpus indicus*) and Mahogany (*Swietenia mahagoni*) Plants in the Sorption of Lead (Pb) and Particulates on Sudirman Road, Pekanbaru, Riau, Indonesia

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ABSTRACT: Sudirman Road is in Pekanbaru, Riau, Indonesia, busy with vehicular activity. The potential for air pollution exists on Sudirman Road due to this condition. Efforts by the local government involve planting Angsana and Mahogany along the side of the road. Angsana and Mahogany have different characteristics, so their effectiveness in absorbing air pollutants differsIt is essential to test the sorption capacity of Angsana and Mahogany for lead and particulates, and determine their effectiveness in different canopy positions. The method used is taking leaf samples around the upper, middle, and lower canopy three times a month, then they are tested using an AAS and PSA. The measurement data were analyzed using ANOVA on SPSS 16. The results showed Angsana and Mahogany could absorb Pb and particulates. Angsana is more effective in absorbing Pb and particulates than Mahogany. Within 30 days, Angsana were able to absorb particulates up to 2,058.8 µg/g and Pb up to 42.39 µg/g compared to Mahogany plants which were only able to absorb particulates up to 1,606.5 µg/g and Pb up to 41.75 µg/g. Based on Pb and particulate sorption, the lower canopy of Angsana and Mahogany is more effective than the upper and middle canopies.

KEYWORDS: Angsana, Mahogany, Air Pollution, Lead, Particulates, PM 10

INTRODUCTION

Pekanbaru City is one of the most important cities in Riau because it supports other cities such as Dumai and Kampar. Pekanbaru City is one of the cities with a very dense population and this results in a dense number of motorized vehicles, especially in Jalan Sudirman which is the center of Pekanbaru City, Riau Province, Indonesia. Traffic conditions on Jalan Sudirman Road are busy everyday, including two-wheeled vehicles, four-wheeled vehicles, and small to large vehicles such as city buses. This condition of busy vehicle activity causes Sudirman Road to have the potential for air pollution.

Air pollution is the entry of pollutant substances (in the form of gases and small particles/aerosols) into the air in certain quantities over a long period, so that they can disrupt the lives of humans, animals, and plants [1]. Sources of air pollutants can be further divided into two large groups, namely :

a. Natural Sources

Originates from natural activities such as volcanic activity, forest fires, and the activities of microorganisms. In general, pollutants produced from natural activities such as smoke, gas, and dust.

b. Anthropogenic Sources

Originates from human activities such as burning rubbish, burning in household activities, industrial activities, and motorized vehicles. Pollutants are usually produced are smoke, dust, grit (fine sand), and gas (CO and NO).

Judging from the sources of air pollution, the largest contributor to air pollution is motorized vehicle activities which reach 85% [2]. Motor vehicle activities will emit exhaust gases consisting of carbon monoxide (CO), various hydrocarbon compounds, various oxides of nitrogen (NOx) and sulfur (SOx), lead (Pb), and dust particulates [3]. The effort that has been made by the Pekanbaru Government is to plant plants along Sudirman Road.

Plants planted along roads can be called shade plants and can function to prevent and minimize air pollution along roads that are heavily used by motorized vehicles [4]. Shade plants can prevent and minimize air pollution because they can absorb toxic gases, reduce noise, provide bird habitat, and produce oxygen gas needed by living things [5]. Preventing air pollution process by plants can be done by absorption and adsorption through the leaves [6].

There are several types of shade plants, and each type influences its ability to absorb or adsorb pollutants [7], this is due to differences in morphology, physiology, and environmental conditions. The shade plants found along Sudirman Road are Angsana and Mahogany plants. Angsana (*Pterocarpus indicus*) can be used as a shade plant because it has strong roots so it doesn't damage roads, the stems don't break easily and have branches that don't hang down so they don't block the view, the leaves and fruit don't fall off easily

and are small so when they fall does not endanger road users [8]. Apart from that, according to research results [9], Angsana can absorb lead better than Glondokan. Mahogany (*Swietenia mahagoni*) can also be used as a shade plant because mahogany leaves can absorb surrounding pollutants and reduce air pollution. Around 47% - 69% of plant biomass is stored carbon, so these plants can be used as shade plant. Mahogany is a plant that requires enough water to maintain soil moisture and requires sufficient sunlight [10]. Based on research [11], it is known that the lead content in mahogany leaves ranges from 17-80 ppm in different locations, this indicates that mahogany can absorb lead pollutants and other substances in the air.

Based on the description above, considering the large benefits of shade plants in absorbing air pollutants and based on previous research that shade plants have different abilities in absorbing pollutants in the air, it is necessary to carry out research to determine the effectiveness of the Swansana and Mahogany plants in absorbing pollutants, especially lead (Pb) and particulates.

Lead (Pb) harms human health, if there is excessive Pb content in the human body it will cause health problems [7]. These health problems can disrupt the respiratory system, nervous system, liver, kidneys, heart, digestive system, and production system [12]. Likewise with Particulate Matter (PM10) which is very easily inhaled and enters the lungs, so PM10 is classified as Respirable Particulate Matter (RPM). Health problems that PM10 can cause are disorders of the upper and lower respiratory systems (alveoli). In the alveoli, small particles accumulate which can damage the lung tissue or tissue system, while dust smaller than 10 μm will cause eye irritation [13].

MATERIAL AND METHODS

This research was conducted in the shopping area of Sudirman Road, Pekanbaru City, with the objects to be studied being the leaves of the Angsana plant and the leaves of the Mahogany plant. The stages in this research are as follows:

a. Plant sampling

The samples that will be studied from the two plants are the leaves, the leaves are picked from the petioles, and leaves that are not too young or old are selected. The leaves were collected by taking around the leaves from the upper canopy (9 meters), middle canopy (6 meters) and lower canopy (3 meters). The leaf samples taken were approximately 200 grams and taken during the day (13.00 – 14.00). Samples were taken for 1 month, namely at the beginning of the month, middle, and end of the month (15 days apart) then taken to the Laboratory of the Pekanbaru Center for Standardization and Industrial Services for preparation before testing with AAS to find out how much lead (Pb) the content had and particulates found in the leaves of the Angsana plant and the mahogany plant.

b. Observation of environmental conditions (climate)

The environmental conditions observed were temperature using a thermometer, air humidity using a hygrometer, and the number of vehicles using a hand counter

c. Plant sample testing

This plant sample test was carried out to analyze lead and particulate sorption using AAS

d. Particulate sample testing

Testing of particulate samples includes testing the distribution of particulate sizes using a Particle Size Analyzer (PSA)

e. Data analysis

Data analysis used statistical methods with the SPSS version 16 application, namely the ANOVA test.

RESULTS AND DISCUSSION

Environmental Conditions

There are several environmental conditions that are observed to determine the effectiveness of the absorption capacity of Angsana plants and mahogany plants in absorbing Pb and particulates. The environmental parameters observed are temperature, humidity, and number of vehicles. The results of the observations are as follows:

Table 1. Environmental Conditions

Date	Time	Temperature	Humidity	Number of Vehicles	
				2 Wheels	4 Wheels
June 15, 2022	01.00 PM	32^{0}C	55%	2.632	1.896
June 30, 2022	01.00 PM	32^{0}C	54%	2.374	1.648
July 15, 2022	01.00 PM	31^{0}C	63%	2.258	1.454

Based on Table 1, sampling was carried out from mid-June to mid-July during the day at 13.00 – 14.00 WIB with sampling divided into 15 days within 30 days (1 month). The aim of sampling at a distance of 15 days was to determine the effectiveness of the absorption capacity of Angsana plants and Mahogany plants in absorbing Pb and particulates, while sampling was carried out during the day because in bright conditions the plant stomata were open, they were able to absorb pollutant gases to a greater extent than in dark conditions. At each sampling, the temperature ranged between 31-32ºC while the humidity ranged between 54-63%. The number of vehicles on Sudirman Road Pekanbaru with 3 sampling times has decreased.

Pb Sorption in Angsana and Mahogany Plants

The sorption of Pb in Angsana and Mahogany plants varied greatly in each canopy. In this study, the canopy studied were the upper canopy, middle canopy and lower canopy. The following is the data of Pb sorption in Angsana and Mahogany plants in each canopy.

Table 2. Lead sorption results (Pb) in Angsana and Mahogany plants based on canopy position

Date	Pb sorption (µg/g)					
	Angsana			Mahogany		
	Upper Canopy	Middle Canopy	Lower Canopy	Upper Canopy	Middle Canopy	Lower Canopy
June 15, 2022	42,60	41,19	42,93	38,35	39,02	41,75
June 30, 2022	38,20	38,26	39,35	32,56	32,48	33,73
July 15, 2022	33,44	32,48	33,63	28,69	29,64	32,70

There were differences in Pb uptake results in Angsana and Mahogany plants in each canopy and at each sampling time. These differences can be seen in Figure 1 below.

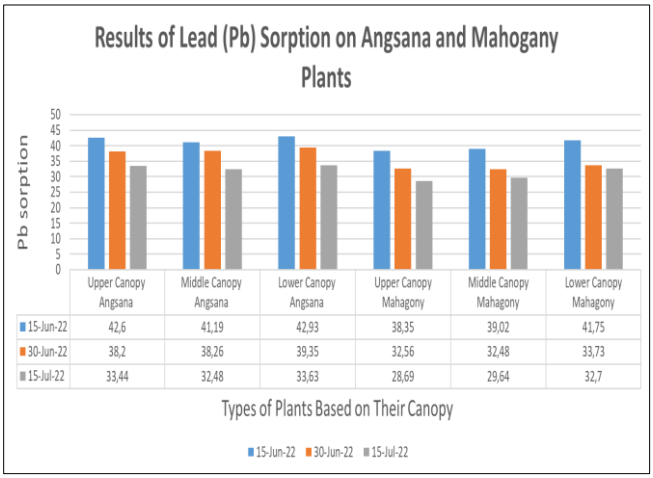

Figure 1. Results of lead sorption (Pb) on Angsana and Mahogany plants based on canopy position

In Table 2 and Figure 1, it can be seen that the highest lead sorption for Angsana and Mahogany plants was on June 15, 2022, after that on June 30, 2022, and July 15 2022 there was a decrease for both Angsana and Mahogany plants, this was due to the number of vehicle. It is known that the number of vehicles decreases for each sampling time so the emissions in the air produced are also smaller because the source of pollution decreases. The highest Pb uptake in Angsana plants for each canopy was as follows: lower canopy 42.39 µg/g, middle canopy 41.19 µg/g, and upper canopy 42.60 µg/g, while the highest Pb uptake in mahogany plants for each crown was as follows, the lower canopy is 41.75 µg/g, the middle canopy is 39.02 µg/g and the upper canopy is 38.35 µg/g. These results show that the most effective canopy is the lower canopy for both Angsana and Mahogany plants, this is due to the canopy density factor because the lower canopy has a denser canopy compared to the middle canopy and upper canopy [6]. Angsana plants can absorb Pb up to 42.39 µg/g and mahogany plants can absorb Pb up to 41.75 µg/g indicating that the Swansana plant is more effective in absorbing Pb, this is due to the morphology of the Angsana plant species where the Angsana plant has fresh green leaf color. , the leaves are wide, and oval in shape, and the leaflets are denser, with 5-11 leaflets sitting alternately [14].

Particulate Sorption on Angsana and Mahogany Plants

The sorption of particulates in Angsana and Mahogany plants varies greatly in each canopy. In this study, the headings studied were the upper canopy, middle canopy, and lower canopy. The following is the data of particulate sorption on Angsana and Mahogany plants in each canopy.

Table 3. Results of particulate sorption on Angsana and Mahogany plants based on canopy position

Date	Particulate sorption (µg/g)					
	Angsana			Mahogany		
	Upper Canopy	Middle Canopy	Lower Canopy	Upper Canopy	Middle Canopy	Lower Canopy
June 15, 2022	222,6	1476,1	2085,8	699,6	206,7	1606,5
June 30, 2022	332,4	385,9	1675,2	291,5	323,6	1052,6
July 15, 2022	366,5	1156,4	1473,8	103,2	163,3	912,1

There were differences in the results of particulate sorption on Angsana and Mahogany plants in each canopy and at each sampling time. These differences can be seen in Figure 2 below:

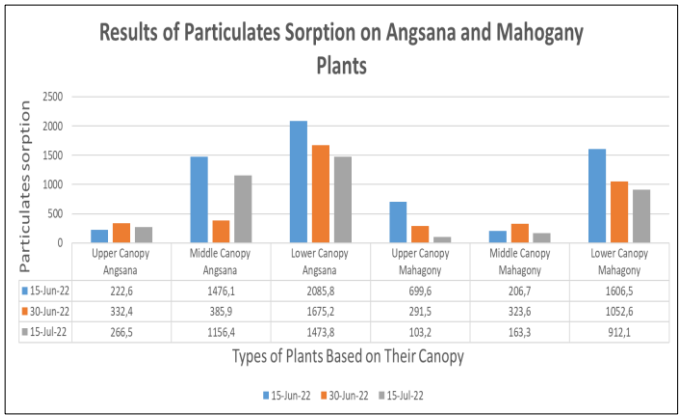

Figure 2. Results of particulates sorption on Angsana and Mahogany plants based on canopy position

In Table 3 and Figure 2, at the time of sampling, there are fluctuations in particulate sorption on the Angsana plants in the middle canopy, upper canopy, and Mahogany plants in the middle canopy. This is due to the rainfall factor because the samples were taken during the rainy season [15]. The sampling on June 15, 2022 did not rain, for the sampling on June 30 2022 there was rain in the evening, while for the sampling on July 15, 2022, there was rain in the evening and drizzle in the morning, this caused fluctuations in particulate adsorption in these two plants. The highest particulate uptake in the Angsana plant for each canopy was as follows: lower canopy 2,058.8 µg/g, middle canopy 1,476.1 µg/g, and upper canopy 332.4 µg/g, while Mahogany plant had the highest particulate uptake for each canopy are as follows: lower canopy 1,606.5 µg/g, middle canopy 323.6 µg/g, and upper canopy 699.6 µg/g. These results show that the most effective canopy is the lower canopy for both Angsana and Mahogany plants, this is because the distance between the pollutant source and the lower canopy is closer so that when friction occurs between the vehicle tires and the road, particulates fly and the particulates fly faster. sticks to the lower canopy compared to other canopies. Angsana plants are able to absorb particulates up to 2,058.8 µg/g and mahogany plants are able to absorb particulates up to 1,606.5 µg/g indicating that the Angsana plant is more effective in absorbing particulates, this is due to the morphology of the Angsana plant species where the Angsana plant has fresh green leaves. , the leaves are wide, and oval in shape, and the leaflets are denser, with 5-11 leaflets sitting alternately [14].

Analysis of Particulate Size (PM10) in the Canopy Position of Angsana and Mahogany Plants

Based on the results of the uptake of Pb and particulates in these two plants, the Angsana plant was able to absorb more Pb and particulates than the Mahogany plant. The results of measuring Pb and particulate adsorption levels in the two plants also showed that the most effective canopy was the lower canopy in absorbing particulates. This is also supported by the results of the Particle Size Analysis test on the canopy position of each plant in Table 4 and Table 5. The test using the Microtrac Particle Size Analyzer was carried out to determine how many particles with a diameter of 10 micrometers or less were attached to the leaf surface.

Table 4. Results of adsorption of PM10-sized particulates on Angsana plants

Canopy position	Date		
	June 15, 2022	June 30, 2022	July 15, 2022
Upper	4,9 %	9,5 %	7,8 %
Middle	36,6 %	10,4 %	19,2 %
Lower	73,6 %	28,3 %	24,7 %

From Table 4, variations in data on the presence of PM10-sized particulates in each canopy position are obtained. During 3 sampling times, there was the most PM10 attached to the surface of Angsana plant leaves in the lower canopy with 73.6% in the first sampling, 28.3% in the second sampling, and 24.7% in the third sampling. This shows that the lower canopy position is more effective in absorbing PM10 because the lower canopy is closer to the pollutant source. This also happens to Mahogany plants in Table 5, where the lower canopy of Mahogany plants is more effective in absorbing PM10. During the 3 sampling times, 27.5% of PM10 was found attached to the surface of the leaves of mahogany plants in the lower canopy, in the first sampling 21.4%, in the second sampling 21.4% and in the third sampling 16.1%.

Table 5. Results of adsorption of PM10-sized particulates on Mahagony plants

Canopy position	Date		
	June 15, 2022	June 30, 2022	July 15, 2022
Upper	15,7 %	9,3 %	2,3 %
Middle	6,8 %	9,9 %	5,6 %
Lower	27,5 %	21,4 %	16,1 %

CONCLUSIONS

Based on the results of the analysis and discussion of research data, the conclusions that can be drawn from research regarding the effectiveness of Angsana and Mahogany plants in absorbing lead (Pb) and particulates on Sudirman Road Pekanbaru are as follows:

1. Angsana and Mahogany plants can absorb lead (Pb) and particulates (PM10) in the air. The plant that is more effective in absorbing lead (Pb) and particulates (PM10) is the Angsana plant. Within 30 days, Angsana plants were able to absorb up to 2,058.8 µg/g of particulates compared to Mahogany plants which were only able to absorb up to 1,606.5 µg/g of particulates. Pb uptake in Angsana plants can be up to 42.39 µg/g compared to Mahogany plants which can only absorb up to 41.75 µg/g Pb. This is due to the morphology of the Angsana plant which has fresh green leaves, wide oval leaves, and denser leaflets with 5-11 leaflets sitting alternately.
2. The most effective canopy position in absorbing lead (Pb) and particulates (PM10) is the lower canopy of both Angsana and Mahogany plants. This is because the distance between the pollutant source and the lower canopy is closer, so pollutants will stick to the lower canopy more quickly than another canopies.

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