Absorption of Cadmium (Cd) Metal Particulates on Tanjung (*Mimusops Elengi*) and Bungur *(Lagerstroemia Speciosa*) Leaves

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ABSTRACT
Selection of the right road shade plants can help maintain urban air quality. In this study, the absorption pattern of Tanjung (*Mimusops elengi*) and Bungur (*Lagerstroemis speciosa*) plants for cadmium metal particulate matter deposited on the leaf surface was observed. Sampling was carried out 3 times in the dry season with an interval of 10 days. The sampling point is on the edge of the highway, taking 3 locations which are each about 600 m apart. Leaf samples were taken at a height of 3, 6, and 9 m. The particulate samples in the leaves were destroyed and then analyzed for cadmium content using Atomic Absorption Spectrophotometer (AAS). The results showed that the average particulate deposited on the surface of Tanjung leaves was 1,210.20 g/g leaf weight, while on Bungur leaves it was only 965.90 g/g leaf weight. This happens because the composition of the Tanjung leaves is more dense with a circular crown and branching than the Bungur leaves. Although the particulate weight in Tanjung leaves was higher, the average Cd content in particulates was lower at 0.00124 g/g leaf weight, while in Bungur leaves it was 0.00176 g/g leaf weight. It is suspected that Tanjung leaves have a faster Cd absorption rate than Bungur leaves. This was confirmed by the higher average Cd content in Tanjung leaves, which was 0.00157 g/g leaf weight, while Bungur leaves were 0.00136 g/g leaf weight. It can be concluded that the Tanjung plant captures more particulate matter than Bungur leaves, except in the railroad track area where periodic vibrations often occur. The leaves of the Tanjung plant also absorb Cd metal faster from the particulates that deposited on it than the leaves of Bungur.

Keywords: *Tanjung, Bungur, Plant, Particulate, Cadmium, Absorption*

1. INTRODUCTION

The massive activity of industry, transportation, and power generation causes the burning of fossil fuels and biomass on a large scale. This process causes the emission of gaseous pollutants, particulates and heavy metals into the atmosphere. Car and truck exhaust, heating furnaces, incinerators, power plants, as well as steel and foundry operations also emit carbon particulates in the form of soot, carbon black, coke, and graphite [1]. Particulate matter can absorb various compounds such as poly aromatic hydrocarbons (PAH), heavy metals, elemental carbon, soot, acids, salts, sulfur oxides (SO_2) and nitrates (NO_3^-) [2]. Atmospheric conditions change gradually so that they become very different from the previous natural conditions [3].

Measurements of heavy metals found in particulate matter (PM) in the Indonesian atmosphere in 10 major cities showed that 13 kinds of metals were detected, namely Na, Mg, Al, K, Ca, Cr, Mn, Fe, Co, Ni, Cu, Zn, and Pb. The results showed that the lowest concentration was Cr metal of 1.3-7.2 (ng/m^3) and the largest concentration of Pb was 0.2-2664.2 (ng/m^3). The only non-metallic elements detected were Si and S [4]. The distribution pattern of PM 2.5 and PM 10 is influenced by humidity and temperature [5]. At night the concentrations of PM 10 and PM 2.5 were higher than during the day due to a decrease in temperature. There is a decrease in the diffusion of particles so that they are condensed near the soil surface due to high humidity. This causes the concentration of PM 2.5 and PM 10 to increase at night, even though the traffic density is lower than during the day. According to Turyanti [6], the maximum exposure concentration of PM 10 and SO_2 occurs in the middle of the night until the morning. Temporarily there are fluctuations in air pollutant concentrations, concentrations during the day are low and increase in the evening until the early hours of the morning. Meteorological factors, especially wind patterns, greatly affect the pattern of pollutant distribution.

Heavy metals that enter the atmosphere have harmful effects on living things. These elements are toxic and have high density, specific gravity, or atomic weight [3]. According to Cakmak [7] an increase in metal concentrations of Ca, Cd, Pb, Sr, Sn, V, and Zn in the atmosphere correlates with a significant increase in heart rate of 1-3 beats per minute. These metals also increase blood pressure by 1-3 mmHg and reduce lung function by 4% of total capacity. This shows that the metals in PM 2.5 have an acute effect on cardiovascular and respiratory physiology.

Cadmium (Cd) is one of the metals that can be exposed to the environment through a number of activities such as zinc and tin casting, metal plating, as a color pigment material, batteries and plastics[8].While the Cd metal that is emitted into the atmosphere comes from the mining process and the destruction of rocks containing Cd. This metal can also be emitted from the primary metal production process, namely the conversion of ore into primary metals Zn, Pb and Cu. In this case, Cd is a by-product. Cd is also exposed to the atmosphere through the iron and steel industry. Other sources of cadmium emissions are secondary metal smelting, manufacturing industries such as paints, plastic stabilizers and the battery industry. Burning fossil fuels is one of the sources of Cd metal emissions in the atmosphere [9]

In the human body, Cd can cause high blood pressure, kidney damage, testicular tissue damage, and red blood cell damage. Cd compounds are weakly mutagenic and genotoxic to Leydig cells in the testes. The genotoxic mechanism of Cd is by causing indirect oxidative stress in cells as a result of inhibition of antioxidant enzymes and suppressing antioxidant molecules such as GSH. Cd is very active in inducing apoptosis in various cells and inhibits DNA repair [8]. In acute Cd can adversely affect the respiratory and digestive tract. Cadmium accumulates before becoming dominant in the kidney with a biological half-life of 10-20 years. Long-term exposure to cadmium can cause irreversible kidney problems (.

One way to reduce the adverse effects of Cd in particulates is to plant trees that can absorb particulates in homes, offices, and other public facilities. The ability of plants to accumulate particulate matter is not the same. Research on this topic will help city planners to select the most suitable plants for controlling air pollution. Evaluation of the leaves and waxy coating of 35 plant species (11 shrubs, 24 trees) in accumulating particulates showed that species of *Cephalotaxus sinensis*, *Euonymus japonicus*, *Broussonetia papyriferar*, *Koelreuteria paniculata*, and *Quercus variabilis* captured small particles more efficiently. These plants also have a high ability to accumulate all sizes of particulate matter. It was also observed that the ability to accumulate particulates of shrubs and trees did not differ. The combination of planting shrubs and trees with different heights will reduce particulate pollution near ground level and higher air [10]

Zhang et al. [11] measured the ability of plants to accumulate particulate matter and metals of Ni, Cr, Cu, Pb, and Zn in the leaves of Euonymus japonicus. The results show that the area where the plant grows has only a small effect on the deposition of particulate matter. Meanwhile, the rainy season has a more significant effect. The fact also shows that the level of accumulation of heavy metals is higher in the college community than in the urban park area. *Euonymus japonicus* has the ability to clean the atmosphere and is ideal for reducing urban environmental pollution.

The ability of plants to absorb particulates is thought to be influenced by the nature of the leaf surface, the shape of the branching and the density of the plant crown. Meanwhile, environmental factors that affect the amount of entrapment by plants are wind direction and speed, emission concentrations from motorized vehicles and distance from emission sources, as well as the length of exposure of leaves to pollutants [12]

Based on a theoretical study of the effect of metals on particulate matter on human health and the differences in plant ability to absorb these pollutants, this study examines the effectiveness of Tanjung (*Mimusops elengi*) and Bungur (*Lagerstroemia speciosa*) plants in absorbing Cd on particulates. The two plants were chosen because they are the dominant protective plants in the Timoho road area and several other roads in Yogyakarta.

2. METHODS

Tools and Materials

The main materials of this research are particulates on the surface of Tanjung leaves and Bungur leaves. The leaves are taken from the Tanjung and Bungur plants on Timoho road. While the chemicals are concentrated HNO_3, H_2SO_4, a solution of $Cd(NO_3)_2$ 1000 ppm, distilled water, aquadest, and Whatman 42 filter paper, and a set of Atomic Absorption Spectrophotometer (AAS).

The tools used in this research are a set of glassware, analytical balance, sample bottles, oven, microwave digestion flask, micropipette, Atomic Absorption Spectrophotometer (AAS).

Sampling of Tanjung Leaves and Bungur Leaves

The leaves are selected that are not too old or young, with the assumption that there has been enough time to absorb the surrounding air pollutants. Leaves were picked from 3 locations each about 600 m apart. At each sampling point, leaves were taken with the top (9 meters), middle (6 meters) and bottom (3 meters) positions of the plant. The sampling was repeated 3 times, each 10 days apart.

Particulate Separation from Leaves

Leaf samples were weighed ± 200 grams, washed with 100 mL of distilled water 4-5 times until all particulates were removed. The washing water is centrifuged to separate the particulates. The particulates were placed in a petri dish and the remaining water was evaporated in the oven at a temperature of ± 105ºC for 2 hours. The weight of the particulates that settle on the upper surface of the leaf weighing 200 grams is recorded and the weight of particulates (µg) per gram of leaf weight is calculated.

Determining the Concentration of Cd in Particulates

The particulates were dissolved in 2 mL of HNO_3 and 5 mL of H_2SO_4 then diluted to 10 mL with distilled water. 1 mL of the solution was taken to be diluted to 25 mL and analyzed by Atomic Absorption Spectrophotometer at λ of 233 nm.

Determining the Concentration of Cd in Leaves

The cleaned leaves are cut into small pieces, weighed ± 1 gram. The leaf sample was put into a microwave digestion flask and 5 mL of concentrated HNO_3 was added. The sample was digested using a microwave digestion flask and then diluted to 25 mL of distilled water. The concentration of Cd was analyzed by Atomic Absorption Spectrophotometer.

3. RESULTS AND DISCUSSION

Effect of Sampling Location on Weight of Particulate Deposits.

Table 1. Effect of location on the weight of particulate deposits.

Location	Tanjung Leaf Particulate Weight (µg/g)	Bungur Leaf Particulate Weight (µg/g)
1	991.40	1,266.18
2	1,507.75	949.71
3	1,131.43	681.80
Avearge	1,210.20	965.90

Table 1 shows that Tanjung leaves trap more particulate deposits than Bungur leaves, except at location 1. According to Taihuttu and Purnomohadi in Hermawan [12], the ability of plants to absorb particulates is influenced by leaf shape, branching and lush plant canopy. The leaves of the Tanjung tree are scattered, flat-edged, and pinnately boned. The leaves are round or ovoid elongated and 9-16 cm long. Bungur leaves have a length of 9-28 cm, a width of 4-12 cm, so the leaves of the Tanjung plant are smaller. The glossy smooth surface of the Tanjung leaves should also not support its ability to hold more particulate deposits than Bungur leaves. It is suspected that the ability of the Tanjung plant to capture more particulate deposits is influenced by the shape of the branching and the shape of the canopy. The canopy and branching shape of the Tanjung tree, which is lush horizontally or like the letter V, actually causes the arrangement of the leaves to be more dense than the Bungur leaves. More particulates that settle from the atmosphere are caught by the Tanjung leaf surface than Bungur leaves.

The data from Table 1 also shows that the weight of the particulate deposits of Tanjung leaves at sampling point 1 is smaller than that of Bungur leaves. If it is related to the sampling location environment, point 1 is the closest to the two-way railroad crossing. Heavy rail traffic can cause vibration effects that cause shaking of plants, including their leaves. The narrower leaves of the Tanjung plant will more easily lose particulate deposits than the leaves of the Bungur plant. This effect does not occur at locations 2 and 3 which are quite far from the railroad crossing.

Effect of Leaf Crown Height on Weight of Particulate Deposits

Table 2. Effect of canopy height on the weight of particulate deposits.

Height (m)	Tanjung leaf particulate weight (µg/g)	Bungur leaf particulate weight (µg/g)
9	1,026.55	576.83
6	1,219.70	1,313.23
3	1,380.09	1,007.62

Table 2 shows that the lower the location of the Tanjung leaves, the higher the mean particulate deposits. Meanwhile, in Bungur plants, the highest adsorption occurred at a height of 6 m (middle). It is suspected that the difference in the pattern of capture of the particulate deposits is influenced by differences in leaf density and plant crowns [12]. Tanjung leaves are denser with a dense circular crown. Particulates that escape from the leaf surface above, will be caught by the leaves below. As a result, the lower leaves will catch the accumulated particulates from a height of 3 m and the particulate remnants that escape from the leaves above. In Bungur plants this does not happen, because the density of Bungur leaves is lower, and the branches and leaf crowns point in different directions so that the empty spaces between leaves are wider, causing more particulates not to be caught.

Effect of Sampling Period on Weight of Particulate Deposits

Table 3. Effect of sampling period on the weight of particulate deposits.

Period	Tanjung leaf particulate weight (µg/g)	Bungur leaf particulate weight(µg/g)
I	774.88	777.15
II	1,138.88	800.42
III	1,712.79	1,1320.12

From Table 3 it can be seen that both Tanjung leaves and Bungur leaves consistently experienced an increase in the amount of sediment from period I to period III. This happened because during the observation period the sampling area was still experiencing the dry season. There is no rain that can cause washing of particulate deposits from above the leaf surface, resulting in the accumulation of particulates on the leaf surface.

Effect of Sampling Location on Cd Metal Content in Particulate

The effect of the sampling location can be observed by averaging the Cd particulate matter per leaf weight at each location for all sampling periods and leaf crown heights. However, because in the II and III sampling periods, Cd contents were not detected (below the measurement limit), so the influence of the sampling location could only be observed from the first sampling period.

Table 4. Cd contents in particulates in the I sampling period

Location	Tanjung leaf particulate Cd content (µg/g)	Bungur leaf particulate Cd content (µg/g)
1	0.00093	0.00162
2	0.00124	0.00193
3	0.00156	0.00174
Average	0.00124	0.00176

From Table 4, it can be seen that the average concentration of Cd in the particulates deposited in Tanjung leaves is higher than Bungur leaves. This indicates that Tanjung leaves (which contain more particulates) absorb Cd metal faster than Bungur leaves. The highest mean for Tanjung leaves was found at location 3 (around the city hall) and for Bungur leaves at location 2 (around gas stations). These two locations are areas where vehicles are often found stopped while the engine is still running. It is suspected that the Cd source is related to the particulates emitted from the vehicle.

Effect of Leaf Height on Cd Metal Content in Particulates

The effect of leaf crown height on Cd metal content in particulates can be observed by averaging particulate Cd contentss per leaf weight for each leaf crown height in all sampling periods and sampling locations. However, because in the II and III sampling periods, Cd levels were not detected (below the measurement limit), so the effect of leaf crown height could only be observed from the first sampling period.

Table 5. Effect of leaf crown height on particulate Cd contents

Height (m)	Tanjung leaf particulate Cd content (µg/g)	Bungur leaf particulate Cd content (µg /g)
9	0.00342	0.00641
6	0.00354	0.00603
3	0.00373	0.00528

The data in Table 5 shows that the leaves of the Tanjung tree are lower, the higher the Cd content in the particulates. This is in line with the weight of the particulates deposited on the leaf surface, the lower it gets the bigger. Whereas in Tanjung plants the opposite is true, the Cd metal contained in the particulates is getting smaller and smaller. Data on the weight of particulate deposits according to the height of the canopy, showed the largest at 6 m. This asymmetry led to the assumption that the particulates deposited at a height of 9 m in Bungur leaves were richer in Cd than particulates at other heights. However, this still needs further proof.

Effect of Sampling Period on Cd Metal Content on Particulate

Table 6. Cd contents in particulates in the I sampling period

Period	Tanjung leaf particulate Cd content (µg/g)	Bungur leaf particulate Cd content (µg/g)
I	0.00119	0.00197
II	Below detection limit	Below detection limit
III	Below detection limit	Below detection limit

Table 6 from the sampling period I shows that the average concentration of Cd particulates deposited on Tanjung leaves is 0.00119 (µg/g) and 0.00197 (µg/g) on Bungur leaf particulates. It appears that the average Cd content in particulates on Tanjung leaves is lower than on Bungur leaves. The higher number of particulates but the lower Cd content indicates the Tanjung leaves' ability to absorb Cd is greater than Bungur leaves.

In the second and third sampling periods, Cd contents were not detected at all sampling locations, even though in those 2 periods the average weight of particulate deposits on Tanjung and Bungur leaves increased consistently. There are 2 possible causes. First, maybe the particulate characteristics are different in each period. Particulates in period I may be richer in Cd than in periods II and III. The second possibility, with the longer the particulates sticking to the leaf surface, it is possible that the Cd metal has been adsorbed into the leaves. To answer this assumption, further research is needed.

Effect of Sampling Location on Cd Metal Content in Leaves

The effect of sampling location can be observed by averaging the Cd content in leaves per leaf weight at each location for all sampling periods and leaf crown heights. There were 3 observation points with undetectable contents of Cd in Tanjung leaves (below the detection limit), while in Bungur leaves there were 9 observation points where Cd levels in leaves were not detected.

Table 7. Effect of sampling location on Cd content in leaves

Location	Cd content in Tanjung leaves (µg/g)	Cd content in Bungur leaves (µg/g)
1	0.00186	0.00132

2	0.00149	0.00136
3	0,00137	0.00139

Table 7 shows the average Cd content in Bungur leaves is almost the same. Meanwhile, the average Cd content in Tanjung leaves was mostly found at sampling location I where the particulate weight was actually the smallest compared to other locations. The sampling location I is close to the railroad crossing. From this fact, it is necessary to investigate what factors influence the sorption of Cd metal into Tanjung leaves so that the adsorption is greater. Does the vibration caused by the railroad crossing have an effect?

Effect of Leaf Crown Height on Cd Metal Content in Leaves

The effect of leaf crown height on the average Cd metal content in the leaves could be observed by averaging the Cd content in the leaves per leaf weight at each location and all sampling periods. There were 3 observation points with undetectable levels of Cd in Tanjung leaves (below the detection limit), while in Bungur leaves there were 9 observation points where Cd levels in leaves were not detected.

Table 8. Effect of leaf crown height on Cd contents in leaves

Leaf Height (m)	Cd content in Tanjung leaves (µg/g)	Cd content in Bungur leaves (µg/g)
9	0.00134	0.00137
6	0.00138	0.00137
3	0.00183	0.00133

The data in Table 8 shows that in Tanjung leaves, the lower the leaf crown, the higher the concentration of adsorbed Cd. This is in sync with the observation of the average weight of the particulates that settle on the leaf surface, the lower the leaf crown, the more particulate deposits. This fact is also in sync with the data on the average Cd content in the particulates, which shows that the lower the leaf crown, the higher the Cd content in the particulates. This also confirms the assumption that Tanjung leaves absorb Cd metal faster than Bungur leaves.

Effect of Sampling Period on Cd Metal Content in Leaves

The effect of the sampling period on the average Cd metal content in the leaves can be observed by averaging the Cd content in the leaves per leaf weight at each sampling location and at all heights. There were 3 observation points with undetectable contents of Cd in Tanjung leaves (below the detection limit), while in Bungur leaves there were 9 observation points where Cd contents in leaves were not detected.

Table 9. Effect of sampling period on Cd content in leaves

Period	Cd content in Tanjung leaves (µg/g)	Kadar Cd dalam daun Bungur (µg /g)
I	0.00367	0.00333
II	0.00033	0
III	0.00189	0.00033

The data in Table 9 shows that the average Cd metal content in the leaves fluctuated from one period to the next. The particulate weight data for the II and III sampling periods were larger and the Cd metal content in the particulates was not detected. If the characteristics of the particulates are the same between sampling periods, then with the increasing number of deposits and decreasing levels of Cd in the particulates, it can be expected that the contents of Cd in the leaves will increase in the II and III sampling periods. However, the data in Table 9 shows that this is not proven. This leads to the assumption that the characteristics of the particulates between the sampling periods are different. To prove it, further research is needed.

4. CONCLUSION

a. The Tanjung tree retains more particulate deposits on its leaves because it has a denser leaf structure and a circular crown and branching shape.

b. In areas with a lot of vibration, Bungur leaves are better abble to retain the particulates that settle on it.
c. The leaves of the Tanjung tree absorb more Cd from particulates than the leaves of the Bungur tree.
d. It is suspected that the particulates deposited in the II and III sampling periods have lower Cd contents compared to the I period.

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