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Morphological Characteristics and Plant Species for Noise Reducer and Pb Metal Absorbers at Adisucipto Airport: Yogyakarta, Indonesia

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ABSTRACT

The dense activity of aircraft at the airport leads to a strong mobilisation of transportation, generating noise. Meanwhile, increased aviation mobilisation has the potential to produce Pb metal since the utilisation of landscape plants is an effort to reduce noise and Pb. Therefore, this study aims to determine the ability of three species of landscape plants to absorb noise and Pb at Adisucipto airport, Yogyakarta in Indonesia. The study was conducted from August 2019 to September 2020, and the survey and the laboratory method were used with nested design data analysis followed by the Tukey HSD 5% test. The results showed that fan pine had a higher ability to absorb noise. On the contrary, croton had a higher ability to absorb Pb metal.

Keywords: Absorbers, airport, landscape plants, noise, Pb metal, reducer

INTRODUCTION

An airport is an area with certain boundaries used to land and takes off aeroplanes (Setiawan et al., 2013; Sumathi & Parthasarathi, 2018). The dense activity of aircraft at the airport results in the high mobilisation of transportation, which can trigger noise, a form of environmental pollution (noise pollution) that can disturb comfort and damage human hearing (Clark et al., 2013). The noise level is influenced by the frequency of flights and jet aircraft engines. It causes disturbance to airport workers (*ground handling*) and residents outside the area with a 1-5 km radius.

Furthermore, the noise level can disturb the surrounding residential areas (Herawati,

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2016), negatively impact human health and environmental comfort. This effect is determined by ear sensitivity and *sound pressure level* (SPL). Continuous noise results in heart disease, physical and mental fatigue, and hearing loss (Black et al., 2007). In addition, an increase in the number of flight frequencies also has the potential to produce pollutants that are released into the air polluting the environment. They come from aircraft fuel, in-plane air controllers (AC), and air fresheners in aircraft. Avtur and kerosene as aircraft fuel produce carbon dioxide (CO_2), methane (CHx), NOx, CO, and SO_2 emissions, and contrails (pollutant materials that effectively absorb heat and have an impact on global warming). In addition, chlorofluorocarbon (CFC) in air conditioning, air freshener in aircraft, and NOx damages the ozone layer in the stratosphere (Ashford et al., 2011). Furthermore, pollutants have a negative impact on human health (Corbitt, 2004; Andersen et al., 2011), and one of the efforts to minimise the number is by creating a noise barrier using landscape plants.

Apart from functioning as greenery and beauty, these plants are used as a noise barrier and function as a living filter. It reduces pollution levels by absorbing, detoxifying, accumulating, and or regulating metabolism in the air. Therefore, air quality can be increased by releasing oxygen (Shannigrahi et al., 2010), and the ability of plants to reduce noise is seen from the texture of the leaves and plant growth (plant canopy density). The broad, coarse leaf texture and dense leaf are the most effective plant characteristics in reducing noise. Plants have the ability to absorb and accumulate pollutants and capture lead particles and other pollutants released by public transportation through their leaves (Hendrasarie, 2007). According to Koeppe and Miller (1970), the ability to absorb pollutants is strongly influenced by the surface conditions of plant leaves. Plants with hair (pubescent) or rough surfaces (wrinkles) have a higher ability to absorb pollutants than those with smoother and flatter surfaces. Similarly, Megia et al. (2015) reported that the ability of plant leaves to absorb pollutants is influenced by morphological characteristics, such as leaf size and shape, the presence of hair on the surface, and texture.

MATERIALS AND METHODS

Time, Location, and Sample Collection

The study was conducted from August 2019 to April 2020 at Adisucipto Airport, Yogyakarta Special Region, Indonesia (Figure 1). Furthermore, analysis of samples was conducted at the Yogyakarta Agricultural Technology Research Center Laboratory, the Plant Production Management Laboratory, Faculty of Agriculture, and the Plant Structure and Development Laboratory, Faculty of Biology, Gadjah Mada University using survey methods and laboratory analysis. The selected plants used had the highest dominance based on the results of pre-observations. Initial observations showed that the dominant plant species were fan pine (*Platycladus Orientalis*), red shoots (*Syzygium myrtifolium*), and croton (*Codiaeum variegatum*).

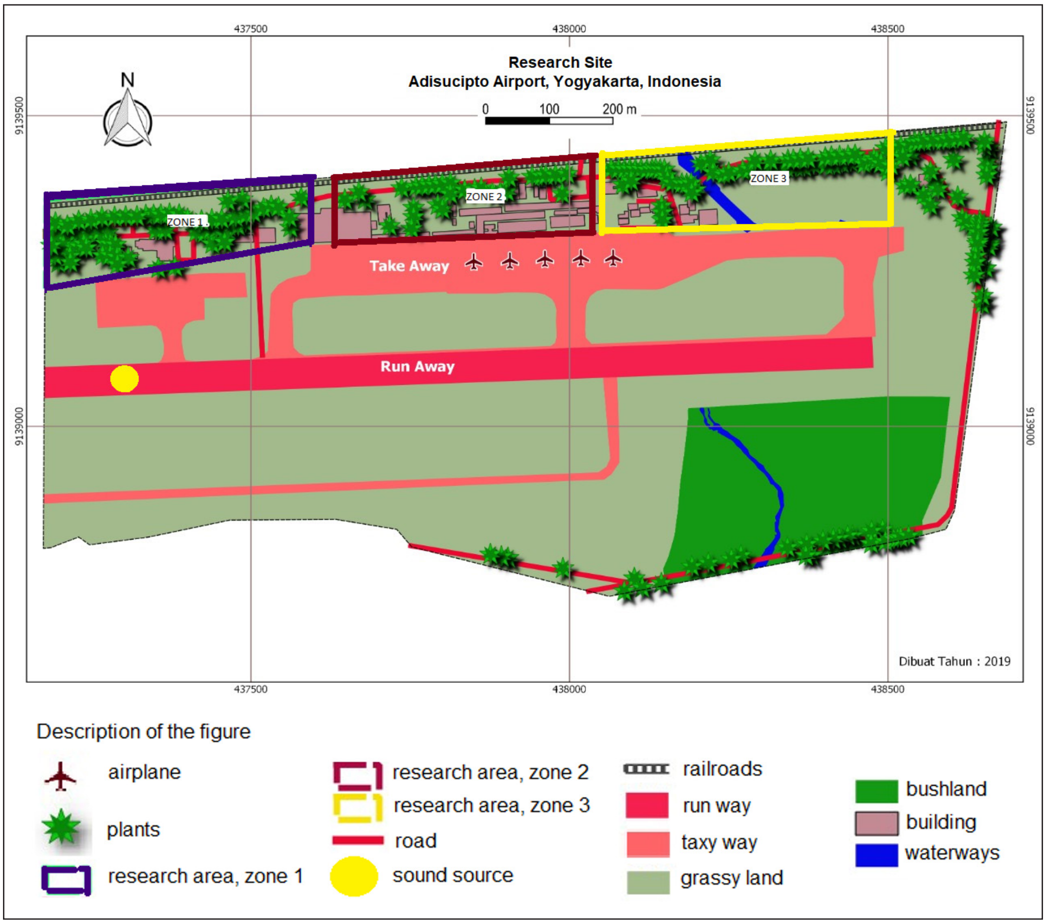

Figure 1. Research Site at Yogyakarta Adisucipto Airport, Indonesia

Analytical Method

The results of preliminary observations showed that the Adisucipto airport landscape area was divided into three zones, namely 1) the difference in the distance between the observation zone and the sound source was 0.5 km located in the airport park area of terminal A, 2) the difference in the distance between the observation zone and the sound source was 1 km located in the terminal area B, and 3) the difference in distance between the observation zone and the sound was 1.5 km located in the airport parking area. These three zones showed that the environmental design used was a nested type. In each zone, there were three species of landscape plants to be studied, namely *P. Orientalis* (fan pine), *S. myrtifolium* (red shoot), and *C. variegatum* (croton). The number of samples was four stands per species/zone as replicates in blocks. The study was conducted with a survey method and divided into ten stages of activity, namely: 1) planning, 2) licensing, 3) sample organisation, 4) field preparation, 5) observation and data collection, 6) sampling, 7) sample testing in the laboratory, 8) data analysis, 9) data interpretation, and 10) preparation of research reports.

Noise Measurement

Two points measured noise measurement. The first point was outside the canopy (A1), and the second was inside (A2) (Figure 3). This noise measurement was conducted because the area of the airport environment was very heterogeneous. Thus, to find out that plants reduced the noise, the total decibels outside the canopy should be subtracted by the total decibels inside the canopy. This measurement was conducted eight times on 12 experimental plant sample points.

Noise measurement in the area was consistent with KEP-48 / MENLH / 11/1996, a 10-minute measurement of every five seconds reading with the sound level meter's minimum and maximum decibel values. The measurement of the noise level was divided into several time intervals, including morning: 07.00-10.59 WIT, afternoon: 11.00-14.59 WIT, and night : 15.00-18.00 WIT. (noted : WIT = West Indonesia Time).

Identification of Pb Metal

The observation of Pb heavy metal analysis was conducted in 3 stages: preparation and sampling, diluents and standard solutions, and preparation for testing and metal analysis in landscape plants. One hundred grams of the sample were taken, put in a clean plastic container and checked for Pb content using Atomic Absorption Spectrophotometry (AAS). The dilution solution for metal was conducted based on SNI 06-6989-.4-2004 standards. The procedure used was nitric acid (HNO_3) plus aqua dest to pH 2. In addition, landscape plant samples were cleaned with running tap water, dried at room temperature. Also, 100 grams of the sample was weighed and dried in an oven at a temperature (50 to 100ºC) for three hours. Then, That sample was cooled in a closed desiccator, weighed again as dry weight, and pounded until smooth using a stamper mortar. It was weighed as much as 0.5 g, plus 100 ml of aqua dest and the addition of 5 ml of concentrated nitric acid and deconstruction using hotplate tool until the solution was approximately 20 ml clear. Also, it was filtered using Whatman filter paper, and distilled water was added to the filtrate until the solution became 100 ml. Furthermore, it was read by atomic absorption spectrophotometry with a wavelength and a cathode lamp of Pb 217 nm. Finally, the prepared samples were analysed using Atomic Absorption Spectrophotometry (AAS).

Pb Metal Absorption

Pb absorption was carried out by comparing the uptake or total Pb content in plants in the airport area with the home garden. In addition, the ability of plants to absorb Pb was calculated by reduced airport Pb metal with Pb metal in home gardens.

RESULTS AND DISCUSSION

Morphological Characteristics of Plants

Plant observations, including morphological components in several types of landscape, can be seen in Table 1.

Table 1

Leaf description observation of landscape plants at Adisucipto airport

Plant Species	Leaf Shape	Leaf Edge Shape	Leaf Surface
P. orientalis (Fan Pine)	needle	flat	coarse
S. myrtifolium (Red Shoot)	oval	flat	smooth and slippery
C. variegatum (Croton)	round wavy	flat	smooth

The results showed that the three landscape plants had different leaf shapes and surfaces, while the edges had the same shape. Furthermore, the leaf arrangement on the stem and angle for each of the three landscape plants were presented in tabular form below.

Table 2

Leaf arrangement observation, leaf arrangement on a stem, and leaf angle

Plant Species	Leaf Arrangement	Stem Leaf Arrangement	Corner of the Leaf
P. orientalis (Fan Pine)	dichotom	spread	blunt
S. myrtifolium (Red Shoot)	pinnate	spread	flat
C. variegatum (Croton)	curved	spread	pointed

Table 2 showed that *P. orientalis* (fan pine), *S. myrtifolium* (red shoot), and *C. variegatum* (croton) in all zones had the same leaf stem arrangement, which is scattered. This include arrangement of *P. orientalis* (fan pine) was dichotomous, *S. myrtifolium* (red shoot) pinnate, and curved *C. variegatum* (croton). In addition, the leaf angles in *P. orientalis* (fan pine) were blunt, *S. myrtifolium* (red shoot) flat, and *C. variegatum* (croton) had pointed corners.

The measurements of the physical character of landscape plants for each airport zone are presented in Table 3. It indicated that the three landscape plants have different canopy shapes: *P. orientalis* (fan pine), *S. myrtifolium* (red shoot), and *C. variegatum* (croton) with a conical, globular and cylindrical shape, respectively. In addition, Table 3 showed the largest to the smallest area of plant crown projections, namely *P. orientalis* (fan pine), *S. myrtifolium* (red shoot), and *C. variegatum* (croton). The results showed that *P. orientalis* (fan pine) had a larger crown area than *S. myrtifolium* (red shoot) and *C. variegatum* (croton). Therefore *P. orientalis* (fan pine) had a higher average ability to reduce noise than *S. myrtifolium* (red shoot) and *C. variegatum* (croton).

Table 3
Observation of canopy shape, canopy projection area, leaf area index, and area of landscape plant canopy at Adisucipto airport

Plant Species	Zone	Canopy Shape	Canopy Projection Area (m^2)	*Leaf Area Index* (LAI)	Canopy Area (m^2)
P. orientalis (Fan Pine)	1	conus	5652,00	5,63	31792,50
	2		4083,57	6,28	25658,43
	3		4003,89	5,38	21520,92
S. myrtifolium (Red Shoot)	1	globular	2802,55	5,73	16070,86
	2		1814,92	7,25	13158,17
	3		1739,30	8,18	14227,47
C. variegatum (Croton)	1	cylinder	1533,20	0,84	1287,35
	2		1430,88	0,71	1015.92
	3		1978,59	0,91	1797,22

Zone Noise Level

The results of noise level measurements conducted during the study can be seen in Figure 2. Figure 2 showed that the noise level in all zones was different. The level in one and two was higher than in zone three. Therefore, the highest noise occurs in zone one, namely 76.13 db, followed by two 74.45 db and three 73.45 db. It was due to differences in the distance from the sound source to the zone area. The distance from the sound source to zone one was 0.5 km, two was 1 km, and three was 1.5 km. Apart from differences in distance, noise levels are also influenced by other factors, such as a very heterogeneous environment. The noise state was determined by many factors, namely heterogeneous environmental conditions and distance from sound sources. Environmental differences that are very heterogeneous are one of the factors causing noise in the airport area.

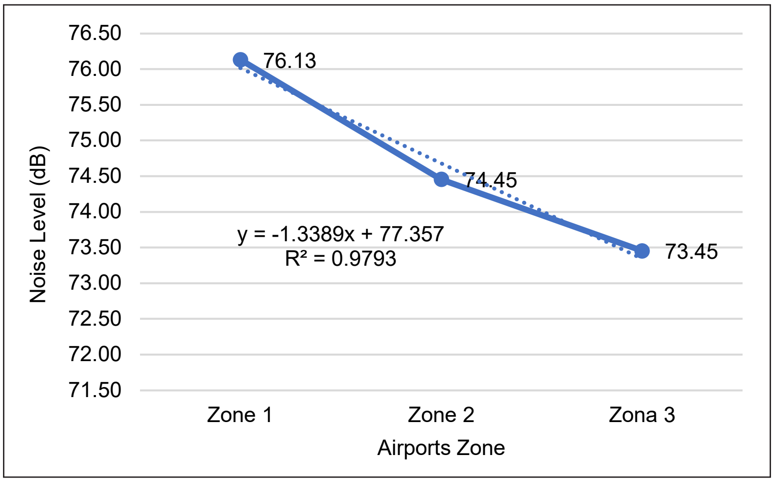

Figure 2. Noise levels in all airport zones

Noise Reduction Function

The noise reduction results outside and in the canopy of morning landscape plants (Table 4) showed a significant difference. Variation in zones have a different effect on noise between the outer and inner plant canopy, and the greatest reduction capability was in zone one.

Table 4
The result of noise reduction outside the canopy within the canopy of landscape plants in the morning

Plant Species	Average ability (db)			
	Zone1	Zone2	Zone3	Average
P. orientalis (Fan Pine)	11.38a	4.29c	3.95c	6.54
S. myrtifolium (Red Shoot)	6.19b	2.96cde	3.25cde	4.13
C. variegatum (Croton)	3.36cde	2.61d	2.42e	2.80
Average	6.98	3.29	3.21	4.49
Coefisien Variansi (%)				13.65

Note. Numbers followed by the same letter in the same column or row are not significantly different according to the Tukey HSD test; ns means not significantly different, * at the 5% significance level

The analysis showed that the greatest reduction results to the lowest in the morning were fan pine, red shoots, and croton. The average ability of landscape plants as noise reducers in the morning against the differences outside and inside the canopy was 6.54 db of pine cones, 4.13 db of red shoots, and 2.80 db of croton. The reduction of landscape plants in the three zones was 4.49 db.

Furthermore, the average noise reduction of landscape plants at the difference between the outer and inner canopy noise levels observed during the day are presented in Table 5.

Table 5
The result of noise reduction outside the canopy within the canopy of landscape plants during the day

Plant Species	Average ability (db)			
	Zone 1	Zone2	Zone3	Average
P. orientalis (Fan Pine)	6.17a	3.84bc	4.16b	4.72
S. myrtifolium (Red Shoot)	4.24b	2.92cd	3.24bcd	3.47
C. variegatum (Croton)	2.72d	2.46d	2.58d	2.59
Average	4.38	3.07	3.33	3.59
Coefisien Variansi (%)				11.74

Note. Numbers followed by the same letter in the same column or row are not significantly different according to the Tukey HSD test; ns means not significantly different, * at the 5% significance level

Table 5 showed a significant difference in the ability of the three species of landscape plants. In Table 5, it can be concluded that the distance (zone) has a significant effect on the ability of plants to reduce noise. The average ability of landscape plants to reduce noise during the day showed a significant difference. *Platycladus orientalis* (fan pine) was more effective at reducing noise than *C. variegatum* (croton) and was not significantly different in *S. myrtifolium* (red shoot).

Table 6
The result of noise reduction outside the canopy within the canopy of landscape plants in the afternoon

Plant Species	Average ability (db)			
	Zone 1	Zone 2	Zone 3	Average
P. orientalis (Fan Pine)	5,93a	4,12abc	4,01abc	4,69
S. myrtifolium (Red Shoot)	5,11ab	3,20dc	3,15d	3,82
C. variegatum (Croton)	3,62bcd	2,60d	2,57cd	2,93
Average	4,88	3,31	3.24	3,81
Coefisien Variansi (%)				5,82

Note. Numbers followed by the same letter in the same column or row are not significantly different according to the Tukey HSD test; ns means not significantly different, * at the 5% significance level. * Data converted in ancient sine form $\sqrt{log10(y)/100}$.

Table 6 above showed that the zones significantly affect the noise reduction results of the three landscape plants in the afternoon, and the highest results are in zone one. *Platycladus orientalis* (fan pine) was a landscape plant with the largest reduction results with a reduction of 5,93 db, while red shoots are 5,11 db and croton 3.62 db. In addition, the noise reduction of *P. orientalis* (fan pine) in zone two was not significantly different from the red shoots and significantly different from the croton, with the value of *P. orientalis* (fan pine) 4.69 db, *S. myrtifolium* (red shoots) 3.82 db, and *C. variegatum* (croton) 2.93 db. In zone three, the results from the three landscape plant species have no significant differences.

The results of noise reduction showed that landscape plants are used as noise absorbers. When sound waves spread into the air, the lower frequencies result in clearer diffraction (Yang et al., 2013). Furthermore, Yang et al. (2013) also explained that this resulted in large and dense plant arrangements with high noise attenuation values. Sound waves propagate through the air and leaves, while the energy causes leaf molecules to resonate. Therefore, *P. orientalis* (fan pine) and *S. myrtifolium* (red shoot) are better at reducing noise than *C. variegatum* (croton). It was because the arrangement of plants, which became a noise barrier, was quite thick. It makes it quite difficult for sound waves to pass through the barrier of the landscape plants. According to Hidayat (2010), plants reduce noise even though they do not eliminate it. It was possible when the planting pattern was with a high density resembling a wall or building barrier.

Price (1988) explained that leaves have an important role in reducing noise. Plants with large number of leaves are better at reducing noise than those with a small number. Maleki and Hosseini (2011) results also showed that plants with leaf thickness are more effective at reducing noise.

The results showed that the *P. orientalis* (fan pine) has the highest ability to reduce noise with a large header. According to Carpenter et al. (1975) explanation, the noise suppression capacity of vegetation was highly dependent on the plant canopy. Fitriyati and Nasrullah (2005) reported that the capacity to reduce noise by vegetation depends on the type, density, and denseness. Putra et al. (2018) stated that trees reduce sound by absorbing waves from leaves, branches, and twigs. The plant species that are most effective at reducing sound have a thick canopy with dark leaves. Plant foliage absorbs up to 95% noise (Putra et al., 2018) and causes the reduction ability of *P. orientalis* (fan pine) better than *S. myrtifolium* (red shoot) and *C. variegatum* (croton) (Table 3).

Heavy Metal (Pb) Absorption

The content of heavy metal Pb in the three types of landscape plants (Table 7) showed a significant difference. *C. variegatum* (croton) has the highest ability in absorbing Pb metal, and the highest to lowest plants ability to absorb Pb were *C. variegatum (croton)*, *S. myrtifolium (red shoot)*, and *P. orientalis* (fan pine).

Table 7
Pb level in these three species of landscape plants at the Adisucipto airport area

Plant Species	Pollutant Pb (ppm)			
	Zone 1	Zone 2	Zone 3	Average
P. orientalis (Fan Pine)	5.56f	2.02h	1.70h	3.09
S. myrtifolium (Red Shoot)	17.18c	11.76e	4.30g	11.08
C. variegatum (Croton)	22.35a	19.59b	13.09d	18.34
Average	15.03x	11.12y	6.36z	10.84
Coefisien Variansi (%)				2.48

Note. Numbers followed by the same letter in the same column or row are not significantly different according to the Tukey HSD test; ns means not significantly different, * at the significance level of 5%

The levels of heavy metal Pb in Table 7 above showed that *C. variegatum* (croton) has a higher ability than *S. myrtifolium* (red shoot) and *P. orientalis* (fan pine) in the three zones. The ability of *C. variegatum (croton)* to absorb Pb was because this was a biosorption plant or the ability to reduce heavy metals from water bodies (Kurniawati et al., 2016). In zone one, plants with the highest to low Pb absorption were *C. variegatum (croton)* at 22.35 ppm, *S. myrtifolium (red shoot)* at 17.18 ppm, and *P. orientalis* (fan pine) at 5,56 ppm. In zone two, the highest to lowest adsorptions were also similar to one, namely *C. variegatum (croton)* 19.59 ppm, *S. myrtifolium* (red shoot) 11.76 ppm, and *P. orientalis* (fan pine) 2.02 ppm. In zone three, metal absorption has decreased slightly compared to zones one and two. The highest Pb metal adsorptions of the three species were *C. variegatum (croton)* 13.09 ppm, *S. myrtifolium* (red shoot*)* 4.30 ppm, and *P. orientalis* (fan pine) 1.70 ppm.

The results of Pb adsorptions by plants in all zones were then compared with the Pb content of those in home gardens (Table 8).

Table 8
The differences between Pb pollutant content with control on three species of landscape plants in the Adisucipto airport area and home gardens

Plant Species	Pb (ppm)		
	Airport Area	Home Garden	Average
P. orientalis (Fan Pine)	3,09c	0,22e	1,66
S. myrtifolium (Red Shoot)	11,08b	0,44de	5,76
C. variegatum (Croton)	18,34a	0,64d	8,85
Average	10,84x	0,44y	5,64
Coefisien Variansi (%)			1,24

Note. Numbers followed by the same letter in the same column or row are not significantly different according to the Tukey HSD test; ns means not significantly different, * at the significance level of 5%

Table 8 above showed that the Pb content of the three landscape plants in the airport area was higher than that of home gardens. It showed that the airport area has a Pb heavy metal content. Plants in the zone area have a high Pb content, with a level of 10.84 ppm. These results showed that the three landscape plants absorb heavy metal contents and can be used as landscape plants to fulfil ecological functions.

Based on the description above, it was explained that the binding of Pb metal varies. *C. variegatum (croton)* was relatively better in accumulating heavy metals in plant leaves, and this ability was different for each vegetation type. Dudka et al. (1996) compared the concentrations of Pb and Cd metals in potato, banana, and wheat crops. The results obtained showed that the concentrations of Pb and Cd were different in plant parts and species. It was consistent with (Fergusson, 1990), where it was reported that many factors influence heavy metal levels in vegetation, including the type of vegetation, the content and availability of these heavy metals in the soil.

DISCUSSION

Plants in the very suitable category have physical characteristics and proper planting following the criteria of gas pollutants adsorbent. Observation showed that the three landscape plants are tolerant and capable of absorbing air pollution and cleaning dirty air more effectively through the tree canopy. In addition, the three landscape plants have great potential to absorb gaseous pollutants since they are expected to be preserved.

Azzahro et al. (2019) reported that a canopy reduces the pollutants released in the environment by diverting wind gusts into a wider atmosphere, and it absorbs pollutants on the surface of the leaves, stems, and twigs. Therefore, the plant selection to increase the ability of green open spaces to absorb pollutants should follow the physical criteria of plants that can absorb gaseous pollutants. It includes having a dense canopy and a large number of leaves. Increasing the absorption of gaseous pollutants was conducted by adding a combination of shrubs, bushes, and ground cover crops to each tree. This combination increases the filtering of gaseous pollutants. In the Adisucipto airport area, plants were found to absorb tolerant pollutants.

Landscape plants are one of the most promising solutions to tackle air pollution, reducing noise and absorbing heavy metal particles. Therefore, the planning and selection for urban areas, such as airports, should be conducted since air pollution does not worsen. Apart from functioning as a chemical pollutant absorbent, landscape plants also reduce qualitatively and quantitatively noise (Nugraheni et al., 2018). Furthermore, it was explained that landscape plants as a metal binder or bioaccumulator absorb and accumulate heavy metals in plant parts and reduce noise.

In the previous study related to noise reduction, *P. orientalis* (fan pine) was the plant species with the best ability, followed by *S. myrtifolium* (red shoot) and *C. variegatum* (croton). Meanwhile, from the aspect of its ability to absorb Pb metal pollutants, it was reversed because *C. variegatum* (croton) has the best ability to absorb Pb, followed by *S. myrtifolium* and *P. orientalis* (fan pine). There are at least two kinds of pollutants, namely noise and heavy metals. It includes a combination of several species, namely *P. orientalis* (fan pine), *C. variegatum (croton)*, and *S. myrtifolium (red shoot)*. The landscape function was perfect in reducing these two pollutants. The composition of the three species needs to be regulated in a balanced proportion considering that each of them has a specific optimal function. Therefore, in arranging the landscape, a mixed crop was the best choice to optimise its function. Besides functioning as a chemical pollutant absorbent, they also reduce qualitatively and quantitatively noise (Martuti, 2013).

This study examined three dominant landscape plants in the Adisucipto area. The selection of the dominant plants was carried out during pre-observation. They were *P. orientalis* (fan pine), *S. myrtifolium* (red shoot), and *C. variegatum* (croton), and the study was conducted in the airport area using the zoning method. The area was divided into three zones of 1, 2 and 3 with a distance of 0.5 km, 2 km, and 1 km from the sound source, respectively.

The average noise level in each zone was different (Figure 2), occurring in zone 1 at 76.13 db, the average noise in zone 2 was 74.45 dB, and the average noise in zone 3 was 73.45 db. These differences indicated that the amount of sound produced by each zone was different. Therefore, the closer to the sound source, the higher the noise level. Furthermore, high pollutants were also due to heterogeneous environmental conditions.

The experimental results showed that zoning the airport area did not affect the scope of human activity. Based on the Minister of Environment Decree No. KEP-48 / MENLH / 11/1996, the noise standard for residential areas was 55 db (State Minister of the

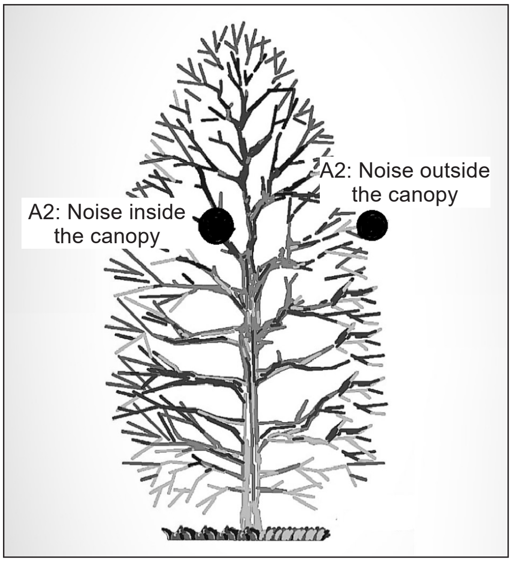

Figure 3. Noise measurement

Environment, 1996). Therefore, the noise has not had a real effect in reducing the sound for the space needs of human activities.

Landscape plants with different morphological characteristics have different abilities to reduce noise. Differences in the absorption of Pb metal occurred in the three species. Meanwhile, differences in reduction and absorption also happened in the zoning area. The highest noise reduction ability in each zone (zone 1,2,3) was *P. orientalis* (fan pine) plants. It reduces noise up to 6.54 db, while the highest ability to absorb heavy metals was by *C. variegatum* (croton) with the absorption of 17,77 ppm by the difference between the Pb content of the airport area (18,34 ppm) and home garden (0,64 ppm). Therefore, the dominant abilities of landscape plants were different.

The morphological characteristics of needle-shaped *P. orientalis* (fan pine) leaves (Table 3) had a high noise reduction value. Furthermore, it has a fast photosynthetic rate compared to *S. myrtifolium* (red shoot) and *C. variegatum* (croton). Therefore, needle-shaped plants with a fast photosynthesis rate can be used for effective noise reduction.

The noise condition at zone 1 of the airport was 76.13 db, which was expected to be reduced to 6.54 db. In high noise conditions, zone 1 had high pollutant levels. Therefore, it was necessary to have a proportional composition of planting in the airport landscape area. Therefore, recommendations for the arrangement in the first layer of zone one was *P. orientalis* (fan pine) with a larger proportion. In contrast, the second and third layers were *C. variegatum* (croton) and *S. myrtifolium* (red shoot). The selection of *P. orientalis* (fan pine) in layer one of zone 1 was because the plant absorbs air pollution and does not reach areas outside the airport.

The percentage of plant composition in zone one for *P. orientalis* (fan pine) was 50%. Furthermore, *C. variegatum* (croton) in the second layer with a total percentage of 25% was expected to absorb pollutants where the highest source was in zone 1. The *S. myrtifolium* (red shoot) plant in the third layer with a composition of 25% was expected to be a noise reduction plant. It was because the sound not obstructed by *P. orientalis* (fan pine) can be suppressed. Moreover, the proportional planting of *S. myrtifolium* (red shoot) in layer three should absorb pollutants in areas outside the airport since three species of landscape plants can filter ecologists.

Furthermore, in the second zone, with a noise level of 74.45 db and high metal pollutants, landscape plants should minimise ecological conditions at the airport. The planting proportion in zone two was *C. variegatum* 50% (croton), *P. orientalis* (fan pine) 30%, and *S. myrtifolium* (red shoot) 20%. *C. variegatum* (croton) on the first layer absorbs pollutants from planes and other airport activities. In the second layer, planting a *P. orientalis* (fan pine) reduces the sound source from planes and other activities. Finally, *S. myrtifolium* (red shoot) with moderate metal reduction and absorption capabilities neutralises the second zoning area in the third layer.

In zone three, the proportions of landscape plants were 40% *S. myrtifolium* (red shoot), 30% *C. variegatum* (croton), and 30% *P. orientalis* (fan pine). In layer one, the arrangement of *S. myrtifolium* (red shoot) plants reduces noise from pressure at sound sources of the airport. In addition, the plant suppresses pollutants from the airport area to the residential zone. *C. variegatum* (croton) was planted in the second layer to expect the pollutant absorption to be more optimal since it does not reach the residential area. Finally, in the third layer, *P. orientalis* (fan pine) was planted at a percentage of 20% since open sound sources can be absorbed to prevent them from reaching the houses in the airport area.

The significance of the urgency in selecting *P. orientalis* (fan pine) plants becomes the input for planting vegetation in the airport area. Furthermore, plant species in the same family as *P. orientalis* (fan pine), such as Cupresaceae and needle-shaped leaves, were used to combine plant selection in green open space arrangement. The selection of plant species, such as *S. myrtifolium* (red shoot), was used as an alternative for planting in airport landscapes. Moreover, shrubs may also be used as input or recommendations for selecting vegetation planting in the airport landscape. Besides *P. orientalis* (fan pine) and *S. myrtifolium* (red shoot), *C. variegatum* (croton) species with high canopy characteristics were used as input as one of the available vegetation in the airport layout.

The morphological characteristics of *P. orientalis* (fan pine), *S. myrtifolium* (red shoot), and *C. variegatum* (croton) were used as input for selecting the airport landscape. Planting a mixed crop with the input of various plant species may be perfect in utilising the function of landscape plants as an air filter, especially in reducing noise and absorbing air pollution.

CONCLUSION

P. orientalis (fan pine) was a landscape plant with an increased noise reduction ability of 6.54 db. This study reported that the plant with the most potential as a Pb absorbent was *C. variegatum* (croton), with absorption of 17,77 ppm. Furthermore, a mixed crop was recommended because landscape arrangement provides an optimal function. Besides functioning as a chemical pollutant absorbent, landscape plants also act as noise reduction, qualitative and quantitative.

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REFERENCES

Andersen, Z. J., Hvidberg, M., Jensen, S. S., Ketzel, M., Loft, S., Sørensen, M., Tjønneland, A., Overvad, K., & Nielsen, O. R. (2011). Chronic obstructive pulmonary disease and long-term exposure to traffic-related rir pollution. *American Journal of Respiratory and Critical Care Medicine, 183*(4), 455-461. https://doi.org/10.1164/rccm.201006-0937OC

Ashford, N. J., Mumayiz, S., & Wright, P. H. (2011). *Airport engineering planning, design and development of 21st century airports fourth edition*. John Wiley & Sons, Inc. https://doi.org/10.1002/9780470950074

Azzahro, F., Yulfiah., & Anjarwati. (2019). Penentuan hasil evaluasi pemilihan spesies pohon dalam pengendalian polusi udara pabrik semen berdasarkan karakteristik morfologi [Determining the results of the evaluation of tree species selection in air pollution control of cement factories based on morphological characteristics]. *Journal of Research and Technology, 5*(2), 89-98.

Black, D. A., Black, J. A., Issarayangyun, T., & Samuels, S. E. (2007). Aircraft noise exposure and resident's stress and hypertension: A public health perspective for airport environmental management. *Journal of Air Transport Management,* 13(5), 264-276. https://doi.org/10.1016/j.jairtraman.2007.04.003

Carpenter, P. L., Walker T. D., & Lanphear F. O. (1975). *Plant in the landscape.* W.H. Freeman and Co.

Clark, C., Head, J., & Stansfeld, S. A. (2013). Longitudinal effects of aircraft noise exposure on children's health and cognition: A six-year follow-up of the UK RANCH cohort. *Journal of Environmental Psychology, 35*, 1-9. https://doi.org/10.1016/j.jenvp.2013.03.002

Corbitt, R. A. (Ed). (2004). *Air pollution in standard handbook of environmental engineering second edition*. McGraw-Hill.

Dudka, S., Piotrowska, M., & Terelak, H. (1996). Transfer of cadmium, lead, and zinc from industrially contaminated soil to crop plants: A field study. *Environmental Pollution, 94*(2), 181-188. https://doi.org/10.1016/S0269-7491(96)00069-3

Ferguson, J. E. (1990). *The heavy elements: Chemistry, environmental impact and health effects*. Pergamon Press.

Fitriyati, N., & Nasrullah, N. (2005). The role of vegetation canopy as noise barrier. *Jurnal Lanskap Indonesia, 1*(1), 4-6.

Hendrasarie, N. (2007). Kajian efektifitas tanaman dalam menjerap kandungan pb di udara [Study of the effectiveness of plants in absorbing lead content in air]. *Jurnal Rekayasa Perencanaan, 3*(2), 1-15.

Herawati, P. (2016). Dampak kebisingan dari aktifitas bandara sultan thaha Jambi terhadap pemukiman sekitar bandara [Impact of noise from Sultan Thaha Airport activities Jambi towards settlements around the airport.]. *Jurnal Ilmiah Universitas Batanghari Jambi, 16*(1), 104-108.

Hidayat, I. W. (2010). Study of the ecological function of roadside greenery as environmental bulfer on jagorawi highway. *Jurnal Manusia dan Lingkungan, 17*(2), 124-133.

Koeppe, D. E., & Miller, R. J. (1970). Lead effect on corn mitochondrial respiration. *Science, 167*(3923), 1376-1378. https://doi.org/10.1126/science.167.3923.1376

Kurniawati, L., Syamsidar, H. S., & Kurnia, R. (2016). Fitoremediasi logam kadmium (Cd) dari asap rokok menggunakan tanaman puring [Phytoremediation of cadmium metal (Cd) from cigarette smoke using croton (*Codiaeum variegatum*)]. *Jurnal Al- Kimia, 4*(1), 62-67. https://doi.org/10.24252/al-kimia.v4i1.1457

Maleki, K., & Hosseini, S. M. (2011). Investigation of the effects of leaves, branches and canopies of trees on noise pollution reduction. *Annals of Environmental Science, 5*, 13-21.

Martuti, N. K. T. (2013). The role of plants against air pollution in the protocol street of Semarang city. *Journal Biosantifika, 5*(1), 36-42.

Megia, R., Ratnasari., & Hadisunarso. (2015). Karakteristik morfologi dan anatomi, serta kandungan klorofil lima kultivar tanaman penyerap polusi udara sansevieria trifasciata [Morphological and anatomical characteristics, as well as chlorophyll content of five cultivars of air pollution-absorbing *Sansevieria tripasciata*]. *Jurnal Sumberdaya Hayati, 1*(2), 34-40.

Menteri Negara Lingkungan Hidup. (1996). *Baku tingkat kebisingan* [Standard noise level]. Surat Keputusan Menteri Negara Lingkungan Hidup Nomor: Kep 48/MENLH/1996/25 November 1996. Jakarta.

Nugraheni, D. S., Putri, R. A., & Rini, E. F. (2018). The capability of vegetation cover of rth in absorbing co_2 emission of transportation sector in Surakarta city. *Jurnal Pembangunan Wilayah dan Perencanaan Partisipatif, 12*(2), 182-198.

Price, M. A. (1988). Sound attenuation through trees: Measurement and models. *Journal of Acoustical Society of America, 84*(5), 1836-1844. https://doi.org/10.1121/1.397150

Putra, I. S., Rombang, J. A., & Nurmawan, W. (2018). Analisis kemampuan vegetasi dalam meredam kebisingan [Analysis of vegetation capability to reduce noise]. *Eugenia, 24*(3), 105-115. https://doi.org/10.35791/eug.24.3.2018.22660

Setiawan, I., Majid, S. A., & Yuliantini, Y. (2013). Airport factor in flight delays in Indonesia. *Jurnal Manajemen Transportasi & Logistik, 2*(3), 365-384. http://dx.doi.org/10.25292/j.mtl.v2i3.115

Shannigrahi, A. S., Sharma, R., & Fukushima, T. (2010). Air pollution control by optimal green belt development around the victoria memorial monument, Kolkata (India). *International Journal of Environmental Studies, 60*(3), 241-249. https://doi.org/10.1080/0020723022000008202

Sumathi, N., & Parthasarathi, A. (2018). Analysis of airport operations. *International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS), 7*(3), 119-123.

Yang, H. S., Kang, J., & Cheal, C. (2013). Quantifying scattered sound energy from a single tree by means of reverberation time. *The Journal of the Acoustical Society of America, 134*(1), 264-274. https://doi.org/10.1121/1.4808175