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Using Urban Vegetation to Reduce Airport Noise: An Eco-Friendly and Economical Solution

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Abstract

This study investigated the effectiveness of three types of urban plants Pucuk Merah, Cemara Kifan, and Furing as noise barriers around airports. Using a 2-inch diameter sound tunnel along 6 meters with 3 mm PVC material, noise measurements were made at several points along the tunnel. The results showed that Furing plants had the most significant decrease in noise levels with an average noise reduction percentage of 46.79%. Pucuk Merah and Cemara TFan showed noise reductions of 29.54% and 23.94% respectively. Without the plant barrier, noise was only reduced by 17.77%. The characteristics of thick and dense leaves, as well as the complex structure of the plant, make Furing the most effective noise barrier. These results suggest that the use of plants, particularly furing, as a natural barrier around airports can significantly reduce the negative impact of noise and create a more comfortable environment.

Keywords: *Noise, airports, urban plants, noise barriers, hearing health, environment*

1. INTRODUCTION

The changes brought about by the era of globalization provide diverse challenges, requiring anticipation from the beginning (Dalby, 2021). An increasing understanding of human rights, democracy, gender equality, and the environment is becoming a hallmark of the phenomenon of globalization (Kalu & Attamah, 2021; Zinchenko et al., 2021). In this context, Health and Work Safety have a crucial role, especially in managing human resources and the environment in complex industrial environments. However, technological advancements, especially in the air transport sector, provide great benefits while causing negative impacts on the environment, especially related to air emission pollution and noise around airports(Ekici et al., 2022; Ovdiienko et al., 2021; Wittmer & Müller, 2021).

Addressing these negative impacts requires fundamental steps starting from the planning phase. One aspect that needs to be considered is the noise around the airport, which can interfere with the health and comfort of workers and users of air transportation services(Baudin et al., 2021). The noise can also cause impairment in hearing, balance, and mental-emotional well-being (Chen et al., 2020; Farooqi et al., 2022;

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Sarant et al., 2023). Efforts to address noise have been made, including by using noise barriers, but more research is needed.

This study aimed to investigate the effectiveness of different types of plants as noise barriers around airports. The results of this study are expected to be a guide in reducing the negative impact of noise by using plants as an alternative barrier that is environmentally friendly and economical.

2. METHOD

The application of urban leaf plants (Furing, Red Shoots and Fan Cypress) aims to reduce noise around airports by addressing its negative impact on hearing health and human psychic condition. To test the noise level, a 6-meter-long 2-inch sound tunnel was used designed to minimize sound reflection using 3 mm PVC material. The noise is emitted through loudspeakers placed in front of the mouth of the tunnel where the urban leaf plants are laid. Noise measurements were made every 1 meter in front of urban leaf plants and inside tunnels using sound measuring devices. This study aims to determine the decrease in noise levels by testing several types of urban leaves.

3. RESEARCH FRAMEWORK

In Figure 1. It can be explained that noise generated from airport activities can cause various negative impacts on human health. The noise not only has the potential to cause hearing damage, but can also affect a person's emotional state and trigger disorders of the body's cardiovascular system. To prevent and reduce the negative impact caused by this noise, effective countermeasures are needed. One solution that can be implemented is to utilize certain types of plants in urban areas, which serve as a natural barrier against noise. The use of urban vegetation around the airport is expected to be able to reduce noise so as to minimize the adverse effects caused by airport noise.

Figure 1. Research Framework Data Retrieval

4. DATA RETRIEVAL

Data Retrieval Steps (Figure 2):

1. Loudspeakers are placed at the end of the sound aisle at a distance of 30 cm from the starting point of measurement.
2. Noise level measurements are made at several points shown in the figure, where the SL 1 noise sensor is placed at the end of the aisle to obtain reference data.
3. Several types of leaves that are often found in urban areas have been selected and placed at the end of the voting aisle according to a predetermined leaf arrangement matrix.
4. The noise level given to the barrier media is set at 100 dB, according to the traffic noise level based on previous studies. The type of sound used in this study was continuous sound to ensure consistency of testing.

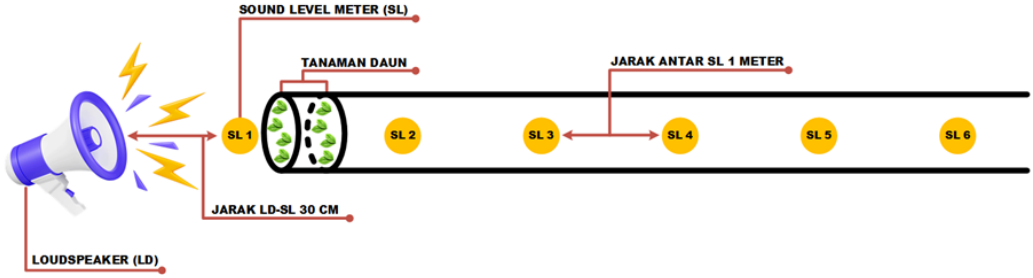

Figure 2. Data Retrieval

5. RESULT AND DISCUSSION

The trend of decreasing noise levels for each barrier from houseplants is shown in Table 1 and Figure 3.

Table 1. Data Retrieval Results

Types of plants	Average noise level (dB) inside tunnels measured at a certain distance (meter)						Noise reduction rate
	0	1	2	3	4	5	%
No Plants	105,7	103,6	98,5	91,3	89,6	86,9	17,77
Pucuk Merah	105,7	98,1	95,7	83,4	78,5	74,5	29,54
Cemara	105,7	102,3	97,5	87,2	84,2	80,4	23,94
Furing	105,7	90,5	86,3	79,1	69,8	56,2	46,79

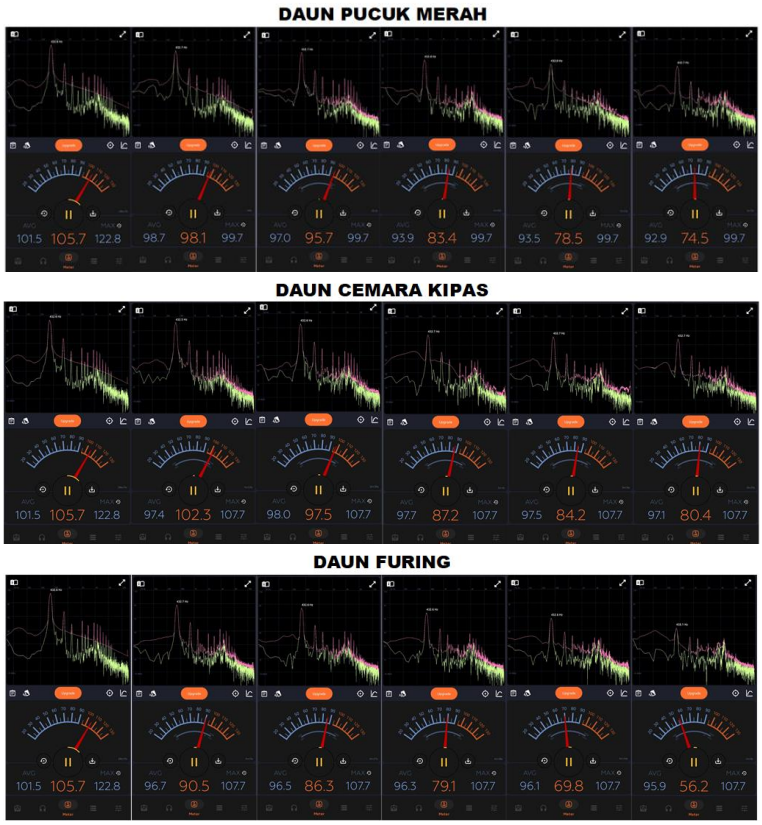

Figure 3. Data Retrieval Results

The trend of decreasing noise levels for each barrier from ornamental plants processed from the data in Table 1 and Figure 3 is shown in the graph in Figure 4, as follows:

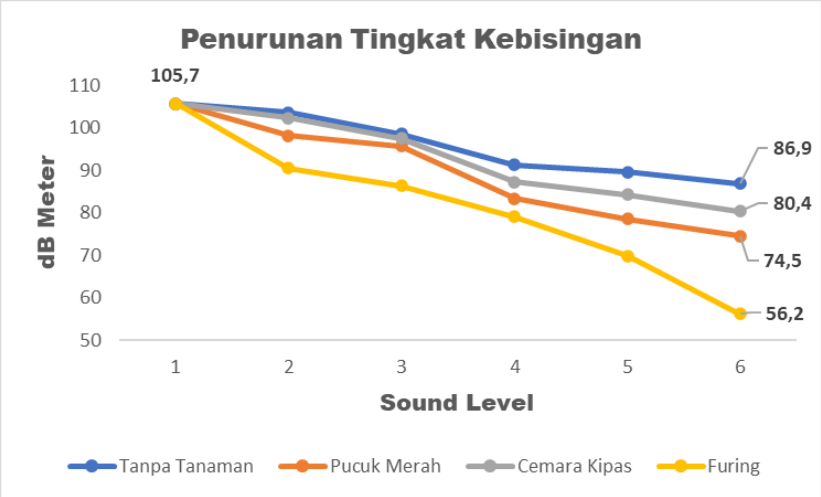

Figure 4. Tendency to decrease noise levels by some types of urban plants

While the percentage of the average noise reduction level by the barrier of some ornamental plants can be seen in Figure 5, as follows:

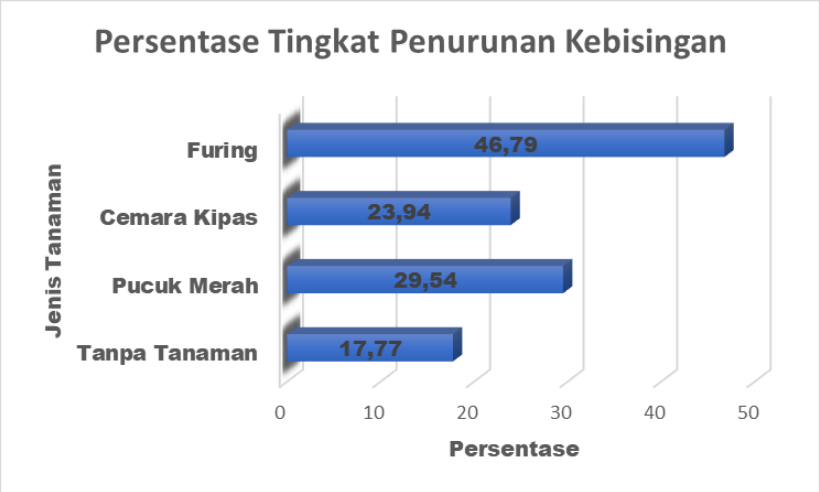

Figure 5. Average noise reduction rate percentage

From Figures 4 and 5 can be obtained information on the types of urban leaf plants that are most effective in reducing noise levels from the highest to the lowest. Furing type urban leaf plants are the most effective in reducing noise levels, followed successively by Red Shoots and Cypress. Each type of urban leaf plant has a different leaf surface area size and leaf characteristics. The characteristics of urban leaves can be seen in Table 2.

Table 2. The characteristics of urban leaves

No.	Types of leaves	Characteristic
1.	**Furing** (Agustin & Hamidah, 2019; Bai et al., 2023; Mfotie Njoya et al., 2014; Ojha & Kumar, 2022)	1. **Leaf Density and Thickness:** Furing leaves have a fairly thick and dense structure. The thickness and density of these leaves help absorb and dampen sound waves, so that the sound passing through this plant becomes dimmer. 2. **Large Surface Area:** The furing plant has many leaves that spread evenly and create a wide surface. The wide and numerous surface of these leaves serves as a sound absorber, capturing incoming sound waves and reducing their intensity. 3. **Plant Structure:** Furing plants grow with dense branches and numerous leaves, creating an effective physical barrier to muffle sound. This complex structure makes sound have to go through many layers before it reaches the other side, which reduces the power of the sound. 4. **Ability to absorb sound waves:** Natural materials such as leaves and plant stems have the ability to absorb sound waves, in contrast to hard surfaces that reflect sound. Furing leaves, with their texture and structure, can absorb some of the energy

		from sound waves, reducing them before they reach the human ear. 5. **Voice Deployment:** The leaves and branches of the furing plant can break down sound waves into smaller parts and spread them in different directions. This dispersion reduces the concentration of sound energy and makes it sound softer and less loud.
2.	**Pucuk Merah** (Mudiana & Ariyanti, 2021; Roşca et al., 2019; Stephens, 2006)	1. **Leaf Density and Thickness:** The leaves of red shoots have a fairly thick and dense structure. The thickness and density of these leaves help absorb and dampen sound waves, reducing the intensity of sound passing through this plant. 2. **Large Surface Area:** The plant of red shoots has many densely scattered leaves, creating a wide surface. This broad leaf surface serves as an effective sound absorber, capture sound waves and reduce their reflection. 3. **Neat Plant Structure:** Red shoot plants usually grow in a neat and tight shape, often formed into hedges. This tight structure creates an effective physical barrier to muffle sound. As sound passes through hedges of red shoots, sound waves must pass through many layers of leaves and stems, which significantly reduces the intensity of such sounds. 4. **Ability to absorb sound waves:** Natural materials from the leaves and stems of red shoots are able to absorb sound waves better than hard surfaces that reflect sound. Numerous leaves and dense stems can absorb some of the energy from sound waves, reducing them before they reach the human ear. 5. **Sound Dissemination and Diffusion:** The complex structure of leaves and stems of red shoot plants can break down sound waves into smaller parts and scatter them in different directions. This diffusion reduces the concentration of sound energy, making the sound sound softer and less loud.
3.	**Cemara Kipas** (Kuzmina et al., 2024; Tyree & Dixon, 1983;	1. **Dense and Dense Leaf Structure:** Fan fir leaves grow very densely and densely, creating an efficient physical barrier to muffle sound. The thickness and density of these leaves help

	Yerezhepova et al., 2024)	absorb and dampen sound waves, reducing the intensity of sound passing through this plant. 2. **Abundant Leaf Surface:** Fan fir plants have many small leaves that spread evenly, creating a wide surface. The broad surface of these leaves acts as a good sound absorber, capturing sound waves and reducing their reflection. 3. **Tall and Thick Plant Structure:** Fan fir usually grows tall and thick, often used as a living hedge. This tall, thick structure creates an effective physical barrier to muffle sound. Sound waves must pass through many layers of leaves and branches before reaching the other side, which reduces the intensity of the sound. 4. **Ability to absorb sound waves:** Natural materials from the leaves and stems of fan fir plants are able to absorb sound waves better than hard surfaces that reflect sound. Numerous leaves and dense stems can absorb some of the energy from sound waves, reducing them before they reach the human ear. 5. **Sound Dissemination and Diffusion:** The complex structure of leaves and branches of fan fir plants can break down sound waves into smaller parts and scatter them in different directions. This diffusion reduces the concentration of sound energy, making the sound sound softer and less loud.

6. CONCLUSIONS AND SUGGESTIONS

Furing plants were the most effective noise barrier among the three types of plants tested. The use of urban vegetation such as Furing around airports can significantly reduce noise and its negative impacts, creating a quieter and more comfortable environment.

Furing plants showed the most significant decrease in noise levels with an average noise reduction percentage of 46.79%. Red shoots took second place with a noise reduction of 29.54%. Cemara TFan is in third position with a noise reduction of 23.94%. Without the plant barrier, noise was only reduced by 17.77%.

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