Recent Trends in Civil Engineering and Built Environment Vol. 4 No. 3 (2023) 362-371

RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

Effectiveness of Natural Traffic Noise Barrier: A Case Study at Muar Bypass (FT224)

Aida Suryyanie Azahar[1], Mohd Ezree Abdullah[1]*

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Associate Professor, Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia

DOI: https://doi.org/10.30880/rtcebe.2023.04.03.039
Received 06 January 2022; Accepted 15 May 2023; Available online 31 December 2023

Abstract: Due to the increasing severity of noise pollution, many road traffic noise models are now accessible around the world. This phenomenon necessitates the construction of road traffic noise barriers in such a manner that they effectively suppress noise behind them while simultaneously creating a low amount of reflected noise in the direction of the source. The purpose of this study was to investigate the effect of tree as a traffic noise barrier. The objective is also to measure the traffic noise and observe type of tree at Muar Bypass (FT224). A review as well as case studies were employed as research methodologies. The first approach used was a review study, in which the results of the previous study were compared to those of current study in order to determine whether there were any differences in outcomes in terms of various areas. When using the second method, a case study, the location chosen as the study area is Muar Bypass (FT224) in sections 4-5 since it meets all of the criteria necessary for this study. The distance between sources and receivers is 50 m. The findings revealed that the amount of traffic noise was reduced in the areas where the trees were denser. The total reduction in noise levels was found to be between 2 and 10 decibels. In addition, the researcher was able to identify nine different species of trees that occur in the region and have been identified as potential noise barriers in this study.

Keywords: Noise Barrier, Traffic Noise, Tree

1. Introduction

The growth in road traffic and the building of new roads has resulting in a growing issue of traffic noise pollution, demanding corrective measures. In urban contexts, traffic noise has always been a concern, and some abatement measures that have been explored for existing roads or highways that are being rebuilt include constructing buffer zones, installing barriers, planting vegetation, and placing noise insulation on buildings. The installation of noise screening in the form of noise barriers or embankments along existing roads and highways, as well as in locations where it will not be feasible to reduce noise annoyance through planning measures in the foreseeable future, may be necessary. According to Pathak *et al*. [1], it has been demonstrated that using the plants that have been selected to

**Corresponding author: ezree@uthm.edu.my*

serve as a sustainable traffic noise barrier may reduce road traffic noise provided they are placed at a sufficient height, width, and density. Sustainably grown traffic noise barriers are ecologically friendly, have a natural appearance, and are consequently in high demand; nevertheless, the effectiveness of screening will be decided by the thickness of the plants and the density of leaves. It has been demonstrated that using the plants that have been selected to serve as a sustainable traffic noise barrier may reduce road traffic noise provided they are placed at a sufficient height, width, and density [1]. Sustainably grown traffic noise barriers are ecologically friendly, have a natural appearance, and are consequently in high demand; nevertheless, the effectiveness of screening will be decided by the thickness of the plants and the density of leaves. There are so many plants that can be as a road traffic noise barrier. This is because air, soil, stems, trunks, branches, and foliage make up the complex medium that is plants that stated by Huang *et al.* [2].

There are two (2) objectives in this research. First objective is to determine the effect of traffic noise barrier using tree. Second, the purpose of research is to measure the traffic noise and identify type of tree at Muar Bypass (FT224).

2. Methodology

2.1 Review study

The literature review processes were done to analyze the important strands pertaining to trees' usefulness as a noise barrier. This research reviewed a suitable amount of related articles within this scope. The literature review includes peer-reviewed journals, refereed conference proceedings, some online reports, and books. The study followed a four-stage cycle of identification, collection, classification, and analysis. The first step was to determine the primary keywords. Due to the study's primary objective of determining the efficiency of trees as noise barriers, the following keywords were utilized in the search: *noise barrier, traffic noise, tree, vegetation, noise annoyance, urban noises, and tree effect.* The engines Science Direct, Research Gate, and Google Scholar were utilized to conduct the literature search. Following the collection of articles, their bibliographies were inspected to find any relevant articles that were overlooked in the first search results.

2.1.1 Year Publication

The literature reviewed in this paper dates from 1976 to 2021. This allowed researchers to determine whether the thought process has evolved over time as a result of the introduction of new methods. Figure 1 shows the frequency of articles published in various decades since the 1970s.

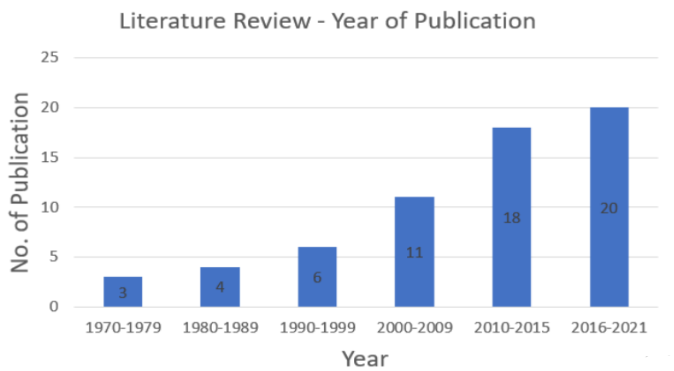

Figure 1: Frequency of articles published in various decades since the 1970s

2.1.2 Top 10 paper widely used

Top ten papers of study also highlighted the top ten utilized papers in the study. Table 1 gives the list of top ten of paper utilized. It was essential to use high-quality and reputable journals for this investigation.

Table 1: Top 10 of paper utilized

No.	Title of paper	Number cited
1	A review and meta-analysis of country-of-origin research	2.224
2	Synthesis of social surveys on noise annoyance	1,211
3	Annoyance from road traffic noise: a review	542
4	The evolution of service innovation research: a critical review and synthesis	479
5	Noise reduction by vegetation and ground	420
6	Investigation of the noise reduction provided by tree belts	345
7	Identifying categories of service innovation: A review and synthesis of the literature	301
8	Noise barriers with reactive surfaces	165
9	Highway noise barriers: new shapes	164
10	Characterization of environmental noise based on noise measurements, noise mapping and interviews: A case study at a university campus in Brazil	154

The final step in the process was to analyze the downloaded papers. These papers were classified into the following categories based on their content analysis. The following topics are discussed: noise barrier, traffic noise, tree, vegetation, noise annoyance, urban noises, and the effect of trees. As a result, the remainder of this paper is organized around these sections.

2.2 Case study

2.2.1 Study area

The research location is picked on one of the busiest traffic routes in Muar which is Bypass Road (FT224). The 13.8 km highway bypass connects Parit Bunga in the northwest to Parit Sakai in the southeast. But this research is focused primarily on the route from section 4 until section 5 that shown in Figure 2. For the location without tree, the area is 15,820 m^2, the area of sparse to medium tree is 9,404 m^2 and the area of dense of tree is 11,402 m^2. The total area for this study area is 36,633 m^2.

Figure 2: The study area selected using Google Map

2.2.2 Modeling

The 3D simulation environment employed in this study is a simplified way to simulating sound propagation in three orthogonal planes as discussed by Van Renterghem *et al.* [3]. From the traffic noise source through the modeling, all measurement distances for the 3D simulation environment were taken to be 50 meters. This distance is maintained at the same value for the purpose of maintaining data accuracy and preventing errors. Table 2 lists the modeling characteristics that were used for this investigation.

Table 2: The characteristic of modeling

Site	Descriptions	Site figure
Dense of tree	Has a large quantity of trees and exist various types of trees (spacing between tree to other tree is less than 5 meters)	
Spare to medium of tree	Has a moderate quantity of trees and there are only a few types of trees that exist (spacing between tree to other tree is 5 meters or more)	
No tree	Open field	

2.2.3 Data

Data noise traffic levels were measured in 2 different times namely 2 days on weekdays (Wednesday and Thursday) and 2 days on weekends (Fridays and Saturday). It is taken at peak hour traffic highway which is morning (8.00 am - 9.00 am), noon (12.00 pm - 1.00 pm) and evening (5.00 pm - 6.00 pm). Observation data (APPENDIX A) were taken during good and sunny weather and wind speed was in the range of 0-2 m/s. Traffic noise levels were measured in 5-min intervals. The equipment used to analyze the data:

- MeterSMART SENSOR Mini Digital Sound Level
- DJI Mini 2
- Measuring tape

In the process of identifying the types of trees in the study area, a landscape contractor has been identified to assist in identifying the types of trees that have the potential to have the characteristics of effectiveness as a noise barrier medium. Figure 3 shows the researcher with landscape contractor in the study area.

Figure 3: Researcher with the landscape contractor in the study area

3. Results and Discussion

3.1 Review study

3.1.1 Spacing between sources and trees

Spacing between sources and trees affects traffic noise. Researchers have studied the effects of this aspect, they said that a noise barrier is particularly effective at close ranges, where a substantial acoustic shadow zone forms. Shielding decreases as the distance between the receiver or source and the barrier increases, as the difference between the lengths of the path sound must travel over the barrier and the length of the (virtual) direct sound path between source and receiver decreases [4]. With 48 increasing distances, noise attenuation decreases. This phenomenon has been named the distance effect. Furthermore, reflection, refraction, scattering and absorption effects due to any obstruction between a noise source and a receiver result in excess attenuation stated by Martens [5]. Relative attenuation can be used to measure the barrier effect. Open-ground measurements only show the influence of distance, but data collected in the tree belt show the effect of both distance and vegetation. Consequently, the difference between the two values results in the relative attenuation of each measurement site inside the forest belt referred by Garg and Maji [6]. dB A/ 20 m is a measure of the mean value of relative attenuation. Referring to King *et. al* [7], the observed sound pressure levels (SPLs) in the field trials were used to compute the excess attenuation values for the five distances under study in the plant communities and above the grass field. During an experiment, the distances between the sources and receivers were 6, 12, 24, 48, and 96 m. Besides, this study also noticed that distances to major roads and highways had a significant effect on the ambient noise level at a specific place such as an in situ noise measurement site stated by Ba and Kang [8]. However, due to the relatively short distance between the source and receiver, refraction effects will have a negligible impact on this study [3]. The researchers experimented with placing the receivers at various distances from the source, including 5, 10, and 20 m, to determine whether there was a difference in traffic noise reduction. However, when the intensity of vegetation climbed from that of sparse to medium intensities, it was discovered that the overall decrease had grown by 50%, indicating that. To sum up, it can prove that the distance between source and receiver play a role in the effectiveness of tree as a traffic noise barrier. The efficiency of a tree in decreasing traffic noise is enhanced when combined with a soft soil setback, which becomes more effective as the distance between the source and the tree increases.

3.1.2 Type and size of plants

The size of the plant is one of the reasons traffic noise can be reduced. It is proven based on (Martens, 1981), the researcher stated that tree belt density, height, length, and width are more important than leaf size and branching features in lowering noise. Table 3 shows the acoustic classification of the three types of vegetation used in this investigation:

Table 3: Type of vegetation

		Type 1	Type 2	Type 3
Type of plant		Beech tree and ash tree forest	The mixed poplar forest and *Stellario carpinetum*	The evergreen spruce-fir forest and belts
Characteristic	Height (m)	6 – 7.5	12 - 17	7.5 – 8
	Diameter of stem (m)	1.5	1.5	1.5

Based on Garg and Maji [6], to conduct acoustic measurements, 35 big plantations of single species with a consistent density and height and 48 + 2 dB A ambient noise were selected. All 19 evergreen tree and shrub species were found on the plantations. Table 4 lists the species and features of the plantation.

Table 4: Lists the species and features of the plantation

	Group 1	Group 2	Group 3
Name of plant	1. *Bambusa dolichoclada* 2. *Garcinia subelliptica* 3. *Ficus microcarpa* 4. *Ilex aquifolium* 5. *Nageia nagi*	1.*Ravenala madagascariensis* 2. *Ilex aquifolium* 3. *Palaquim formosanum* 4. *Nerium indicum* 5. *Podocarpus macrophyllus* 6. *Hibiscus tiliaceus* 7. *Araucaria heterophylla* 8. *Ficus microcarpa* 9. *Senna siamea* 10. *Artocarpus altilis*	1. *Erythrina jasminoides* 2. *Livistona chinensis* 3. *Ilex aquifolium* 4. *Camellia japonica* 5. *Palaquium formosanum* 6. *Podocarpus macrophyllus* 7. *Ficus microcarpa*
Region	Effective reduction	Sub-reduction	Invalid reduction
Visibility	Consisting of huge bushes with visibility < 5 m	Trees and shrubs that visibility ranged 6 - 19 m	Sparsely distributed tree and shrubs, whose visibility > 20 m
Effect to reduce noise	More than 6 dB A	Range 3 – 5.9 dB A	Less than 2.9 dB A

Based on Cook and Haverbeke [9], the scent of lilacs was the focus of this study, however, many other fragrant plants, such as rose and lavender, as well as common thyme, may have a comparable effect; thus, future studies can concentrate on other aromatic plants. On account of the positive association between traffic noise irritation and congruency, in an environment where there is a lot of traffic noise, it may be possible to introduce an aroma with a greater congruency into the region in order to lessen the negative impact of traffic noise. Furthermore, a variety of plants, mostly deciduous trees and shrubs, between 5 and 10 years old, with varying levels of ground cover, were used by the researcher stated by Halim *et al.* [10]. The breadth of the belt ranged between 3 and 25 m. In this study, the psychological consequences of plants were not taken into consideration. The presence of a buffer zone of trees and plants between a heavily traveled road and a residential area is likely to lessen the irritation caused by traffic noise in the neighborhood. To summarize this section, it should be noted that tree species did not have a major impact on the study results. The relevance of height, density, breadth, and length of tree for noise reduction, on the other hand, is the most important factor impacting the research results.

3.1.3 Height of source/ receiver to collect traffic noise data

There are several factors to consider while conducting traffic noise measurements, including the height of equipment utilized by researchers. Based on ISO [4] , it stated that a group of point sources can be described by an equivalent point sound source located in the group's center, particularly if the sources are of comparable strength and height above the local ground plane. The traffic noise has taken with measured at a height of 3 m to 11 m above the ground. Meteorological conditions have a little influence on sound propagation over short distances but have a significant effect over longer distances at increasing source and receiver heights. It has been reported by Martens in the literature that the microphones and speakers were installed in plantations and plant communities, with the microphone's center at a height between 1.2 and 3.9 m above the soil surface, respectively [5]. Every plant community studied had Ae values that differed in some manner, but the frequency range where the ground impact occurred was the most significant. Based on the recent study, the effect of the planting technique is significantly more evident at greater vehicle speeds. Refer by Van Renterghem *et al*. [3], averaged over receiver heights from ground surface to 3 m, a difference of about 1 dBA is observed for a stem height of 1 m high compared to 2.5 m, and for a stem diameter of 22 cm. Even low stems perform well due to the presence of a source close to the vegetation area and close to the ground surface. Besides, Sound Power Level derived from maximum pass-by level of single vehicle at a distance of 7.5 m and at a height of 1.2 m above ground [6]. Effective source height is 0.45 m. A receiver height of 2 m is considered in case of the 3D simulations. To summarize, the fact that the source and receiver are at different heights from the ground will have an impact on the outcomes of the traffic noise data when it is measured, even though the distance between the source and receiver is the same.

3.1.4 Wind speed

Wind speed is the parameter which essential for the environmental noise measurement. In such circumstances, field measurements may occasionally need noise measurements at wind speeds of up to 12 m/s [7]. As stated by ISO [4], meteorological conditions for the wind direction within an angle of +45 degrees from a line extending from a source to a receiver, with a wind speed between roughly 1 m/s and 5 m/s from the source to the receiver. Refer to Ba and Kang [8], the experiment was carried out when wind speed was below 4 m/s, a temperature of 26°C–28°C, a relative humidity of 30–35%, and an air quality index of less than 50 to minimize the impact of environmental conditions. Based on Cook and Haverbeke [9] conducted measurements in identical weather circumstances in order to exclude the influence of climate on the results. Consequently, observations were done at wind speeds less than 2 m/s and during sunny times to maximize the accuracy of this experiment. A cup anemometer was used to measure the wind speed, which was determined to be less than 2 m/s in the forests or above the grass field, and the wind direction was virtually the same as the direction in which the speaker's sound was released. 23 A vented, wet dry bulb Assmann psychomotor psychometer was used to measure the air's humidity and temperature that stated by Martens [5]. Furthermore, noise monitoring studies were conducted in optimum weather conditions ranging from 76% to 93% relative humidity, 25.3 to 43°C and 0 to 0.7 m/s wind speed. Wind speeds of 12-15 km/h, temperatures of -10°C to 50°C and humidity of 95% or more should be avoided when doing sound measurements outside according to Halim *et al.*

[10]. Table 5 shows the comparison between the literature reviews about metrological conditions to traffic noise measurements.

Table 5: Literature reviews about wind speed to traffic noise measurements

References	Wind speed (m/s)
(ISO 1996)	1 -5
(Ba and Kang 2019)	< 4
(Cook and Haverbeke 1974)	< 2
(Martens 1981)	< 2
(Halim et al. 2017)	0 – 0.7

3.2 Case study

3.2.1 Data collected

Figure 4 depicts the traffic noise in observation data collected in study area over a 4-day period at three distinct periods to provide a clearer view of the difference between the three groups. As distance from the noise source increased, the total reduction in noise levels was found to be between 2 and 10 decibels (dB) even with limited planting.

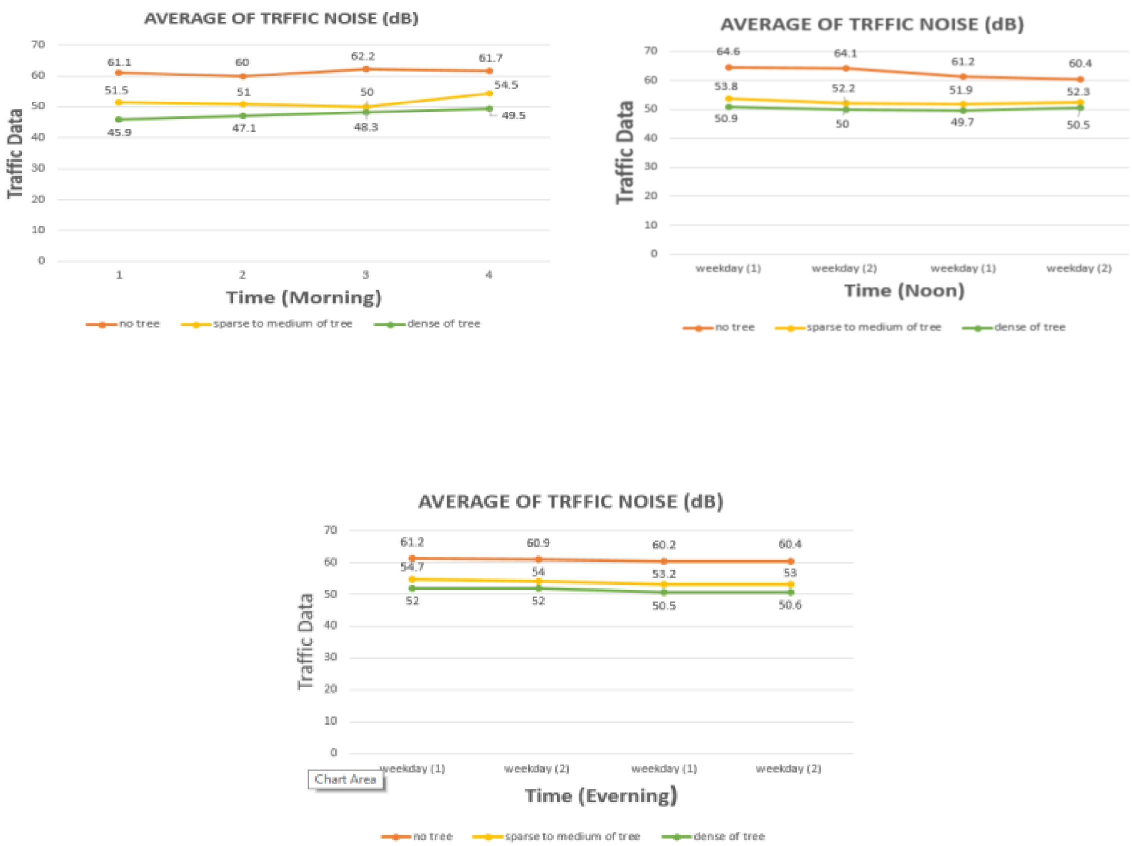

Figure 4: Average of traffic noise in 3 different time

According to the figure, the location with no trees has the greatest average value of traffic noise over the all-time, followed by the average value of the location with sparse to medium tree. While, it comes to the location dense of tree, shows in figure that is the lowest of the traffic noise data. Based on the above results, it can be stated that the tree has an effect in reducing traffic noise and is suitable as a noise barrier.

3.2.2 List of trees obtained

Table 6 contains a list of trees discovered at the study site. There are 9 successfully identified tree species that are there. The majority of these trees are forest trees, as the location is an abandoned area on the boundaries of Muar Bypass. Meanwhile, in the sparse to medium tree cover zone, there is just one species of tree which is *Hevea brasiliensis,* or more popularly known as the rubber tree.

Table 6: Tree that found in study area

Category	Name of plants		Height max (m)
Deciduous tree	Scientific name	Common name	30
	Acacia Mangium	*Sentang*	50
	Azadirachta excelsa	Burrflower Tree	45
	Neolamarckia Cadamba	Indian Prune/ Rukam Manis	20
Semi deciduous tree	*Khaya ivorensis*	African mahogany	35
	Hydnocarpus spp.	Chalmugra	15
Bamboo	*Bambusa heterostachya*	Malay dwarf bamboo	10
	Schizostachyum zollingeri	Buluh Telor bamboo	12
	Dendrocalamus asper	Giant bamboo	30

By identifying the tree species there, it is possible to conclude that all types of trees can have an influence on the decrease of traffic noise in that location. As a noise barrier for important routes, such as highway, it is also an excellent choice.

4. Conclusion

Based on results, traffic noise was measure and type of trees was identified along Muar Bypass (FT224). The effectiveness of trees as a noise barrier to reach the primary purpose of the study was measured. The aspect including the spacing between source and receiver, type and size of plants, height of source/ receiver to collect the traffic data and wind speed. In conclusion, the results show, the location with no trees has the greatest average value of traffic noise over the all-time, followed by the average value of the location with sparse to medium tree and dense of tree. Based on this data analysis, it shows that tree is so effective to be a medium for a traffic noise barrier and all the objectives for this study were successfully achieved.

Acknowledgement

The authors would like to express their gratitude to the Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia, for their assistance.

References

[1] V. Pathak, B. D. Tripathi, And V. K. Mishra, "Dynamics Of Traffic Noise In A Tropical City Varanasi And Its Abatement Through Vegetation," *Environ. Monit. Assess.*, Vol. 146, No. 1, Pp. 67–75, 2008, Doi: 10.1007/S10661-007-0060-1.

[2] J. Huang, Y. Liu, And Y. Li, "Trees As Large-Scale Natural Phononic Crystals: Simulation And Experimental Verification," *Int. Soil Water Conserv. Res.*, Vol. 7, No. 2, Pp. 196–202, 2019, Doi: Https://Doi.Org/10.1016/J.Iswcr.2019.03.004.

[3] T. Van Renterghem, D. Botteldooren, And K. Verheyen, "Road Traffic Noise Shielding By Vegetation Belts Of Limited Depth," *J. Sound Vib.*, Vol. 331, No. 10, Pp. 2404–2425, 2012, Doi: 10.1016/J.Jsv.2012.01.006.

[4] Iso, "Iso9613-2:1996 : Acoustics - Attenuation Of Sound Propagation Outdoors," No. 1, 1996.

[5] M. J. M. Martens, "Noise Abatement In Plant Monocultures And Plant Communities," *Appl. Acoust.*, Vol. 14, No. 3, Pp. 167–189, 1981, Doi: 10.1016/0003-682x(81)90029-3.

[6] N. Garg And S. Maji, "A Critical Review Of Principal Traffic Noise Models: Strategies And Implications," *Environ. Impact Assess. Rev.*, Vol. 46, Pp. 68–81, 2014, Doi: Https://Doi.Org/10.1016/J.Eiar.2014.02.001.

[7] E. King, F. Pilla, J. Mahon, And H. Rice, "Measuring Noise In High Wind Speeds: Evaluating The Performance Of Wind Shields," In *38th International Congress And Exposition On Noise Control Engineering 2009, Inter-Noise 2009*, 2009, Vol. 3.

[8] M. Ba And J. Kang, "Effect Of A Fragrant Tree On The Perception Of Traffic Noise," *Build. Environ.*, Vol. 156, No. February, Pp. 147–155, 2019, Doi: 10.1016/J.Buildenv.2019.04.022.

[9] D. I. Cook And D. F. Haverbeke, "Tree-Covered Land-Forms For Noise Control," No. 1974, 1993.

[10] H. Halim, R. Abdullah, J. Mohd Nor, H. Aziz, And N. Abd Rahman, "Comparison Between Measured Traffic Noise In Klang Valley, Malaysia And Existing Prediction Models," *Eng. Herit. J.*, vol. 1, pp. 10–14, Nov. 2017, doi: 10.26480/gwk.02.2017.10.14.