Relationship of plant types to noise pollution absorption level to improve the quality of the road environment

D Yofianti¹,²* and K Usman²

¹Department of Civil Engineering, Faculty of Engineering, Bangka Belitung University, Kampus Terpadu UBB Balunijuk, Merrawang, Bangka Regency, Bangka Belitung Province, 33172, Indonesia
²Department of Civil Engineering, Faculty of Engineering, University of Lampung, Indonesia

*E-mail: desyyofianti@gmail.com

Abstract. The road conditions with high density and noise levels as well as the limited availability of plants along the road could lead to an increase in noise pollution. The quality of the road environment is influenced by the types of plants planted along the road. This study aims to determine the relationship between types of plants in absorbing noise pollution to improve the quality of the road environment. Data on plant type and noise levels on urban roads are obtained from previous research that has been conducted in several road segments in urban areas. The analysis will show the relationship between certain types of plants in reducing the level of noise pollution along urban roads. The reduced level of noise pollution due to absorption by certain types of plants can increase the comfort of road users in driving. In addition, improving the quality of the road environment can also support the implementation of the Green Infrastructure concept. Therefore, the quality of the road environment can be one of the considerations in planning urban roads.

1. Introduction
Road conditions with high traffic density can cause noise pollution. The sound generated from these vehicles cause noise, especially motor vehicles whose exhausts have been modified. Light and heavy vehicles that are not properly maintained can also produce noise that can disturb other road users and the people who live in the road area, especially in urban areas [1]. The high increase in the number of vehicles in urban areas coupled with congestion further triggers high noise pollution. This condition can have an impact on health [1] both physically and psychologically in the long term [2-5].

Several types of plants are often found planted along roadside, both urban roads and inter-urban roads. The plants planted are tall trees with shady leaves so as to create a shady and comfortable atmosphere for road users. However, unfortunately the number of these plants is still limited. The function of plants along the road is not only as shade trees, but also plays an important role in absorbing pollution [6] that occurs both air pollution and noise pollution so that the quality of the road environment can be maintained. Planting this plant, of course, requires sufficient space, especially for certain types of plants [7].

Therefore, the quality of the road environment is strongly influenced by the types of plants on the left and right sides of the road, so it is necessary to do further research on the relationship between plant species in absorbing noise pollution and improving the quality of the road environment.
The main source of noise from motorized vehicles comes from the sound of trucks which can produce noise between 70-90 dB while car sirens produce sounds between 70-120 dB. Cars with poor soundproofing can also produce noise and some cars may produce more noise pollution than other cars [8]. Cars like jeeps will produce more pollution than sedans or wagons. One that can affect the sound level is the tires or vehicle radio used [8].

Noise level can be measured by several methods, namely SLM (Sound Level Meter) and CoRTN (Calculation of Road Traffic Noise) [9]. The factors considered in the CoRTN method are vehicle volume, speed, gradient, type of pavement, distance and height of the receiver, and the presence of buildings [9], while SLM records all sounds including from vehicles that are captured by sensors on the device. Therefore, the results of calculating the noise level using the two methods will be different. This condition can be seen in the results of the noise level analysis conducted on Jalan Sam Ratulangi 6 in Manado City by Balirante et al [9].

2. Research Method

Noise level data in urban areas is obtained from the results of research that has been done previously with different city locations, such as: Makassar, Manado, Surabaya, and Bandung. The noise level data used comes from the results of the analysis that has been carried out in the city of Manado and the city of Surabaya. For the types of plants used as absorbents of noise pollution obtained from reference studies.

2.1. Data collection

Secondary data collection was carried out based on the internet network with the keywords noise pollution and noise-absorbing plants and urban roads.

2.2. Data analysis

Data analysis was carried out by reviewing data from previous studies, both related to noise levels and types of plants to reduce noise pollution in urban road areas. The analysis was carried out by describing the relationship between the use of plant species on the ability to reduce noise pollution.

3. Result and Discussion

3.1. Characteristics of plant types as noise attenuation

Factors that affect the reduction of noise by plants to noise sources, among others: distance, microclimate, and composition and texture of plants [10]. The results of research by Maleki et al. [11] showed that the farther the distance from the noise source, the lower the noise level. This is due to the absorption of sound by air through a direct comparison to the square of the distance from the noise source [12].

Mahdi and Al-Jumaily [13] explained that the higher the air temperature, the higher the noise level. This condition can be interpreted that the noise level during the day is higher than in the morning and evening, regardless of the volume of vehicles that pass a road. This is because the temperature during the day is at its highest point, while the humidity during the day is at its lowest.

Plants play an important role in reducing noise levels. Furthermore, the composition and texture of plants also have a significant influence on the ability to reduce noise along roads in urban areas, especially the presence of home gardens and city parks.

Gardens with a combination of ground cover plants, shrubs, shrubs, and trees that have a fine plant structure, have the ability to reduce noise more than 75% [14]. These results are reinforced by research conducted by Pudjowati et al [15] which showed that a combination of trees, shrubs/shrubs, and ground cover crops reduced noise better than plants grown alone. In addition, Umiati [16] also said that shrubs/shrubs have a higher ability to reduce noise, which is 0.8 dB than trees which are only 0.2 dB. The type of plant which consists of low shrubs with a height of 30cm – 130cm and has a plant layout spread throughout the garden with a density of <50% can reduce noise optimally [14]. The addition of
the composition of fine plant textures in the garden, and with the right placement will optimize the ability of the garden as a natural noise barrier [10].

Therefore, it can be concluded that plants can only reduce noise but cannot completely eliminate the noise [17]. The plant planting pattern uses high density methods such as walls or building barriers. Furthermore, plants planted in a cross arrangement were better able to reduce noise compared to plants planted in a parallel arrangement. This happens due to the laws of physics associated with the propagation of sound waves. In addition, plants with sufficient leaf thickness are more effective at reducing noise [11].

3.2. Noise pollution levels in urban areas in Indonesia
The average noise level emitted by the noise source is between 83 dB to 92 dB. The high or low noise value is also influenced by differences in the number of motorized vehicles that are the source of the noise, including the composition of the vehicle flow and the speed of traffic flow [18]. In other words, there is a tendency for a linear relationship between the noise level and the factors that cause it.

The level of noise pollution in several cities in Indonesia, namely: Bandung City has a noise level that is above the tolerable pollution threshold value of 60 dB (A) [19]. The noise source comes from 16 noise points including the terminal. Furthermore, Manado City, especially Jalan M.T Haryono, precisely at Simpang Ade Swalayan, which is a business center area, has heavy traffic. This traffic density causes noise which has an impact on residents living around the area [18].

The Indonesian government has issued limits for the level of noise that can be tolerated for each area through the Decree of the State Minister for the Environment No: Kep.48/MENLH/XI/1996, dated November 25, 1996 [19].

| No. | Period  | Predicted Noise Level (PNL) |
|-----|---------|-----------------------------|
| 1.  | 06.00 – 07.00 | 61.24                       |
| 2.  | 07.00 – 08.00 | 60.17                       |
| 3.  | 08.00 – 09.00 | 61.44                       |
| 4.  | 09.00 – 10.00 | 61.24                       |
| 5.  | 10.00 – 11.00 | 60.87                       |
| 6.  | 11.00 – 12.00 | 60.51                       |
| 7.  | 12.00 – 13.00 | 65.15                       |
| 8.  | 13.00 – 14.00 | 63.64                       |
| 9.  | 14.00 – 15.00 | 63.43                       |

Table 1 shows that the noise level on Jalan Sam Ratulangi 6 Manado has exceeded the specified quality standards [9]. Based on the noise value obtained, the level of vehicle traffic noise on Jalan Sam Ratulangi 6 has exceeded the quality standards set. 48 of 1996, which is 55 dB(A) for School Areas [9]. The noise level at the edge of the highway in several big cities in Indonesia is generally close to 70 to 80 dBA [20].

| No. | Location                  | Mon | Tue | Wed | Thu | Fri | Sat | Sun |
|-----|---------------------------|-----|-----|-----|-----|-----|-----|-----|
| 1   | Jalan Airlangga (1)       | 82.9| 82.9| 82.8| 82.9| 82.6| 83.4| 81.8|
| 2   | Jalan Airlangga (2)       | 83.1| 83.0| 82.8| 82.7| 82.8| 83.1| 81.9|
| 3   | Jalan Darmawangsa (1)     | 82.8| 82.8| 82.8| 82.5| 82.7| 83.2| 82.0|
| 4   | Jalan Darmawangsa (2)     | 82.9| 82.8| 82.9| 82.8| 82.8| 83.4| 81.6|
| 5   | Jalan Karang Menjangan (1)| 82.7| 82.5| 82.7| 82.5| 82.8| 83.3| 81.7|
| 6   | Jalan Karang Menjangan (2)| 82.9| 82.8| 83.0| 82.7| 82.8| 83.0| 81.7|
| 7   | Jalan Prof. Dr. Moestopo (1)| 82.9| 82.7| 82.6| 82.9| 82.8| 83.2| 81.6|
| 8   | Jalan Prof. Dr. Moestopo (2)| 82.8| 82.8| 83.0| 82.8| 82.7| 83.3| 81.6|
The results of the analysis show that the main noise source in the area outside the hospital is from the density of motorized vehicles that pass through the highway around the hospital which is an arterial road in the city of Surabaya [21]. The condition of the noise level around RSUD Dr. Soetomo Surabaya as a whole is at an average noise level of 73 dB(A) from all main sampling points every day. This condition is above the hospital noise quality standard, which is 55dB(A) from the area outside the hospital and 45 dB(A) [21].

3.3. Plant types near roadsides in urban area to reduce noise pollution

Planting plants on the side of the road in urban areas to reduce noise is very necessary [1],[7],[22]. The existence of these plants serves as a green line to reduce traffic noise [7] so as to improve the quality of the road environment. This noise is an environmental problem that needs to be solved by decision makers [23] together with the community. Therefore, plants have an important role [24]-[29] that needs to be considered in making decisions to reduce noise pollution, especially in urban areas.

There are several types of plants that can reduce noise, namely: shrubs and conifer trees [7], populus and maple plantings [7]. Although shrubs are low-growing species [29], shrubs can be used to reduce noise, especially if planted under trees [24]. Shrubs and trees can effectively reduce noise by spreading noise through the leaves and branches [3],[24]. Tree parts in the form of density, height, length and width are very important factors to consider in reducing noise compared to leaf size and branching features [4].

Therefore, the planning of green lanes on the side of the road with the composition of the plants is the most decisive factor in reducing the impact of noise caused.

3.4. The impact of noise on the road environment

Noise pollution can be in the form of noise or unwanted sound is an exposure that can pollute the environment. Noise is treated differently in handling other pollutants such as chemical pollution and air pollution. Sound can become pollution when it exceeds the threshold that can be heard normally, causing disturbance to humans and other living things. The noise threshold value to work comfortably for 8 hours in one day is 85 dB. Noise pollution is caused by high volume noises that make the surrounding area noisy and unpleasant. Noise pollution can directly cause physical deafness and psychological distress [19],[25].

Reducing the level of noise pollution due to absorption by certain types of plants can increase the comfort of road users in driving. In addition, improving the quality of the road environment can also support the implementation of the Green Infrastructure concept. Therefore, the quality of the road environment can be one of the considerations in urban road planning.

3.5. Efforts to deal with noise pollution in urban areas

One way to deal with noise is to create a natural noise barrier. Plants in a garden arranged in such a way can reduce noise quite effectively [10]. The ability of plants to reduce noise is influenced by plant morphology, one of which is texture [10]. So that noise does not interfere with health or endanger health, it is necessary to take measures such as the use of silencers at noise sources, insulating, moving, maintaining, planting trees, making artificial hills or arranging space layouts and using personal protective equipment so that noise does not interfere with health or endanger [18].

Decision makers need to also consider the cheapest cost aspect in determining pollution control methods [6]. Environmentalists strongly emphasize the existence of a 'perennial green envelope' in urban areas and along the left and right sides of the road [26]. Besides being able to beautify urban areas, it can also significantly reduce noise generated from motorized vehicles [23].

One effort to reduce noise is to create a noise barrier [10]. Plants can also serve as a natural noise barrier [27]. Based on the results of Umiati's research [16], the types of plants that are effective as noise barriers are those that have a dense, dense, and layered canopy that can reduce noise up to 95%. Rochim and Syahban [28] also stated that the selection of suitable plant species was able to reduce noise optimally.
The existence of city parks is also an effort to reduce noise pollution. The best gardens for noise suppression consist of low shrubs with a height of 30 cm – 130 cm and have a plant layout spread throughout the garden with a density of <50%. The addition of the composition of fine plant textures in the garden, and with the right placement will optimize the ability of the home garden as a natural noise barrier [10].

4. Conclusion
Reducing the level of noise pollution due to absorption by certain types of plants can increase the comfort of road users in driving and improve the quality of the road environment. In addition, improving the quality of the road environment can also support the implementation of the Green Infrastructure concept. Therefore, in planning roads in urban areas, it is necessary to consider aspects of the quality of the road environment.

References
[1] Kassem E and Rochat JL 2016 State-of-the-art review on sustainability design and construction of quieter pavements-part 1: traffic noise measurement and abatement techniques Sustainability 8 1-28
[2] Islam MN, Rahman KS, Bahar MM, Habib MA, Ando K, and Hattori N 2012 Pollution attenuation by roadside greenbelt in and around urban areas Urban For. Urban Green 11 460-464
[3] Williams ID and McCrae IS 1995 Road traffic nuisance in residential and commercial areas Sci.Total Environ. 169 75-82
[4] Ali SA and Tamura A 2003 Road traffic noise levels, restrictions and annoyance in greater Cairo, Egypt Appl,Acoust. 64 815-823
[5] Stansfeld SA and Matheson MP 2003 Noise pollution: non-auditory effects on health Br. Med. Bull. 68 243-257
[6] Tyagi V, Kumar K, and Jain VK 2006 A study of the spectral characteristics of traffic noise attenuation by vegetation belts in Delhi Appl. Acoust. 67 926-935
[7] Karbalaei SS, Karimi E, Naji HR, and Ghasempoori SM 2015 Investigation of the traffic noise attenuation provided by roadside green belts Fluctuation and Noise Letters 14 1550036
[8] Widya J 2021 Inilah efek terburuk dari polusi suara 01 March 2021 available at www.dream.co.id accessed 29 August 2021
[9] Balirante M, Lefrandt LIR and Kumaat M 2020 Analisis tingkat kebisingan lalu intas di jalan raya ditinjau dari tingkat baku mutu kebisingan Jurnal Sipil Statik 8 249-256
[10] Pertiwi D P, Baskara M and Sitawati 2018 Effectiveness composition of plant texture at house garden in reducing noise Jurnal Produksi Tanaman 6 16-24
[11] Maleki K, Hosseini SM, and Nasiri P 2010 The effect of pure and Mixed plantations of Robinia Pseudoacasia and Pinus Eldarica on traffic noise decrease International Journal of Environmental Science 1 213-224
[12] Azura E and Defrianto 2015 Analisa pengaruh vegetasi terhadap tingkat kebisingan di sepanjang jalanPekanbaru – Bangkinang JOM FMIPA 2 32-40
[13] Mahdi ZS and Al-Jumaily K 2012 Atmospheric effects on sound waves propagation Iraqi Journal of Science 53 689-692
[14] Hidayat S, Purwanto and Hardiman G 2012 Kajian tingkat kebisingan pertambangan yang diterima di area permukiman sekitar tambang di Desa Jaladri Kecamatan Winongan Kabupaten Pasuruan Jawa Timur Prosiding Seminar Nasional Pengelolan Sumber Daya Alam dan Lingkungan Semarang 11 September 2012 pp 59-64
[15] Pudjowati UR et al 2013 Effect of vegetation composition on noise and temperature in Waru Sidoarjo highway East Java Indonesia International Journal of Conservation Science 4 459-466
[16] Vaniati S 2011 Pengaruh tata hijau terhadap tingkat kebisingan pada perumahan Jalan Ratulangi Makasar Teknika pp 12-19
[17] Hidayat IW 2010 Kajian fungsi ekologi jalur hijau jalan sebagai penyangga lingkungan pada tol Jagorawi Jurnal Manusia dan Lingkungan 17 124-133
[18] Djalante S 2010 Analisis tingkat kebisingan di jalan raya yang menggunakan alat pemberi isyarat lalu lintas (APILL) (studi kasus: Simpang Ade Swalayan) SMARTek 8 1-21
[19] Decree of the State Minister for the Environment No: Kep.48/MENLH/XI/1996, dated November 25, 1996
[20] Mediastika EC 2009 Materi akustik pengendali kualitas bunyi pada bangunan Yogyakarta: Erlangga
[21] Prasetyo PH and Assomadi AF 2018 Analisis Pola Kebisingan Akibat Transportasi di Sekitar Area Fasilitas Kesehatan Kota (Studi Kasus: RSUD dr. Soetomo Surabaya) Jurnal Teknik ITS 7 54-57
[22] Fang CF and Ling D-L 2003 Investigation of the noise reduction provided by tree belts Landsc.Urban Plan 63 187-195
[23] Pathak VJ, Tripathi BD, and Mishra VK 2011 Evaluation of anticipated performance index of some tree species for green belt development to mitigate traffic generated noise Urban For.Urban Green 10 61-66
[24] Herrington LP 1976 Effect of vegetation on the propagation of noise in the out-of-doors USDA For.Serv.Gen.Tech.Report.US Rocky Mt. For. Range Exp.Stu. 25 229-233
[25] Federal Highway Administration (FHWA) 2011 Highway traffic noise: analysis and abatement guidance Report No. FHWA-HEP-10-025 Federal Highway Administration USDOT: Washington DC USA
[26] RAO PS, Gavane AG, Anka SS, Ansari MF, Pandit VI, and Nema P 2014 Performance evaluation of a green belt in a petroleum refinery: a case study Ecol.Eng. 23 77-84
[27] Kusumaningrum N 2008 Potensi tanaman dalam menyerap CO₂ dan CO untuk menurangi dampak pemanasan global Jurnal Pemukiman 3 96-128
[28] Rochim FN and Syahbana LA 2013 Penetapan fungsi dan kesesuaian vegetasi pada taman public sebagai ruang terbuka hijau (RTH) di Kota Pekalongan (studi kasus: Taman Monumen 45 Kota Pekalongan) Jurnal Teknik PWK 12 314-327
[29] Yofianti D, Pertiwi P C, and Hisyam E S 2020 The impact of tin mining in the Pompong watershed on vegetation sustainability to maintain environmental quality IOP Conf. Ser.: Earth Environ. Sci. 599 012054

Acknowledgment
We gratefully acknowledge the funding from Universitas Bangka Belitung through the RKAKL FT for the publication of this paper.