Indonesian Journal of Environmental Management and Sustainability
e-ISSN:2598-6279 p-ISSN:2598-6260

Research Paper

The Measurement of the Noise Level Based on Roads Classifications in Urban Area (Case Study: Harjamukti, Depok)

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Abstract
Harjamukti Village is located in Depok City which is a buffer zone for the capital city of DKI Jakarta, the rapidly growing housing sector shows that this location has an attractiveness. The next problem that arises is the potential for noise from vehicular traffic due to community mobility. Noise measurements carried out using SNI 8427: 2017 show the LSM value on each road: Tumaritis Road (68.87 dBA), Bungur Road (61.29 dBA), Putri Tunggal Road (73.67 dBA), Putri Tunggal District Road (65.7 dBA) and Sementara Road (61.29 dBA). This study was conducted to see the road class based on the noise and capacity parameters, so that from these two parameters, can we clearly show the road class being analyzed. The measurements were carried out for 24 hours using the standard SNI 8427: 2017. The quality standard for the residential area used was 55 Dba based on the Minister of Environment Decree No. 48 of 1996. The road capacity used is analyzed based on the number of vehicles and the class of each road. Based on the noise parameters (sig 0.006) and capacity (sig 0.000) so that from the noise parameter there is no significant difference in the 5 research locations, while the road capacity shows a significant difference from the 5 research locations. Prediction of road class cannot be determined from the noise value and road capacity, because the noise obtained needs to be analyzed for the types of activities around whether there is an influence from other activities that are also dominant, such as toll roads and road capacity, because there are local road classes whose capacity is not detected different from collector road class.

Keywords
Noise Level, Capacity of Road, Transportation

Received: 24 May 2023, Accepted: 3 December 2023
https://doi.org/10.26554/ijems.2023.7.4.153-159

1. INTRODUCTION

Noise is unwanted sound that can cause discomfort, mental disorders, neurological and physical health. Noise is influenced by the pressure and intensity of sound from natural and anthropogenic sources (Al-Taai, 2021). City development is a threat to environmental quality, especially environmental degradation in the form of noise pollution. High mobility and the threat of the development of new urban planning and transportation modes provide uncertainty and predictions of increasing noise levels in urban urban areas (Chen et al., 2021). The dominant sources of environmental noise are transportation (trains, vehicles, and planes) and industry, among these noise sources, vehicles are the main one with exposure to > 37 million people with an Lden value of > 65 Dba (European Environment Agency, 2014). In Indonesia, transportation is also a major source of environmental noise, especially in urban areas and has an impact on sensitive areas such as schools and settlements (Dirgawati et al., 2021; Pradana, 2019; Tjahjono et al., 2021).

The study of noise has developed a lot in recent years, where public awareness has begun to increase regarding the effects of noise. Factors that affect noise include socioeconomic conditions and city morphology such as buildings, roads and vegetation for the spatial distribution of noise (Han et al., 2015). In several studies it was found that noise has a correlation with income levels, low incomes have a higher level of noise exposure compared to high incomes, but it was found that in high income environments there are higher noise complaints than low incomes due to education and income factors resulting in higher sensitivity higher exposure to noise (Méline et al., 2013). In addition, there is a close relationship between census data (population) and noise caused by higher transportation demand in locations with a large population (Han et al., 2015). Urban noise can be influenced by traffic density and the distance between the source and receiver, so the step that can be chosen is to use low-noise vehicles such as electric or hybrid vehicles. (Mavrin et al., 2018). Spatially there is a close influence between the distance of the highway and the receiver with the noise value and traffic volume which is positively related to the increase in the noise value (Jacyna et al., 2017). This spatial pattern can be seen from the distribution of high noise values > 70 Dba which is still found at a distance of 5 meters while at a distance of 30 meters the noise value > 70 Dba is no longer present (Jacyna et al., 2017).

Noise measurement is principally the sound value measured based on local environmental conditions or a combination of several noise sources at the measured location, resulting in different values (Morillas et al., 2013). Noise values ranging from 0 Dba - 120 Dba, this maximum value can cause pain and hearing damage (Rodrigue, 2020). This study was aimed to see the effect of road classification with the results of noise measurements and to analyze the value of noise and disturbances received by the community in the settlement of Harjamuti Village, Depok.

2. EXPERIMENTAL SECTION

2.1 Research Location

The research location is Harjamukti Village, Cimanggis District, Depok City. Noise measurements were carried out on several roads classified according to Government Regulation No. 34 of 2006 namely: Tumaritis (Local Street), Bungur (Local Street), Putri Tunggal (Collector Street), and Sementara (Local street). In general, the description of the location can be seen in Figure 1. Each road is a two-way street without a separator. The width of each road is: Tumaritis Street (5 m), Bungur Street (5 m), Putri Tunggal Street (7m), and Sementara Street (7m).

In addition to roads with certain classifications measured in this study, at the measurement point the Tumaritis road and Temporary Road are also adjacent to the Toll Road (Figure 1). The measurement point of Jalan Tumaritis is 20 meters from the Jagorawi Toll Road, while the Temporary road is 10 meters from the Cijago Toll Road. The five noise measurement locations are mixed commercial and residential areas and do not have any source of transportation noise other than vehicles.

2.2 Methods

Noise measurements were carried out using a Sound Level Meter Model SDL 600 equipped with a tripod at a height of 1.1-1.5 m. Each measurement point has a distance of 1 meter from the side of the road without any obstructions from the road to the measuring instrument. Noise measurements are carried out on the side of the road by considering the absence of potential noise distractions such as vegetation, buildings and buildings (Yang et al., 2022). Measurements were carried out for 24 hours 7 times with each tool reading for 10 minutes according to SNI 8427: 2017. Measurements were carried out 7 times at 07.00 (representative 06.00- 09.00), 10.00 (representative at 09.00-11.00), 14.00 (representative 11.00-17.00), 19.00 (representative 17.00-22.00), 22.00 (representative 22.00-24.00), 03.00 (representative 24.00-03.00) and 05.00 (representative 03.00-06.00). The calculation of the noise level is based on the Minister of Environment Decree No. 48 of 1996 as follows:

$$LSM = 10 \log 1/24\{16 \cdot 100 \cdot 1 \cdot LS + \ldots + 8 \cdot 100 \cdot 1 \cdot (LM + 5)\}\, dB \quad (1)$$

Note :
LS = Leq during the day
LM = Leq during the night
LSM = Leq during day and night

Noise grouping based on road class is carried out by classifying road functions into 5 classes (Morillas et al., 2021). The grouping of roads in districts or cities uses the classification of roads in Indonesia based on PP No. 34 of 2006 concerning roads as follows:

- Arterial Roads connect national activity centers with regional activity centers
- Collector's Road connects the Capital of the Province with the Regency/City
- Local Roads connect Regencies or Cities with Sub-districts and sub-districts with Kelurahan
- Environmental Roads connect the Kelurahan/Village with activities within the village

Traffic data collection was carried out by surveying based on the classification of 2-wheeled vehicles (motorcycles), 4-wheeled vehicles (cars), vehicles > 4 wheels (trucks and buses). The method used is the calculation of road capacity as follows:

$$C = Co \times FCw \times FCsp \quad (2)$$

Note:
C = Actual capacity (emp/h)
Co = Base capacity (emp/h)
FCw= Freeway width adjustment factor
FCsp = Adjustment factor due to direction separation

2.3 Traffic Noise

Noise parameters that can be described by statistical analysis in the form of percentiles. In general, the noise percentiles are classified into L10, L50, and L90. In this study, the noise data description will be classified into L10, L90, Ls, Lm and Lsm. L10 is the 10th percentile obtained from the 10% distribution of data during the measurement period which indicates the peak noise value. L90 is the distribution of the noise value of 90% over the measurement period which shows the value of background noise (Cohn and McVoy, 1982). While the values of Ls, Lm and Lsm will each describe the equivalent noise level in the day, night and daily measurement periods.

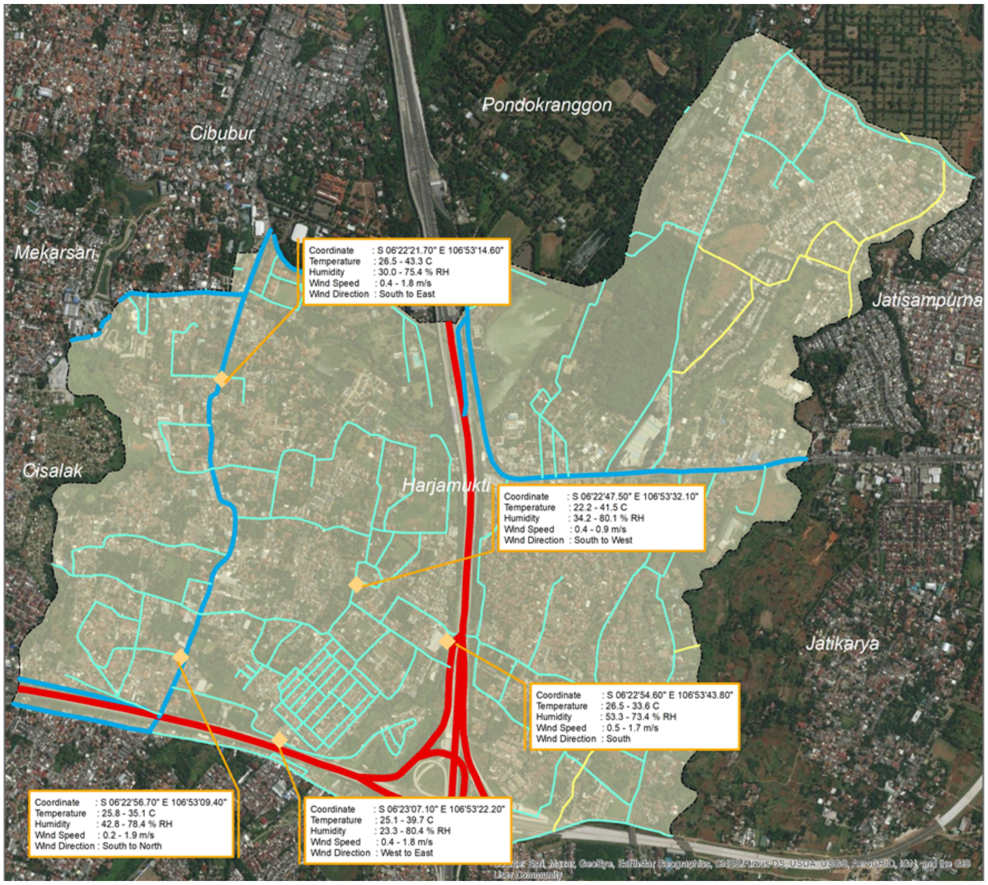

Figure 1. Location of Noise Measurement Points in Harjamuti Village, Cimanggis, Depok

2.4 Statistical Analysis

Road capacity and noise measured in this study were analyzed using correlation to see the relationship between the two variables. The correlation resulting from the two data is shown in the Coefficient of Determination with the following formula:

$$r = \frac{n\sum Xi \cdot \sum Yi - \sum Xi \cdot \sum Yi}{\sqrt{[(n\sum Xi^2 - (\sum Xi)^2)(n\sum Yi^2 - (\sum Yi)^2)]}} \quad (3)$$

Positive and negative correlations can be seen from the value of determination that is owned with a range of 0 < R2 < 1. The data required is n = number of observations, Xi = number of observations of X value, and Yi = number of observations of Y value. in this study describes the noise variable that can be explained by the variable capacity of the road or the explanator.

This study analyzes the effect of each road on the two dependent variables, namely the noise value (measurement results) and traffic characteristics (measurement results), so statistical analysis is needed to answer the results of these two variables. The statistical analysis that will be used is Multivariate Analysis of Variance (MANOVA) with the independent variables being each path. The equation of the model used is as follows:

$$x_{ij} = \bar{x} + (\bar{x}_i - \bar{x}) + (x_{ij} - \bar{x}_i) \quad (4)$$

where, j = 1,2,...,n and t = 1,2,...,g
H0 : = $\mu = \mu = \mu$ g ... 1 2
H1 : at least one pair μ $i \neq \mu$ $j \neq$; $i \neq j$

Manova analysis is used to determine whether or not there is a significant effect between road variations and noise values and road capacity. This analysis can also see the overall and individual differences between the value of road noise and road capacity.

3. RESULT AND DISCUSSION

3.1 Noise Level

The noise value generated from the measurement for 24 hours shows that there are differences in the Leq value at each measurement location, in addition to the results of road traffic monitoring there are quite large differences between each road. The data presentation in Figure 2 can illustrate the relationship between Noise and Road Capacity. This study was conducted to see the effect of each road so that the regression value displayed is the regression value of each road.

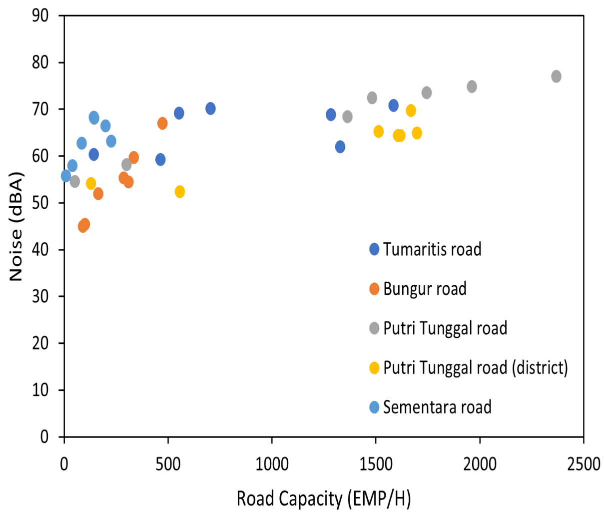

Figure 2. Noise Level Based on Roads Location

Measurable environmental noise is a combination of several activities such as transportation, construction, gardening activities, talking, animals, and loud music (Zannin et al., 2013). A preliminary study was conducted to look at the potential noise sources at each measurement point to obtain the dominant noise source originating from transportation (Han et al., 2018). The results of the noise measurement in Figure 2 show that measurements at 5 locations resulted in a dominant value of > 55Dba, referring to the Minister of Environment Decree No. 48 of 1996 which was above the quality standard for residential areas. While in the noise stratification made by Rodrigue (2020), the noise level is classified into 5 groups, weak (0<40 Dba), moderate (>40 dBA - <60 Dba), loud (>60 dBA - <70 Dba) , very loud (>70 dBA - <100 Dba), and very loud (>100 dBA - <120 Dba) according to the potential impact generated. Figure 2 shows that 37% are in the medium category and 63% are in the hard category. These results are in accordance with the identified noise sources, for locations near toll roads or roads with noise sources from transportation, the resulting noise value is > 70 dBA and busy or congested roads can reach 80dBA (Rodrigue, 2020). Another reference states that the average noise generated by the transportation sector is 66.84 - 69.77 Dba (Apparicio et al., 2018).

The correlation shown in Figure 2 shows that there is a relationship between traffic volume and the resulting noise value. In several studies, the volume of vehicle traffic with the noise value has a fairly high correlation and can be described in a linear model which shows that as the vehicle volume increases, the noise value will also increase (Mavrin et al., 2018). The coefficient of determination resulting from the graph between noise and road capacity can be seen in Table 1.

The results of the measurement of road capacity and noise were tested statistically for normality analysis based on the Shapiro-Wilk test with a p value > 0.05 which indicates the data is normally distributed according to Table 1. Based on the road classification, Collector Road has a higher capacity value than Local Road in other words traffic volume increases according to road class. Roads that are bigger and become main roads will connect more places than secondary or local roads so that main roads have a higher traffic volume than secondary roads and then local roads respectively (Han et al., 2018).

Environmental noise can be caused by several sources including transportation, construction, gardening activities, talking, animals, and loud music (Zannin et al., 2013). Noise mitigation measures can be taken by increasing the distance from noise sources, using sound insulation materials in buildings, improvising machine technology, and not using loudspeakers (Al-Taai, 2021).

Manova analysis in Table 2 shows the p-value <0.05, this value indicates the rejection of H0 and H1 is accepted. On the assumption of H1 there is a significant difference at least from one of the roads to the noise value and road capacity. Several previous studies have found that road classification has an influence on the noise value.

The difference in the results of each road is influenced by the dependent variable, namely noise and capacity with each p-value < 0.005. This p-value shows that there is a difference in each road at least at 1 location, details regarding the results of noise and road capacity can be seen in Table 4.

Multiple comparison test was conducted to identify data at each research location (road) with noise and capacity parameters. In general, the noise variable did not have a significant difference (p-value >0.005), but there were 2 p-values <0.05, Tumaritis Street and Bungur Street and Bungur street and Putri Tunggal Street. In 2 pairs of roads that have a value of sig < 0.05. Meanwhile, for capacity, there is a significant difference between Bungur Street and Sementara Street for Jalan Putri Tunggal. The road classification shows that the single daughter road has the largest capacity as a collector road.

In this study, Bungur road is classified as a local road which has the most significant noise value because it is located in the middle of a residential area, besides that there is less vehicle traffic. Different types of activities and vehicular traffic have an influence on the results of this study. Traffic noise can be influenced by the number of vehicles, vehicle speed, vehicle composition, road network, type of road, and type of building in an area, each of these aspects influences the sound source or affects the sound propagation medium (Fallah-Shorshani et al., 2022). The road network or vehicle distribution can influence the amount of vehicle traffic or influence the composition of the distribution of vehicle types (buses, trucks, diesel vehicles, etc.) (Mavrin et al., 2018). In other cases, increasing vehicle volume has no effect on increasing noise due to intervention in

Table 1. Road Capacity and noise value

Location	Road Classification	Capacity		Noise Level							R2
		Mean	Shapiro-Wilk	LS	LM	LSM	L10	L90	Mean	Shapiro-Wilk	
Tumaritis	Local Road	865.43	0.568	69.9	60.52	68.87	70,25	63.76	65.8	0.066	0.24
Bungur	Local Road	251.00	0.555	62.77	49.05	61.29	64.13	50.54	54.1	0.688	0.95
Putri Tunggal	Collector Road	1324.46	0.443	75	63.19	73.67	74.54	62.23	68.4	0.148	0.97
Putri Tunggal (district)	Collector Road	1255.61	0.07	66.12	59.72	65.7	66.98	61.67	62.1	0.077	0.86
Sementara	Local Road	120.89	0.765	62.77	49.05	61.29	63.12	48.12	63.2	0.364	0.55

Source : Research data and Laboratorium

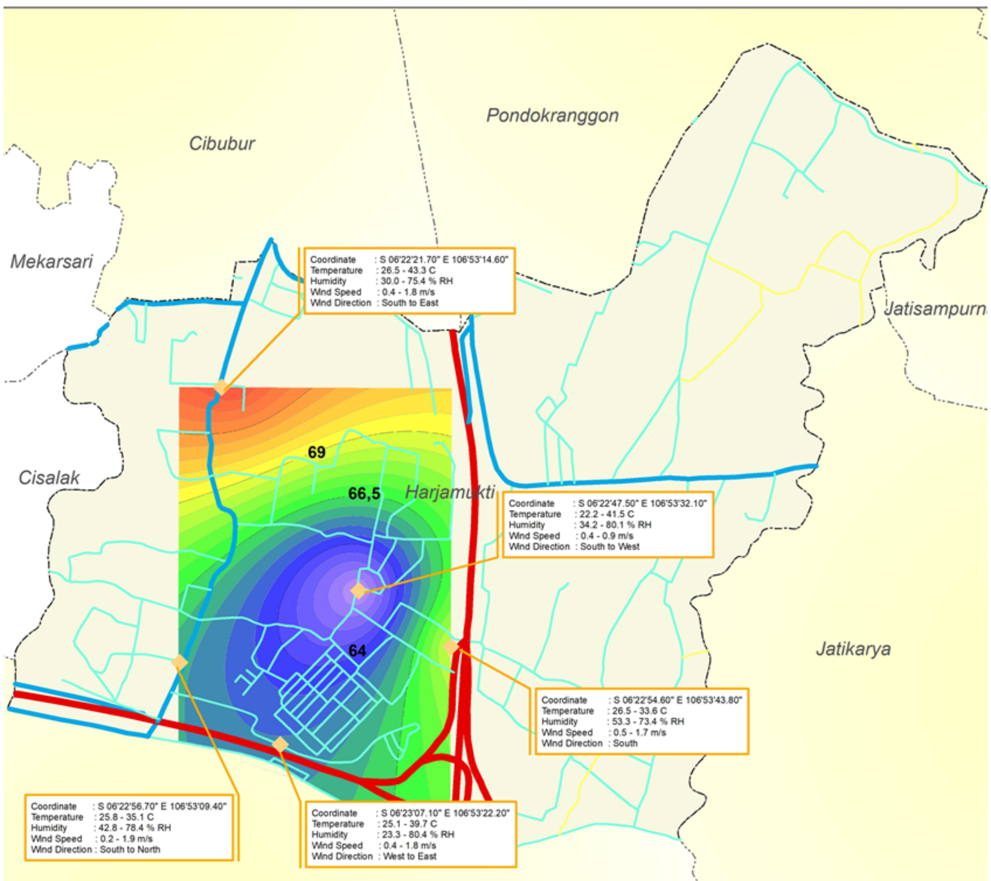

Figure 3. Noise in Harjamukti Village

Table 2. Manova

Source	F hitung	p- value
Road	7.280	0.000

Table 3. Tests of Between-Subjects Effects

Source	Dependent Variable	F hitung	p- value
Road	Noise	4.528	0.006
	Capacity	7.518	0.000

vehicle specifications and vehicle standards used, but it is

Table 4. Multiple Comparison Test

Dependent Variable	X1	X2	Mean Difference	p- value
Noise	Tumaritis	Bungur	11.7000	0.028
		Putri Tunggal	-2.6000	1.000
		Putri Tunggal (district)	3.6714	1.000
		Sementara	2.5857	1.000
	Bungur	Putri Tunggal	-14.3000	0.004
		Putri Tunggal (district)	-8.0286	0.329
		Sementara	-9.1143	0.165
	Putri Tunggal	Putri Tunggal (district)	6.2714	0.908
		Sementara	5.1857	1.000
	Putri Tunggal (district)	Sementara	-1.0857	1.000
Capacity	Tumaritis	Bungur	614.4286	0.114
		Putri Tunggal	-459.0357	0.748
		Putri Tunggal (district)	-390.1786	0.730
		Sementara	744.5357	0.053
	Bungur	Putri Tunggal	-1073.4643	0.080
		Putri Tunggal (district)	-1004.6071	0.031
		Sementara	130.1071	0.282
	Putri Tunggal	Putri Tunggal (district)	68.8571	1.000
		Sementara	1203.5714	0.051
	Putri Tunggal (district)	Sementara	1134.7143	0.018

certain that private vehicles have lower noise than heavy vehicles such as trucks (Vaverková et al., 2021). Besides that, the intersection conditions at the noise measurement location will also affect the noise value, more intersections can increase the noise value compared to roads without intersections (Abdur-Rouf and Shaaban, 2022).

4. CONCLUSION

The classification of roads in this study is seen from the noise value factor and road capacity, statistical analysis shows that from the results of noise measurements there is no significant difference in 5 roads, sig 0.006 (>0.005) while the road capacity value is sig 0.00 (<0.00) indicating a difference between the five monitoring path. The results of the pairwise comparison analysis show that Bungur Road and Temporary Road have significant differences with Putri Tunggal Street and Putri Tunggal Street (kelurahan) where the classification of Putri Tunggal Road is a collector road so that the number of vehicles that pass is more than the temporary road and Bungur road. The relative noise value at the 5 research locations indicates the influence of other activities, namely increasing on Tumaritis roads (R2 = 0.55) and temporary roads because they are adjacent to toll roads, while Bungur roads (R2= 0.24) in residential areas are relatively quiet.

5. ACKNOWLEDGEMENT

The author would like to thank LPPM Sahid University Jakarta for the internal grants provided for this article.

REFERENCES

Abdur-Rouf, K. and K. Shaaban (2022). Measuring, Mapping, and Evaluating Daytime Traffic Noise Levels at Urban Road Intersections in Doha, Qatar. *Future Transportation*, **2**(3); 625–643

Agency, E. E. (2014). *Noise in Europe*. Luxembourg: Publications Office of the European Union

Al-Taai, S. H. H. (2021). Noise and Its Impact on Environmental Pollution. *Materials Today: Proceedings*; 2214–7853

Apparicio, P., J. Gelb, M. Carrier, M.-È. Mathieu, and S. Kingham (2018). Exposure to Noise and Air Pollution by Mode of Transportation during Rush Hours in Montreal. *Journal of Transport Geography*, **70**; 182–192

Chen, F., W. Fu, O. Shi, D. Li, Q. Jiang, T. Wang, X. Zhou, Z. Lu, and S. Cao (2021). Impact of Exposure to Noise on the Risk of Hypertension: A Systematic Review and Meta-Analysis of Cohort Studies. *Environmental Research*, **195**; 110813

Cohn, L. F. and G. R. McVoy (1982). *Environmental analysis of transportation systems*. John Wiley and Sons, New York

Dirgawati, M., G. N. Apriani, A. A. Asyari, and R. Triyogo (2021). Traffic-related Noise at Roadside Schools: Assessment and Prediction in Urban Setting. *Jurnal Teknologi Lingkungan*, **22**(2); 178–189

Fallah-Shorshani, M., X. Yin, R. McConnell, S. Fruin, and M. Franklin (2022). Estimating Traffic Noise Over a Large Urban Area: An Evaluation of Methods. *Environment*

International, **170**; 107583

Han, X., X. Huang, H. Liang, S. Ma, and J. Gong (2018). Analysis of the Relationships between Environmental Noise and Urban Morphology. *Environmental Pollution*, **233**; 755–763

Han, Z.-X., Z.-H. Lei, C.-L. Zhang, W. Xiong, Z.-L. Gan, P. Hu, and Q.-B. Zhang (2015). Noise Monitoring and Adverse Health Effects in Residents in Different Functional Areas of Luzhou, China. *Asia Pacific Journal of Public Health*, **27**(2_suppl); 93S–99S

Jacyna, M., M. Wasiak, K. Lewczuk, and G. Karoń (2017). Noise and Environmental Pollution from Transport: Decisive Problems in Developing Ecologically Efficient Transport Systems. *Journal of Vibroengineering*, **19**(7); 5639–5655

Mavrin, V., I. Makarova, and A. Prikhodko (2018). Assessment of the Influence of the Noise Level of Road Transport on the State of the Environment. *Transportation Research Procedia*, **36**; 514–519

Méline, J., A. Van Hulst, F. Thomas, N. Karusisi, and B. Chaix (2013). Transportation Noise and Annoyance Related to Road Traffic in the French RECORD Study. *International Journal of Health Geographics*, **12**(1); 1–13

Morillas, J. B., V. G. Escobar, and G. R. Gozalo (2013). Noise Source Analyses in the Acoustical Environment of the Medieval Centre of Cáceres (Spain). *Applied Acoustics*, **74**(4); 526–534

Morillas, J. M. B., G. R. Gozalo, D. Montes-Gonzalez, R. Vílchez-Gómez, and V. G. Escobar (2021). Variability of Traffic Noise Pollution Levels As a Function of City Size Variables. *Environmental Research*, **199**; 111303

Pradana, T. I. M. W. I. K., A. (2019). Analysis of Traffic Noise in Taman Kota Lumintang Denpasar. *International Journal of Contemporary Research and Review*, **10**(2); 20585–20591

Rodrigue, J.-P. (2020). *The Geography of Transport Systems*. New York: Routledge

Tjahjono, N., I. Hanafi, L. Latipun, and S. Suyadi (2021). Traffic Noise Level Assessment in the Residential Area around Different Road Functions in Malang City, East Java, Indonesia. *Pertanika Journal of Science & Technology*, **29**(3); 1419 – 1430

Vaverková, M. D., E. Koda, and M. Wdowska (2021). Comparison of Changes of Road Noise Level Over a Century Quarter: A Case Study of Acoustic Environment in the Mountainous City. *Journal of Ecological Engineering*, **22**(1); 139–150

Yang, D., X. Liu, Z. Ren, and M. Li (2022). Relation between Noise Pollution and Life Satisfaction Based on the 2019 Chinese Social Survey. *International Journal of Environmental Research and Public Health*, **19**(12); 7015

Zannin, P. H. T., M. S. Engel, P. E. K. Fiedler, and F. Bunn (2013). Characterization of Environmental Noise Based on Noise Measurements, Noise Mapping and Interviews: A Case Study at a University Campus in Brazil. *Cities*, **31**; 317–327

