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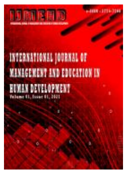

The Influence of Road Service Quality on Traffic Noise Levels

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ABSTRACT

Traffic noise resulting from motor vehicles stands as a significant environmental concern in urban areas. Kendari, serving as the capital of Southeast Sulawesi Province and classified as a Major City in Indonesia, inevitably contends with the phenomenon of noise pollution. This research aims to analyze the influence of road service levels on traffic noise. The study reveals that the road service level along Ahmad Yani Street in Kendari has an average saturation degree of 0.27, classifying it as Level of Service (LoS) B. This reflects a stable traffic flow, though vehicle speeds are gradually reduced. Drivers still retain sufficient freedom in speed selection. Meanwhile, the average noise level on this road segment is measured at 73.6 dB, exceeding the environmental noise threshold stipulated by the Minister of State for the Environment of the Republic of Indonesia's Decree No. KEP-48/MENLH/11/1996. The influence of road service level on noise levels is quantified at 31.3%, with the remaining 68.7% attributed to unexamined factors within this study.

Keywords: *Influence, Noise, Road Service Level, Traffic.*

I. INTRODUCTION

Traffic noise caused by motor vehicles is one of the pressing environmental issues faced by urban areas. This type of noise, whether acknowledged or not, significantly impacts human health and daily activities. The primary contributor to traffic noise is motor vehicles, whose numbers continue to rise each year (Shvetsov, 2021). Consequently, noise pollution has become a major environmental concern, especially in developed countries. Industrial noise is another notable source of disruption, particularly affecting the daily activities of workers (Al-Dosky, 2014).

According to Rahmatunnisa et al. (2017), traffic volume and vehicle speed have an inverse relationship with noise levels. Higher traffic volumes lead to reduced vehicle speeds, which in turn result in increased noise levels. Conversely, lower traffic volumes allow for higher vehicle speeds, which produce lower noise levels. To address such environmental noise concerns, the Indonesian Government issued the Decree of the Minister of Environment of the Republic of Indonesia Number 48/MENLH/11/1996, which specifies noise level standards for different designated areas. Noise mitigation measures include the construction of barriers between the noise source and the receptor. Additionally, vegetation has been identified as an effective noise-dampening component.

Kendari, the capital of Southeast Sulawesi Province, is a rapidly growing urban area in Indonesia categorized as a large city. Like other major cities worldwide, Kendari faces the challenge of managing traffic noise. This challenge is particularly pronounced due to the growth of activity centers that generate high traffic volumes. Research conducted by Lakawa (2015) revealed that the average noise levels on arterial and collector roads in Kendari had already reached 75.4 dB and 73.5 dB, respectively.

The segment of Ahmad Yani Street was chosen as the focus of this study due to its high traffic volume, with both public and private vehicles frequently using the road. This segment is characterized by the presence of diverse activity centers, such as commercial areas, schools, and offices, which attract significant public movement. As a result, these activities place a heavy burden on the road.

Although the road width is still sufficient to accommodate traffic, the annual increase in traffic volume, coupled with side-friction activities along certain segments of Ahmad Yani Street, has the potential to affect its performance. This condition can lead to a decline in the road's level of service. Beyond congestion, these factors also contribute to heightened traffic noise intensity along the road segment.

II. LITERATURE REVIEW

2.1 Road Service Performance

Traffic characteristics describe the behaviors of traffic flow within a road segment, which can vary based on location and time. Traffic refers to the movement of vehicles, people, or animals along a road, while transportation involves the transfer of people and goods from one place to another using vehicles or other means. According to the Republic of Indonesia Law No. 22 of 2009, traffic is defined as the movement of vehicles and people within road traffic spaces.

Homogeneous traffic refers to vehicular traffic on a roadway where the speeds of vehicles are either the same or, if different, the speed differences between vehicles within the same lane and across different lanes are minimal. Another characteristic of homogeneous traffic is the adherence to lane usage and the presence of vehicles of the same type, which results in more orderly traffic flow and helps reduce the occurrence of traffic accidents.

The degree of saturation is a critical measure of road service performance, theoretically capped at a maximum value of 1 (one). When the degree of saturation approaches 1, traffic conditions are near saturation, often characterized by dense traffic and low vehicle speeds.

$$Dj = \frac{Q}{C} \quad (1)$$

where: Dj is Degree of saturation, Q is traffic flow (vehicles/hour), and C is road capacity (vehicles/hour)

Road capacity refers to the maximum traffic flow that a road segment can sustain per hour under specific conditions. In Indonesia, road capacity analysis varies by road type, including urban roads, rural roads, and highways. For two-lane two-way undivided roads (2/2TT), capacity accounts for combined two-way traffic flows. In multi-lane roads, traffic is separated by direction, and capacity is determined per lane.

$$C = Co \times FC_{LJ} \times FC_{PA} \times FC_{HS} \times FC_{UK} \quad (2)$$

where:

C = Road capacity (vehicles/hour)
Co = Base capacity (vehicles/hour)
FC_{LJ} = Adjustment factor for lane width or traffic lane
FC_{PA} = Adjustment factor for directional separation (only for undivided roads)
FC_{HS} = Adjustment factor for side friction on roads with shoulders or curbs
FC_{UK} = Adjustment factor for city size

The level of service is a measure used to assess the quality of a specific road section in accommodating the traffic flow that passes through it. The relationship between road speed and volume needs to be understood because both speed and volume are crucial factors in determining the level of service. When traffic volume on a road increase and the road cannot maintain a constant speed, drivers will experience fatigue and may not be able to meet their planned travel time.

Table 1. Road Service Level Index and Its Characteristics

Level of Service	Characteristics	Dj (Rasio Q/C)	Ideal Speed (km/h)
A	Free-flow conditions with high speeds; drivers can choose their desired speed without obstacles.	0,00 - 0,20	> 48
B	Stable flow, but operational speed is slightly restricted by traffic conditions; drivers retain have considerable freedom in speed selection.	0,21 - 0,44	40 - 48
C	Stable flow, but vehicle speed and movement are regulated; drivers experience limited freedom in speed choice.	0,45 - 0,74	32 - 40
D	Flow is nearing unstable conditions; speed remains controlled, and the volume-to-capacity (V/C) ratio is acceptable.	0,75 - 0,84	26,6 - 32
E	Traffic is at or near capacity; flow becomes unstable, and speed occasionally comes to a halt.	0,85 - 1,00	22,4 - 25,6
F	Forced or congested flow; low speeds, volume exceeds capacity, long queues, and significant obstructions occur.	> 1,00	0,0 - 22,4

B. Traffic Noise

Noise is defined as unwanted sound from activities or operations that, depending on its level and duration, may disrupt human health and environmental comfort (Kep-48/MENLH/11/1996). Any sound deemed undesirable, regardless of its intensity, can be categorized as noise Noise generated by human activities and other sources that can be quantified using measurement instruments is referred to as objective noise, whereas sounds that do not correspond to the auditory perception of the human ear are termed subjective noise. One of the most significant sources of noise in urban areas is motor vehicle traffic. A study has shown a correlation between traffic noise and daily disturbances experienced by residents near roadways (Bhattacharya, 2012). Consequently, it is nearly impossible to avoid traffic noise, especially in major cities worldwide (Kim, at al. 2012). According to Lakawa et al. (2023), the intensity of noise decreases as the distance between the noise source and the receiver increases.

For motor vehicle traffic noise (road noise), the equivalent continuous noise level (Leq) is calculated using the following equation (Mediastika, 2005):

$$L_{eq} = L_{50} + 0,43\ (L_1 - L_{50}) \quad (3)$$

where: L_{eq} is equivalent noise level (dB), L_{50} is noise level exceeded 50% of the time (dB), and L_1 is noise level exceeded 1% of the time (dB)

Table 2. Noise Level Quality Standard

Descriptions	Noise Level dB
a. Appropriation	
1. Housing & Settlement	55
2. Trade and Services	70
3. Office and Commerce	65
4. Green open space	50
5. Industry	70
6. Government and Public Facilities	60
7. Recreation	70
8. Specifically:	
- Airport*	
- Railway Station*	
- Harbor	70
- Cultural Heritage	60
b. Surrounding Activity	
1. Hospital or the like	55
2. School or the like	55
3. Worship place or the like	55

Source: Decree Number: 48/MENLH/11/1996

Several similar previous studies, including one by Waas (2023), conducted research on traffic performance and noise levels caused by school drop-off and pick-up activities during the new normal period. The findings revealed that the average traffic noise level on Dr. Siwabessy Street, Ambon, ranged between 71–73 dB, with a maximum degree of saturation value of 0.73 and a Level of Service (LOS) rating of C.

Utama et al. (2016), found that vehicle volume has a strong correlation with noise intensity, with a correlation coefficient of 0.41. Their study also categorized residential areas into three noise exposure zones based on proximity to the noise source: High Noise Risk Areas (less than 5 meters), Moderate Noise Areas (5–15 meters), and Safe Noise Zones (more than 15 meters).

Putra et al. (2020) investigated the relationship between the degree of saturation and accident rates, identifying a negative correlation. The study concluded that higher saturation levels corresponded to reduced accident rates, emphasizing the importance of this finding for urban road planning and management.

Satoto (2018) conducted a study on transportation noise in residential areas along Sutorejo-Mulyorejo Road in Surabaya. Measurements indicated maximum equivalent noise levels (L_{eq}) of 74,98 and minimum values of 72.04 dBA, both exceeding the standard noise threshold for residential areas (58 dBA). Satoto further highlighted that artificial noise barriers were more effective than natural barriers in mitigating noise levels.

Sotiropoulou et al. (2020) measured and predicted traffic noise along the fronts of high-rise buildings in Athens. They found that the predicted and measured noise levels were highly coherent, with vertical distribution patterns largely confirming findings from previous studies. Their research demonstrated that the CRTN model is highly useful and suitable for predicting traffic noise in front of high-rise buildings during the planning and design stages.

Lastly, Gilani and Mir (2021) developed a traffic noise model using a graph theory approach, integrating various road traffic subsystem parameters, such as vehicle speed, volume, road width, and horn sounds. While the model yields result that are slightly higher than expected, it remains quite satisfactory. This method is highly valuable for predicting noise levels.

III. RESEARCH METHODS

This study was conducted on Ahmad Yani Street in Kendari, Southeast Sulawesi Province. The street was selected as the research location due to its high traffic volume and diverse land use, including residential, educational, office, and commercial areas. Eight observation points were strategically chosen to represent these various land use types.

The traffic survey was carried out at each of the eight observation points. Data collection involved a 10-minute observation period at each site, during which traffic volume and vehicle speed were recorded. Vehicle speed was measured by sampling 15 vehicles per site, comprising five samples each for motorcycles, light vehicles, and heavy vehicles.

Simultaneously with the traffic survey, noise levels were measured at each observation site. A noise measurement device (SLM microphone) was employed for this purpose, placed 1 meter from the road's edge and positioned at a height of 1.2 meters above the ground. Noise data were collected over the same 10-minute period as the traffic survey to ensure synchronized results.

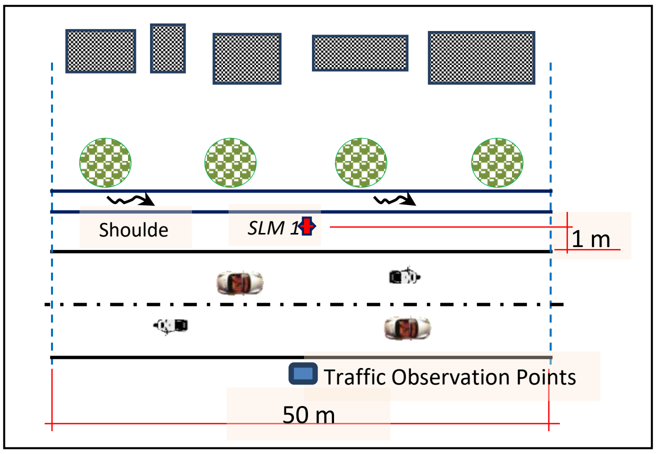

Figure 1. Schematic of Noise Measurement

IV. RESULTS AND DISCUSSION

Traffic data plays a crucial role in the planning stage. Traffic volume refers to the number of motor vehicles passing through Ahmad Yani Street. The calculation is based on the number of vehicles passing through the observation points during the study period, converted into light vehicle units per hour (lvu/h).

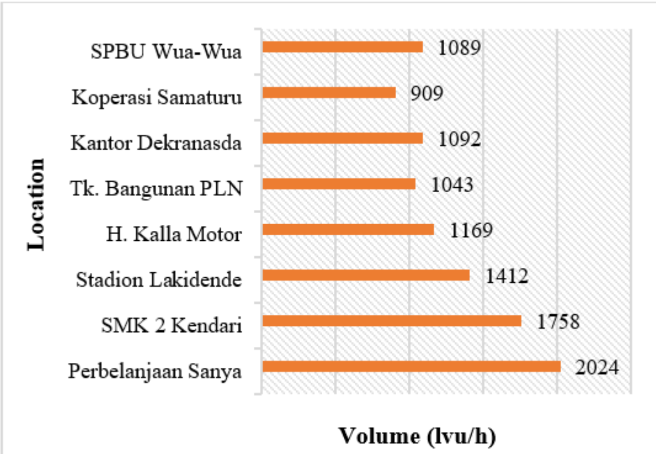

Figure 2. Traffic Volume

As shown in Figure 2, the average traffic volume on Ahmad Yani Street is 1312 lvu/h. The highest volume occurs in front of the Sanya Shopping Center, with 2024 lvu/h. This is due to the land use in this area being a commercial zone, which naturally attracts a significant amount of traffic. Conversely, the lowest traffic volume occurs in front of the PLN Building Supply Store, with 955 lvu/h. Vehicle composition along the road is predominantly motorcycles (60%), followed by light vehicles (36%) and heavy vehicles (4%).

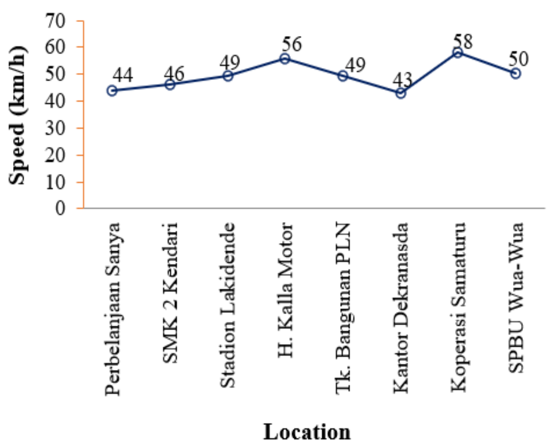

Figure 3. Vehicle Speed

As shown in Figure 3, the average vehicle speed on Ahmad Yani Street is 50 km/h. The highest vehicle speed occurs in front of the Samaturu Cooperative Office, at 58 km/h. The lowest speed is observed in front of the Dekranasda Office, at 43 km/h. It appears that these variations in speed are influenced not only by traffic density but also by factors such as road grade, surface conditions, and driver behavior.

Road performance is a quantitative metric that evaluates the operational condition of a traffic facility, forming an integral part of roadway analysis. This performance is assessed using the degree of saturation, which is determined by the flow-to-capacity ratio. For undivided roads, the road basic capacity (Co) is set at 2900 light vehicle units per hour (lvu/h), while for divided roads, Co is 1650 lvu/h per lane.

On Ahmad Yani Street, the average road capacity is 4775 lvu/h (two-way). This indicates that the road can efficiently accommodate traffic at this rate before its performance begins to decline due to traffic volume exceeding the roadway's capacity.

Table 3. Recapitulation of Saturation Degree (Dj) and Road Service Level (LoS)

No	Location	Code	Types of Land Use	Dj	LoS
1.	Sanya	T1	Shopping Centre	0,47	C
2.	SMKN 2 Kendari	T2	School	0,37	B
3.	Stadion Lakidende	T3	Sport Facility	0,30	B
4.	Kalla Motor	T4	Commerce	0,22	B
5.	Tk. Bangunan PLN	T5	Shops	0,19	A
6.	Ktr Dekranasda	T6	Offices	0,20	A
7.	Ktr Koperasi Samaturu	T7	Offices	0,17	A
8.	SPBU Wua-Wua	T8	Residential	0,41	B

According to Table 3, the road performance on Ahmad Yani Street has an average degree of saturation of 0.27, with a Level of Service (LoS) index of B. This indicates stable traffic flow, with drivers having sufficient freedom to select their speeds. However, the operational speed begins to be constrained by traffic conditions, with average vehicle speeds ranging from 40 to 48 km/h. These conditions may change during peak hours, suggesting that the road's service level is conditional.

The equivalent noise level (L_{eq}) is a parameter that determines the intensity of environmental noise generated by traffic on highways. Due to the variability in noise production, a simple statistical method is employed to calculate the relevant noise indicators at each observation point.

Table 4. Traffic Noise Level

No	Location	Code of Segment	Noise Level (dBA)				
			L_1	L_{10}	L_{50}	L_{90}	L_{eq}
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	Sanya	T1	82.4	75.4	69.3	64.3	74.9
2	SMKN 2 Kendari	T2	82.4	75.8	68.6	61.4	74.5
3	Stadion Lakidende	T3	79.2	75.1	69.5	63.8	73.6
4	Kalla Motor	T4	79.7	75.1	67.8	59.1	72.9
5	Tk. Bangunan PLN	T5	81.9	76.0	68.2	60.6	74.1
6	Ktr Dekranasda	T6	79.9	75.4	69.1	62.4	73.7
7	Ktr Koperasi Samaturu	T7	79.7	73.7	66.0	56.5	71.8
8	SPBU Wua-Wua	T8	80.9	73.3	67.1	60.9	73.0
	Noise Average						**73.6**

Based on the analysis presented in Table 4, the average traffic noise level on Ahmad Yani Street is 73.6 dB, which exceeds the environmental noise threshold established by the Minister of Environment's Decree of the Republic of Indonesia No. 48/MENLH/11/1996 for areas such as schools, residential areas, offices, and commercial zones. The highest noise level occurs in front of the Sanya Shopping Center at 74.9 dB, while the lowest noise level is recorded in front of the Samaturu Cooperative Office at 71.8 dB. These findings suggest a direct relationship between traffic density and road noise intensity: as traffic density increases, so does the noise level. Key factors contributing to urban noise include vehicle volume, traffic density, superelevation, and air temperature (Lakawa, 2023).

Table 5. Model Summary of Road Service Level on Traffic Noise

Model Summary[b]					
Model	R	R Square	Std. Error of the Estimate	F Change	Sig. F Change
1	.559[a]	.313	8.851	2.730	.150
a. Predictors: (Constant), Level of Service					
b. Dependent Variable: Noise					

According to Table 5, the correlation value is 0.559, and the coefficient of determination (R-Square) is 0.313. This means that the influence of road service level on noise level accounts for 31.3%, while the remaining 68.7% is attributed to other factors not examined in this study. The mathematical model describing the influence of road service level on noise level is expressed as $y = 721.482 + 0.486x$, where x represents the road service level and y represents the noise level.

V. CONCLUSION

5.1 Conclusion

The road performance of Ahmad Yani Street in demonstrates an average degree of saturation of 0.27, corresponding to a Level of Service (LoS) of Level B. Traffic flow is stable, although operational speeds are beginning to decline, with drivers still maintaining adequate freedom to choose their speeds. The average traffic noise level is 73.6 dB, surpassing Indonesia's environmental noise threshold for areas such as schools, residential zones, offices, and commercial areas. The highest recorded noise level is 74.9 dB, while the lowest is 71.8 dB. The influence of road service quality on noise levels is 31.3%, indicating that other factors contribute significantly to traffic noise levels. Further investigation is required to identify and address these additional factors to mitigate traffic noise and improve environmental quality.

5.2 Acknowledgement

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REFERENCES

Al-Dosky, B.H.M. 2014. Noise level and annoyance of Industrial factories in Duhok city. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 8(5), p. 01-08.

Bhattacharya, D and Pal, D. 2012. A Study of Road Traffic Noise Annoyance on Daily Life in Agartala City Using Fuzzy Expert System and Multiple Regression Analysis. *International Journal of Scientific and Research Publications*, 2(5), p. 1-7.

Gilani, T.A., Mir, M.S. 2021. Modelling Road Traffic Noise Under Heterogeneous Traffic Conditions Using the Graph-Theoretic Approach. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-021-13328-4.

KEP-48/MENLH/11/1996, tentang baku tingkat kebisingan [KEP-48/MENLH/11/1996 Minister of State for the Environment of the Republic of Indonesia's decree No. 48, the year 1996, concerning Noise Level Standards].

Kim, M., Chang, S.I., Seong, J.C., Holt, J.B., Park, T.H., Ko, J.H., Croft, J.B. 2012. Road Traffic Noise Annoyance, Sleep Disturbance, and Public Health Implications. *Am J Prev Med*, Vol. 43(4), p. 353–360.

Lakawa, I., Syamsuddin., Hujiyanto., Ilham, V.A. 2023. Noise Mapping Due to Motor Vehicle Activities in The By-Pass Ring Road area of The City of Kendari. *Scientific Review Engineering and Environmental Sciences*, 32(4), p. 392-406. https://doi.org/10.22630/srees.5550.

Lakawa, I., Hujiyanto., dan Haryono. 2023. A Study of Heterogeneous Traffic Noise Trigger Parameters for Urban Areas. *Technium*, 13, p.79-87. https://doi.org/10.47577/technium.v13i.9572.

Lakawa, I., Samang, L., Selintung, M., Hustim, M. 2015. Relationship Models of Traffic Volume Vs Noise Level. *International Journal of Development Research*, Vol. 5(9), p. 5463-5466.

Mediastika, C.E. 2005. Akustika Bangunan: Prinsip-Prinsip dan Penerapannya di Indonesia [Building Acoustics: Principles and Applications in Indonesia]. Jakarta: Erlangga.

Pedoman Kapasitas Jalan Indonesia. 2014. Kapasitas Jalan Perkotaan. [Indonesian Road Capacity Guidelines (2014). Urban Road Capacity].

Putra, A.A., Kriswardhana, W., Hayati, N.N. 2020. Hubungan Derajat Kejenuhan Dengan Angka Kecelakaan di Ruas Jalan Gajah Mada Kabupaten Jember [The Relationship Between Degree of Saturation and Accident Rates on Gajah Mada Street, Jember Regency]. *Rekayasa Sipil*, 9(2), p. 52-58. http://dx.doi.org/10.22441/jrs.2020.v09.i2.03.

Rahmatunnisa, F.G., Sudarwati, M.R., Sufanir, A.M.S. 2017. Analisis Pengaruh Volume dan Kecepatan Kendaraan Terhadap Tingkat Kebisingan Pada Jalan Dr. Djunjunan di Kota Bandung [Analysis of the Effect of Vehicle Volume and Speed on Noise Levels on Dr. Djunjunan Street in Bandung City]. *8th Industrial Research Workshop and National Seminar Politeknik Negeri Bandung*, July 26-27. 2017.

Satoto, H.F. 2018. Analisis Kebisingan Akibat Aktifitas Transportasi Pada Kawasan Pemukiman Jalan Sutorejo-Mulyorejo [Noise Analysis Due to Transportation Activities in the Residential Area of Sutorejo-Mulyorejo Street. Heuristic]. *Jurnal Teknik Industri HEURISTIC*, 15(1), p. 49-62.

Shvetsov, A. 2021. Aspects of Traffic Noise Reduction. *Akustika*, 39, p. 27-29.

Sotiropoulou, A., Karagiannis, L., Vougioukas, E., Ballis, A., Bouki, A. 2020. Measurements and prediction of road traflc noise along high-rise building façades in Athens. *De Gruyter*, Vo. 7, p. 1-13.

Law of the Republic of Indonesia Number 22 of 2009 Concerning Road Traffic and Transportation

Utama, B.P., Wardana, I.W., Istirokhatun, T. 2016. Pemetaan Kebisingan Lalu Lintas di Tiga Ruas Jalan (Perintis Kemerdekaan, Ngesrep, Jatingaleh) di Kota semarang Akibat Kegiatan Transportasi [Mapping Traffic Noise on Three Roads (Perintis Kemerdekaan, Ngesrep, Jatingaleh) in Semarang City Due to Transportation Activities]. *Jurnal Teknik Lingkungan*, Vol. 5(1), p. 1-6.

Waas, R.H., Matitaputty, V. 2023. Analisis Kinerja Lalu Lintas dan Tingkat Kebisingan Akibat Aktivitas Antar Jemput Sekolah di Masa New Normal (Studi Kasus: Ruas Jalan Dr. Siwabessy Ambon) [Traffic Performance Analysis and Noise Levels Due to School Pick-Up and Drop-Off Activities in the New Normal Era (Case Study: Dr. Siwabessy Street, Ambon)]. *Publikasi Riset Orientasi Teknik Sipil (Proteksi)*, Vol. 5(1), p. 13-20.