RESEARCH PAPER

Noise from the traffic volume of motorcycle during the Covid-19 pandemic: A case study of Wiyata Mandala Junior High Schoool Bogor

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Abstract. Each motor vehicle produces a variety of noise. For areas which directly intersects the highway this noise has a considerable impact. The volume of motorcycles and private as well as public vehicles all have a significant effect on noise. From all analytical calculations, the largest equation was obtained one the second day of research on the second point of Sound Level Meter 2 (SLM2). The calculation is that $y = 0,0158x – 1,0176$. This equation indicates that if there is no decrease in the volume of the motorcycle, the noise level on the SLM2 is 65.21 dB$_A$. If there is an increase or decrease in the volume of a motorcycle, it will have a significant effect on noise. The second largest equation was obtained on the second day of the research at the third point from the Sound Level Meter 3 (SLM3) and the calculation of the equation is $y = 0,01 – 6,074$. The purpose of the above equation is that if there is an increase in the volume of a motorcycle, the noise on the SLM3 is 60.840 dB$_A$. According to the findings, there was a reduction in the number of motorcycles during the Covid-19 pandemic, because schools were closed and students did not attend school.

Keywords: Traffic volume; noise; motorcycles; sound level metre; pandemic Covid-19

1.   Introduction

Today, transportation plays an important role in human life since it helps people move from one location to another. The increasing development of transportation influences the increasing number of vehicles. It, however, creates environmental problems such as air pollution and noise.

The city and district of Bogor are located in a strategic location. It is close to DKI Jakarta, the capital city of Indonesia. Bogor serves as a buffer zone for the Jakarta-Banten metropolitan area. Considering its role as a buffer zone for the cities of Jakarta and Banten, the city and district of Bogor's main highways are usually clogged with vehicles, either by local residents or passing vehicles.

The notion of constructing activity and economic hubs as a magnet for people mobility has a very close influence on regional development. A well-controlled area development is able to accommodate all the economic demands of the community, including transportation planning, economic development, urban planning, and other forms of integrated accessibility (Pratama et al., 2018; Kinoshita et al., 2019; Annema & Van Wee, 2000).

In road planning, for example, it is necessary to improve both existing and new by expanding the road's capacity from subgrade to top coating. This road improvement supports transportation from the point of origin to the urban area. Improving the quality of good and well-planned roadways is also part of city development (Pratama et al., 2018; Fauzi & Hariyadi 2018).

The true development of the growing economy is the attraction of people to one or more objects of activity such as recreation areas, places for gathering people in large numbers, and influencing travel patterns. People's travel patterns vary greatly depending on the needs of their transportation users. Transportation users affect the real economic progress of any population activity (Mangiri et al., 2020; Oktavia et al., 2020; Rustiadi, 2001).

The noise generated by these vehicles is considered normal for road users and local residents, but there are public facilities along the highway that are disturbed by the noise, including school students who need peace in the learning process. Each motor vehicle produces a variety of noise (Buchari, 2007; Bangun et al., 2009). This noise has a considerable impact on the tranquility of the area that is directly in contact with the highway. Therefore, setting the distance between the main school building and the road must be taken into account to ensure the comfort of the school students (Hobbs, 1995).

A soundproof study room space or a yard with high walls or plants with dense leaves (Syaiful & Mudjanarko, 2019; Syaiful & Fadly, 2020).

Likewise, when a motorized vehicle passes through a certain lane, the sound it produces will increase. The increase in the level of noise generated will be higher as the number of motor vehicles on the road grows. This study was conducted on the edge of the highway. The impact of motorized vehicles passing in front of this location will be substantial. In-depth calculations are needed to measure the noise level it causes (Syaiful & Wahid, 2020; Syaiful & Andana, 2021).

The income of the population which has a huge influence in the current environment is highly affected by the economy's growth plan. To improve this condition, the underlying concept of regional development must be enhanced. Developed areas are usually very dependent on the pattern defined during the initial planning. Good patterns will likely support actual activities and patterns are formed according to the demands of the times (Rustiadi & Junaidi, 2011).

One of the most important locations to pay attention to is the place of education or schools. Meanwhile, in Bogor district, there is a school called Wiyata Mandala Junior High School, which is adjacent to the highway. The purpose of this study was to determine the noise level caused by the volume of motorcycle traffic on the road in front of Wiyata Mandala Junior High School. The effect of noise on traffic volume is shown by a linear equation, implying that the larger the traffic volume, the higher the noise level. The noise disturbance studied and observed are restricted to noise source level disturbances which do not affect air or waste pollution levels.

2. Literature Review

The highway is a land transportation infrastructure that plays a very important role in the transportation sector, especially for the continuity of the distribution of goods and services. The function of the road is to serve existing and developing traffic loads and flows, and can provide security and comfort to road users. The main characteristics of roads that affect the capacity of road traffic are influenced by several factors (Menteri Pekerjaan Umum Republik Indonesia, 1997; Tamin, 2000; Warpani, 2002).

Traffic flow is the number of vehicles that cross the road at a time and distinguishing between directions. The unit of traffic flow is the number of vehicles per unit time or SMP/*Satuan*

Mobil Penumpang /unit time. Volume is the number of vehicles that cross the road for a long time regardless of direction. The volume is measured in units of vehicles per hour (Menteri Pekerjaan Umum Republik Indonesia, 1997; Saputro & Hariyadi, 2015). The volume of free current in real conditions is shown in Equation 1.

$$FV = (FV_0 + FV_w) \times FFV_{sf} \times FFV_{cs} \tag{1}$$

Where FV is actual free flow volume (LV), [km/hour]; FV_0 is basic free flow volume (LV), [km/hour]; FV_w is an effective traffic road width adjustment [km/hour]; FFV_{sf} is side resistance adjustment factor; and FFV_{cs} is box size adjustment factor.

The capacity value is shown in Equation 2,

$$C = C_0 \times F_{cw} \times FC_{sp} \times FC_{fs} \times FC_{cs} \tag{2}$$

Where C is capacity [pcu/hour]; C_0 is basic capacity for certain conditions [pcu/hour]; F_{cw} : traffic lane width adjustment factor; FC_{sp} is direction separator adjustment factor; F_{fs} is side resistance adjustment factor; and FC_{cs} is city size adjustment factor.

The level of road performance is shown in equation 3.

$$D = \frac{Q}{C} \tag{3}$$

Where DS is degree of saturation; Q is traffic flow capacity; and C is capacity.

Noise is an unwanted sound from a business or activity at a certain level and time that can cause disturbance to human health and environmental comfort (Anonim, 1996; Hidayati, 2007). Based on the nature and spectrum of sound, noise is divided into five. First is continuous noise with a wide frequency spectrum. This noise is relatively constant within the limits of approximately 5 dB$_A$ for a period of 0.5 seconds consecutively. Second, continuous noise with a narrow frequency spectrum. This noise is also relatively constant, but only has a certain frequency (at a frequency of 500, 1000, and 4000 Hz) such as secular chainsaws, gas valves. Third, intermittent noise. This noise does not occur continuously, but there is a period of relative calm, for example traffic noise and noise at the airport. Fourth, impulsive noise. This type of noise has a change in sound pressure exceeding 40 dB$_A$ in a very rapid time and usually shocks the hearing, e.g. gunshots, explosions of fireworks, and cannons. Fifth, repeated impulsive noise. This noise is similar to impulsive noise, except it occurs repeatedly, for example in a forging machine (Bangun et al., 2009). These limits of noise levels for some areas or environments can be shown in Table 1.

Noise-related studies have been done by several researchers. A study of Buchari (2007) was conducted to increase work productivity through preventing noise-induced deafness in the workplace by implementing a hearing conservation program that involves all elements within the company. The subject of this study is production employees with hearing loss. The method of measuring the level of deafness of each employee to the production machine is to measure their hearing to a certain limit using a tool. Each employee is regularly checked with an Audiometry tool to determine their hearing level. Noise on employee hearing conservation is carried out by preventing health problems that have an impact on hearing. The conclusion of the study is that employees must perform technical control, administrative control, and use hearing protection equipment.

Meanwhile, Hidayati (2007) conducted a research with the goal of determining the value of the intensity of the noise level generated by traffic with the threshold of the applicable rules and solutions. The subjects of her research were elementary and junior high school students in

Surakarta. The method used was a direct survey by taking motorized vehicle data and noise using SLM. The vehicle speed was calculated empirically on the walls of the elementary and junior high schools. The result was still above the specified threshold of 55 dB$_A$. The treatment was to change the road profile, create a barrier, and control the noise center with a green line.

Table 1. Noise level limits

Health area/environment designation	Noise level (dB$_A$)
1. Designation of area	
a. Housing and settlement	55
b. Industry and services	70
(transportation terminals, airports, railway stations, ports)	65
c. Office and trade	50
d. Green open space	70
e. Industry	60
f. Government and public facilities	70
g. Recreation	
2. Environment of activities	
a. Hospital or the like	55
b. School or the like	55
c. Places of worship or the like	55

(Menteri Negara Lingkungan Hidup Republik Indonesia, 1996)

The research objective of Bangun et al. (2009) was to analyze the noise level with the level of disturbance of the community on the densely populated Bojongsoang street. He conducted this reasearch by taking field data, questionnaires, traffic data for 16 hours, noise data with SLM. The analysis with correlation test was using Pearson coefficient with linear regression model. The results showed that the noise levels were past the threshold of 76.3 dB$_A$. Because densely populated settlements are not handled properly, the results remained skewed and limited to research reports. The survey only assessed each respondent directly and did not represent the actual results.

Syaiful & Mudjanarko (2019) recently completed a study to determine the noise level in front of the Baiturrahman Grand Mosque, Semarang. The object of the research is the congregation of the mosque, the takmir of the mosque. The research method was measuring the volume of motorized vehicles that pass in front of the mosque, as well as conducted structured interviews. Results and discussion of all measurement results with the furthest distance, which is 56.35 meter below the threshold, which is 55 dB$_A$. It means that it is safe and recommended to worship at the Baiturahman Grand Mosque in Semarang. The conclusion of the study was that further research is needed to measure the noise level whose value is above the threshold, namely the closest distance of 0.00m.

3. Research Methods

The data which was observed in this study was the level of noise on a straight road with regional characteristics. The assumption is that the increase in noise level (y) is a dependent variable and is influenced by several independent variables, namely x_1 is the first independent variable/motorcycle volume (SPM). Based on the data above, the linear regression model approach is obtained. The linear equation formula is therefore,

$$y = a_0 + a_1 x_1 + \cdots + a_n x_n \qquad (4)$$

Where $a_0, a_1, \ldots, a_n$ are coefficients derived from the research data.

The samples used were road users in front of the Wiyata Mandala Junior High School in Bogor district, including teachers, students, and people who passed in front of the school. The sample studied can represent daily activities carried out between 06.00 - 18.00 WIB (Western Indonesian Time). The day that represents every educational activity for four days, namely Saturday, Sunday, Monday and Tuesday, means a day that represents every activity of residents and the school. However, during the Covid-19 pandemic, residents' activities decreased quite drastically. Field data collection was carried out for 4 days: Saturday, 12 September 2020, at 06.00-18.00; Sunday, 13 September 2020, at 06.00-18.00; Monday, 14 September 2020, at 06.00-18.00; and Tuesday, 15 September 2020, at 06.00-18.00. The study was conducted for 12 hours each day, starting at 6 am to 6 pm. The reason was because this timespan includes the peak hours of the morning, afternoon and evening. The location of this research was in front of Wiyata Mandala Junior High School, Salabenda-Parung Rd Km 4, Salabenda Bogor, West Java (16629), which is a main road.
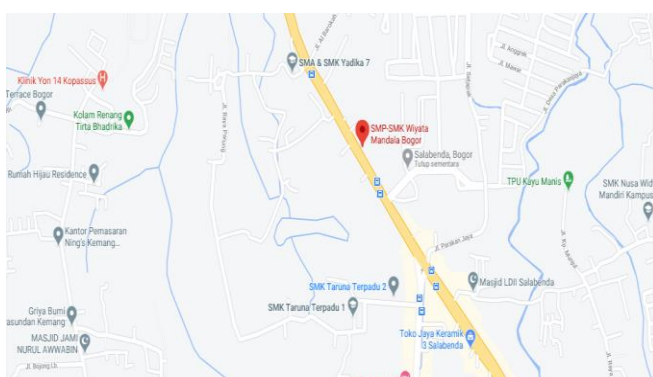

Figure 1. Research location map
Source: Google Maps

Figure 2. Research location in front of Wiyata Mandala Junior High School Bogor
Source: private documentation

3.1. Material

The material used in this study was in the form of data retrieved from motorcycle traffic data and noise data derived from the measurement results of the Sound Level Meter (SLM) noise instrument.

The main and supporting equipment used in this study were sound level meter, roll meter, digital camera, manual counting tool, and a laptop. There was also a note-taking officer to support the data collection. There were three SLMs used in this study as the main tool for calculating noise, including: Krisbow Manual SLM KW06-291 (SLM1); Krisbow Manual SLM KW06-291 (SLM2) ; and Extech Auto SLM HD600 (SLM3). Another tool that was pivotal for the study was roll meter, which is a tool for measuring the distance between the SLM point and the road and school wall building. Digital camera in this study was used to document all processes during the research. Tally or manual counting tool was used to count the number of motorcycles passing on the highway. Laptop was used as a tool in data collection and processing data obtained from the field during the research. Officers in charge of stationery and note-taking were to assist in recording everything gathered during data collection in the field.

3.2. Research method

The research flow chart begins with the collection of primary data and secondary data in the field. The primary data are motorcycle traffic volume data and noise data with a predetermined time of 12 hours. Simultaneously, secondary data, including road geometric data and traffic sign

traffic data, were collected. Furthermore, motorcycle volume and noise data were taken together and processed according to the data collection guidelines. The results of the data were analyzed using Microsoft Excel, Microsoft Word and SPSS. The results of the data using these softwares yielded a linear equation, allowing it to be concluded whether it is within the noise threshold or exceeds it.
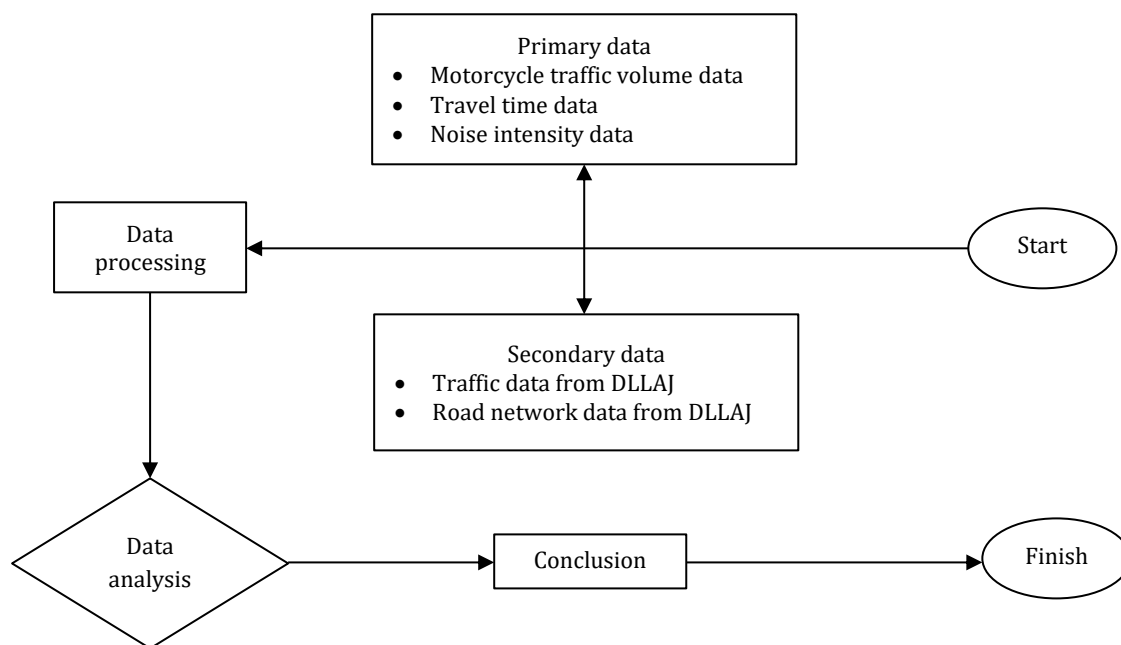

Figure 3. Research flow chart

4. Results and discussion

4.1. Traffic data results

Motorcycle traffic data was calculated every 15 minutes for 12 hours each day. Data was collected from 6:00 to 18:00 for 4 days: Saturday 12 September 2020, Sunday 13 September 2020, Monday 14 September 2020, and Tuesday 15 September 2020. This traffic data was derived from the results of the Passenger Car Equivalence (EMP/*Equivalen Mobil Penumpang*) calculation. The purpose of this calculation is to make traffic analysis as simple as possible by calculating the passenger car unit factor (SMP/*Satuan Mobil Penumpang*) for each motor vehicle (Menteri Pekerjaan Umum Republik Indonesia, 1997). For urban roads, heavy vehicle (HV) is 1.30, light vehicle (LV) is 1.00, motorcycle (MC) is 0.40, and non-motorized vehicle is 1.00.

In practice, the grouping is divided into two groups, namely motorcycles and light vehicles. Motorcycles (MC) have a value of 0.4 and light vehicles (private cars, public transportation and freight transport) with an EMP of 1.00.

4.2. Motor vehicle volume processing results

The data from Saturday, 12 September 2020, was used to generate the results of processing the volume of motorized vehicles. Based on the volume calculation, the number of vehicles per hour is 3.66 vehicles/hour, derived from the number of motorbikes passing by divided by the travel time of fifteen minutes.

4.3. Vehicle volume data processing and noise caused by motorcycles

The data processing of the volume of motorcycles and noise used the SPSS version 22 program. After selecting the data in the field, the processing results which indicate the recommended data for motorcycle traffic volume is described in the discussion section.

4.4. Correlation test

Correlation testing is used to find the relationship between two or more independent variables which are jointly associated with the dependent variable, so that the contribution of the independent variable under investigation to the dependent variable is understood (Usman & Akbar, 2011). The result is presented in Table 2.

Table 2. The R and R^2 of the models

Date	R^2
September 12 2020, distance 0 meter	0.999
September 12 2020, distance 3.44 meters	1.000
September 12 2020, distance 15.25 meter	0.985
September 13 2020, distance 0 meter	1.000
September 13 2020, distance 3.44 meters	1.000
September 13 2020, distance 15.25 meters	0.991
September 14 2020, distance 0 meter	0.974
September 14 2020, distance 3.44 meters	0.996
September 14 2020, distance 15.25 meters	1.000
September 15 2020, distance 0 meter	0.997
September 15 2020, distance 3.44 meters	1.000
September 15 2020, distance 15.25 meters	0.987

4.5. Data statistical analysis

The hypotheses are

Ha = There is a significant effect between the volume of motorcycles, the volume of private vehicles and public transportation with noise.

Ho = There is no significant effect between the volume of motorcycles, the volume of private vehicles and the volume of public transportation with noise

Statistical analysis of data on Saturday, September 12, 2020 was at a distance of 0 meter with SLM1. Analysis and data processing using SPSS version 22 obtained noise level (y) and motorcycle volume (SPM/x) based on 95% confidence level. The results of statistical analysis (Equation 4) using observation data taken on Saturday 12 September 2020, which represents a distance of 0 meter using SLM1, a distance of 3.44 meters using SLM2, and a distance of 15.25 meters using SLM3 are shown in Figure 4, 5, and 6. Meanwhile, the regression models for observation taken on Sunday, September 13, 2020 with the distance 0 meter using SLM1, 3.44 meters distance using SLM2, and 15.25 meters distance using SLM3 are shown in Figure 7, 8, and 9. This study also made an observation on Monday, September 14, 2022. The regression models for 0 meter using SLM1, 3.44 meters distance using SLM2, and 15.25 meters distance using SLM3 are shown in Figure 10, 11, and 12.

Based on the analysis, all of the regression models in Figure 4 to 15 show that H_a is accepted. This means that there are significant effects between the volume of the motorcycle and the noise.

4.6. Results and discussion

The distance of 0.00 meter in Figure 4 shows that the equation is y = 0.28 – 22.953. It indicates that the noise level is 82.000 dB$_A$. Therefore, the noise level is very high. Furthermore, it is shown in the form of Table 2.
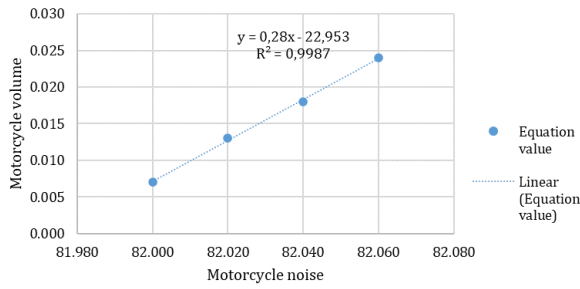
Figure 4. Graph of data analysis distance 0 meter using SLM1 in September 12, 2020
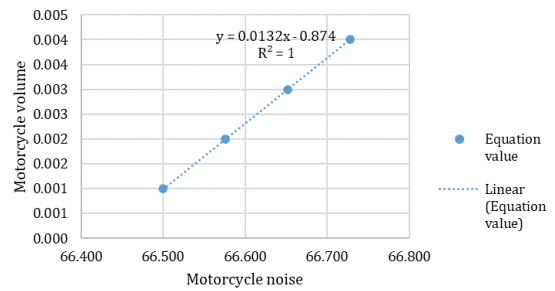

Figure 5. Graph of data analysis distance 3.44 meters using SLM2 in September 12, 2020
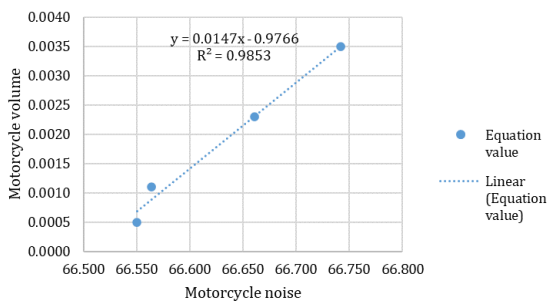

Figure 6. Graph of data analysis distance 15.25 meters using SLM3 in September 12, 2020
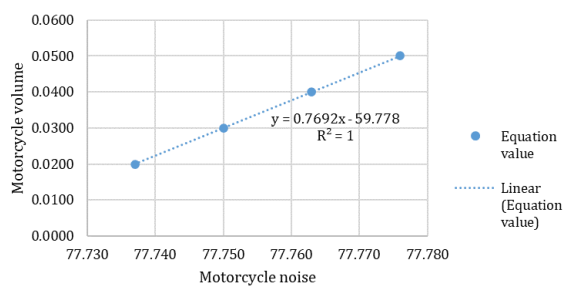

Figure 7. Graph of data analysis distance 0 meter using SLM1 in September 13, 2020
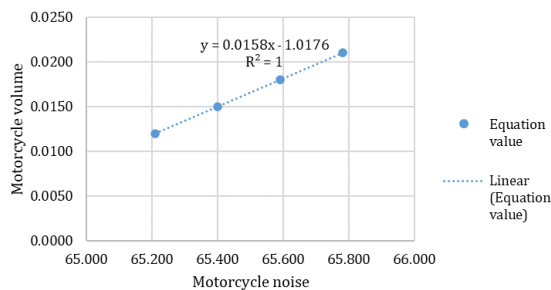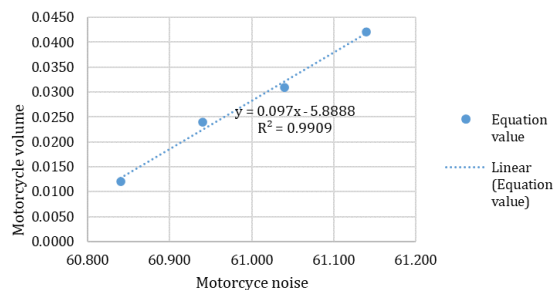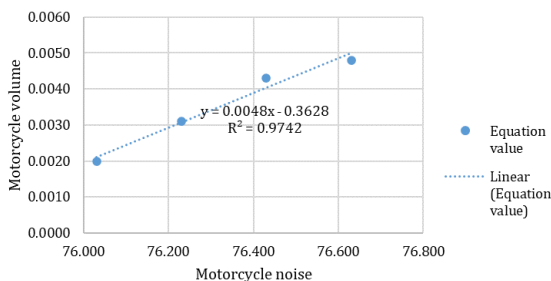

Figure 8. Graph of data analysis distance 3.440 meters using SLM2 in September 13, 2020

Figure 9. Graph of data analysis distance 15.250 meters using SLM3 in September 13, 2020

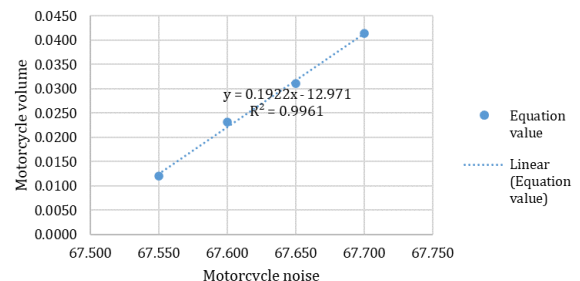**Figure 10.** Graph of data analysis distance 0 meter using SLM1 in September 14, 2020

Figure 11. Graph of data analysis distance 3.440 meters using SLM2 in September 14, 2020
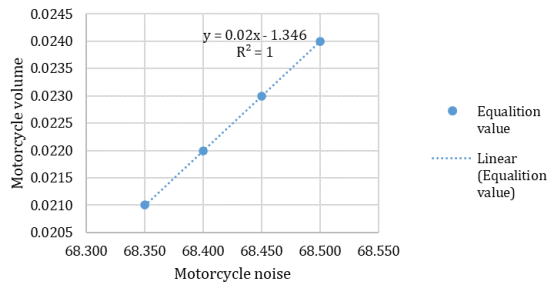
Figure 12. Graph of data analysis distance 15.250 meters using SLM3 in September 14, 2020

Figure 13. Graph of data analysis distance 0 meter using SLM1 in Septemner 15, 2020

Figure 14. Graph of data analysis distance 3.44 meters using SLM2 in September 15, 2020

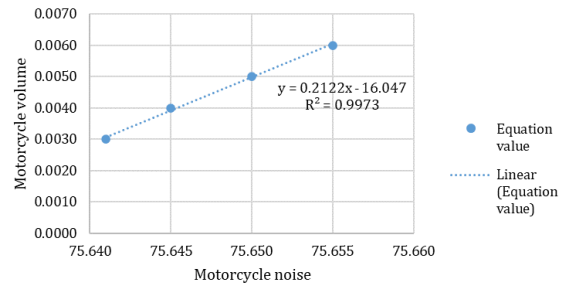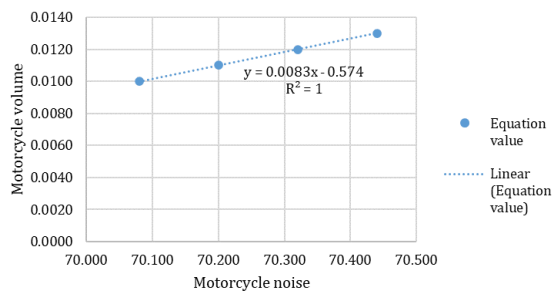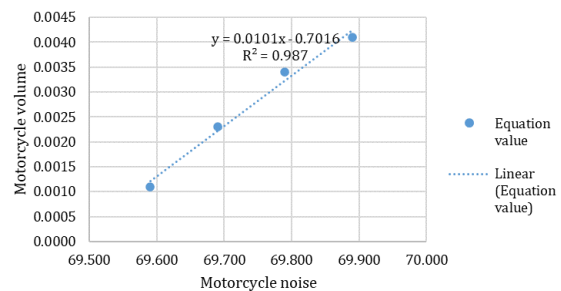**Figure 15.** Graph of data analysis distance 15.25 meters using SLM3 in September 15, 2020

Table 2. The results of the equation and the optimum noise level for each distance

No	Distance	Equation	Noise level (dB$_A$)	Description	Lowest order
1	September 12, 2020				
	0.000 m/SLM1	y = 0.28x – 22.953	82.000	High	3
	3.440 m/SLM2	y = 0.874x – 0.0132	66.500	High	1
	15.250 m/SLM3	y = 0.01x – 0.6711	66.550	High	2
2	September 13, 2020				
	0.000 m/SLM1	y = 0.7692x – 59.778	77.737	High	3
	3.440 m/SLM2	y = 0.0158x – 1.0176	65.210	High	2
	15.250 m/SLM3	y = 0.01x – 6.074	60.840	High	1
3	September 14, 2020				
	0.000 m/SLM1	y = 0.005x – 0.3781	76.030	High	3
	3.440 m/SLM2	y = 0.2x – 13.5	67.550	High	1
	15.250 m/SLM3	y = 0.02x – 1.346	68.350	High	2
4	September 15, 2020				
	0.000 m/SLM1	y = 0.2122x – 16.047	75.641	High	3
	3.440 m/SLM2	y = 0.0083x – 0.574	70.080	High	2
	15.250 m/SLM3	y = 0.01x – 0.6949	69.590	High	1

From Table 2 above, the research on September 12, 2020 with the distances of 0.00 meter, 3.44 meters and 15.250 meters respectively are as follows: y = 0.28x – 22.953. If the number of motorcycle (*x*) is zero the noise is – 22.953. As soon as one motor is added, the noise will increase to 0.28 times. Therefore, the total noise at that time is -22.953 + 0.28 = -22.673. It can also be applied to other models.

This shows that noise increases significantly if there is a significant increase in the number of motorcycles The point of sampling the sound of the vehicle at the closest distance to the noise source is to show that the closer the testing tool is to the source, the louder the sound. This is also supported by a research at RSUD Dr. Sutomo Surabaya where all sampling points averaged 73 dB$_A$, which were above the noise quality standard of 55 dB$_A$ (Prasetyo PH and Assomadi AF, 2018). The position of motorized vehicles on the highway when when passing the school causes disturbance to the students studying there. According to a research on a school which is exposed to noise sources found that during the morning and afternoon rush hours, the noise level was 90 dB$_A$. Meanwhile, during the morning rush hour from the farthest distance, the noise is 48 dB$_A$, meaning that distance affects the noise level (Saputro GE and Rusli M, 2019).

5.   Conclusion

The volume of motorcycles has a significant effect on noise and from all of the analytical calculations, the largest equation was obtained on the second day of the study from the of Sound Level Meter 2 (SLM2), which is y = 0,0158x – 1,0176. This equation indicates that if there is no decrease in the volume of the motorcycle, the noise level in SLM2 is 65.21 dB$_A$. If there is a motorcycle volume, there will be a significant effect on noise. The second largest equation was obtained on the second day of the research from the Sound Level Meter 3 (SLM3) which resulted on this calculation: y = 0,01x – 6,074. The meaning of the above equations is that if there is an increase in the volume of the motorcycle, the noise in SLM3 is 60.840 dB$_A$. Based on the findings, there was a reduction in the number of motorcycles during the Covid-19 pandemic because students did not come to school due to lockdown and school closure.

Acknowledgment

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