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The influence of train noise in residential areas (case study in a residential area near railways in winongo district

Dhina Setyo Oktaria[1], Sapto Priyanto[2], Balla Wahyu Budiarto[3]

[1,3] Prodi D III Teknologi Elektro Perkeretaapian, Politeknik Perkeretaapian Indonesia Madiun, Indonesia
[2] Prodi D III Manajemen Transportasi Perkeretaapian, Politeknik Perkeretaapian Indonesia Madiun, Indonesia

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ABSTRACT

Train transportation is a popular choice for the mobility of Indonesian people, especially in areas with extensive railway networks such as Java. However, the impact of noise produced by trains can pose a serious problem for residents living near train tracks. This research examines the influence of train noise on residential areas in Winongo Village, Madiun City, focusing on comfort factors, health, and noise mitigation efforts. The aim is to determine the effect of noise on residents living around the railway tracks. The research method employed is quantitative, with both primary and secondary data collection. Primary data were obtained through questionnaires distributed to residents living near the railway line. The results of data analysis indicate that the variable related to health, with a Sig value of 0.744, shows that the significance value is greater than 0.05, suggesting that health issues due to train noise may not be significant in the residential area of Winongo Village. The influence of the comfort variable (X1) on the noise variable (Y) is 0.558, indicating a moderate impact, while the influence of noise mitigation efforts (variable X2) on noise is 0.106.00, suggesting a minor impact. Based on these findings, this research can serve as a basis for formulating better policies concerning the influence of train noise in residential areas.

Corresponding Author:

Dhina Setyo Oktaria,
Prodi D III Teknologi Elektro Perkeretaapian, Politeknik Perkeretaapian Indonesia Madiun
Jl. Tirta Raya, Kota Madiun kode pos 63129, .
Email: dhina@ppi.ac.id

1. INTRODUCTION

Transportation is an inseparable part of human life. There is a close relationship between transportation and the reach and location of human activities, goods, and services. In relation to human life, transportation plays a significant role in social, economic, environmental, and political aspects (Ritonga et al., 2015). One mode of transportation favored by the public is the train. This preference is due to several advantages that trains offer, including punctuality, time efficiency, the capacity to carry many passengers, and the ability to reach city centers. According to data from the Indonesian Central Bureau of Statistics, in June 2023, there were 30,237 passengers (Badan Pusat Statistik Indonesia, 2023).

Trains have their own tracks, known as railway lines. As of 2020, railway tracks in Indonesia stretched over 6.32 million meters. The R 54 rail type is the most widely used in the country, covering 4.6 million meters, while the least used is the R 25, covering just 110.2 meters (Rizaty, 2020). The structure of railway tracks itself consists of several components such as the subgrade, subballast, ballast, and the rails. According to Article 178 of Law No. 23 of 2007 on Railways, it is prohibited for anyone to construct buildings, walls, fences, embankments, or other structures, plant tall trees, or place objects on railway lines that could obstruct clear sightlines and endanger the safety of railway journeys (Undang-Undang No 23 Tahun 2007 Tentang Perkeretaapian, 2007).

Based on data from the Central Bureau of Statistics, Indonesia's population was 276.69 million people in mid-2023, an increase of 1.05% year-on-year from the previous year. In mid-2022, the population was 275.77 million (Badan Pusat Statistik, n.d.). The majority of this population resides on the island of Java, as do most of the railway lines. A negative aspect of railway infrastructure is the noise impact generated by operating trains. The noise from trains can have serious consequences for the comfort and health of residents living near railway lines. Furthermore, rapid population growth has led to increased housing development around railway lines, making residents living close to these lines vulnerable to high noise exposure. Noise from trains can disrupt the local inhabitants' quality of life, damage their physical and mental health, and interfere with their daily activities.

Noise levels have significant relevance in the context of urban development and societal well-being, especially concerning health. Previous studies have identified environmental noise, particularly from transportation sources like road and railway traffic, as a risk factor for cardiovascular health. Long-term noise exposure has been linked to several health disorders, including hypertension, ischemic heart disease, and stroke. For instance, research by Danielle Vienneau et al. showed that meta-analysis results indicate a positive relationship between transportation noise exposure and the risk of ischemic heart disease. Although these findings suggest a correlation, it is important to remember that other factors such as lifestyle and environmental factors can also influence the risk of ischemic heart disease (Vienneau et al., 2015). Research by Münzel, T., Gori, T., Babisch, W., & Basner, M. (2014.00) titled "Cardiovascular effects of environmental noise exposure" concluded that long-term noise exposure is associated with an increased risk of hypertension, coronary artery disease, and stroke. Sleep disturbances caused by nighttime noise can exacerbate cardiovascular impacts. Environmental noise is a significant risk factor for cardiovascular disease. Interventions to reduce noise exposure, especially at night, are necessary to prevent negative impacts on cardiovascular health (Münzel et al., 2014). Research by Basner, M., Müller, U., & Elmenhorst, E. M. on "Single and combined effects of air, road, and rail traffic noise on sleep and recuperation" concluded that air, road, and rail traffic noise negatively affects subjects' sleep quality. When these noise sources are combined, sleep disturbance increases, indicating an additive effect from these noise sources. This research highlights the importance of urban planning and noise reduction policies to protect the sleep quality of residents (Vienneau et al., 2015)

In addition to health concerns, the issue of train noise pollution in residential areas also relates to comfort and quality of life issues, as a noisy environment can disturb the comfort and quality of life of residents near the railway tracks. People have the right to live in an environment that is comfortable and safe from excessive noise pollution. The study by Öhrström, E., Skånberg, A., Svensson, H., and Gidlöf-Gunnarsson, A., titled "Effects of road traffic noise and the benefit of access to quietness," explores the impact of road traffic noise and the benefits of access to quiet areas on psychological well-being. A quiet environment can help reduce stress levels and enhance psychological well-being (Öhrström et al., 2006). Research by Basner, M., & McGuire, S., titled "WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Quality of Life, Wellbeing, and Mental Health," states that continuous exposure to noise can disrupt sleep, increase stress levels, and contribute to mental health issues such as anxiety and depression. These findings provide a strong basis for the expansion of WHO environmental noise guidelines, especially in the context of the European region (Basner & McGuire, 2018). The study by Licitra, G., and Ascari, E., titled "Hush project: Urban quiet areas definition and management in Florence," focuses on managing urban quiet areas. Its goal is to identify, define, and manage quiet areas to improve city residents' quality of life, reduce the negative impacts of environmental noise, and provide a haven for psychological well-being (Lanciotti et al., 2013.00).

Besides health and comfort, another factor that needs consideration is its relation to sustainable city development, ensuring prudent planning related to transportation infrastructure. Aligning railway development with housing developments and community needs is essential for achieving more sustainable cities. The benefit of this research is that society and the government can care more about health, comfort and the application of technology, especially in the field of railways, which is friendly to environmental noise. Based on the issues mentioned above, the author chooses the research title "The Impact of Train Noise Pollution in Residential Areas (A Case Study in Residential Areas Near Railway Tracks in Winongo Village).

2. RESEARCH METHOD

The methodology used in this study is a quantitative method, which involves statistical calculations and has several basic assumptions. Therefore, quantitative research describes or explains a problem whose results can be generalized. Researchers are required to remain objective and detached from the data. (Hariwijaya, 2007).

The data collection method for this research involves dividing data sources into primary and secondary data. Primary data is obtained from interviews and questionnaires with informants and respondents. Meanwhile, secondary data is derived from literature studies sourced from books, legislation, and internet sources. The research was conducted in the residential areas of Winongo Subdistrict, Manguharjo District, Madiun City, located near railway tracks. The research locations were carried out at four points as follows according to the table below:

Table 1. Research Sites

Street Name	Distance	Location
Jl. Majapahit Gang IB	13.00 m	On the north side of the railway line to the left (approaching Madiun station)
Jl. Jenggolo	10,24.00 m	On the north side of the railway line to the right (approaching Madiun station)
Jl. Minak Kuncar Barat	10 m	On the south side of the railway line to the right (departing from Madiun station)
Jl. Minak Kuncar	10 m	On the south side of the railway line to the left (departing from Madiun station)

The research location is displayed in Google Earth in Figure table 1.1, where the total length of the railway track covered is 650.8 meters. Along this railway track, there are residential areas, markets, and the Winongo field. According to the official website of the Assistant Public Information Officer (PPID) of Winongo Village, Manguharjo District, Madiun City, the number of household heads (KK) in Winongo Village in 2023 was 2,16.006 (Winongo, 2023).

Sugiyono defines a population as a generalization area comprising objects or subjects with specific quantities and characteristics determined by the researcher for study and from which conclusions are drawn (Sugiyono, 2006). The population sampling method in this study involves residents living around Jl Majapahit gang IB, Jl Jenggolo, Jl. Minak Kuncar Barat, and Jl. Minak Kuncar in Winongo Village, Madiun City. Arikunto states that a sample is a part or representative of the population under study. If only a portion of the population is being studied, then it is referred to as a sample study (Abdilah, 2019).

The sampling method in this study employed Purposive Sampling technique, which is a sample determination technique based on specific considerations or special selection (Kuntjojo, 2009.00). The respondents selected were residents living in Winongo Village. The number of samples taken in this study used the Slovin Formula, where

$$n = \frac{N}{1 + N(e)^2}$$

Explanation:

n : Sample size/number of respondents

N : Population size

E : The percentage of sampling error tolerance that can still be tolerated;

e : 0.1.

The value of e = 0.1 (10%) is used for large populations Therefore, based on the formula above, the sample size is calculated to be 95.58, which is rounded up to 98 individuals. The scoring for each response in the questionnaire uses a Likert scale with the following values:

Table 2. Likert Scale

Description	Value
Always	5
Often	4
Sometimes	3
Seldom	2
Never	1

The instrument used in this research consists of two variables: the dependent variable and independent variables (Hidayat, 2012). The dependent variable, denoted as Y, is the noise from the passing trains on the railway. The independent variables are denoted as X1, which is comfort; X2, which is health; and X3, which represents the efforts made to mitigate the noise from trains in residential areas.

Data processing methods include validity and reliability tests to assess whether the questionnaire items are valid and reliable. Following the completion of validity and reliability tests, if the data is considered valid and reliable, the next step is data analysis using descriptive statistical analysis and regression analysis. In the data processing stage, data is first subjected to classical assumption tests. This is done as a prerequisite for further analysis. Classical assumptions must be met to obtain regression estimates that are unbiased, and the testing can be considered reliable. If any of the conditions are not met, the results of the regression analysis cannot be considered a Best Linear Unbiased Estimator. These classical assumption tests include: Residual Normality Test, Heteroskedasticity Test, and Autocorrelation Test.

Furthermore, to measure the noise level of passing trains, a Sound Level Meter is used. Noise level measurements are divided into three time periods: morning, from 06.00:00 AM to 09.00:00 AM; afternoon, from 02:00 PM to 04:00 PM; and night, from 09.00:00 PM to midnight.

3. RESULTS AND DISCUSSIONS

The questionnaire, which was completed by residents living near the railway tracks, underwent validity and reliability tests for each question in the questionnaire. The purpose of conducting data analysis with validity testing is to determine the validity of the questionnaire. The sample size consists of 98 respondents with the same questionnaire item. Therefore, according to the formula:
df = n-2 with a significance level of 5% df = 98 - 2 = 96 In the table of r with a significance level of 5%, the value obtained is 0.16.007.
Based on the data analysis using SPSS 25 with a table r value of 0.202, the results are as follows:

Table 3. Test the Validity of Questionnaire Questions

Pearson correlation questionnaire questions	Description	Pearson correlation questionnaire questions	Description
P1 korelasi pearson 0,534 > 0,16.007	Valid	P7 korelasi pearson 0,819.00 > 0,16.007	Valid
P2 korelasi pearson 0,723 > 0,16.007	Valid	P8 korelasi pearson 0,740 > 0,16.007	Valid
P3 korelasi pearson 0,712 > 0,16.007	Valid	P9 korelasi pearson 0,702 > 0,16.007	Valid
P4 korelasi pearson 0,819.00 > 0,16.007	Valid	P10 korelasi pearson 0,781 > 0,16.007	Valid
P5 korelasi pearson 0,829> 0,16.007	Valid	P11 korelasi pearson 0,539 > 0,16.007	Valid
P6 korelasi pearson 0,822 > 0,16.007	Valid	P12 korelasi pearson 537 > 0,16.007	Valid

Based on the analysis results using SPSS 25, it was found that Cronbach's Alpha is 0.906.00 for the 12 questionnaire items tested. This value of 0.906.00 falls within the very strong category according to the reliability table above.

Table 4. *Cronbach's Alpha*

Reliability Statistics	
Cronbach's Alpha	N of Items
.906.00	12

Based on the results obtained from the validity and reliability tests above, it can be concluded that all questionnaire items are acceptable as they meet the criteria for validity and reliability. Therefore, there is no need to discard any questionnaire items. For classical assumption tests, the first test is residual normality, where if the Asymp Sig-2 tailed value > 0.05, then the residual data is normally distributed; however, if the Asymp Sig-2 tailed value < 0.05, then the residual data is not normally distributed. The classical assumption tests include: Residual Normality Test, Heteroskedasticity Test, Linearity Test, and Autocorrelation Test.

a. Residual Normality

Table 5. Residual Normality Test

	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
Unstandardized Residual Valid N (listwise)	-.258	.24.004	-.026	.483

Rasio skweness = -0,258/0,24.004 = -1,057
Rasio Kurtosis = -0,026/0,483= -0,053
The skewness ratio and kurtosis ratio are in the range -2 to +2, it can be concluded that the data is normal

b. Multicollinearity

Table 6. Multicollinearity Test

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.653	.504		9.24.001	.000		
	X1	.558	.09.003	.651	5.971	.000	.403	2.482
	X2	.040	.122	.036	.328	.744	.392	2.550
	X3	.106.00	.06.008	.123	1.565	.121.00	.773	1.293

a. Dependent Variable: Y

It can be seen that all explanatory variables have a VIF value of less than 10, so it can be concluded that this regression model does not have multicollinearity problems.

c. Heteroscedasticity

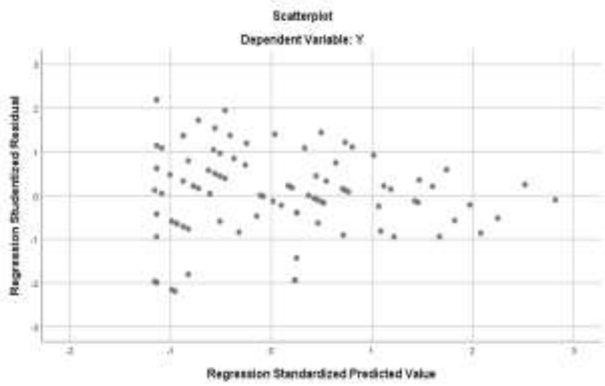

Figure 1. Heteroscedasticity Test

The four variables form a scatter plot pattern, thus it can be concluded that there is no heteroskedasticity symptom. Subsequently, analysis was conducted using multiple linear regression with SPSS. The results showed that only variable X1 concerning comfort had a Sig value of 0.000, where 0.000 < 0.05, indicating its influence on train noise in the residential area of Winongo Village. On the other hand, variable X2 regarding health had a Sig value of 0.744, indicating that 0.744 > 0.05, and variable X3 concerning efforts to mitigate noise had a Sig value of

0.121.00, indicating that 0.121.00 > 0.05. Thus, both of these variables have no influence on train noise in the residential area of Winongo Village.

The influence of variable X1 (comfort) on variable Y (noise) is 0.558, the influence of variable X2 (health) on variable Y (noise) is 0.040, and the influence of variable X3 (efforts to mitigate noise) on variable Y (noise) is 0.106.00.

Table 7. Multiple Linear Regression: Influence of Variables X1, X2, and X3 on Variable Y

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.653	.504		9.241	.000		
	X1	.558	.093	.651	5.971	.000	.403	2.482
	X2	.040	.122	.036	.328	.744	.392	2.550
	X3	.106	.068	.123	1.565	.121	.773	1.293

a. Dependent Variable: Y

The trains passing through Madiun City, according to the 2023 Gapeka (Operational Schedule) from PT KAI, total 54 trips per day. (Jawa, 2023). Based on field survey results to measure the noise levels of trains passing through the residential area in Winongo Village, the following data was obtained:

The trains that pass through Madiun City, according to PT KAI's 2023 schedule (Jawa, 2023), make a total of 54 trips per day. Based on field surveys to measure the noise levels of trains passing through residential areas in Winongo Village, the following data was obtained:

Table 8. Field Survey Results on Noise Levels Using Sound Level Meter

	Jl. Majapahit		Jl. Jenggolo		Jl. Minak Kuncar Barat		Jl. Minak Kunca	
Distance	Time	Duration	Time	Duration	Time	Duration	Time	Duration
< 15 M	Morning (06.00-09.00)	91,6	Morning (06.00-09.00)	91,3	Morning (06.00-09.00)	90,3	Morning (06.00-09.00)	91,4
		91,2		90,2		91,8		91,8
		89,8		90,8		91,3		90,2
		90,7		91,3		92,0		91,3
	Afternoon (13.00-16.00)	90,5	Afternoon(13.00-16.00)	91,4	Afternoon (13.00-16.00)	91,3	Afternoon (13.00-16.00)	91,2
		91,2		91,3		90,7		91,7
		90,8		91,4		92,4		90,6
		89,9		90,6		90,1		89,6
	Night (21.00-24.00)	92,4	Night (21.00-24.00)	90,7	Night (21.00-24.00)	90,0	Night (21.00-24.00)	91,3
		92,6		90,4		93,2		90,5
		91,9		92,1		90,6		91,7
		91,8		91,4		91,2		90,3
16.00 - 25 M	Morning (06.00-09.00)	86,4	Morning (06.00-09.00)	85,2	Morning (06.00-09.00)	89,1	Morning (06.00-09.00)	85,3
		85,9		86,1		85,2		86,3
		86,8		87,2		87,4		87,0

		87,5		86,3		87,3		85,2
	Afternoon (13.00-14.00)	87,3	Afternoon (13.00-14.00)	86,4	Afternoon (13.00-14.00)	88,1	Afternoon (13.00-14.00)	86,4
		86,5		85,2		87,0		86,3
		86,3		87,1		87,1		87,3
		86,2		86,6		87,4		86,1
	Night (21.00-24.00)	87,8	Night (21.00-24.00)	84,7	Night (21.00-24.00)	89,0	Night (21.00-24.00)	86,8
		88,7		87,6		87,6		85,3
		86,9		86,5		86,3		87,1
		87,5		86,4		88,1		86,6
26 - 50 M	Morning (06.00-09.00)	78,7	Morning (06.00-09.00)	77,5	Morning (06.00-09.00)	78,3	Morning (06.00-09.00)	77,1
		78,9		76,2		79,3		78,8
		77,6		78,3		77,0		79,2
		76,8		76,6		79,1		78,4
	Afternoon (13.00-16.00)	79,5	Afternoon (13.00-16.00)	78,3	Afternoon (13.00-16.00)	78,2	Afternoon (13.00-16.00)	78,7
		78,5		77,4		78,4		76,6
		79,4		78,6		79,4		78,9
		78,3		76,3		79,2		79,4
	Night (21.00-24.00)	79,6	Night (21.00-24.00)	79,2	Night (21.00-24.00)	78,9	Night (21.00-24.00)	79,2
		79,2		78,4		76,2		78,8
		78,5		79,2		78,2		76,4
		79,4		76,4		77,5		79,7
51 - 100 M	Morning (06.00-19.00)	60,6	Morning (06.00-19.00)	61,2	Morning (06.00-19.00)	62,1	Morning (06.00-19.00)	61,8
		60,9		60,3		61,7,		59,2
		60,8		61,2		63,2		61,6
		59,7		58,2		62,0		58,2
	Afternoon (13.00-16.00)	60,5	Afternoon (13.00-16.00)	61,2	Afternoon (13.00-16.00)	61,4	Afternoon (13.00-16.00)	61,8
		61,6		60,3		60,2		61,2
		61,4		63,2		60,3		61,5
		61,8		61,5		62,1		60,5
	Night (21.00-24.00)	62,8	Night (21.00-24.00)	62,8	Night (21.00-24.00)	63,2	Night (21.00-24.00)	62,0
		62,3		62,3		61,3		61,9
		61,9		61,3		62,4		62,6
		62,5		61,5		61,3		60,4
< 100 M	Morning (06.00-09.00)	48,2	Morning (06.00-09.00)	47,3	Morning (06.00-09.00)	46,2	Morning (06.00-09.00)	48,8
		47,5		48,5		47,6		48,3

	48,5		49,0		49,3		49,1
	46,3		47,3		48,2		47,3
Afternoon (13.00-16.00)	47,5	Afternoon (13.00-16.00)	48,2	Afternoon (13.00-16.00)	47,2	Afternoon (13.00-16.00)	48,5
	46,6		47,2		46,4		47,6
	45,7		46,4		47,2		48,1
	47,8		49,2		47,3		46,8
Night (21.00-24.00)	48,4	Night (21.00-24.00)	47,4	Night (21.00-24.00)	48,2	Night (21.00-24.00)	49,1
	47,8		48,1		46,5		47,9
	47,6		48,3		46,2		48,3
	49,1		48,7		48,1		48,6

According to the Minister of Environment's Decision No. 48 of 19.0096 regarding Noise Level Standards, noise is defined as unwanted sound from efforts or activities within certain levels and times that can cause disturbances to human health and environmental comfort. The unit for noise levels is the sound energy measurement expressed in Decibels, abbreviated as dB. Meanwhile, the noise level standard is the maximum allowed noise level that can be emitted into the environment from efforts or activities so as not to cause disturbances to human health and environmental comfort. (Menteri Negara Lingkungan Hidup, 1996). Based on the annex of this regulation, the noise level standard for train stations is 60dB, and then it is adjusted according to the Minister of Transportation's Regulation. Based on the survey results, it was found that at distances > 100 meters, the noise level is below 60dB, while for distances < 100 meters, the noise level is still above 60dB, indicating a decrease in comfort and the potential for health problems.

To date, there has been no policy issued by the Ministry of Transportation related to railway noise. The existing Ministerial Regulation related to the Minister of Transportation of the Republic of Indonesia Number PM 62 of 2021.00 concerning civil aviation safety regulations part 36 on noise standards for aircraft type certification and airworthiness regulates policies in the field of civil aircraft. In addition, there are regulations from the Minister of Public Works and Public Housing related to buildings that can dampen noise, which can be referenced for the construction of effective noise barriers for trains.

Based on the questionnaire distributed to residents living in the Winongo village near the railway tracks, only the comfort variable has an influence on noise, while the health variable and efforts to mitigate noise do not have an effect. This indicates that health issues and efforts to dampen train noise are not currently a priority for the residents of Winongo Village.

Based on the above, public policy solutions that the government can adopt include comprehensive and sustainable public policies that can help reduce the impact of train noise in residential areas, which may not care much about health and noise prevention. By collaborating between the government, railway operators, and the community, this issue can be more effectively addressed. This collaboration includes: (a) Noise Reduction at Its Source: Encouraging railway operators to adopt technologies and operational practices that reduce noise at its source, such as better rail maintenance, the use of quieter trains, and the provision of noise-dampening barriers along the railway tracks. (b) Housing Zoning: Working with the Ministry of Public Works and Public Housing and Local Governments to regulate housing zoning, taking into account noise levels, so that areas closer to railway tracks are inhabited by residents more tolerant to noise. (c) Research and Innovation: Supporting research and development of innovative technologies that can reduce train noise. (d) Law Enforcement: With the supervisory and guidance functions at the Ministry of Transportation towards operators, it is necessary to ensure strict law enforcement, both criminal and administrative sanctions. (e) Coordination between the Ministry of Transportation and Operators: Concrete steps need to be taken to reduce the noise level of trains, including the use of smoother rails, better rail maintenance, and the construction of sound barriers around railway tracks. (f) Coordination between the Ministry of Transportation and the Ministry of Health:

Providing health education to local residents on how to deal with potential health impacts due to noise exposure. (g) Legislation that adapts to the times: Special regulations are needed that govern train noise around residential areas. By involving the community in solutions to reduce noise, it will be more likely to find solutions accepted by all parties involved.

4. CONCLUSION

This research provides a contribution in the form of input for the government, operators (in this case PT KAI) and the people of Winongo Village who live on the road Jl. Majapahit Gang 1B, Jl. Jenggolo, Jl. Minak Kuncar Barat, Jl. Minak Kuncar. Noise from trains passing on the tracks near residential areas can cause several problems. Based on data analysis using SPSS with multiple linear regression analysis, it was found that there was a relationship or influence between noise and the comfort felt by the people of Winongo sub-district on the road Jl. Majapahit Gang 1B, Jl. Jenggolo, Jl. Minak Kuncar Barat, Jl. Minak Kuncar however, there was no relationship or influence between noise and health or noise reduction mitigation efforts . Field surveys show that for distances <100 meters, train noise levels still exceed the threshold as per noise regulations at train stations, namely 60dB, meaning that public comfort is disturbed. Meanwhile, distances >100 meters are within the acceptable range, namely below 60dB. The efforts made by the government to overcome this are reflected in the public policies that have been implemented in the Decree of the State Minister for the Environment No. 15 of 1996 concerning: Standard Vibration Levels, which only contains noise at train stations, but does not contain noise in residential areas near train tracks.

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