



Analysis and Mapping of Noise Intensity on Workers' Non-Auditory Complaints at Tjoekir Sugar Factory, Jombang

Nurtasyia Ningsih

Tehnik Lingkungan & Institut Teknologi Adhi Tama Surabaya, Indonesia

kiflimohammad@gmail.com

Abstract

PG Tjoekir Jombang is a sugar production company that uses production machines for cost efficiency and to increase the homogeneity of production quality. This activity causes noise exposure in the workplace which threatens the comfort and health of workers. This study aims to analyze the noise level in the work area of the Tjoekir Jombang Sugar Factory (PG) and its relationship to non-auditory complaints experienced by workers. The method used is a descriptive quantitative approach through direct measurement of noise using a sound level meter and distributing questionnaires to 60 respondents. The measurement results show that most work areas have noise levels exceeding the threshold of 85 dB(A) at the grinding, cooking, turning, finishing and power house stations. Mapping using Surfer software produces 3 zones, namely high intensity levels in red > 85 dB (A), yellow to orange at 80-85 dB (A), and low levels <85 dB (A). The Chi-Square test showed a significant relationship between noise intensity and non-auditory complaints ($p < 0.05$). The results of the Chi-Square test showed a significant relationship between noise levels and communication disorders ($p = 0.007$) and psychological disorders ($p = 0.033$). However, the relationship with Physiological complaints was not significant ($p = 0.354$). These findings indicate that noise has a real impact on certain aspects of health, so appropriate control efforts need to be made.

Keywords – Sound Intensity Level, Non-Auditory Complaints, Chi-Square, Surfer Mapping

INTRODUCTION

The development of the manufacturing industry in Indonesia has also encouraged the increased use of machines in the production process. Production machines are designed to speed up the work process, save production costs and increase production results, but the presence of production machines also has an impact on the work environment. One of the impacts that can be felt by workers is noise. Noise is included in the physical risk factors which, if it exceeds the safe limit (NAB), can disrupt comfort and cause health and safety problems for workers. The International Labor Organization (ILO) stipulates that the noise threshold in the workplace is 85 dBA for 8 hours per day [1]. Data from the World Health Organization (WHO) shows that around 466 million people in the world experience hearing loss, and around 16% of these cases are related to noise exposure in the workplace [2].

Various reports from international organizations such as WHO, ILO, and NIOSH are supported by research [3] that noise in the workplace is still a serious problem globally because there are 600 million people in the world exposed to noise while working in companies. Noise disturbances are not only auditory such as hearing loss, but also have non-auditory impacts such as decreased communication skills, psychological disorders and physiological disorders [4]. This is supported by Tarwaka [5], exposure to noise above 85 dBA for 8 hours of work can cause hearing loss, stress, and even cardiovascular system disorders. Therefore, it is important for every industry to make efforts to control noise, either through technical modifications to noise sources, administrative work pattern arrangements, to the provision of personal protective equipment. All of these steps are also in line with national regulations that require companies to maintain the safety and health of workers.

One example of an industry with high potential for noise exposure is PG Tjoekir Jombang, a sugar factory that has been operating since 1884. This factory uses various types of machines in its production process, namely milling machines, high grade fugal machines, [6], rotary vacuum filters, boilers, evaporators and others. Similar research at the PG Semboro sugar factory by Khoirun Nisa [7] stated that high noise above 85 dB(A) at all production stations means that it is an unsafe condition for exposure to 8 hours of work. Unfortunately, protection for workers such as the use of ear protection is still minimal. Some workers also began to complain of discomfort to communication disorders. Seeing this condition, this study was conducted to analyze and map the existing noise levels and examine their relationship with non-auditory complaints in workers. It is hoped that the results of this study can be the basis for improving a safer and healthier work environment for all parties.

METHODOLOGY

a. Types of research

This study is a descriptive quantitative study with a survey and field observation approach. The main objective of this study is to determine the level of noise intensity at various measuring points at the production station at the Tjoekir Jombang Sugar Factory (PG) and to analyze its relationship with non-auditory complaints experienced by workers.

b. Time and Research Time

The research was carried out at 7 stations, namely the grinding station, purification station, evaporation station, cooking station, and finishing and packaging rotation station as well as 1 power house of the Tjoekir Jombang Sugar Factory from November to January 2024 from 08.00-15.00 WIB.

c. Data Analysis Techniques

The independent variable is noise intensity measured by SLM (Sound Level Meter) calculated using the Leq dB (A) formula and mapping is carried out with Surfer Software per work station. While the dependent variable is non-auditory complaints including noise complaints, communication disorders, psychological disorders and physiological disorders obtained from the results of the questionnaire from 60 respondents. The drawing of the relationship between sound intensity and non-auditory complaints uses SPSS software with a

univariate test of frequency distribution and a bivariate test with the Chi Square Test.

RESULTS AND DISCUSSION

The results of noise intensity measurements at several work points at PG Tjoekir Jombang which are spread across stations and power houses. The results of measurements at 76 sampling points spread across all stations with 10 measuring points each but only 6 measuring points at the completion station due to the limited space.

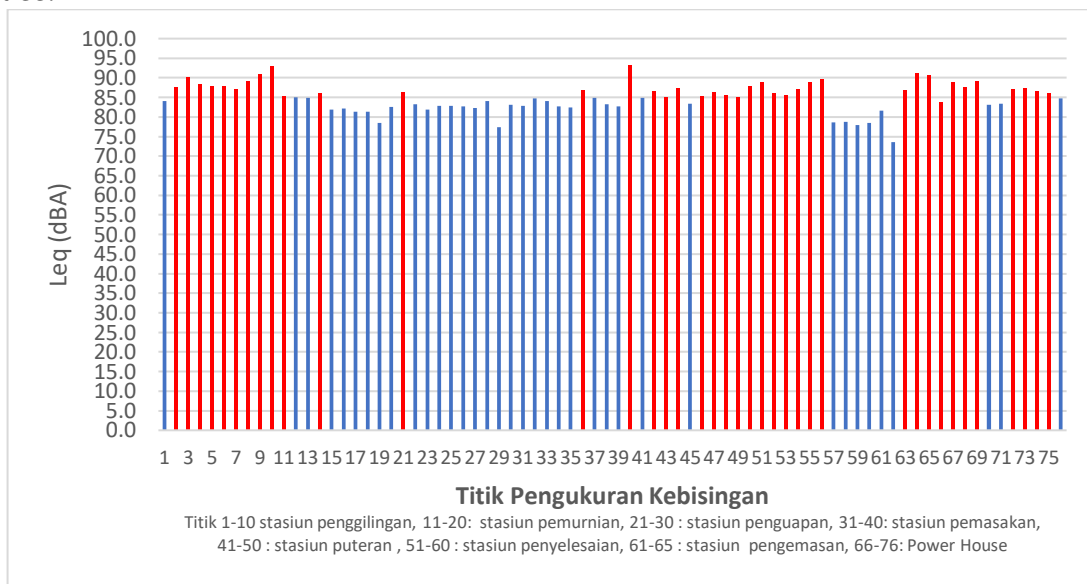


Figure 1. Graph of noise intensity at PG Tjoekir Jombang

The noise distribution graph illustrates the variation in the measured sound intensity level at various measurement points in the production area of PG Tjoekir Jombang. Data were obtained from 76 measurement points using sound level and converted using Leq using A-weighted decibel weighting [dB(A)]. Based on the graph shown, it can be seen that the noise level fluctuates between 73.5 dB(A) to 93.3 dB(A). The red color indicates a point exceeding the TLV while the blue color is less than the TLV. The point with the highest noise is at point 40 at the Cooking Station (± 93.3 dB), while the point with the lowest noise is at point 62 around 73.3 at the packaging station. The distribution of red is highest in the grinding station, cooking station, turning and finishing station. The cause of the high noise intensity value is the presence of production machines that are operating at the time of measurement as seen in table 1. At the grinding station there are several machines such as milling machines that produce very loud and buzzing sounds. While the turning station has an HGF (High Grade Fugal) machine and a Vibrating machine at the finishing station. This shows that more than 50% of the work area has a noise intensity exceeding the daily exposure threshold of 85 dB (A), as stipulated in Permenaker No. 5 of 2018. This means that most workers are exposed to noise that is risky to occupational health, especially in the long term.

Table 1. Graph of noise intensity at PG Tjoekir Jombang

Type	Location	Measurement Point	Noise source
85 dBA- 93.3 dBA	St. Mill	2, 3,	The center of the sound of loading and unloading lorries
		4	Imbibition machine
		5	Milling Machine
		6	Adjacent to the sugarcane bagasse transport rail
		7,8,9,10	Close to the heater (steam) machine
	St. Purification	11,14	Close to the heater (steam) machine and Rotary Vacuum Filter
	St. Evaporation	21	Close to the Evaporator machine
	St. Cooking	36, 40	The sound of the maschiite flow process to the Cooling Through machine.
	St. Puteran	42, 43,44,	LGF (Low Grade Fugal) engine sound
46, 47,48,49,50		HGF (High Grade Fugal) engine sound	
St. Settlement	51,52, 53,54,55, 56	Noise from the dryer, the hum of the vibrating machine and the falling of sugar when filling sugar.	
St. packaging	63,64,65,	The sound of a sack sewing machine	
Power House	67,68,69,72,73,74,75	Noise from generator and boiler from outside	

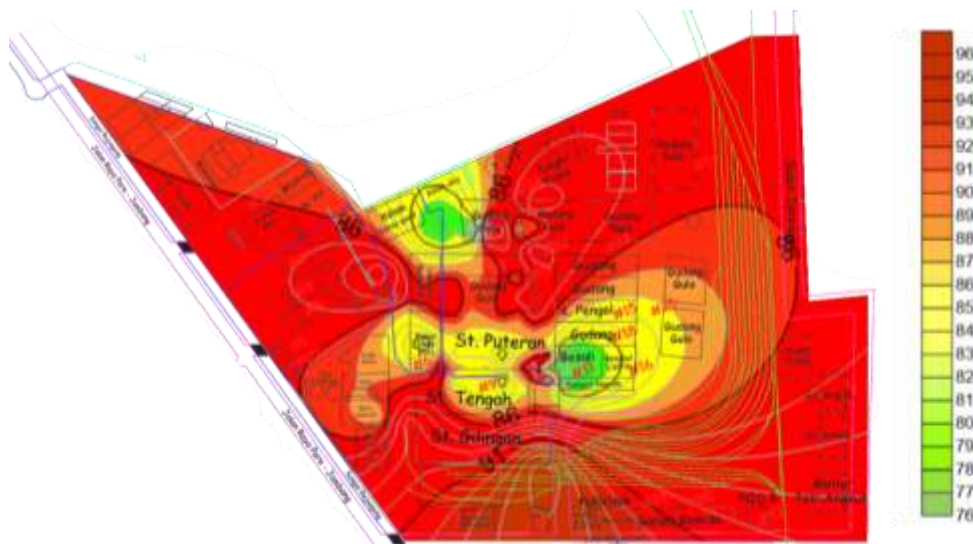


Figure 2. Mapping of noise distribution at PG Tjoekir Jombang using Surfer

Noise intensity mapping was carried out using Surfer software to produce a visualization of noise distribution in the work area of PG Tjoekir Jombang. Measurement data was taken from 76 strategic work location measurement points spread across several stations, namely the grinding station, purification station, evaporation station, cooking station, finishing and packaging rotation station and power house. The mapping results are displayed in the form of contours and heatmaps, which show variations in noise levels at each point. The red color indicates areas with high noise (> 85 dBA), while yellow to orange at 80-85 dBA depicts areas with moderate noise levels and low noise levels < 80 dBA with green.

Figure 2 shows the results of mapping the results of Surfer data processing with the layout of the PG Tjoekir Jombang factory adjusted, it can be seen that the grinding station, finishing station and power house are zones with the highest noise intensity, reaching 85-93.3 dBA. The refining, evaporation, cooking and evaporation areas are in the moderate noise category (80-85 dBA). While the packaging area shows relatively low noise (below 80 dBA).

The map helps identify noise hotspots, which form the basis for prioritizing control and job rotation policies. The results also clarify the spatial correlation between work locations and high non-auditory complaints, with workers assigned to red (high noise) areas reporting more physical and psychological symptoms than those in green areas. This mapping is not only useful for academic analysis, but also as a practical tool in noise risk management, development of mandatory PPE zones, and decision-making on engineering control policies (such as installing acoustic barriers or enclosures).

From the results of the univariate test showed the distribution of respondents as many as 60 people in the study covering the basic characteristics of workers at PG Tjoekir Jombang who became participants including age, education level and length of service. The results of the frequency of workers' ages from the age range of 25-45 years with 31.7% at the age of 25-30 years, 21.7% aged 31-35 years, 36-40 years of age by 28.3% and age 41-45 years with a percentage of 18.3%. While the highest level of education from high school / vocational school is 75% with bachelor's and diploma below 13%. Work period in the range of 10 to 45 years with a distribution of 26.7% in the 10-15 year work period and the longest as many as 9 people have served for 31-35 years as many as 1. Distribution of respondent frequencies to sound intensity, communication disorders, psychological disorders and physiological disorders. The amount of noise exposure measured was high > 85 dB (A) by 50%, which means that the value is balanced with the low exposure. However, when viewed, PG Tjoekir Jombang is classified as very high exposure to noise. Respondents stated that they experienced very high communication disorders with a percentage of 60% seen from decreased concentration, like to shout when talking to coworkers, unable to understand the person they are talking to. High psychological disorders were also experienced by such as discomfort at work, more easily emotional, decreased productivity and unable to stay in the workplace by 61.7%. Meanwhile, respondents did not feel they were experiencing low physiological disorders by 60% because they rarely had headaches, were not nauseous, did not feel they were experiencing imbalance disorders, palpitations, pain and difficulty breathing.

Table 2. Results of the Chi Square correlation test of noise intensity on work communication disturbances

Noise perceptio n in workers	Communication Disorders								Total				P Value (CC)
	Tall				Low								
	C	% B	E.C .K	% K	C	% B	E.C .K	% K	C	% B	E.C .K	% K	
Tall	3 3	78. 6	28	82. 5	9	21. 4	14	45	4 2	100	42	70	0.007
Low	7 1	38. 9	12	17. 5	1 1	61. 1	6	55	1 8	100	18	30	
Total	4 0	66. 7	40	100	2 0	33. 3	20	10 0	6 0	100	60	100	

Table 3. Results of the Chi Square correlation test of noise intensity on psychological disorders

Noise perception in workers	Psychological Disorders								Total				P Value (CC)
	Tall				Low								
	C	% B	E.C.	% P	C	% B	E.C.	%P	C	% B	E.C.	% P	
Tall	21	50	16.8	87.5	21	50	25.2	58.3	42	100	42	70	0.033
Low	3	16.7	7.2	12.5	15	83.3	10.8	41.7	18	100	18	30	
Total	24	40	24	100	36	33.3	36	100	60	100	60	100	

Table 4. Results of the Chi Square correlation test of noise intensity on physiological disorders

Noise perception in workers	Physiological Disorders								Total				P Value (CC)
	Tall				Low								
	C	% B	E.C.	% F	C	% B	E.C.	%F	C	% B	E.C.	% F	
Tall	28	66.7	25.9	75.7	14	33.3	16.1	60.9	42	100	42	70	0.354
Low	9	50	11.1	24.3	9	50	6.9	39.1	18	100	18	30	
Total	37	61.7	37	100	23	38.3	23	100	60	100	60	100	

C = count, %B : % Noise, EC : Expected Count, %K : % Communication, %P: %Psychological, %F: %Physiological, CC: Continuity Correction

The relationship between noise intensity and non-auditory complaints at the PG Tjoekir Jombang production station can be seen from the results of the bivariate test using Chi Square shown in tables 2, 3 and 4. The Chi-Square test analysis was conducted to determine whether there was a significant relationship between noise levels in the work area and non-auditory complaints experienced by workers. The data analyzed included 60 respondents from various work stations with high and low noise intensity classifications and the types of complaints reported. Based on the results of the 2x2 Chi-Square test, the Continuity Correction (Asymp. Sig.) significance value was obtained at 0.007 in the relationship between noise intensity and communication disorders. While Psychological disorders were 0.033. Because the significance value is smaller than $\alpha = 0.05$, it can be concluded that there is a

statistically significant relationship between noise levels and communication disorders and Psychological disorders. However, because the physiological disturbance value of the Continuity Correction (Asymp. Sig.) significance value of 0.354 is greater than α , it is rejected and does not affect the noise intensity value. These results indicate that the higher the noise level experienced by workers, the greater the likelihood of non-auditory complaints such as fatigue, stress, difficulty sleeping, and decreased concentration. This strengthens the findings in previous research by Sasmita [8] which stated that long-term noise exposure not only affects hearing, but also the psychological and physiological aspects of workers. These findings indicate the importance of noise control, especially in work areas with high exposure, such as grinding stations, turning stations, finishing stations and power houses. In addition, these results can be the basis for compiling work rotation policies, the use of personal protective equipment, and routine health monitoring programs for the management of PG Tjoekir Jombang

CONCLUSION

Based on the results of the research and data analysis that has been carried out, the following conclusions were obtained:

- a. Noise levels in most work areas exceed the threshold of >85 dB(A) namely at the grinding, cooking, turning, finishing and power house stations. This indicates that most workers are in conditions of noise exposure that are risky to health.
- b. Surfer noise mapping provides a clear visualization of the distribution of noise points with 3 zones, red high intensity >85 dB(A), medium yellow to orange 80-85 dB(A), and low green <80 dB(A).
- c. The results of the Chi Square test analysis showed a significant relationship between noise levels and non-auditory complaints ($p < 0.05$) in communication disorders (0.007) and physiological disorders (0.033). However, it was not significant in physiological complaints (0.354).

THANK-YOU NOTE

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