Analysis Noise Level in Production the Palm Oil: A Case Study

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ARTICLE INFO

Article history
Received January 17, 2022
Revised August 2, 2022
Accepted August 14, 2022
Available Online August 31, 2022

Keywords
Noise Exposure
Noise Mapping
Palm Oil Mill
Hierarchy of Control

ABSTRACT

Excessive noise exposure during the manufacturing process is a widespread issue. This research aimed to analyze noise exposure in the kernel recovery station in the manufacturing process of palm oil. We conduct some measurements and calculations for noise exposure analysis to get the Equivalent Noise Level (Leq) value during the daytime for each measurement point. The noise measurement was conducted on four machines, including a depericarper and polishing drum machine, ripple mill machine, silo dryer machine, and clay bath machine. In addition, this research showed noise contour mapping to define the noise distribution. The results of this research are that only the clay bath machine had Ls below the threshold. The clay bath machine workstation has good noise levels. The Depericarper, Polishing Drum, Ripple Mill, and Silo Dryer Machine must be quieter. Thus, this research used the Hierarchy of Control Approach to reduce and control hazardous noise exposure. The stage of HOC includes elimination, substitution, engineering, administrative control, and Personal Protective Equipment (PPE).

1. Introduction

Following the Indonesia Minister of Manpower Regulation, noise refers to any undesired noises produced by manufacturing and labor tools that, at a specific volume, may cause hearing impairment [1]. Noise has directly impacted human health beyond six decades ago [2]. Excessive noise exposure during manufacturing is widespread in the sector [3, 4]. Noise derived from industrial activities is considered a critical occupational risk. Noise nuisance in industry, especially in production plants, is extra essential than in different operating areas [5]. Industrial noise is a long-standing issue that can cause permanent hearing loss in workers. Meanwhile, for the industry, noise can purpose financial losses because of repayment costs [6]. In 1970, OSHA imposed a loudness regulation on all American businesses, mandating them to avert occupational hearing damage [7]. Noise exposure has been shown to increase employee mistakes rates of workplace accidents and lower productivity [8]. Excessive noise can lead to hearing loss and negatively influence physical and psychological health. Muscle strains, agony, raised vital signs, vital sign fluctuations and bloodstream system, pupil dilation, and insomnia are the most common physiological impacts of noise. The main psychological effects of

Please cite this article as: Panjaitan, N., & Panggabean, U. N. A. (2022). Analysis Noise Level in Production the Palm Oil: A Case Study. Jurnal Teknik Industri, 23(2), 121–132. https://doi.org/10.22219/JTIUMM.Vol23.No2.121-132

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noise are unease, fear, unpleasantness, worry, exhaustion, slowed mental activity, and less effective work [9] [4]. Noise is also suggested to have effects on various organs and systems such as gastrointestinal, respiratory, immune, reproductive, and neurogenic system [10]. According to WHO estimates, roughly 16 percent of the world's population is deafened due to workplace noise exposure[11, 12].

Noise exposure is the leading cause of preventable hearing loss [12]. In Asia's manufacturing industry, Noise Induced Hearing Loss (NIHL) is one of the most prevalent workplace damages [13]. Because NIHL is a sedentary disease that cannot be cured, prevention is so crucial. [14]. NIHL because noise happens while the noise intensity could be excessive, which results in mechanical harm to the cochlea [15]. The ordinary human ear and frightening system have their maximum quantity to accept and comprehend the sound level [16]. NIOSH suggests an excessive noise limit of 85 dB(A), depending on a time-weighted average of eight hours (8-hr TWA). Noise levels of this magnitude and above are deemed dangerous [17]. According to the Indonesian Minister of Health Regulation No. 70 of 2016, the critical noise value is 85 dB(A) [18]. Furthermore, with an intense period of 8 hours per day and 40 hours per week, the critical value for excessive noise is 85 dB, according to Minister of Manpower Regulation No. 5 of 2018 about Transmigration on Occupational Safety and Health, Work Environment [19]. Meanwhile, working hours in this case are divided into two shifts. Shift one works from 07.00 to 19.00 Western Indonesian Time (WIB), and shift two works from 19.00 to 07.00.

The company, in this case, uses noisy machines in its manufacturing process. Specialized machinery and equipment are a pressing issue in manufacturing processes. If such equipment is not maintained properly, it will generate dangerous noise within the workplace [4]. A secure and healthy place of work is crucial for workers. In current operating conditions, most manufacturing workers do not care about noise exposure, which may show their unwillingness to use hearing protection [20]. Hearing loss due to noise exposure and other physical aberrations can be avoided by reducing noise exposure in the workplace and improving noise-protection protocols. Workers who are exposed to noise must use proper earplugs or earmuffs. [21]. The greatest method to increase the operation's quality while lowering the chance of an accident is to take safety management seriously. Although the majority of risks and hazards can be avoided by employing accessible procedures, accidents can still occur due to a lack of understanding on the part of the personnel. Most accidents in business are caused by unsafe labor and working conditions [22].

According to research [23], noise affects cognitive performance and brain signals. While the research [21], the worker's perception of noise disturbance occurring during the agreed time, workers feel disturbed by noise. Hence, noise exposure is really necessary to discuss in this research. In addition, it is based on the exposure length that exceeds the NIOSH standard, which is 8 hours per day of exposure for a noise level of 85 dB. The purpose of this study was to investigate the noise levels that were present in the kernel recovery station during the production of palm oil. This study also shows the noise contour mapping of the measurement location to figure out how the noise is spread out.

2. Methods

The methodology for this study is presented in this section. The first one is the procedure measurement using an instrument (Sub-section 2.1) And the mathematical model for processing the data generated from measurement (Sub-section 2.2).

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2.1 Algorithms for Measurement Using an Instrument

For this study, the noise intensity of production machines in this palm oil mill was measured using a 4-in-1 Environmental Meter, especially the kernel recovery station. The measurement in the kernel recovery station was conducted on 4 August 2021. The noise level was measured using the instrument 1 meter from the noise source and 1.5 meters from the floor. [1] [4]. Noise exposure levels differ daily and night, higher all day and decrease at night [24].

The procedure to measure the exposure of noise level using an instrument such as 4 in 1 environmental meter or Sound Level Meter is as follows [25]:

1. Before creating a measurement, the instrument has to turn on early to warm the microphone so it is loose from moisture.
2. The instrument is positioned at the height of 1.2–2 meters above the surface.
3. Readings of numbers at the instrument are achieved

2.2 Data Collection

Table 1 shows the noise level generated by the production units in the kernel recovery station.

Table 1. Data Generated From Measurement

Measurement Location		Mean Measurement Result (dB)	Threshold Value (dB)	Information
Depericarper and Polishing Drum Machine	1	85.32	85.0	Above the NAB
	2	86.26	85.0	Above the NAB
	3	85.34	85.0	Above the NAB
	4	85.88	85.0	Above the NAB
	5	85.86	85.0	Above the NAB
Ripple Mill Machine	1	85.06	85.0	Above the NAB
	2	84.62	85.0	Bellow the NAB
	3	84.16	85.0	Bellow the NAB
	4	84.66	85.0	Above the NAB
Silo Dryer Machine	1	85.24	85.0	Above the NAB
	2	85.84	85.0	Above the NAB
	3	85.54	85.0	Above the NAB
Clay bath Machine	1	80.90	85.0	Bellow the NAB
	2	81.20	85.0	Bellow the NAB
	3	81.05	85.0	Bellow the NAB

The problems in this company are working hours exceeding the NIOSH standard, and some kernel recovery station machines exceeding Indonesia's ministry standard.

The Leq is the amount of A-weighted energy provided by a constant noise level over a certain period that is extremely comparable to a changing level over the same period. Leq is measured in dBA [6]. According to KEP-48/MENLH/11/1996, the formula for calculating Leq is: [21]:

$$Leq_{daytime} = 10.\log\frac{1}{16}\{\sum t_i.10^{0,1\,Li}\} \quad (1)$$

Where,

$Leq_{daytime}$ = noise level during the day (dB)
t_i = time interval for measurement
Li = Leq averages data over a period.

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We must apply noise mapping after calculating the Leq during the day to determine the noise exposure pattern. Noise mapping data defines the relative position of all noise sample locations. Using the surfing software, create a noise contour map by drawing a line connecting spots in the workspace with a certain noise intensity [26]. Noise mapping is the graphic illustration of the sound level distribution happening in a given location and the condition of the environment for a defined duration [27]. In addition, this research used the Noise Hierarchy Controls Approach to control noise [1].

3. Results and Discussion

This section presents the result from the calculation of Equivalent Noise Level (Leq) during daytime and the noise mapping (Sub-section 3.1). In addition, this section discusses the method of noise control, called the Noise Hierarchy Control Approach (Sub-section 3.2)

3.1 The Result of the Calculation and Noise Mapping

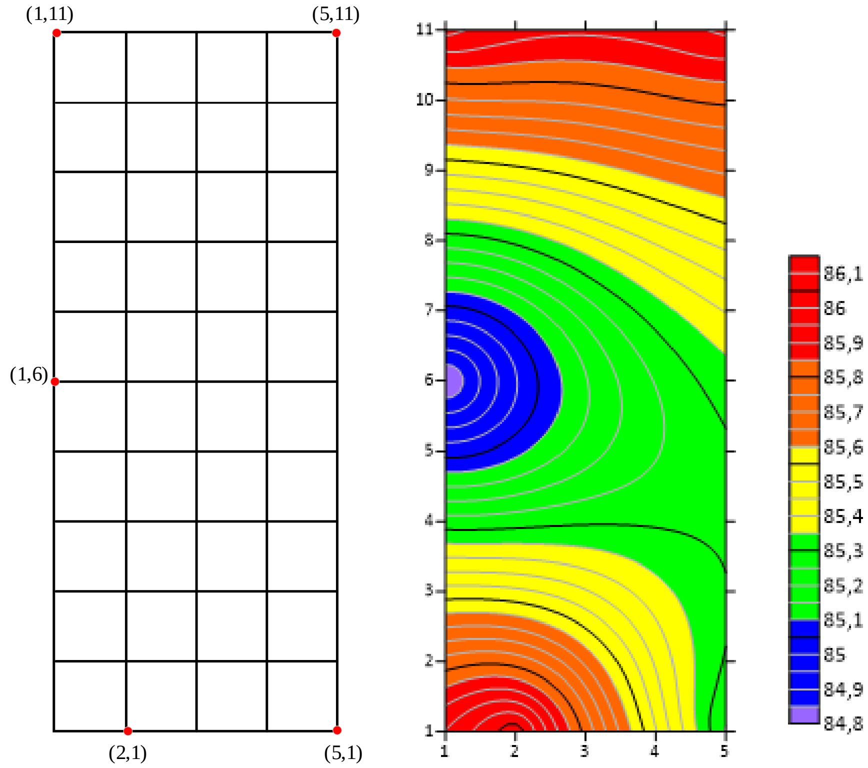
The work duration in this case study is 12 hours per day. Table 2 displays the results of Ls. Ls was calculated using Equation (1).

Table 2. Numerical Results

Location		LEQ daytime (dBA)	Information
Depericarper and Polishing Drum Machine	1	85.24	Above the NAB
	2	86.09	Above the NAB
	3	84.79	Bellow the NAB
	4	85.97	Above the NAB
	5	85.96	Above the NAB
Ripple Mill Machine	1	85.09	Above the NAB
	2	84.68	Bellow the NAB
	3	84.40	Bellow the NAB
	4	84.70	Bellow the NAB
Silo Dryer Machine	1	85.49	Above the NAB
	2	85.61	Above the NAB
	3	85,55	Above the NAB
Clay bath Machine	1	80.83	Bellow the NAB
	2	81.07	Bellow the NAB
	3	80,95	Bellow the NAB

Table 2 demonstrates that multiple measurement locations in this instance, including the kernel recovery station, exceed the Minister of Manpower Regulation No. 5 of 2018, which establishes a sound level of 85 dBA. With a daily exposure duration limit of eight hours. The results showed that of the 4 production locations, the clay bath machine is the only location where Ls does not exceed the threshold. this shows that the clay bath machine workstation has a good noise level. the other three workstations such as the Depericarper and Polishing Drum Machine, Ripple Mill Machine, and Silo Dryer Machine produce noise levels that are not good so they need to be improved.

This study utilized the Surfer 16 application to assign the noise mapping of the machines. Draw the area using the x-axis, which represents the width, and the y-axis, which represents the length. Additionally, the drawing should contain the measurement coordinates. Fig. 1(a) depicts the coordinates of the measurement depericarper and polishing drum machine, whereas Fig. 1(b) depicts the noise contour maps from the Surfer 16 application. The form of noise contour mapping is presented in Table 3.



(a) (b)

Fig. 1. Noise contour mapping depericarper and polishing drum machine: (a) Coordinate points

Table 3. The Information of Noise Contour Mapping

Indicator	Information
	Most Dangerous
	Dangerous
	Wary Area
	Wary Area
	Safe Area
	The safest area

Based on Fig. 1, the result of noise contour mapping in the blue and purple areas is safe, and the green area is slightly above the NAB of 85 dB. Meanwhile, the red, orange and yellow areas are dangerous and excessive working hours above 8 hrs.

Further, the noise mapping for every measurement location is also being made with Surfer 16 application. The summary of noise contour mapping for other locations is presented in Table 4.

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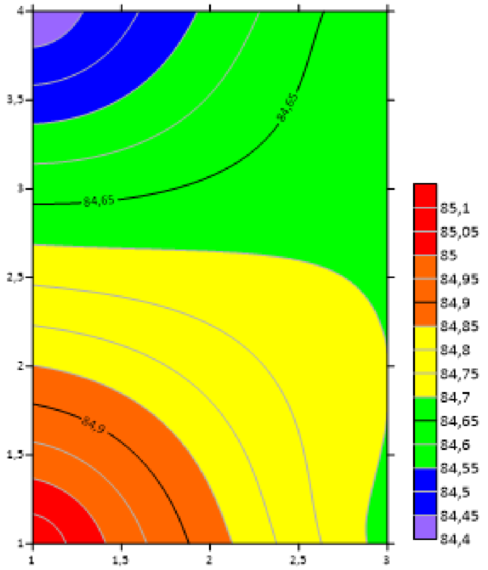
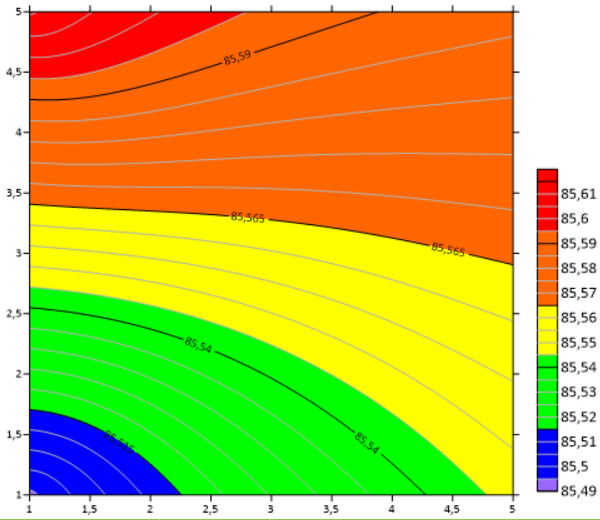
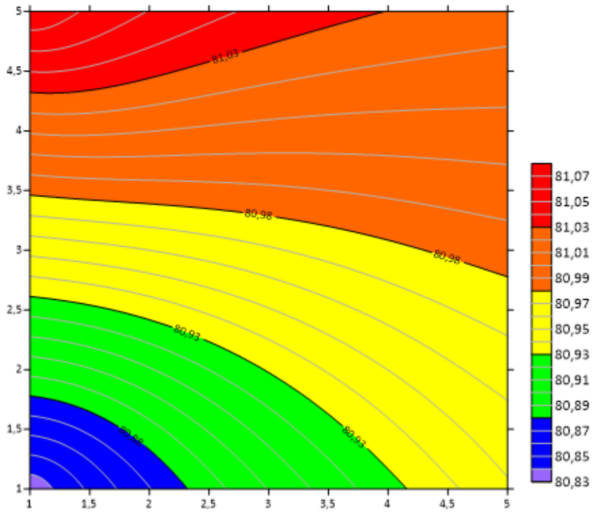
Table 4. The Summary of Noise Contour Mapping

Measurement Location	The Noise Contour Mapping
Ripple Mill Machine	
Silo Dryer Machine	
Clay bath Machine	

3.2 Method of Noise Control

The Hierarchy of Control Approach is being used in this study to control the excessive noise exposure in this palm oil mill. The following is a list of the stages of this approach [28]:

1. Elimination: getting rid or reducing of hazardous substances, dangerous equipment, or practices that aren't necessary for a working system.
2. Substitution: When hazardous materials are identified as a risk, replacing them with a less hazardous alternative is better.
3. Engineering: Physical barriers, defenders, physical obstacles that are permanently in place, physical obstacles that are interconnected, devices that detect the presence of people, computerization, and separation, are all examples of adjustment design.
4. Administrative controls: administrative controls include cutting the time employees are exposed to dangers, constantly moving workers around, and providing signs.
5. Using Personal protective equipment (PPE) minimizes the body surface contact from critical areas. This action may need to be accompanied by training on correctly utilizing the equipment.

The practicality of removing or substituting an engineering control strategy to eliminate noise-related dangers cannot be guaranteed. However, administrative controls, such as installing tracking control systems, may be extremely important. It is important to maintain the right noise level whenever a regulation system has been implemented. Another type of administrative control is environmental observation for control reasons. It requires continual monitoring of the exposure circumstances to detect any changes [29].

Ear protection is provided to workers in the workplace as part of their PPE. Earplugs and earmuffs are two forms of ear defenders that can be used to protect against noise in the workplace. Noise reduction is possible with any earplug. Earmuffs can lower noise by 40 to 50 dB, while earplugs can reduce it by 30 decibels. On the other hand, employee compliance with wearing ear protection when there is excessive noise remains a big concern. Employees who wear hearing protection have trouble conversing with coworkers and experience ear discomfort [1]. As a result, this study proposes an alternative earmuff design based on anthropometry to make an earmuff more comfortable. Anthropometry measures human body proportions in the design process to address ergonomic problems. Anthropometry creates a product that improves the working operator's productivity while lowering the risk of injury induced by the product's design. Anthropometry data processing methods include average calculation, deviation, testing for uniformity, test data adequacy measurement, normality test, and percentile calculation [30].

The body dimension used in this earmuff design is head circumference, and the determination of anthropometry for head circumference is the principle of average (P50). The final result of this dimension is 18 cm. The software to design this earmuff is SolidWorks 2018. Here the 2D and 3D designs of the earmuff are shown in Fig. 2.

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Fig. 2. Final Designs of Earmuff

Besides the design of the earmuff, this study also presents the display design (see Fig. 3) as another form of the control system to remind workers to work safely and always use PPE.

Fig. 3. Display Control in Indonesia Version

4. Conclusion

This research aimed to analyze noise exposure in the kernel recovery station in Production the Palm Oil. Noise measurement was conducted on four production machines, including the depericarper and polishing drum machine, ripple mill machine, silo dryer machine, and clay bath machine. Based on the results, the clay bath machine is the only place Ls does not exceed the threshold. It shows that the noise level at the clay bath machine workstation is good. The noise levels from the Depericarper and Polishing Drum Machine, the Ripple Mill Machine, and the Silo Dryer Machine are not good, so they need to be fixed. This research also presents the noise contour mapping of the measurement location to define the noise distribution. This research uses the Hierarchy of Control Approach to reduce and control hazardous noise exposure. The stage of HOC includes elimination, substitution, engineering, administrative control, and PPE (Personal Protective Equipment). However, this research has limitations in the calculation of Equivalent Noise Level (Leq) during nighttime and during the day-night time. Therefore, future research needs to analyze and calculate Equivalent Noise Levels (Leq) during nighttime and day-night. The shortcoming of this study is incomplete ways to calculate Leq. There are three ways to calculate equivalent noise levels, i.e., Leq during daytime (Ls), Leq during night time (Lm), and Leq during day and night (Lsm) [21]. However, in this study, the authors defined Leq during daytime (Ls). For further research, the authors wish to develop this kind of research to make it better and more complete.

Data Availability

This publication does not include all of the raw data. Please contact the author through email if want the raw data.

Acknowledgments

The authors acknowledge with much appreciation to the anonymous reviewers for their contributions to insightful remarks and helpful ideas that helped improve this paper's quality.

Declarations

Author contribution: Conceptual model, Methodology, Oversight, and Validation were all carried out by the first author. The second author conducted Writing, Editing and Software Running.
Funding statement: This research does not require funding.
Conflict of interest: The authors declare no conflicts of interest.
Additional information: No additional information is available for this paper.

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