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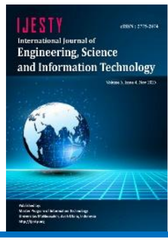

Mapping and Analysis of the Effect of Noise on Auditory and Non-Auditory Disorders Among Workers at the PMKS Production Station of PT. Sisirau

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Abstract

PT. Sisirau Palm Oil Mill Company is engaged in the production of crude palm oil (CPO) and kernel. In its production processes, the company continuously operates heavy machinery around the clock. These machines generate high noise levels, potentially causing both auditory (hearing-related) and non-auditory (communication, physiological, psychological, and work-productivity) disturbances among workers. This study aims to map the noise levels and analyse their impact on auditory and non-auditory disorders among workers at the production workstations of PT. Sisirau's palm oil mill. Measurements were taken at 74 points across five production workstations: the kernel station, boiler station, engine room, clarification station, and press station. Using a Sound Level Meter, noise measurements were converted into equivalent continuous sound levels, followed by regression analysis employing the t-test to determine the relationship between noise exposure and worker disturbances. The results show that most measurement points at the production workstations exceeded the established Threshold Limit Value (TLV), with an average noise level of 98 dB. This indicates that noise levels in production areas are very high and require immediate reduction measures. Moreover, the statistical analysis revealed a significant correlation between noise levels and both auditory and non-auditory disturbances among workers (P-value = 0.002 < 0.05). In other words, as noise exposure increases, so does the risk of hearing impairment, communication problems, physiological and psychological effects, and reduced work productivity. These findings underscore the urgent need for noise control efforts, improvements to the working environment, and the implementation of more effective and consistent occupational health and safety policies to safeguard the health and safety of workers at PT. Sisirau's palm oil mill.

Keywords: *Noise Level, Equivalent Noise Level, Auditory Disturbance, Non-Auditory Disturbance, Mapping.*

1. Introduction

Ergonomics is the science that studies how to create a work environment that matches human capabilities and limitations, thereby increasing workers' efficiency and comfort in performing their tasks [1][2]. Proper implementation of ergonomics can help workers achieve more optimal productivity by taking into account various aspects such as body posture, working conditions, workload, and the use of ergonomic equipment. One important element of the work environment that is often overlooked is noise [3]. Noise in the workplace is a serious issue that can affect the physical and mental health of workers. Excessive noise in the work environment can cause various problems such as stress, fatigue, hearing loss, and decreased work productivity [4][5]. In the industrial sector—especially in companies that use heavy machinery such as Palm Oil Mills (PMKS)—noise is one of the most serious threats. One such company facing this challenge is PT. Sisirau Palm Oil Mill. PT. Sisirau is a company engaged in the production of Crude Palm Oil (CPO) and kernel. In its production process, the company operates heavy machinery continuously for 24 hours. These machines generate high noise levels that potentially cause health problems for workers exposed directly. Based on preliminary observations, noise levels at production workstations range between 61–103 dB, which significantly affects the workers. These high noise levels are caused by the operation of large machines located in several stations, such as the kernel station, boiler station, engine room, clarification station, and press station.

2. Literature Review

2.1. Ergonomic

Ergonomics originates from the Greek words ergon (work) and nomos (law), meaning "the laws of work" or "work regulations." Ergonomics is a scientific discipline concerned with the design of work environments, tools, and tasks that align with the physical and mental capabilities of humans [6]. The primary aim of ergonomics is to improve worker well-being by minimising the risk of occupational injuries, physical fatigue, and psychological disorders. Its application spans various domains, including physical ergonomics (e.g., designing equipment in accorandce with human anatomy), cognitive ergonomics (e.g., managing mental workload), and organizational ergonomics (e.g., structuring work schedules) [7] The fundamental concept of ergonomics is "fitting the work to the worker", which emphasizes adapting job demands to the capacities of the worker to enhance both productivity and occupational safety. Proper ergonomic interventions can significantly improve comfort, efficiency, and overall quality of life at work. For instance, an ergonomically designed chair that supports proper posture can reduce the risk of lower back pain in office workers. Additionally, optimal workplace conditions—such as appropriate lighting and temperature play a critical role in enhancing human performance. Consequently, ergonomics contributes not only to physical health but also to the mental well-being of workers [8].

2.2. Physical Work Environment

The physical work environment encompasses various tangible aspects present in the workplace that directly influence workers' performance [9]. Several key indicators of the physical work environment include lighting, air temperature, noise levels, interior colour schemes, room layout, workspace safety, and the suitability of the equipment used. Each of these components plays a vital role in creating a comfortable, safe, and conducive work atmosphere to support employee productivity. Therefore, company management must pay close attention to and effectively manage the physical work environment to support the well-being and optimal performance of their human resources [10]. Several factors influence the physical work environment, including:

1. Lighting. Lighting refers to the amount of light entering a room. It must be appropriately adjusted according to needs, not too bright and not too dim [11]
2. Air Temperature. Air temperature refers to the level of heat or cold felt in a particular environment, measured in degrees Celsius or Fahrenheit [12]
3. Noise. Noise is defined as an unwanted or disturbing sound that may come from various sources, such as production equipment, traffic, or surrounding activities. Noise is inseparable from industrial development, as nearly all machine-based production processes generate noise [13]
4. Movement Space (Workspace). Movement space refers to the physical area available for individuals to move freely and comfortably while performing specific tasks or activities. Adequate movement space allows workers to operate without obstruction, improving efficiency and reducing the risk of injury [14].

2.3. Noise

Noise is defined as unwanted sound originating from production machinery or equipment, which may lead to hearing impairment at certain levels of exposure [15]. Noise is a sound that can negatively affect human health and has the potential to cause a variety of health issues. In the workplace, noise can trigger stress, hearing loss, and other psychological problems [16]. The health impacts of noise on workers include both auditory and non-auditory disturbances. Auditory impacts may include progressive hearing loss. Initially, the effects may be temporary, and hearing may return to normal once exposure is stopped. However, prolonged exposure can lead to permanent hearing damage. Non-auditory effects of noise may include physiological, psychological, communicative, and balance-related disturbances [17]. Therefore, it is essential to manage and reduce workplace noise to protect the health and well-being of workers. Workplace noise can be classified into two categories based on its characteristics and its impact on humans:

1. Based on characteristics:
   a. Continuous Noise. Noise with a difference in intensity of less than 3 dB between the highest and lowest levels, such as the sound from textile spinning machines.
   b. Fluctuating Noise. Noise with a difference in intensity greater than 3 dB between the highest and lowest levels.
   c. Impulsive Noise. Noise characterised by a very high intensity for a short duration, such as gunfire.
   d. Intermittent Noise. Noise that occurs periodically and repeatedly over time, such as grinding sounds that stop when the machine is turned off.
2. Based on the impact on humans:
   a. Irritating Noise. Noise that is not necessarily loud but can still be disturbing, such as the sound of snoring.
   b. Masking Noise. Noise that covers or masks important sounds or signals indirectly endangers worker safety because warning signs or danger signals can go unheard.
   c. Damaging/Injurious Noise. Noise that exceeds the Threshold Limit Value (TLV) potentially causes permanent hearing loss or damage.

Noise levels can be classified based on their intensity, which is measured in decibels (dB), as shown in Table 1.

Table 1. Levels and Sources of Sound at Specific Noise Scales

Noise Level dB(A)	Sound Source	Intensity Scale
10-20	Human breathing, wristwatch ticking	16 hours
20-40	Library, whispering, rustling leaves	12 hours
60-85	City traffic, vacuum cleaner	8 hours
90-110	Chainsaw, pneumatic drill, heavy traffic	4 hours
120-140	Jet engine at 100 feet, thunder, gunshot, rock concert	2 hours

Sources: (Decibel Chart of Common Sound Sources)

2.4. Noise Measurement

Noise measurement aims to obtain data regarding the intensity and frequency of sound in the workplace environment, as well as to identify and mitigate its negative impacts. The methods that can be used to measure noise in the workplace are as follows:

1. Measurement by Sampling Points. Noise measurement using sampling points is a method of assessing noise intensity by taking samples at several specific locations. These sampling points are selected based on areas that most accurately represent the noise conditions in the workplace [18]. The distance from the noise source must be specified, for example, 3 meters at a height of 1 meter. Additionally, the direction of the microphone on the measuring device must be considered. The device commonly used for noise measurement is the Sound Level Meter, as shown in Figure 1 below:

Fig 1. Sound Level Meter

2. Measurement Using Noise Contour Maps. A noise contour map is a visual representation of noise levels in a given area, illustrated using contour lines. Each contour line connects points with the same noise level. This map provides essential information on how noise is distributed across an area, helps identify major noise sources, and evaluates the potential impact of noise on humans or the environment. The use of noise contour maps is particularly beneficial as it allows for the visualisation of noise conditions across large areas. In constructing the contour map, color codes are used to indicate different levels of noise intensity: blue represents areas with noise levels below 70 dB; green indicates areas with noise levels ranging from 70 to 80 dB; yellow corresponds to noise levels between 80 and 90 dB; orange denotes areas with noise levels ranging from 90 to 100 dB; and red represents very high noise intensity, between 100 and 110 dB. The explanation of the colour codes representing noise levels can be seen in Table 2.

Table 2. Noise Level Standards

Colour	Noise Level
	100 dB – 110 dB
	90 dB – 100 dB
	80 dB - 90 dB
	70 dB – 80 dB
	<70 dB

Source: Occupational Safety and Health Administration

2.5. Threshold Limit Value (TLV)

According to the Ministry of Manpower Regulation No. 5 of 2018, Ministerial Decree No. According to PER-51/MEN/1999, ACGIH (2008), and Indonesian National Standard (SNI) 16-7063-2004, the Threshold Limit Value (TLV) is a reference level that defines the maximum allowable exposure to pollution or disturbance that can affect the environment. Repeated exposure to noise levels of 85 dB or higher may lead to adverse health effects such as permanent hearing loss, tinnitus, and difficulty understanding speech in noisy environments [19]. The TLV for noise is a critical indicator used to determine the maximum noise level that can be tolerated by workers without causing health issues, particularly hearing loss. In Indonesia, the noise TLV is regulated under the Ministry of Manpower Regulation No. PER.13/MEN/X/2011, which sets a limit of 85 dB for 8 hours of daily work. If noise levels exceed 85 dB, the exposure duration must be proportionally reduced, or hearing protection must be worn by the workers. The permitted noise levels and maximum daily exposure durations, as specified in Ministry of Manpower Regulation No. 5 of 2018, are presented in Table 3 below:

Table 3. Noise TLVs Based on Ministry Regulation No. 5 of 2018

No	Noise Level (dB)	Daily Exposure Duration
1.	82	16 hours
2.	83,3	12 hours
3.	85	8 hours
4.	88	4 hours
5.	91	2 hours
6.	94	1 hours
7.	97	30 minutes
8.	100	15 minutes
9.	103	7,5 minutes
10.	106	3,5 minutes
11.	109	1,88 minutes

Source: Ministry of Manpower, 2018

2.6. Types of Disorders Caused by Noise

The types of disorders resulting from noise exposure are as follows:

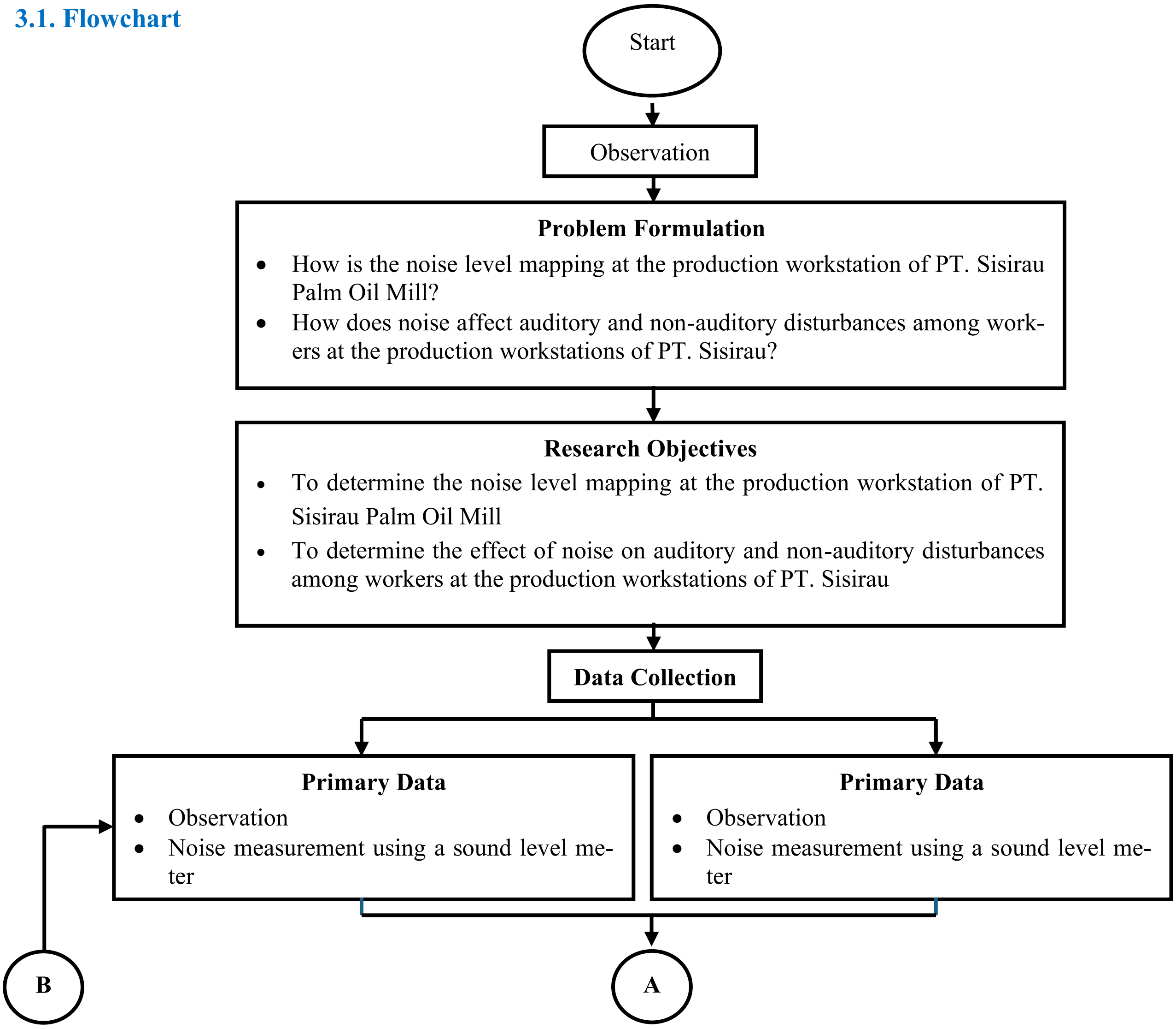
1. Auditory Disorders
   a. Noise-Induced Hearing Loss (NIHL). Noise-Induced Hearing Loss (NIHL) is a hearing impairment that occurs when the sensitive structures in the inner ear are damaged due to excessive noise exposure, either suddenly or gradually. Chronic exposure to noise levels exceeding 85 dB(A) leads to degeneration of the outer hair cells in the organ of Corti, which function as sound frequency amplifiers, thereby progressively reducing hearing sensitivity [20].
   b. Acoustic Trauma. Acoustic trauma occurs as a result of exposure to extremely high-intensity sound (140 dB or more) in a short duration, which can directly damage the ear's structure.
2. Non-Auditory Disorders
   a. Physiological Disorders. Physiological disorders are conditions in which the normal function of the body is disrupted, either due to internal factors such as disease or organ dysfunction, or external factors such as work environment or daily activities. Physiological disorders caused by noise refer to the negative impact of noise on the physical functions and systems of the human body.

b. Sleep Disorders. Sleep disorders refer to problems affecting a person's sleep patterns, which can significantly impact physical and mental health. Excessive noise can disrupt sleep quality, potentially leading to chronic fatigue, reduced concentration, and serious mood disturbances [21].
c. Communication Disorders. Noise exceeding the auditory threshold can interfere with verbal communication, forcing individuals to speak louder or repeat themselves to be understood, which reduces the efficiency of interaction. This not only affects message comprehension but also increases the risk of miscommunication and errors in task execution [22].
d. Balance Disorders. Exposure to high levels of noise can lead to dizziness or vertigo and nausea due to stimulation of the vestibular system in the inner ear. When noise reaches a certain intensity, the vestibular receptors responsible for balance may become overstimulated [23].
e. Emotional Disorders. Noise can cause emotional instability, such as irritability or frustration, especially when exposure is prolonged. Continuous exposure to loud sounds may lead to prolonged stress on the nervous system, triggering negative emotional responses. [24]
f. Work Performance Disorders. Workers exposed to high noise levels often experience decreased work performance due to mental and physical fatigue. Continuous noise exposure can disrupt concentration, making it difficult for workers to focus on tasks, which ultimately reduces productivity [25].

3. Methods

The research methods used in this study include the following:
1. Literature Review. The literature review was conducted by collecting references from various sources such as journals, books, and papers relevant to the study. These sources were then evaluated, reviewed, and analysed to serve as a foundation for the research implementation.
2. Observation. Direct observation was carried out at PT. Sisirau Palm Oil Mill to collect data through on-site monitoring of the research object, specifically the noise levels at production workstations.
3. Interview. The interview stage aimed to gather information by directly questioning respondents. In this study, the researcher interviewed twenty operators working at the production stations.
4. Questionnaire. The questionnaire is a data collection tool consisting of a series of written questions provided to respondents to be answered independently.
5. Documentation. Documentation is a technique of data collection by tracing documents or historical records related to a person or event. Research data may be obtained through facts stored in the form of letters, photo archives, daily records, meeting minutes, and activity journals.

3.1. Flowchart



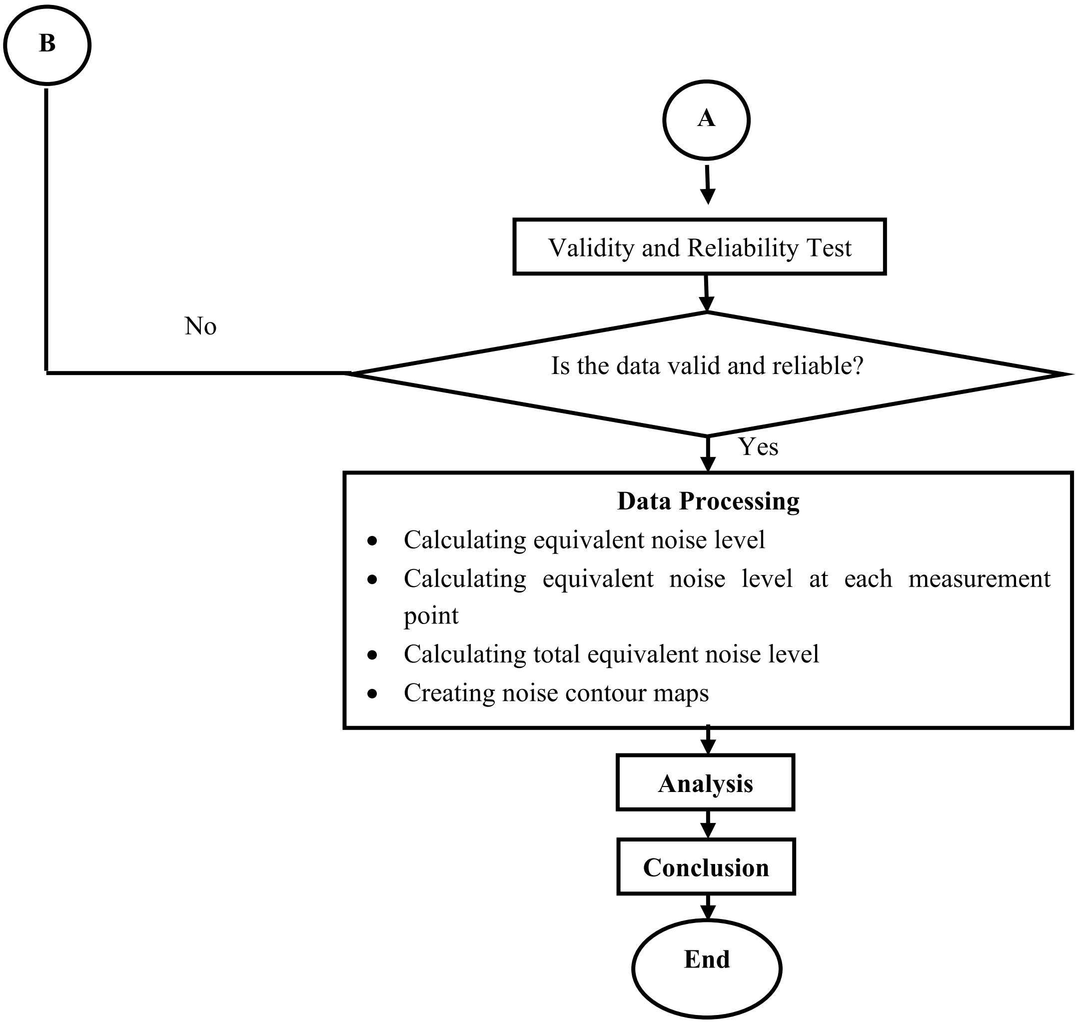


Fig 2. Flowchart

3.2. Data Collection

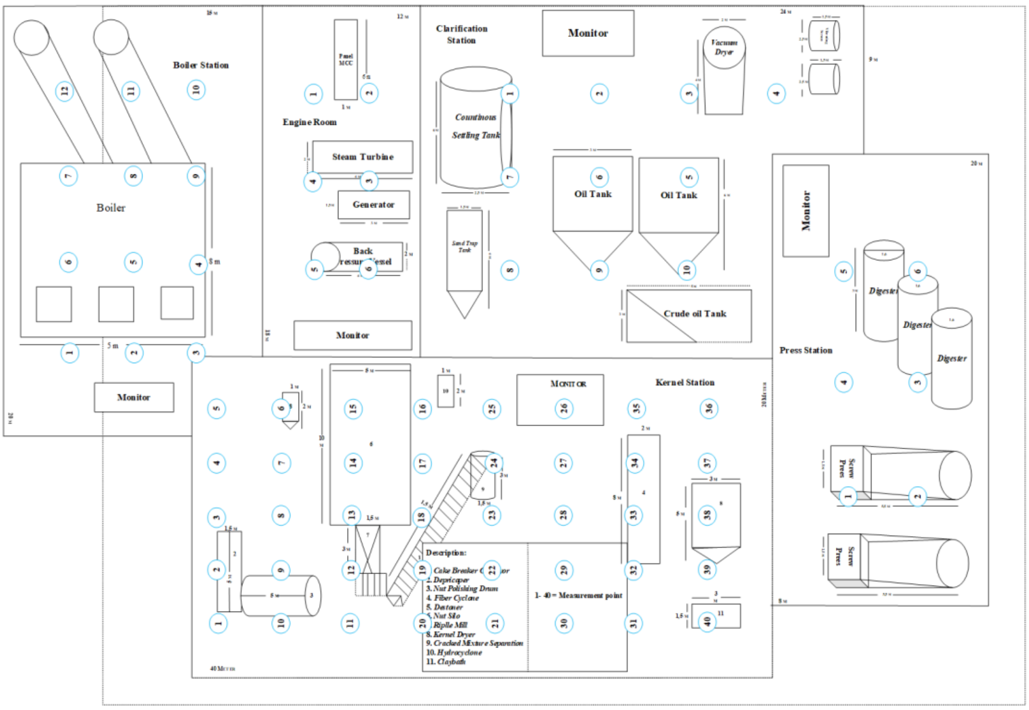


Fig 3. Measurement Layout

4. Results and Discussion

1. Equivalent Noise Level (Leq). Based on the noise calculation method in KEP-48/MENLH/11/1996, the equivalent noise level (Leq) is determined as follows. The noise level data at the kernel station for points 1 to 40 was recorded at 09:00. The measurement fraction for the first day at points 1 to 40 is 1/40.

$$Leq=10\ Log\ \{\frac{1}{40}\ 10^{0,1x100,4}+\frac{1}{40}\ 10^{0,1x101,6}+....+\frac{1}{40}\ 10^{0,1x102,6}\}=101,1$$

The recapitulation results of the Leq calculations at the Kernel Station from the first to the fifth day can be seen in Table 4.

Table 4. Recapitulation of Leq Calculations at Kernel Station

Time	Leq Value (dB)				
	Day 1	Day 2	Day 3	Day 4	Day 5
09.00	101,1	101,2	101,0	101,2	101,2
12.00	101,1	101,3	101,0	101,0	101,0
15.00	101,1	101,4	101,3	101,2	101,2
18.00	101,3	101,2	101,2	101,2	101,2
21.00	101,4	101,2	101,2	101,2	101,0
24.00	101,3	101,0	101,1	100,8	101,1
03.00	101,2	101,1	101,1	101,4	101,2
06.00	101,2	101,4	101,1	101,2	101,2

2. Equivalent Noise Level at Each Measurement Point. The noise level data for each point and measurement time over five days is more representative when expressed through equivalent noise level values. The calculated equivalent noise level at Point 1 at 09:00 is as follows:
   L (Day 1): 100.4
   L (Day 2): 102.2
   L (Day 3): 100.3
   L (Day 4): 101.2
   L (Day 5): 102.6
   The measurement fraction over five days is: 1/5

$$Leq=10Log\ \{\frac{1}{5}\ 10^{0,1x100,4}+\frac{1}{5}\ 10^{0,1x102,2}+....+\frac{1}{5}\ 10^{0,1x102,6}\}=101,5$$

   The same calculation method was applied to Points 2 through 40 for each measurement time. The recapitulated equivalent noise levels at each point of the Kernel Station are presented in Table 5.

Table 5. Recapitulation of Equivalent Noise Levels at Kernel Station Measurement Points

Point	Equivalent Noise Level							
	09.00	12.00	15.00	18.00	21.00	24.00	03.00	06.00
1	101,5	101,0	102,2	101,7	101,5	101,3	101,6	101,7
2	102,0	101,1	101,7	101,6	101,5	102,0	101,4	100,8
3	101,9	100,7	101,5	101,8	102,2	101,4	101,7	101,9
4	98,5	98,1	98,5	98,3	98,3	98,2	98,5	99,3
5	100,9	101,4	101,7	101,4	102,0	100,9	101,0	101,6
6	101,7	101,3	101,8	101,7	100,9	101,5	102,5	102,2
7	101,3	101,5	101,3	101,7	101,6	102,2	101,6	101,3
8	101,2	101,3	101,7	102,4	101,4	101,7	101,5	101,2
9	101,1	101,8	101,3	101,9	100,9	101,4	101,7	101,1
10	101,2	101,8	101,1	101,5	101,6	101,1	101,5	101,5
11	101,4	101,6	101,0	101,5	102,7	101,2	101,1	101,6
12	101,3	101,9	101,0	101,7	102,1	101,2	103,0	101,8
13	102,4	101,9	101,9	101,5	101,2	100,7	101,0	100,9
14	101,5	102,1	101,5	102,2	101,8	101,2	101,6	101,9
15	101,8	101,7	101,6	101,9	102,2	101,5	101,5	101,9
16	101,2	101,2	101,5	101,8	102,2	101,7	102,2	101,5
17	101,7	101,6	101,9	101,0	101,6	101,4	100,5	102,5
18	102,3	101,5	101,6	101,9	101,8	101,4	102,0	101,7
19	101,3	101,5	101,8	101,8	102,0	101,8	100,6	101,3
20	98,5	98,1	98,7	98,0	98,0	98,1	98,4	98,0
21	98,0	98,0	98,3	98,0	98,3	97,6	98,2	98,1
22	98,0	97,7	99,3	97,8	98,0	97,9	98,0	98,9
23	98,0	98,1	99,1	98,0	97,6	97,7	98,0	99,2
24	97,8	97,9	98,6	97,7	98,2	97,7	98,5	98,6
25	97,8	98,0	98,7	98,1	98,2	97,8	97,9	98,4
26	102,2	101,2	101,8	101,4	101,9	102,5	101,8	101,4
27	101,5	101,7	101,7	101,6	101,5	101,2	102,0	101,7
28	101,9	101,9	101,3	100,9	101,4	101,0	102,2	101,2

29	101,3	101,4	102,1	101,8	101,9	101,6	102,2	101,5
30	101,3	102,0	101,5	101,0	101,4	102,1	101,6	101,8
31	101,7	102,2	101,4	101,4	101,8	101,5	100,8	101,9
32	101,4	101,3	101,3	100,9	101,6	101,2	101,1	101,6
33	100,9	101,3	102,1	102,0	101,3	102,1	101,2	102,3
34	102,3	101,1	101,7	102,1	101,6	101,4	101,6	101,4
35	101,4	102,2	101,8	101,3	101,4	101,4	101,9	102,1
36	101,6	101,3	100,8	101,7	101,2	102,0	101,9	101,4
37	101,6	101,7	101,9	101,9	101,5	101,7	101,7	102,3
38	101,1	101,5	101,8	101,7	101,9	101,4	101,9	101,5
39	102,2	101,6	102,1	102,1	101,5	101,6	101,9	101,5
40	101,4	101,2	102,4	102,1	101,7	101,5	100,8	100,9

3. Total Equivalent Noise Level. The equivalent noise level data for each point and time is classified into two types: daytime noise level and nighttime noise level. The time intervals follow the regulation KEP-48/MENLH/11/1996, where daytime measurements (Leq Day) cover 15 hours (07:00–22:00) and nighttime measurements (Leq Night) cover 9 hours (22:00–07:00). Noise level measurements were taken at 09:00, 12:00, 15:00, 18:00, 21:00, 24:00, 03:00, and 06:00. The equivalent noise level calculation for Point 1 is as follows:
   Leq (09:00) = 101.5
   Leq (12:00) = 101.0
   Leq (15:00) = 102.2
   Leq (18:00) = 101.7
   Leq (21:00) = 101.5
   Leq (24:00) = 101.3
   Leq (03:00) = 101.6
   Leq (06:00) = 101.7
   Time fractions:
   f1 07:00–10:00 = 3/15
   f2 10:00–13:00 = 3/15
   f3 13:00–16:00 = 3/15
   f4 16:00–19:00 = 3/15
   f5 19:00–22:00 = 3/15
   f6 22:00–01:00 = 3/9
   f7 01:00–04:00 = 3/9
   f8 04:00–07:00 = 3/9

$$Leq=10 \text{ Log } \{\frac{3}{15}\ 10^{0,1x101,5}+\frac{3}{15}\ 10^{0,1x101,0}+....+\frac{3}{15}\ 10^{0,1x101,7}\}= 104,6$$

The recapitulated results of the total equivalent noise level at the Kernel Station are shown in Table 6.

Table 6. Recapitulation of Total Equivalent Noise Levels at Kernel Station

Point	Ls (dB)	TLV (dB)	Reduction
1	104,6	85	19,6
2	104,5	85	19,5
3	104,7	85	19,7
4	101,5	85	16,5
5	104,4	85	19,4
6	104,8	85	19,8
7	104,6	85	19,6
8	104,6	85	19,6
9	104,4	85	19,4
10	104,4	85	19,4
11	104,5	85	19,5
12	104,9	85	19,9
13	104,4	85	19,4
14	104,7	85	19,7
15	104,7	85	19,7
16	104,7	85	19,7
17	104,6	85	19,6
18	104,8	85	19,8
19	104,5	85	19,5
20	101,2	85	16,2
21	101,1	85	16,1
22	101,3	85	16,3
23	101,3	85	16,3
24	101,2	85	16,2
25	101,1	85	16,1
26	104,8	85	19,8

27	104,6	85	19,6
28	104,5	85	19,5
29	104,8	85	19,8
30	104,7	85	19,7
31	104,6	85	19,6
32	104,3	85	19,3
33	104,7	85	19,7
34	104,6	85	19,6
35	104,7	85	19,7
36	104,6	85	19,6
37	104,8	85	19,8
38	104,6	85	19,6
39	104,8	85	19,8
40	104,5	85	19,5

Based on the recapitulation table, most of the measured noise levels exceed the Threshold Limit Value (TLV) and require mitigation actions. Since a large number of measurement points exceed the acceptable noise threshold, the noise condition at the production workstation of PT. Sisirau Palm Oil Mill is classified as unsafe. To visualise the direction and pattern of noise distribution in the production workstations, a noise contour map was created using Surfer software, as shown in Figure 3 below.

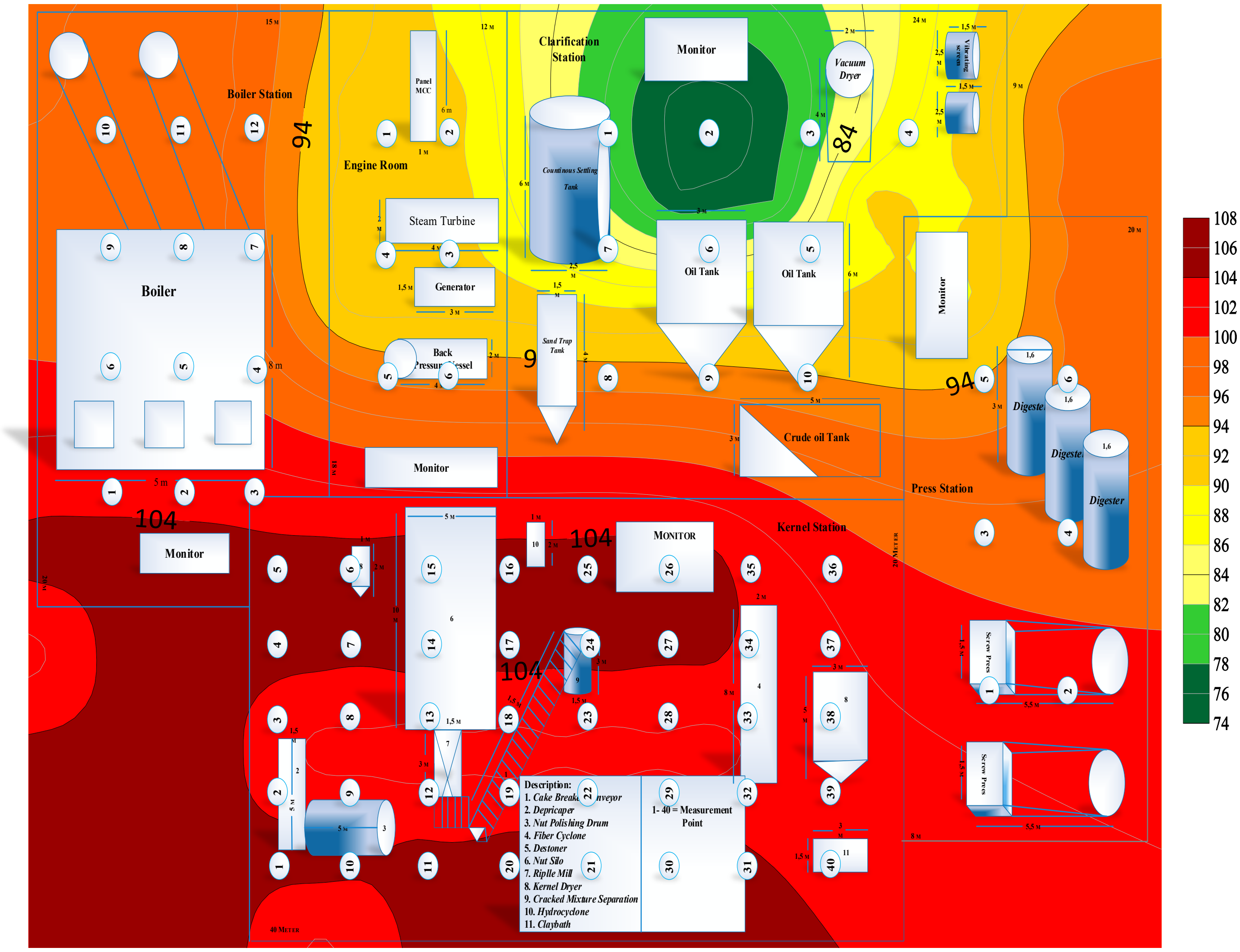


Fig 3. Noise Mapping

4.1. Effect of Noise on Auditory Disorders

Table 7. Effect of Noise on Hearing Disorders

	Hearing Disorders										
Variable	**Very Often**		**Often**		**Occasionally**		**Never**		**Total**		**P Value**
Noise	n	%	n	%	n	%	n	%	n	%	
Very Disturbing	9	45	8	40	0	0	0	0	17	85	0,002
Not Disturbing	0	0	0	0	3	15	0	0	3	15	
Total	**9**	**45**	**8**	**40**	**3**	**15**	**0**	**0**	**20**	**100**	

Based on the research findings and data analysis using the T-test, the resulting P-Value = 0.002 (P < 0.05) indicates that Ha is accepted and H_0 is rejected, meaning that noise has a significant effect on hearing disorders among workers at PT. Sisirau Palm Oil Mill. This implies that the higher the noise level experienced by respondents, the greater the degree of auditory (hearing) impairment felt.

4.2. Effect of Noise on Communication Disorders

Table 8. Effect of Noise on Communication Disorders

Communication Disorders											
Variable	**Very Often**		**Often**		**Occasionally**		**Never**		**Total**		**P Value**
Noise	n	%	n	%	n	%	n	%	n	%	
Very Disturbing	12	60	5	25	0	0	0	0	17	85	0,000
Not Disturbing	0	0	3	15	0	0	0	0	3	15	
Total	**12**	**60**	**8**	**40**	**0**	**0**	**0**	**0**	**20**	**100**	

The T-test analysis yielded a P-Value = 0.000 (P < 0.05), meaning Ha is accepted and H_0 is rejected, indicating that noise has a significant effect on communication disorders among PT. Sisirau Palm Oil Mill workers. This means the higher the noise level experienced, the more severe the communication difficulties encountered by the respondents.

4.3. Effect of Noise on Physiological Disorders

Table 9. Effect of Noise on Physiological Disorders

Physiological Disorders											
Variable	**Very Often**		**Often**		**Occasionally**		**Never**		**Total**		***P Value***
Noise	n	%	n	%	n	%	n	%	n	%	
Very Disturbing	1	5	13	65	3	15	0	0	17	851	0,013
Not Disturbing	0	0	0	0	3	15	0	0	3	15	
Total	1	5	13	65	6	25	0	0	20	100	

Based on the T-test results, the P-Value = 0.013 (P < 0.05) indicates that Ha is accepted and H_0 is rejected, showing that noise significantly affects physiological disorders among PT. Sisirau workers. This suggests that as noise levels increase, the extent of physiological disturbances also increases.

4.4. Effect of Noise on Psychological Disorders

Table 10. Effect of Noise on Psychological Disorders

Psychological Disorders											
Variable	**Very Often**		**Often**		**Occasionally**		**Never**		**Total**		**P Value**
Noise	n	%	n	%	n	%	n	%	n	%	
Very Disturbing	3	15	11	55	3	15	0	0	17	85	0,036
Not Disturbing	0	0	1	5	2	10	0	0	3	15	
Total	3	15	12	60	5	25	0	0	20	100	

From the T-test analysis, the P-Value = 0.036 (P < 0.05) shows that Ha is accepted and H_0 is rejected, meaning that noise has a significant impact on psychological disorders among workers at PT. Sisirau. Thus, higher noise levels lead to greater psychological disturbances experienced by the respondents.

4.5. Effect of Noise on Work Productivity Disorders

Table 11. Effect of Noise on Work Productivity Disorders

Work Productivity Disorders											
Variable	**Very Often**		**Often**		**Occasionally**		**Never**		**Total**		**P Value**
Noise	n	%	n	%	n	%	n	%	n	%	
Very Disturbing	3	15	14	70	0	0	0	0	17	85	0,001
Not Disturbing	0	0	0	0	3	15	0	0	3	15	
Total	3	15	14	70	3	15	0	0	20	100	

According to the research and T-test results, the P-Value = 0.001 (P < 0.05) indicates that Ha is accepted and H_0 is rejected, meaning that noise significantly affects work productivity among workers at PT. Sisirau. This demonstrates that the higher the noise level encountered by respondents, the more substantial the decline in their work productivity.

5. Conclusion

Based on the research findings and the discussion presented, the following conclusions can be drawn:

1. Noise level mapping at the production workstations of PT. Sisirau Palm Oil Mill shows a distribution of noise levels dominated by the colour red, indicating very high noise exposure. This condition signifies that the noise levels at the production workstations are extremely hazardous for workers. The noise mapping was conducted by measuring noise levels at 74 predetermined points, resulting in an average noise level of 98.8 dB. This value exceeds the Threshold Limit Value (TLV) established by the government regulation KEP-51/MEN/1999, which is set at 85 dB.
2. Noise at the production workstations of PT. Sisirau has a significant effect on auditory disturbances. Statistical test results show a P-value of 0.002 < 0.05, indicating a significant correlation between noise levels and hearing disorders. In addition, noise also has a significant impact on non-auditory disturbances. The statistical test also produced a P-value of 0.002 (< 0.05), indicating that noise

levels significantly affect non-auditory issues experienced by workers. This document can be used as a template for Microsoft Word versions 6.0 or later.

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