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Management Ergonomics Sector Analysis Oil Palm Plantation

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Abstract

Indonesia, the world's largest palm oil producer, significantly impacts global crude palm oil (CPO) production. Despite its economic value, manual labor in oil palm plantations often involves non-ergonomic practices, particularly in tasks like loading and unloading, leading to worker fatigue and increased risks of Musculoskeletal Disorders (MSDs). This research aims to evaluate ergonomic risks and MSD prevalence among oil palm workers by analyzing body posture during daily tasks. Data were collected using the RULA method, Nordic Body Map, and environmental measurements, supported by interviews and observations. Findings reveal that improper lifting and posture during harvesting contribute to fatigue and MSDs among workers. Recommendations for improvement include regular ergonomic training, adjustments to work posture, and the addition of safety equipment like fire extinguishers. By implementing these changes, the study seeks to improve worker safety, minimize MSD occurrences, and boost productivity in oil palm plantations. These insights are vital for ensuring sustainable practices in the industry and promoting the well-being of plantation workers.

Keywords: palm oil, posture work, fatigue, and anthropometrics.

Introduction

Development industry oil growing Indonesian palm oil fast the has interesting attention world community, in particular producer oil vegetable world's main. Indonesia is a producing country oil palm the world's largest since 2006(Potter, 2015) (Barcelos et al., 2015). In 2016, Indonesia succeeded in outperforming Malaysia. Indonesia's CPO production share has been reaching 53.4% of the world's total CPO, while Malaysia has a share of 32%. Thereby case in the oil market global vegetable, oil Palm oil has also successfully outperformed oil soya bean (soybean oil) since 2004. In 2004, total CPO production reached 33.6 million tons, while oil soya bean is 32.4 million tons. In 2016, the share of world CPO production reached 40% of total vegetable crops the world's main, meanwhile, oil soya bean share amounted to 33.18 % (United States Department of Agriculture, 2016).

One of the subsector's big potential is subsector plantation. Contribution subsector Plantation 2020 that is amounting to 3.63 percent of the total GDP and 26.50 percent to the sector Agriculture, Forestry, and Fisheries or is ordered first in the sector. Palm oil is one commodity that results in owned plantations role enough important in the activity economy of Indonesia because of its ability to produce oil and lots of vegetables needed

by the industrial sector (Syahza & Asmit, 2020). Its nature is resistant to oxidation with pressure height and the ability to dissolve material chemistry is not dissolved by the material solvent others, as well Power high layering makes oil coconut palm be used. For diverse allocation, among others that is for oil cook, oil industry, as well as material fuel (biodiesel) 2. As a producing country oil palm 3rd largest in the world, Indonesia has great potential. To promote oil palm oil and palm kernel goods inside and abroad. The potential market that will absorb marketing oil palm oil (CPO) and palm kernel oil (PKO) are industry fractionation/ramification (esp industry cooking oil), special fats (cocoa butter substitute), margarine/shortening, oleochemicals, and bath soap (Indonesian Palm Oil Statistics, 2020).

Palm oil *(Elaeis)* is the plant industry's important producer of oil cooking, oil industry, as well as material fuel (biodiesel) (Onoja et al., 2019; Rival & Levang, 2014; RIVANO, 2023). His plantation produced profit big so that Lots of old forests and plantations were converted become plantation coconut palm oil. Indonesia is the producer of coconut palm largest in the world. In Indonesia, it is spread in the Aceh area, the coast of eastern Sumatra, Java, and Sulawesi. Until the moment This activity works on plantations of coconut palm specifically activity unloading and loading Still done manually relying on power man as well as using tools and methods that don't notice the limitations of humans. (Surya & Badruddin, 2014).

Posture Work is a point decider in analyzing the effectiveness of something job. If posture work done by the operator is already good and ergonomic so can confirm results obtained by the operator will good. However, when the posture of the operator's work is not ergonomic then the operator will easily fatigue. If the operator is easy to experiences fatigue so results in the work carried out by the operator will also experience a decline or not by expectations (Susihono & Prasetyo, 2012).

Fatigue or damage to muscles can result in spasms (cramps muscles), spasms muscle, loss of balance, and sprains. Fatigue muscle can also cause painful critical until causes loss of sensation (numbness) in the part burdened body. (Ng et al., 2011). Condition fatigue Of course potential. For gives rise to problems specifically Musculoskeletal Disorders (MSDs) against worker palm oil. Not only factor fatigue just, however, positioning the wrong body when working the palm or even when lifting the palm can give rise to musculoskeletal disorders and changes in posture. Anthropometrics is part of perfect ergonomics special learn size covering body linear dimensions, as well content and also includes area size, strength, speed, and other aspects of movement body. By definition, anthropometry can stated as something related to studies with size dimensions body man covers area size, strength, speed, and other aspects of movement body man.

According to Istisya, Denny, & Setyaningsih, (2023) The results obtained are that the dangers of working on oil palm plantations include being pricked by thorns, being hit by palm fronds and fruit, being injured, strong weather and winds, poisonous animals, poisoning, skin irritation and itching, and disturbances. Respiratory and musculoskeletal. It can be concluded that the introduction of work hazards in oil palm plantations includes

physical, biological, chemical, and ergonomic hazards. So that in the future workers who work on oil palm plantations can use these potential dangers to control the occurrence of work-related accidents or diseases.

Different from previous studies, which highlighted various types of physical, biological, chemical, and ergonomic hazards in oil palm plantations, this study uses more specific and in-depth ergonomic assessment methods, such as RULA (Rapid Upper Limb Assessment). This method was used to analyze work posture as well as the risk of Musculoskeletal Disorders (MSDs), which has not been the main focus of previous research. Another novelty introduced in this study is the evaluation of the level of fatigue and workload faced by workers in oil palm plantations. By measuring and evaluating fatigue levels, this study makes a new contribution to understanding how fatigue factors affect worker productivity and health in the long term.

This study focuses on key variables, namely work posture, fatigue levels, and the application of ergonomics in palm oil plantations. Posture assessment is conducted using the RULA (Rapid Upper Limb Assessment) method, aimed at analyzing the effectiveness of work posture in reducing the risk of MSDs. Additionally, workload measurements and fatigue evaluations are essential variables in assessing the suitability between tasks and workers' physical capacity.

This research provides a new contribution to the ergonomics literature in the palm oil plantation sector by focusing on detailed measurement of MSD risks using the RULA method, which is rarely applied in the context of Indonesian plantations. The study also identifies specific areas for improvement in work posture to reduce injury risks for workers.

The high incidence of work-related injuries in the palm oil plantation sector and its impact on productivity and operational costs highlight the urgency of this research. Given the sector's crucial role in the Indonesian economy, improving working conditions to enhance worker welfare is essential for the industry’s sustainability.

This research aims to evaluate ergonomic risks among palm oil workers in Indonesia, identify health conditions related to work posture, and provide recommendations to improve work practices to minimize the risk of musculoskeletal injuries. Benefits of Research: This research is expected to offer practical benefits to plantation companies and policymakers by enhancing workplace safety through ergonomic approaches. By improving work posture and reducing physical fatigue, the study aims to boost productivity and quality of life for workers, ultimately supporting the sustainability of Indonesia's palm oil industry.

Method Research

This study uses a quantitative approach with a descriptive research design to evaluate ergonomic risks in oil palm plantations. The method used in data acquisition is carried out with the process of interviewing, observing, and measuring posture body users with the RULA method, and measuring ordinary palm oil workers used in gardens. Data collection was carried out on March 6 2022 from 10.00 to 12.00 WIB located in

Kepenuhan Raya Village, District Kepenuhan, Rokan Hulu Regency, Riau. As for some instruments used including, among others following. 1) IOS-based camera application used for document activity moment study. 2) IOS-based thermometer application used for measuring temperature in the environment work. 3) A Lux meter application is used to measure noise in the environment work. 4) Application Decibel X based based on the iOS used to measure noise in the environment Work. 5) Sphygmomanometer measures pressure blood at the moment study. 6) Application Angulus used for measuring corner posture body subject. 7) IOS-based Stopwatch application used for register burden work. 8) The Nordic Body Map questionnaire was used To register complaint musculoskeletal.

Data analysis was carried out by calculating the RULA value as an indicator of ergonomic risks faced by workers. The results of this measurement are then classified to determine the level of risk and the need for work posture improvement. In addition, quantitative data from the Nordic Body Map Questionnaire was analyzed using the Likert scale to identify the level of musculoskeletal complaints. Measurement of cardiovascular fatigue (CVL) is also used to evaluate the physical capacity of workers during the work process. The results of this analysis are expected to provide specific recommendations to improve ergonomic work practices in oil palm plantations.

Results and Discussion

Tasks

Tasks or tasks discussed include position and attitude work, utilization of muscle in do activity harvesting, as well interaction man with machine.

Anthropometrics

Tools used are palm dodos with material iron and long dodos wood about 5 meters, heavy dodos tool 5 kg. The area of the place is 20.000 meters (2-hectare area) with 1 worker. There are about 255 trees and coconut palms with are about 8 years old. 1 palm bunch weight around 10-20 kg. Once in a while harvest obtained about 300 kg. Harvest schedule 2 times a year a month or every 15 days. For the price of palm per kilo is around IDR 3,900 (depending on the age of the tree palm oil). Type of Fertilizer used for plant coconut palm This consists of Urea, KCL, Dolumite, Kisrid, NPK, Borate, and Fertilizer Cage.

Position and Attitude Worker Palm

Based on the results of measurement posture body use the RULA (Rapid Upper Limb Assessment) method was obtained results as follows.

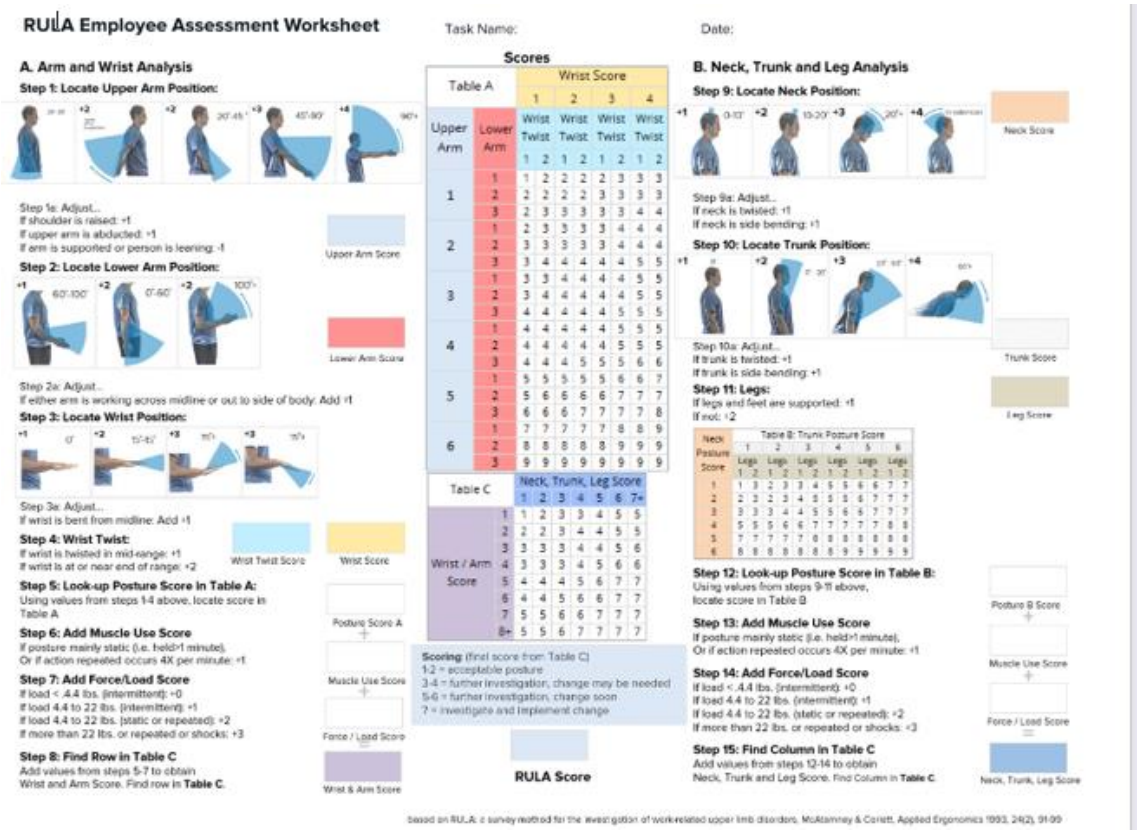


Figure 1. RULA Employee Assessment Worksheet

This figure represents a RULA (Rapid Upper Limb Assessment) worksheet used to evaluate the ergonomic risk levels associated with upper limb movements and postures in workplace tasks. RULA is a survey method designed to identify and assess the potential for work-related upper limb disorders based on posture, muscle use, and force exerted during specific tasks.

The worksheet is divided into two main sections:

a. Section A: Arm and Wrist Analysis – Steps 1 to 8 assess the positions and movements of the upper arm, lower arm, wrist, and wrist twist. Scores are assigned for each component, which are then combined to determine the "Wrist & Arm Score."
b. Section B: Neck, Trunk, and Leg Analysis – Steps 9 to 15 analyze neck, trunk, and leg positions to evaluate ergonomic risks. This section provides a "Neck, Trunk, Leg Score" based on observed postures and movements.

Each score can be adjusted based on additional factors such as muscle use and force/load exerted. The final RULA score helps determine the level of ergonomic intervention needed, ranging from minimal adjustments to immediate changes to improve posture and reduce potential injury risk.

Workload Calculation

Workload or capacity work physique relates with capacity maximum from system physiology in produce energy for work muscle. One burden physics used is Cardiovascular Load (CVL), which is a comparison enhancement pulse Work compared to with pulse pulse maximum. Determination classification burden Work based on enhancement pulse Work compared to with pulse stated maximum in burden cardiovascular (%CVL) (Hakiim et al., 2018). Pulse Rate: Measurement of pulse pulse during work is something method for evaluating cardiovascular strains. One piece of equipment that can used for counting pulse pulse is telemetry with the use stimulation Electro Cardio Graph (ECG). If equipment the not available, then one can note manually put on a stopwatch with 10 pulse method. The method that can calculate pulse work is as follows**:**

$$\text{Pulse (P)} \left(\frac{pulse}{minute}\right) = \frac{10\,pulse}{minute} x60\ second$$

$$\text{Resting Pulse (RP)} \frac{10\,pulse}{8{,}1}\ x\ 60\ second = 74{,}07$$

$$\text{Working Pulse (WP)} \frac{10\,pulse}{6{,}97}\ x\ 60\ second = 86{,}08$$

$$\%\text{CVL} = \frac{100\ x\ (working\ pulse - resting\ pulse)}{(maximum\ heart\ rate - resting\ pulse)}$$

Description:

Man: Pulse maximum = 220 – age

Woman: Pulse maximum = 200 – age

Is known worker is 36 years old, so the max DN is 184. Following results of the calculation.

$$\%\text{CVL} = \frac{100\ x\ (working\ pulse - resting\ pulse)}{(maximum\ heart\ rate - resting\ pulse)} = \frac{100\ x\ (86{,}08 - 74{,}07)}{184 - 74{,}07} = \frac{1201}{109{,}93} = 10.92\%$$

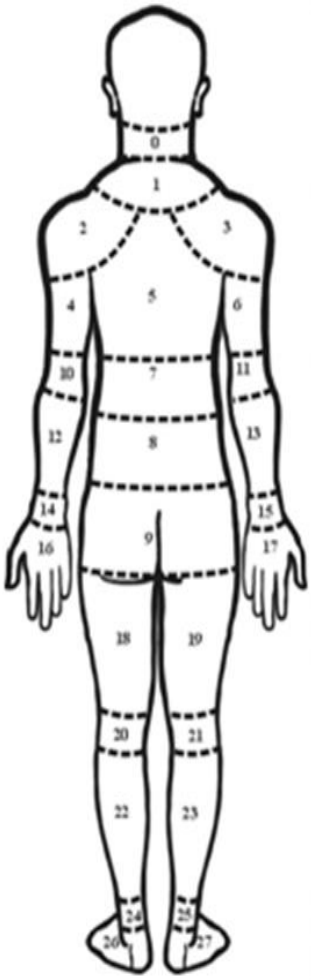
Table 1. CVL Classification

% CVL	Classification
<30%	Didn't happen to fatigue
30% to <60%	Required repair
60% to <80%	Work in time short
80% to < 100%	Required action quick
>100%	Not allowed activity

Source: Data Processed

Based on the results calculation burden Work physique The man is 36 years old, working harvesting categorized as No happen fatigue with CVL percentage 10.92%.

Complaint Musculoskeletal
Nordic Body Map Before Work



NO. URT	JENIS KELUHAN	TINGKAT KELUHAN				
		TS	AS	S	CS	SS
0	Sakit/kaku di leher bagian atas					
1	Sakit/kaku di leher bagian bawah					
2	Sakit/kaku di bahu kiri					
3	Sakit/kaku di bahu kanan					
4	Sakit pada lengan atas kiri					
5	Sakit di pinging					
6	Sakit pada lengan atas kanan					
7	Sakit pada pinggang					
8	Sakit pada bokong					
9	Sakit pada pantat					
10	Sakit pada siku kiri					
11	Sakit pada siku kanan					
12	Sakit pada lengan bawah kiri					
13	Sakit pada lengan bawah kanan					
14	Sakit pada pergelangan tangan kiri					
15	Sakit pada pergelangan tangan kanan					
16	Sakit pada tangan kiri					
17	Sakit pada tangan kanan					
18	Sakit pada paha kiri					
19	Sakit pada paha kanan					
20	Sakit pada lutut kiri					
21	Sakit pada lutut kanan					
22	Sakit pada betis kiri					
23	Sakit pada betis kanan					
24	Sakit pada pergelangan kaki kiri					
25	Sakit pada pergelangan kaki kanan					
26	Sakit pada kaki kiri					
27	Sakit pada kaki kanan					
JUMLAH						

KETERANGAN :

TS = Tidak Sakit
AS = Agak Sakit
S = Sakit
CS = Cukup Sakit
SS = Sangat Sakit

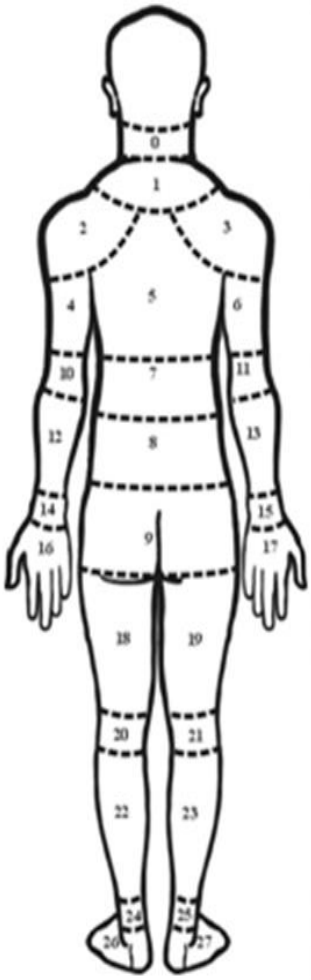


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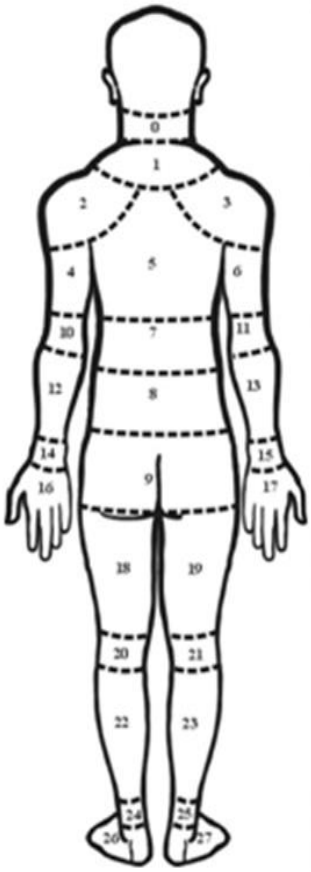
Figure 2. Musculoskeletal Complaints Assessment Sheet Using the Nordic Body Map Method

This figure shows the assessment sheet for musculoskeletal complaints using the Nordic Body Map method. This method is used to identify and measure physical complaints experienced by workers in various body parts due to work activities. Each affected body part is recorded based on the level of pain felt by the worker. Body parts are numbered (NO URT) from 0 to 27, with the "Type of Complaint" column specifying the exact location of complaints, such as the neck, shoulders, back, and legs.

The total number of complaints in each category is calculated to determine the overall level of musculoskeletal pain experienced by the worker. This assessment sheet

helps identify body areas that require greater ergonomic attention to enhance work comfort and productivity while reducing the risk of long-term injuries.

Nordic Body Map After Work



NO. URT	JENIS KELUHAN	TINGKAT KELUHAN				
		TS	AS	S	CS	SS
0	Sakit/kaku di leher bagian atas					
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Figure 3. Musculoskeletal Complaints Assessment Sheet Using the Nordic Body Map Method

To determine the level of musculoskeletal complaints, this paper uses the Nordic Body Map. Then, the results are scored using a predetermined Likert scale with the information not sick with a score of 1, somewhat sick with a score of 2, sick with a score of 3, somewhat sick and very sick with a score of 4 (Dewi, 2020). One oil palm worker filled in the complaints he felt while harvesting palm oil in this work posture. The perceived total score is 36. The following is the Nordic Body Map risk level classification.

Table 2. Classification table risk Nordic Body Map

Likert Scale	Total Score	Individual	Risk Level	Corrective Action
1	28-49		Low	Found yet exist action repair
2	50-70		Currently	Possible required action later day
3	71-90		Tall	Required action quick
4	91-122		Very High	Required action comprehensive as soon as possible

Source: Data Processed

For these palm oil workers, the risk level classification is low, which means that action may be needed in the future. This could be because the work posture is not done every day and at a long frequency. Then, the working posture is also not in a static position for >1 minute, so that the palm oil worker does not experience serious musculoskeletal disorders.

Organization

Palm oil milling is a side job to fill your free time. This palm oil harvesting work is carried out 3 times a week with a working time of 2 to 3 hours. The time for carrying out this harvesting activity is not regulated because it depends on the number of ripe fruit. This causes harvesting to pile up and require more time. There are no information labels yet, such as there are no fire extinguishers available on the land.

Environmental

1. Physical Environment

a. Temperature

Measuring the environmental temperature using a smartphone weather application obtained a temperature of 240 C with 100% humidity. The air temperature on the earth's surface is relative, depending on influencing factors such as the duration of sunlight. This has a direct impact on changes in air temperature. Air temperature varies by place and overtime on the earth's surface. According to location, air temperature varies vertically and horizontally and according to time from hour to hour of the day, and according to the month of the year (Rahim, et al., 2016). The thermal comfort temperature for Indonesians is in the temperature range of 22.8°C - 25.8°C with a humidity of 70% (Talarosha, 2005).

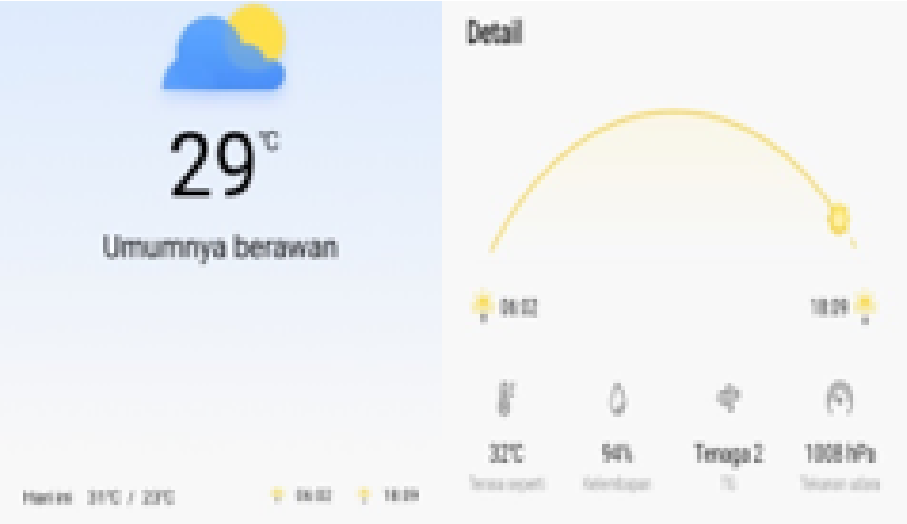

Figure 3. Temperature and Humidity

b. Lighting

Figure 4. Lux Meters

Light is needed by humans to see visual objects. It is with the light reflected by these objects that we can see them. So it will create visual comfort if you get enough lighting. If the lighting is insufficient or excessive, it will interfere with comfortable vision. (Widiyantoro et al., 2017). In this measurement using a smartphone with the Lux Meter application, the result was 3,817 lux.

The basis for determining the law used as a consideration for determining the amount of light intensity based on the type of work is based on the Minister of Labor Regulation No. 7 of 1963 Article 14 concerning the amount of light intensity in the

workplace with criteria according to work activities, one of which is: moderate light category (kiss). A minimum of 100 Lux is required and moderately precise (ksat) lighting requires a minimum of 200 Lux.

c. Noise

Noise is all unwanted sounds originating from production process equipment or work tools which at a certain level can cause hearing problems. Based on PEMENAKER No.13/MEN/X/TAHUN 2011 concerning Threshold Limit Values (NAB) for physical and chemical factors in the workplace, it stipulates that the NAB of noise is 85dBA as the highest intensity and is a value that can still be accepted by workers without causing disease or health problems in daily work for a period not exceeding 8 hours a day or 40 hours a week (Kuswana in Siswati, 2017) (Darlani & Sugiharto, 2017). The results of this noise measurement were carried out with a smartphone using a noise meter application and the results were 25 dB. Below noise standards and does not cause health problems.

Figure 5. Noise Meters

The image shows a noise meter interface labeled "Meter Kebisingan" (Noise Meter). Key elements include:

1) Current Noise Level: Displayed as 25 dB.
2) Range of Noise Levels:
   a) Minimum (MIN): 18 dB
   b) Average (AVG): 29 dB
   c) Maximum (MAX): 60 dB
3) Graph: At the bottom, a graph shows the noise levels over time, ranging from 0 to 100 dB. The fluctuations in the graph indicate varying noise levels over a short period.

This noise meter suggests a generally low to moderate noise environment, with the average level at 29 dB, which is within a relatively quiet range suitable for settings like libraries or quiet offices. The peak at 60 dB indicates occasional louder sounds.

2. Chemical Environment

The chemicals found in plantation land are fertilizers and pesticides. Biological Environment, In the environment around the harvesting area there are snakes, mosquitoes, flies, mice, and grasshoppers. Facilities are available when harvesting tools.

Conclusion

Based on the analysis of the results of palm oil harvesting activities, it can be concluded as follows. 1) Unergonomic harvesting lifting positions can cause unphysiological work positions and attitudes which can cause fatigue when working. 2) Unergonomic harvesting lifting positions can increase workers' musculoskeletal complaints. The conclusion is that some alternatives and improvements can be made to minimize the occurrence of work accidents and work illnesses, namely as follows. 1) Stretching between harvesting activities. 2) Pay attention to the lifting position when working. 3) Provide information labels and fire extinguishers in the harvest area.

The implementation of improvements and attention to ergonomic aspects in oil palm harvesting activities is very important to improve the health and safety of workers. With measures such as regular stretching, correct lifting positions, as well as safety facilities such as information labels and fire extinguishers, it is expected that the risk of musculoskeletal injuries and complaints can be significantly reduced. This not only supports the physical well-being of workers but also contributes to increasing productivity and work efficiency in the long term in the oil palm plantation sector.

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