Analysis of noise level and dust concentration in the disintegration work station

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Abstract. The disintegration work station of UKM that operates in the field of processing coconut fiber into coco fiber press, coco peat, orchid growing media, and noisy and dusty foot mats. The purpose of this study was to determine the level of noise and dust concentration at the disintegration work station of coconut coir SMEs and provide recommendations for improvement. Research on noise levels was carried out using environmental meters four in one. Research on dust concentration was carried out using a highvolume air sampler. The research method used in the measurement of dust concentration using the gravimetric method. The noise level at the disintegration work station is 109.6 dB at measurement point 1; 107.1 dB at measurement point 2; and 108.5 dB at measurement point 3 has exceeded the noise limit set by the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number PER.13/MEN/X/2011 for 8 working hours, which is 85 dB. Noise mapping using surfer 15 software shows that the noise level of the disintegration work station exceeds the threshold value of 3 measurement points. The actual noise exposure time of the worker exceeds the standard exposure time. The actual daily noise dose value exceeds the standard daily noise dose. The level of dust concentration at the disintegration work station is included in the hazardous category based on the Decree of the Head of the Environmental Impact Management Agency No. 107 of 1997.

1. Introduction
Noise is a type of pollution that is based more on the area than other types of pollution, for example water pollution [1]. Noise has a very detrimental effect on human health, so it is necessary to do further research related to noise to understand more about noise and control noise exposure [2]. WHO estimates that in western Europe, every year 61,000 people experience cardiovascular disease caused by noise. In addition, noise decreases quality of life [3]. Noise causes physiological effects such as dizziness, emotional feelings and discomfort, as well as communication disorders [4].

As a result of industrialization in big cities, air pollution and energy consumption has increased [5]. Air pollution is a complex mixture of pollutants such as particles, chemicals, and biological materials. Air pollution can cause negative effects on health, including asthma, chronic obstructive pulmonary disease, lung cancer and cardiovascular disease [6]. Epidemiological studies show an association between daily concentrations of air pollution and poor respiratory health [7]. Air pollution has also become a risk factor that can cause diabetes mellitus [8]. WHO research "Health risks of air pollution in Europe-HRAPIE" was conducted by determining the concentration of dust to determine the impact of air pollution on health [9]. Concentrations of air pollution in India four times exceed the average annual air quality standards (40 μg/m³) and ten times exceed USEPA levels (15 μg/m³) [10]. Air pollution is a major environmental problem in Beijing. During the 9-year observation period, the...
mean PM10 concentration was 138.5 ± 92.9 μg/m$^3$ [11]. PM10 concentrations reached 119.14 μg/m$^3$ in Győr, Hungary [12].

The working environment conditions at the coconut fiber processing plant disintegration work station are noisy and dusty. Workers also have not used the appropriate PPE in carrying out their work. Workers do not use earmuffs or earplugs to reduce noise levels received by workers, and do not use masks to prevent dust from entering the respiratory tract. Workers only use helmets that are not necessary to do the work. Business entities also do not provide personal protective equipment, such as earplugs, earmuffs, or masks for workers.

Based on preliminary research, it was found that the noise level at the disintegration work station was 109.8 dB, which had exceeded the noise limit set by the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number PER.13/MEN/X/2011 Concerning the Threshold Factor Value Physics and Chemical Factors in the Workplace for 8 working hours, which is 85 dB [13].

While the level of dust concentration at the disintegration work station is 368 μg/m$^3$. Based on the Decree of the Head of the Environmental Impact Management Agency No. 107 of 1997 Concerning Calculation and Reporting and Information on Air Pollution Index, dust concentration in the range of 300 μg/m$^3$-more is included in the dangerous category and has a bad impact on the respiratory system of exposed workers [14].

Based on the background above, the researcher is interested in researching about the noise level and dust concentration at the Pusaka Bakti disintegration work station and providing appropriate countermeasures.

2. Research methods
The variables contained in this study are as follows:
1. Independent variables are variables that affect the dependent variable positively or negatively. In this study, the independent variables included noise level (dB) and dust concentration level (μg/m$^3$).
2. The dependent variable is a variable whose value is influenced by other variables. In this study, the dependent variable is the proposed improvement in reducing noise and dust exposure received by workers.

This type of research is a descriptive study. Descriptive research is research conducted to describe systematically, factually, and accurately about the facts and properties of an object to solve problems [15].

Noise measurement points are 3 measurement points, which are determined based on the position of the worker being and spending his work time [16]. The instrument used in measuring noise is a four in one environmental meter. Measurements at the disintegration work station are carried out for 3 days, starting at 07.00-17.00 Western Indonesia Time. Measurements were made for 3 days with 3 measurement points. Each measurement must represent a certain time interval [17], with the following determination:
1. L1 is taken at 09.00 representing the hours of 08.00-10.00
2. L2 is taken at 11.00 representing 10.00-12.00 hours
3. L3 is taken at 14.00 representing 13.00-15.00 hours.
4. L4 is taken at 16.00 representing 15.00-17.00 hours

While in the measurement of dust concentration, the determination of the number of measurement points is based on the source of contaminants. The tool used in measuring dust concentration is the high volume air sampler. Measurements at the disintegration work station are carried out for 3 days, starting at 07.00-17.00 Western Indonesia Time.

The equivalent noise level is calculated by the following equation [18].

$$L_{eq} = 10 \log \left( \sum t_j 10^{L_j/10} \right)$$ (1)
\[ L_{eq} = \text{Equivalent noise level} \]
\[ L_j = \text{Sound pressure level} \]
\[ t_j = \text{Time fraction} \]

The noise dose is calculated by the equation below:

\[ D = \sum C_i T_i \]  
(2)

\[ D = \text{Noise dose (must be \( \leq 1 \))} \]
\[ C_i = \text{Noise exposure time} \]
\[ T_i = \text{Time allowed for a certain noise level} \]

If the noise dose is \( > 1 \), then the condition is very dangerous for the operator's hearing.

While \( T_i \) is calculated using the following equation:

\[ T_i = \frac{8}{2(L_{eq} - 85)/3} \]  
(3)

\[ T_i = \text{Maximum exposure time per day permitted (hours)} \]
\[ L_{eq} = \text{Noise level (dB)} \]
\[ 8 = \text{Number of work hours per day permitted 85 dB} \]
\[ 3 = \text{Exchange rate} \]

For the calculation of the concentration of dust in air \([C]\) it can be calculated using the following equation [19]:

\[ [C] = \frac{M_t - M_0}{T \cdot V} \text{ (µg/m}^3\text{)} \]  
(4)

\([C]\) = Dust concentration (µg/m\(^3\))
\[ M_t = \text{Filter weight after sampling (µg)} \]
\[ M_0 = \text{Filter weight before sampling (µg)} \]
\[ T = \text{Length of sampling (hours)} \]
\[ V = \text{Air sampling rate (m}^3\text{/hour)} \]

3. Results and discussion

3.1. Equivalent noise level calculation (Leq)

The recapitulation of Leq calculation at point 1 to 3 can be seen in Table 1:

| Measurement Time | Leq Value at Point 1 | Leq Value at Point 2 | Leq Value at Point 3 |
|------------------|----------------------|----------------------|----------------------|
| L1               | 107.7                | 104.3                | 106.3                |
| L2               | 109.5                | 106.4                | 108.2                |
| L3               | 112.7                | 109.6                | 111.2                |
| L4               | 108.1                | 105.5                | 107.1                |

Based on the table above, the Leq value at each measurement point with the highest yield is the measurement point 1 at the L3 measurement time, which is 112.7 dB. While the Leq value at each measurement point with the lowest result is the measurement point 2 at L1 time is 104.3.

The equivalent noise level graph (Leq) can be seen in Figure 1.
Based on Figure 1, it can be seen that the $L_{eq}$ value exceeds the threshold value based on the Decree of the State Minister for the Environment Number: KEP-48/MENLH/11/1996 which is 85 dB for 8 working hours/day.

3.2. Noise level calculation ($L_s$)
The recapitulation of $L_s$ calculation at point 1 to 3 can be seen in Table 2:

| Point | $L_s$ |
|-------|-------|
| 1     | 109.6 |
| 2     | 107.1 |
| 3     | 108.5 |

Based on the table above, the noise level ($L_s$) with the highest yield is measurement point 1 which is 109.6 dB. While the results of the measurement of noise level ($L_s$) with the lowest results are the measurement point 2 at L1 time which is 107.1 dB. The noise level graph ($L_s$) can be seen in Figure 2.

Based on Figure 2, the noise level value ($L_s$) at the disintegration work station has exceeded the standards stipulated by the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number PER.13/MEN/X/2011 Concerning Threshold Values of Physical Factors and Chemical Factors in the Workplace for 8 working hours, which is 85 dB.

3.3. Noise mapping
Description of the direction/pattern of the spread of noise at the disintegration work station can be done by making a noise map using noise surfer 15. The number of noise measurement points taken is 3 points. The following are the coordinates of the noise mapping disintegration work station.

Based on Figure 2, the noise level value ($L_s$) at the disintegration work station has exceeded the standards stipulated by the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number PER.13/MEN/X/2011 Concerning Threshold Values of Physical Factors and Chemical Factors in the Workplace for 8 working hours, which is 85 dB.
Table 3. Noise measurement coordinate point.

| No | X (m) | Y (m) | $L_s$ (dB) |
|----|-------|-------|------------|
| 1  | 3     | 1.5   | 109.6      |
| 2  | 4.2   | 2.5   | 107.1      |
| 3  | 3     | 3.2   | 108.5      |

Noise mapping at the disintegration work station using surfer software 15. Surfer software is a grid-based mapping program that interpolates XYZ data that is placed irregularly into grids that are spaced regularly [20].

Based on Figure 3, it can be seen as a whole that the work area noise level at the disintegration work station exceeds the threshold value based on the Decree of the Minister of Manpower and Transmigration of the Republic of Indonesia No.Per.13/MEN/X/2011 which is 85 dB for 8 working hours/day.

3.4. Maximum allowable exposure time

Maximum permissible exposure time at measurement point 1 is 0.49 hours. The maximum exposure time allowed for each measurement point can be seen in Table 4.

Table 4. Maximum allowable exposure time.

| Point of Measurement | $T_i$ (Hour) |
|----------------------|--------------|
| 1                    | 0.49         |
| 2                    | 0.70         |
| 3                    | 0.51         |

Based on the table above, maximum permissible exposure time with the highest value is at measurement point 2, which is 0.70 hours. The graph of maximum permissible exposure time at each measurement point is shown in Figure 4. Based on this figure, the actual noise exposure time is greater than maximum permissible exposure time. Where the actual noise exposure time is 8 hours per day, while maximum permissible exposure time is 0.49-0.70 hours per day.
3.5. Daily noise dose
Following are the results of the Daily Noise Dose calculation for each worker at the disintegration work station in Table 5.

| Point of Measurement | Daily Noise Dose |
|----------------------|------------------|
| 1                    | 1,777.78%        |
| 2                    | 1,142.86%        |
| 3                    | 1,568.63%        |

Table 5 shows the daily noise dose at each measurement point with the highest value at measurement point 1, which is 1,777.78%. While the daily noise dose at each measurement point with the lowest value is at measurement point 2, which is 1,142.86%. The actual daily noise dose graph and the standard daily noise dose graph can be seen in Figure 5.

According to NIOSH the criteria for a safe dose is no more than 100% whereas based on the graph above, the daily noise dose has exceeded the limit set by NIOSH, which is 1,142.86% - 1,777.78%.

3.6. Dust concentration measurement results
The results of measurements of dust concentrations at points 1 and 2 with the gravimetric method can be seen in Table 6.
Table 6. Dust concentration at each measurement point.

| Point of Measurement | Dust Concentration (µg/m³) | Day 1 | Day 2 | Day 3 |
|----------------------|-----------------------------|-------|-------|-------|
| 1                    |                             | 383   | 380   | 382   |
| 2                    |                             | 376   | 372   | 375   |

Based on Table 6, it was found that the dust concentration on the first day at point 1 was 383 µg/m³ and 376 µg/m³ at point 2. On the second day, dust concentration of 380 µg/m³ at point 1 and 372 µg/m³ was obtained at point 2. On the third day, a dust concentration of 382 µg/m³ was obtained at point 1 and 375 µg/m³ at point 2. The measurement results were then adjusted to the air pollutant index limit standards according to the Decree of the Environmental Impact Management Agency No. 107 of 1997 concerning Calculations and Reporting and Information on Air Pollution Standards Index. There are four categories of air pollutant index, namely good, moderate, unhealthy, very unhealthy, and dangerous. Air pollutant index limit according to the Decree of the Environmental Impact Management Agency No. 107 of 1997 concerning Calculations and Reporting and Information on Air Pollution Standards Index can be seen in Table 7.

Table 7. Air pollution index limits.

| Category        | Range (µg/m³) | Particulate                                      |
|-----------------|---------------|-------------------------------------------------|
| Good            | 0-50          | No effect                                       |
| Average         | 51-100        | There was a decrease in visibility              |
| Unhealthy       | 101-199       | Visibility goes down and dust is everywhere     |
| Very Unhealthy  | 200-299       | Increased sensitivity in patients with asthma and bronchitis |
| Dangerous       | 300-lebih     | A dangerous level for all exposed populations    |

Based on Table 7, dust concentration in the range of 0-50 µg/m³ is in the good category and there are no negative effects. Dust concentrations in the range 51-100 µg/m³ are in the moderate category and cause a decrease in visibility. Dust concentrations in the range 101-199 µg/m³ are in the unhealthy category and cause a decrease in visibility and dust contamination occurs everywhere. Dust concentrations in the range 200-299 µg/m³ are in the very unhealthy category and cause increased sensitivity in patients with asthma and bronchitis. Dust concentrations in the range of 300 µg/m³-more are in the hazardous category and their effects are dangerous for all exposed populations. The graph of actual dust concentration and standard dust concentration is shown in Figure 6.
Based on Figure 6, the actual dust concentration is higher than the standard dust concentration. Dust concentration at the disintegration work station is 372-383 µg/m$^3$, so the dust concentration is included in the dangerous category. This can be dangerous for the breathing of all exposed workers.

3.7. Noise Reduction

The way to overcome the noise is by engineering control and the use of personal protective equipment (PPE). Engineering control is carried out by applying lubricants every week to reduce friction in engine parts and mounting bumpers to reduce vibration. The bumper material used is made of anti-vibration rubber. The bumper is mounted on the bottom of the engine foot, which can be installed in two ways. The first method is to be planted below the surface of the land, while the second method is to be planted below the surface. Noise reduction by bumper installation is shown in Figure 7.

Another control that can be done to control noise is the use of personal protective equipment (PPE). Personal protective equipment (PPE) is useful for reducing the level and frequency of noise received by the ear. PPE that can be used is earmuff. Earmuffs are better than earplugs, because in addition to blocking sound barriers through the air, they also inhibit delivery through the throat bone. This earmuff can reduce the noise intensity by 30 dB to 40 dB.

Earmuffs are protective gloves consisting of 1 (one) set of cups designed to cover both ears worn neatly on the head by a headband. The cup may be made of plastic or rubber and cover the ears without pressing it. And at the same time it closes properly in the head and very little sound can enter.

The requirements that must be met by earmuffs are:

a. Its effectiveness has been tested by an authorized body to carry out the test
b. Ear protection equipment must be adapted to each individual workforce
c. Maintenance and how to use ear protection devices must be known to the relevant workforce (socialization)
d. The protective equipment used must be checked at certain times to ensure that the condition is still well used.

![Earmuff](image)

**Figure 8.** Earmuff.

### 3.8. Dust Reduction

Countermeasures that can be done to reduce dust exposure to workers are through engineering control and the use of PPE. Engineering control is carried out by designing machines by adding conveyor and coco fiber storage tanks.

![Front engine design](image)

**Figure 9.** Front engine design.

Meanwhile, the design of the rear engine is shown in Figure 9.

![Rear engine design](image)

**Figure 10.** Rear engine design.

Control with the use of PPE is the use of masks. Wearing a mask made specifically for breathing called the N95 Respirator will be better because it is designed to fit the face and is equipped with a very efficient tool to filter out harmful particles in the air, even particles with a small size. A breathing mask that can be used for example is 3M 8210 N95 Respirator.

![N95 respirator](image)

**Figure 11.** N95 respirator.

Disposable masks can be used to prevent dust from entering the respiratory tract. Disposable masks that can be used for example are the Sensi brand with a unit price of IDR 890. This type of mask has a lower price so that it can be taken into consideration to reduce dust exposure in UD disintegration work station workers. Puska Bakti.
4. Conclusion

The conclusions obtained based on the results of the analysis and discussion that have been carried out are as follows:

1. The equivalent station noise level at measurement point 1 is 107.7 dB for L1; 109.5 dB for L2; 112.7 dB for L3; and 108.1 dB for L4. Whereas for measurement point 2, the noise level obtained was 104.3 dB for L1; 106.4 dB for L2; 109.6 dB for L3; and 105.5 dB for L4. And for measurement point 3, the noise level obtained is 106.3 dB for L1; 108.2 dB for L2; 111.2 dB for L3; and 107.1 dB for L4.

2. The noise level at the disintegration work station is 109.6 dB at measurement point 1; 107.1 dB at measurement point 2; and 108.5 dB at measurement point 3 has exceeded the noise limit set by the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number PER.13/MEN/X/2011 Concerning the Threshold Value of Physical and Chemical Factors in the Workplace for 8 hours of work, which is 85 dB.

3. Noise mapping using surfer 15 software shows that the disintegration work station noise level exceeds the threshold value of 3 measurement points.

4. The level of dust concentration at the disintegration work station on the first day at point 1 is 383 μg/m³ and 376 μg/m³ at point 2. On the second day it is 380 μg/m³ at point 1 and 372 μg/m³ at point 2. Based on Decree of the Head of the Environmental Impact Management Agency No. 107 of 1997 concerning Calculations and Reporting and Information on Air Pollution Standards Index included in the dangerous category, namely in the range of 300-plus.

5. Proposed countermeasures for reducing noise are through engineering control and the use of PPE. Engineering control is carried out by applying lubricants every week to reduce friction in engine parts and mounting bumpers to reduce vibration. The use of PPE is the use of ear muffs. Proposed countermeasures to reduce dust concentration with engineering control and the use of PPE. Engineering control is carried out by designing machines by adding conveyor and coco fiber storage tanks. Use of PPE with the use of an N95 Respirator mask or disposable mask.

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