Mapping of noise levels made by drilling machines on project x using contour zone method

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Abstract. Project x is an apartment development activities in Tangerang which in the process of construction resulted in the occurrence of noise. Noise is one of the incidents that can lead to health problems for the surrounding community. Therefore, this research aims to know the spread of noise, the amount of noise reduction that can be reduced by using a hearing protective device and workers’ perceptions of noise against hearing loss. The method used is the contour zone. Data used is the result of noise measurement Project x in the daytime and nighttime conditions. The result obtained is the noise level in the project work area during the daytime in area 1, 2 and 3 with a distance of 2 meters are 97.1 dB, 94.4 dB, 93.9 dB, and length of 4 meters are 94.4 dB, 91.5 dB, 93.0 dB and night measurements at a distance of 2 meters are 102.2 dB, 100.1 dB, 96.5 dB, and length of 4 meters are 94.7 dB, 94.7 dB, 97.4 dB. The calculation of day and night above exceeds the noise threshold value set by the Ministry of Labor which is 85 dB. The perception of the worker with the noise disturbances that occur at The Yukata Project. Using hearing protection devices will reduce the noises, but at nighttime conditions in areas 1 and 2 at a distance of 4 meters, the noise level still exceeds the noise threshold value which has been determined by the ministry of labor. Keywords: Likert, Noise, Mapping, Contour Zone.

1. Introduction
In this part, the research background, and literature review will be shown.

1.1 Research background
The current state of basic human needs especially in living areas experiencing an increase, this can be seen from the increasing number of apartment buildings. One of the developing residential projects is the x project, which produces a lot of noise in its construction process.

Noise is all unwanted sounds that are sourced from the tools of the production process and or work tools that are at a certain point can cause hearing loss [5]. Noise is one type of pollution that needs to be considered at this time because it has a direct impact on the level of comfort and human health. The impact of the noise itself varies, namely hearing loss, health problems such as psychological disorders, physiological disorders, and balance disorders [5]. The damaging effects that often occur if a person is exposed to noise for too long are the effect of hearing, but using the personal protective equipment provided by the company can be attempted.
In 2012, Waskita Realty was established and used as a division of PT. Waskita Karya (Persero), Tbk. This company focuses on providing reliable services in the property sector in Indonesia. In 2017, Waskita Realty in collaboration with Trinity Group is in the process of constructing project x. The construction process of this project resulted in the creation of a noise due to the collision between a mini crane pile drilling machine and building material from the construction of the Yukata apartment.

An effort to control noise in the project work and housing environment to be more effective, it is necessary to measure noise levels using noise mapping or contour maps to determine the pattern of noise distribution that occurs in the project work and housing environment. To create a noise contour map due to the activity can use a software called Surfer. It is also necessary to analyze the workers’ perceptions of the noise to hearing loss whether it is influential or not, using a Likert scale in processing questionnaire data and calculating the value of noise reduction that can be dimmed by the hearing protection devices used by workers.

1.2 Literature Review

1.2.1. Effects of Noise on Health. Noise is an event that can cause a variety of health problems, such as physiological disorders, psychological disorders, communication disorders and hearing loss (deafness) [6].

The most common effects of noise on worker health are effects on hearing, the main effect of noise on health is damage to the sense of hearing, which can cause temporary or permanent deafness.

1.2.2. Noise Measurement Method. Based on the Decree of the Ministry of Environment No: KEP-48/MenLH/11/1996, Regarding the Noise Standard Level, 25 November 1996. The calculation of noise level can be done in two ways [4], as follows:

1. Simple Way
   - With a sound level meter, the dB sound pressure level is measured for 10 minutes for each measurement and readings are done every 5 seconds.
2. Direct Way
   - With an integrating sound level meter that has a measuring facility of $L_m$, which is $Leq$ with a measuring time of every 5 seconds, it is measured for 10 minutes.

1.2.3. Noise Level Calculation. Here are some ways to calculate the noise standard level according to the ministry of environment No:Kep-48/MenLH/11/1996 [4], as follows:

1. Noise level during the daytime ($L_d$). The level of noise that occurs during the day with a sound pressure level for 16 hours between 06.00 - 22.00. Daytime noise levels can be denoted by the symbol $L_s$. Can be formulated as follows:

$$Leq_{\text{daytime}} = L_d = 10 \log \frac{1}{t_i} \left( \sum l_i \cdot 10^{0.1L_i} \right) dB$$

$L_d$ is daytime noise level (dB), $t_i$ is measurement time interval, and $l_i$ is Leq averages at a certain time interval.

2. Noise Level at Night ($L_n$). The level of noise that occurs at night with the sound pressure level for 8 hours between 22.00 - 06.00 with a minimum of data collection for 3 measurements with a certain frequency range. Can be formulated as follows:

$$Leq_{\text{nighttime}} = L_n = 10 \log \frac{1}{t_i} \left( \sum l_i \cdot 10^{0.1L_i} \right) dB$$

$L_n$ is night noise level (dB), $t_i$ is interval of measurement, and $l_i$ is Leq averages at a certain time interval.

3. Noise Levels During Day and Night ($L_{\text{sum}}$). Daytime to nighttime noise levels is used to find out whether noise has exceeded the noise level from field measurements or not. Can be formulated as follows:
\[ L_{sn} = 10 \log \{ 16.10^{L_o/10} + 6.10^{(L_m+5)/10} \} \text{dB} \]  
(3)

\( L_{sn} \) is value of noise level during day and night, \( L_o \) is value of noise level during daytime, and \( L_m \) is value of noise level during the night.

1.2.4. Hearing Protection Equipment for Noise. The using of hearing protection equipment for noise is something that must be done, especially for a worker who is exposed to more than 85 dB per day. Personal protective equipment used must be able to reduce noise to less than 85 dB. There are three types of hearing protection devices [4], namely:

1. Earplugs: can reduce noise 8 - 30 dB, usually used for protection up to 100 dB.
2. Earmuff: can reduce noise from 25 to 40 dB, used for protection up to 110 dB.
3. Helmet: can reduce noise 40 - 50 dB.

1.2.5. Threshold Value and Noise Zone. Threshold Value The noise limit permitted by the Ministry of Manpower is 85 dB because it is considered safe for most workers when working 8 hours/day or 40 hours/week.

Each noise has an area that is divided according to the noise points that are permitted by the Ministry of Environment as regulated in KEP-48/MENLH/11/1996 [4], namely:

1. Zone A: Intensity 35 - 45 dB.
   Zones designated for research sites, health / social care places.
2. Zone B: Intensity 45 - 55 dB.
   Zones designated for housing and public settlements, schools, and places of worship.
3. Zone C: Intensity 55-65 dB.
   Zones designated for offices, cultural heritage, public facilities, and markets.
4. Zone D: intensity 65 - 75 dB.
   Zones designated for industries, recreation areas, terminals, and factories.
5. Other zones (transportation): An intensity of more than 75 dB. Zones adapted to the Ministry of Transportation such as railway stations, seaports, and airports.

1.2.6. Noise Measuring Tool. Sound Level Meter is a device used for measuring a sound intensity, sound level meters used to measure sound intensity levels can use sound sources and used to measure sound levels in decibels (dB) [3]. Measurements using sound level meters are usually used in the study of noise pollution for noise quantification, but especially for industry, environment and aircraft noise.

1.2.7. Surfer Software. A surfer is one of the software used for making contour maps and three-dimensional modeling, surfer does not require high hardware or operating systems. Therefore, surfers are comparatively easy in their applications. Surfer can be used on Windows 9x and Windows NT operating systems. Provide convenience in loading various types of contour maps or 3-dimensional (3D) spatial models [2].

1.2.8. Likert scale. Likert scale is a scale that can be used to measure attitudes, opinions, and perceptions of a person or group of people about a phenomenon or phenomenon of education [1]. With a Likert scale, the variables to be measured are translated into variable indicators.

The indicators used for questions/statements are strongly agreed (5), agree (4), quite agree (3), disagree (2), strongly disagree (1). In determining the total score of each statement using the following formula [1].

\[ T \times Pn \]  
(4)

T is total number of respondents who choose, and Pn is choice of Likert score.
1.2.9. Noise Reduction Rate. Noise Reduction Rate is a measure of the ability of a hearing protector to reduce noise levels [7]. The following are the calculation methods used to calculate NRR according to The United States Occupational Safety and Health Administration (OSHA) [7], namely:

1. Single Use

Single-use is the use of one ear protector only, can use earplugs or earmuffs. The following formula is used:

\[
NRR_{\text{actual}} = (NRR_{\text{label}} - 7) \times 50\%
\]

\(NRR_{\text{actual}}\) is actual noise reduction level, \(NRR_{\text{label}}\) is the level of noise reduction seen on the packaging tool label, value of 7dB is determination of noise reduction using hearing protection devices by the National Institute for Occupational Safety and Health (NIOSH), and 50% is average safety provisions used based on the National Institute for Occupational Safety and Health (NIOSH) methods.

2. Methods

The method used in this study is divided into 3 stages, namely:

1. Perform noise mapping, the steps are:
   a. Calculate noise equivalent during the daytime (\(L_d\)). Calculates nighttime equivalent noise (\(L_n\)) and calculates noise day-night equivalent (\(L_{dn}\)). The data used is noise level measurement data.
   b. Performing noise mapping with the contour zone method using Surfer 15.0 to determine the spread of noise that occurs. The data used is the result of the calculation of the equivalent noise level.

2. Analyzing worker perceptions of hearing loss due to noise with the following steps:
   a. Distributing questionnaires.
   b. Analyze worker perceptions using a Likert scale.

3. Calculating the value of noise reduction from the hearing protection equipment used by workers.

3. Result and Discussion

3.1. Noise Mapping

After calculating noise level data, the data is then processed by the surfer for noise/contour noise mapping. The results of the pattern of noise distribution are as follows.
Based on the result in **Figure 1** in the project work area 1, the noise threshold value is 85 dB. All areas in the countor map are red which means the noise value is more than 85 dB. Region 1 has a maximum average noise intensity of 106 dB and a minimum of 88 dB. So, workers are required to use hearing protection equipment.

Based on the result in **Figure 2** in the project work area 2, it is obtained to exceed the noise threshold value of 85 dB. All areas in the countor map are red which means the noise value is more
than 85 dB, region 2 has a maximum average noise intensity of 106 dB and a minimum of 88 dB. So, workers are required to use hearing protection equipment.

![Work Area Contour Map](image)

**Figure 3. Work Area Contour Map 3**

Based on the result in Figure 3 in the project work area 3, it is obtained to exceed the noise threshold value of 85 dB. All areas in the contour map are red which means the noise value is more than 85 dB, region 3 has a maximum average noise intensity of 99 dB and a minimum of 87 dB. So, workers are required to use hearing protection equipment.

![Residential Area Contour Map](image)

**Figure 4. Residential Area Contour Map 1**

Based on the result in Figure 4 in the housing area 1 was obtained, exceeding the noise threshold value of 55 dB for the housing zone. All areas in the contour map are red which means the noise value is more than 55 dB. Area 1 has a maximum average noise intensity of 70.5 dB and a minimum of 66.5 dB.
Based on the result in Figure 5 in the housing area 2 was obtained, exceeding the noise threshold value of 55 dB for the housing zone. All areas in the contour map are red which means the noise value is more than 55 dB, region 2 has a maximum average noise intensity of 71.5 dB and a minimum of 69.5 dB.

3.2. Noise Reduction Rate
To reduce the level of noise that occurs, the actual noise reduction level of the hearing protection equipment used by workers is carried out. Hearing equipment (earplug and earmuff) used by workers has the same Noise Reduction Rating (NRR) is 33 dB. So, the results after using the formula (5) the results of NRR actual is 13 dB.

3.3. Workers’ Perceptions of Noise against Hearing Loss
Analyze worker perceptions about noise against hearing loss with the following steps:

a. Conducting questionnaires.
   Questionnaires were distributed to workers aged between 25-40 years, male sex and previously worked in a place that has a noise of 1-year duration. From this limit, 12 respondents were obtained.

b. Calculate the questionnaire using a Likert scale.
   1. Calculate Likert total score.
      The score parameter used to calculate the resulting value is strongly agree (5 point), agree (4 point), quite agree (3 point), disagree (2 point) and strongly disagree (1 point). The result of likert total score by using the formula (4) is question 1 36 points, question 2 40 points, question 3 is 36 points, question 4 is 37 and question 5 is 44 points.
   2. Determine the highest score (Y) and the lowest score (X).
      \[ Y = \text{the highest score of likert} \times \text{number of respondents} \]
      \[ Y = 5 \times 12 = 60 \]
      \[ X = \text{lowest score} \times \text{number of respondents} \]
      \[ X = 1 \times 12 = 12 \]
   3. Determine the interpretation of Likert scores with intervals.
      \[ I = \frac{100}{\text{score value (likert)}} \]
      \[ I = \frac{100}{5} = 20 \]
      The distance interval from the lowest 0% to the highest 100% is 20. The following are the interpretation criteria based on the interval:
4. Calculate the index (%) of each question.

\[
\text{Index} \% = \left( \frac{\text{Total Score}}{\text{Y}} \right) \times 100
\]

- a. **Question 1**, Index = \((36/60) \times 100 = 60\% = \text{Agree}
- b. **Question 2**, Index = \((40/60) \times 100 = 66.67\% = \text{Agree}
- c. **Question 3**, Index = \((36/60) \times 100 = 60\% = \text{Agree}
- d. **Question 4**, Index = \((37/60) \times 100 = 61.67\% = \text{Agree}
- e. **Question 5**, Index = \((44/60) \times 100 = 73.33\% = \text{Agree}

5. Average index calculation for all questions :

\[
X = \frac{\sum Xi}{n}
\]

\[
X = (\sum 321.67\%) / 5 = 64.3\% 
\]

Based on the index value obtained from the calculation of all questions into the score interpretation of 64.3%, it can be concluded that the workers feel disturbed by the noise that occurs in the Yukata Project.

4. Conclusions

Based on the results and discussion, the following conclusions are obtained:

1. From the results of contour noise mapping, noise distribution patterns that occur in the construction of project \(x\) in area 1, 2 and 3 on project’s area with a distance of 2 meters during day time the noise level that occurs in the area exceeds the noise threshold value there are 97.1 dB; 94.4 dB and 93.9 dB and at a distance of 4 meters the noise level are 94.4 dB; 91.5 dB and 93.0 dB. While at night time measurements in area 1, 2 and 3 with a distance of 2 meters, the noise level that occurs in the area exceeds the noise threshold value are 102.2 dB; 100.1 dB and 96.5 dB and at a distance of 4 meters the noise level are 94.7 dB; 94.7 dB and 97.4 dB.

2. Workers' perceptions of noise disturbances that occur at agreed intervals, workers feel disturbed by the noise that occurs at the project \(x\).

3. The value of reduction of the hearing protection device used by workers, either earplug or earmuff during daytime conditions at a distance of 2 meters and 4 meters in area 1, 2 and 3 is 13 dB, the same thing is also obtained at night conditions.

5. References

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