Measurement and Evaluation of Sound Intensity at The Medan Railway Station Using a Sound Level Meter

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Abstract. Trains are means of transportation that are used by people to avoid traffic congestion. However, train stations are also most frequently exposed to noise. This is due to the sound intensity of the operational activities in the location. Passengers and station officers are environmental components exposed to noise. In this study, the value of sound intensity level at the railway station of Medan city is measured using Sound Level Meter. This measurement was carried out for six days. The highest sound intensity level for the train departure is 96.67 and for the train arrival is 96.66. Meanwhile, the lowest sound intensity level of train departures is 81.41 and the arrival of trains is 83.75. It was found that the high level of sound intensity is sourced from the friction of the wheels with the rail surface, notification speakers and train horns. The results of this study can be used to find the most appropriate solution to reduce the noise level in the railway station area.

1. Introduction

Sound is a mechanical wave that propagates. Sounds are generated through vibrating objects or substances such as the sound of train engines. The sound is potentially noise when it is disturbing the human surrounding, which happens with high sound intensity. Noise can interfere with community activities and can be an environmental problem in urban areas [1]. In addition, it can interfere with the quality of life and health [2]. This is because a sound pressure level greater than the value of the hearing threshold can damage hearing. The train station is one of the most frequent places exposed to noise. The sound source at the train station comes from the operational activities at the location. The impact of this noise reduces the comfort of passengers who will use rail transportation services.

As for the control done so that the results obtained are effective, it is necessary to identify in the station area the level of noise (intensity) received by employees and passengers. Based on decree of the Minister of Manpower, number: KEP-51/MEN/1999, on the value of the noise threshold in the workplace [3], especially at the railway station has been set a maximum limit of 70 dBA. The value of the noise threshold in the workplace is the highest intensity and is the average value that can still be received by the workforce without causing a steady loss of hearing, for continuous uptime.

To find the right solution in resolving the noise problem at the railway station, the noise intensity measurement in the area is done. Measurements are performed using a Sound Level Meter. Sound level meter (SLM) is an instrument for measuring the sound pressure level [4]. This tool can be used as a noise level gauge that can cause pain in the ears. The aviation industry area is one of the working environments that use the tool. With the results obtained from this instrument, it can indicate when the noise intensity level increases beyond the threshold value in the railway station area. Factors that most influence the noise level in railway stations can also be known from the results.
2. Sound

The sound is a form of response from the ear as the sound waves cause the ear membrane to roll. The waves including the longitudinal waves propagate in the air. The sound waves come from vibrating objects [5]. Sounds can be used by humans to search for an object [6]. In general, the human ear has sensitivity to sound with a frequency of 20-20,000 Hz. In addition, there is a range of frequencies below 20 Hz, called infra-sounic (infra-sōl) and above 20,000 Hz is called an ultra sounic sound.

The sound has four main elements: Sound source, receiver, media and sound Wave (Soundwave). At the train station, one of the sound sources is the railroad. The railroad consists of two components: the structure of the upper (superstructure) and the lower structure (substruc
ture). Friction between the wheels with the top of the rails raises sound. The sound generated by people in the station is heard. This is because the waves of sound produced will propagate through the air media [5]. So this wave reached the ears of the people who were at the station.

2.1. Sound intensity

The human ear is always aware of the frequency of the sound is very wide even though the frequency is very small. The weakest sound has a maximum frequency of 103 Hz, with a displacement amplitude of approximately 10^{-9} cm. If viewed from this variation, the human ear is a very sensitive organ. Thus, the receiver may feel disturbed. Excessive noise intensity can result in hearing loss. This condition requires a set of less than 15 dB [7].

![Figure 1. Diagram of the sound source is radiating energy](image)

The intensity of the noise in a specific direction at a point is the rate of the average sound energy. This energy is transmitted in the passing direction of one unit that is perpendicular to the direction being passed. In other words, the sound intensity level equals the sound frequency level. The intensity of the propagation of the wave is the average amount of the sound power divided by the surface area perpendicular to the direction of the propagation. Thus, the intensity of the noise can be formulated into:

\[ I = \frac{P}{A} \]  

Where \( P \) is a sound power (watt) and \( A \) broad field (m²). The sound energy is transmitted to the source in every direction as large, so the area reached is equal to the surface area of the sphere. So that equation 1 can be written as:

\[ I = \frac{P}{4\pi r^2} \]  

As for the sound intensity, values can be calculated using the equation below:

\[ \beta = 10 \log \frac{I}{I_0} \]
On a closed surface, the average sound energy flow from the sound source is equal to the sound force from the source [8]. In other words,

\[ \int_S l \, ds = 0. \]  \hfill (4)

2.2. Noise

Noise levels can be reviewed from several aspects. Sound source is one of those aspects. The noise level reviewed from the sound source can be seen in Table 1 [9].

| Sound source                              | Intensity (dB) |
|-------------------------------------------|----------------|
| Riveter                                   | 95             |
| Elevated train                            | 90             |
| Highways (crowded vehicles)               | 70             |
| Regular conversations                     | 65             |
| Ordinary sound radio in the house         | 40             |

If the noise level exceeds the threshold, it will negatively impact the environment (human) around it. Noise occurs in the train station one of the cases that can interfere with and harm human health. This noise can lead to Auditory Effect or Non-Auditory Effect [10], in the sense of hearing loss. In general there are some effects of noise on health, [10] among others deafness, heart attack, increase in cholesterol, high blood pressure, hyper tension, causes emotional disturbance and constriction of blood vessels.

Noise problems are becoming a globalised problem. Indonesia is one of the countries experiencing this problem. In Indonesia, Government makes regulations related to noise level. In Decree of the Minister of Environment No. 48 year 1996 about the raw noise level [11], in explaining raw noise level for some places. It can be seen as shown in Table 2 as follows.

| Area Allocation/Environment                        | Noise level (dB) |
|-----------------------------------------------------|------------------|
| A. Area Allocation                                  |                  |
| 1. Housing and settlements                          | 55               |
| 2. Trade and services                               | 70               |
| 3. Office and Trade                                 | 65               |
| 4. Open Space Green                                 | 50               |
| 5. Industry                                         | 70               |
| 6. Government and public facilities                 | 60               |
| 7. Recreation                                       | 70               |
| 8. Special :                                        |                  |
| - Port                                              | 70               |
| - Cultural heritage                                 | 60               |
| B. Environment                                      |                  |
| 1. Hospitals or similar                             | 55               |
| 2. School or similar                                | 55               |
| 3. Places of worship or similar                     | 55               |
2.3. Noise measuring instrument
There are several types of tools to measure noise level. Such as the Sound Level Meter, ISLM and noise dosimeter. In this case, the measuring instrument used is the Sound Level Meter, which SLM can determine the level of noise in various environments in an effort to reduce the risk of hearing loss caused by noise [4].

![Sound Level Meter (SLM)](image)

SLM has its own ability. This tool is capable of measuring noise levels starting from 26 dB (A). In addition, the functions of this tool can reach 99 notes, as well as 6 customized measurement ranges. This tool is dimensional 264 x 68 x 27 mm and weighs 260 gr. In addition, the Sound Level Meter has three main parts. These parts are microphones, electronic circuits and a reader display. Microphones function to detect sound variations and convert them into electrical signals. This electrical signal will be processed by electronic circuits in the instrument. The result of the process on the electronic circuit will be shown in the reader display which is the result of measurement. Sound Level Meter is also used for the evaluation and treatment of Parkinson's disease [4].

3. Methodology
The Medan City railway station was chosen to be the location for this noise level measurement. Before conducting direct measurements in the field, secondary data collection from the threshold data value of the KepMen LH RI No. 48 year 1996 and PermenKes RI number 718 year 1987 were carried out [12]. In addition, an interview with the Medan City Railway machinist was obtained to determine the speed of trains, departure and arrival schedules, as well as the schedule of notifications and passenger calls at the railway station.

After obtaining the required secondary data, a primary data collection was performed. This data collection is done by conducting direct measurements at Medan City railway station using Sound Level Meter tool. In this process there are two stages that required. These stages are the preparation stage of the instrument and measurement stage. In the preparation stage of the appliance, the battery installation is performed. Once the battery is plugged in, the appliance is switched on by pressing the power button. The battery that has been installed should be checked if the battery is still in good condition or not. Checks are done by looking at the alert line on the monitor. If the tool check is done, then go to the measurement stage. At this stage there are several steps that are passed as shown in Figure 3.
Measurements were carried out at several locations in Medan City Rail station area. Each measuring location is performed for 1-2 minutes of observation with approximately 6 times the reading. The measurement result is the number shown on the monitor. The collected data (primary data) is associated with the previously collected secondary data. Furthermore, all data is processed to determine noise intensity level, as well as to know the impact on the surrounding environment. After getting the sound intensity level results and knowing the impact on the next research makes conclusions and suggestions from the results of his research until completed.

4. Results and discussion
The results that have been collected and processed are analyzed in order to draw conclusions. Measurement of noise intensity level is done at the location of Medan railway station. The measurement lasted 6 days which was on 14-19 July 2018, using the Sound level Meter tool. From the data obtained there is a difference in the average noise intensity level between morning, afternoon and evening at the time of departure and arrival of trains. It can be seen in Table 3 and Table 4.

| Times | Saturday/July 14th 2018 | Monday/July 15th 2018 | Tuesday/July 16th 2018 | Wednesday/July 17th 2018 | Thursday/July 18th 2018 | Friday/July 19th 2018 |
|-------|-------------------------|-----------------------|------------------------|-------------------------|------------------------|-----------------------|
| Morning | 87.71 dB | 85.46 dB | 87.52 dB | 81.41 dB | 87.71 dB | 86.21 dB |
| Afternoon | 96.67 dB | 94.85 dB | 96.41 dB | 91.62 dB | 96.05 dB | 93.94 dB |
| Night | 94.92 dB | 90.80 dB | 93.36 dB | 88.4 dB | 88.32 dB | 85.58 dB |

From Table 3, it can be seen the noise intensity level value at the time of train departure. Leq value on average the highest noise intensity level for departures in May on Saturday afternoon of 14 July 2018 amounted to $\beta = 96.67\ dB$. This is due to the high level of passenger density on Saturday afternoon. The density of this passenger because on that day many people of Medan City who return to their hometown. In addition, the train is quite fast pace ($\pm 30\ km/h$). This situation raises a loud noise because of the friction between the wheels of the train with the end of the rail. In addition, the sound from the notification speakers for departures and train horns affects the level of noise intensity at such stations. The average value of Leq is the lowest noise intensity level occurring on Tuesday morning of
July 17, 2018 for $\beta = 81.41 \text{dB}$. This is due to the time the passenger is very significant, so the train has a smaller rate ($\pm 20 \text{ km/h}$).

![Graph of average noise intensity level at departure.](image)

**Figure 4.** Graph of average noise intensity level at departure.

| Times  | Saturday/July 14th 2018 | Monday/July 15th 2018 | Tuesday/July 16th 2018 | Wednesday/July 17th 2018 | Thursday/July 18th 2018 | Friday/July 19th 2018 |
|--------|-------------------------|-----------------------|-------------------------|--------------------------|-------------------------|------------------------|
| Morning| 93.36 dB                | 89.36 dB              | 92.60 dB                | 83.75 dB                 | 90.85 dB                | 89.38 dB               |
| Afternoon| 93.40 dB               | 94.06 dB              | 95.06 dB                | 91.26 dB                 | 94.28 dB                | 93.22 dB               |
| Night  | 96.66 dB                | 90.44 dB              | 92.90 dB                | 87.20 dB                 | 84.98 dB                | 84.92 dB               |

From Table 4 can be seen the value of noise intensity level at the arrival of trains. Leq value on average the highest noise intensity level for the arrival occurs on the night of Saturday 14 July 2018 of $\beta = 96.66 \text{dB}$. This is because on Saturday night the density of passengers is quite high. Many passengers who come to visit the city of Medan is one of the factors that influence. So it raises a loud sound, coupled with the sound of the notification speaker for the arrival of trains and the Horn of the train. As for the average Leq value of the lowest noise intensity level in can be on Tuesday the 17th of July 2018 amounted to $\beta = 83.75 \text{dB}$. This was due to a significant decrease in the number of passengers at that time, so the train drove and stopped slowly ($\pm 20 \text{ km/h}$).

![Graph of average noise intensity level at arrival.](image)

**Figure 5.** Graph of average noise intensity level at arrival.
4.1. Sound intensity

The value of noise intensity level can be determined from the value of sound intensity. Sound intensity can be calculated using equation (3). By using the received 6-day noise intensity level data, the sound intensity is obtained for several trains as shown in Table 5.

| Times          | Saturday/ July 14th 2018 | Monday/ July 15th 2018 | Tuesday/ July 16th 2018 | Wednesday/ July 17th 2018 | Thursday/ July 18th 2018 | Friday/ July 19th 2018 |
|---------------|--------------------------|------------------------|--------------------------|---------------------------|--------------------------|------------------------|
| Morning       | $I = 10^{-3.25}$         | $I = 10^{-3.25}$       | $I = 10^{-3.36}$         | $I = 10^{-3.25}$          | $I = 10^{-3.25}$         | $I = 10^{-3.25}$        |
|               | Watt/m²                  | Watt/m²                | Watt/m²                  | Watt/m²                   | Watt/m²                  | Watt/m²                |
| Afternoon     | $I = 10^{-2.24}$         | $I = 10^{-2.52}$       | $I = 10^{-2.36}$         | $I = 10^{-2.84}$          | $I = 10^{-2.40}$         | $I = 10^{-2.61}$        |
|               | Watt/m²                  | Watt/m²                | Watt/m²                  | Watt/m²                   | Watt/m²                  | Watt/m²                |
| Night         | $I = 10^{-2.50}$         | $I = 10^{-2.92}$       | $I = 10^{-2.67}$         | $I = 10^{-3.16}$          | $I = 10^{-3.17}$         | $I = 10^{-3.45}$        |
|               | Watt/m²                  | Watt/m²                | Watt/m²                  | Watt/m²                   | Watt/m²                  | Watt/m²                |

Figure 6. Graph of sound intensity at departure.

While the sound intensity value for the train arrival is shown as in Table 6 below.

| Times          | Saturday/ July 14th 2018 | Monday/ July 15th 2018 | Tuesday/ July 16th 2018 | Wednesday/ July 17th 2018 | Thursday/ July 18th 2018 | Friday/ July 19th 2018 |
|---------------|--------------------------|------------------------|--------------------------|---------------------------|--------------------------|------------------------|
| Morning       | $I = 10^{-2.67}$         | $I = 10^{-3.07}$       | $I = 10^{-2.74}$         | $I = 10^{-3.63}$          | $I = 10^{-2.92}$         | $I = 10^{-3.07}$        |
|               | Watt/m²                  | Watt/m²                | Watt/m²                  | Watt/m²                   | Watt/m²                  | Watt/m²                |
| Afternoon     | $I = 10^{-2.66}$         | $I = 10^{-2.60}$       | $I = 10^{-2.50}$         | $I = 10^{-2.88}$          | $I = 10^{-2.58}$         | $I = 10^{-2.68}$        |
|               | Watt/m²                  | Watt/m²                | Watt/m²                  | Watt/m²                   | Watt/m²                  | Watt/m²                |
| Night         | $I = 10^{-2.34}$         | $I = 10^{-2.96}$       | $I = 10^{-2.71}$         | $I = 10^{-3.28}$          | $I = 10^{-3.51}$         | $I = 10^{-3.51}$        |
|               | Watt/m²                  | Watt/m²                | Watt/m²                  | Watt/m²                   | Watt/m²                  | Watt/m²                |
Figure 7. Graph of sound intensity at departure.

From the results that have been obtained for 6 days, the noise intensity level for the Saturday afternoon is 14 July 2018 of $\beta = 96.67 \text{ dB}$. As for the Saturday night train arrival on 14 July 2018 amounted to $\beta = 96.66 \text{ dB}$. So it can be seen that the noise level at the train station is very far from the set threshold of $\beta = 70 \text{ dB}$.

5. Conclusion

Sound Level Meter tool is an effective to measure the level of noise intensity in an area. Value of noise intensity level at the city railway station of Medan at the time of departure and arrival of trains were obtained. Highest noise intensity level value for train departures is $\beta = 96.67 \text{ dB}$ were measured from the average value of the noise intensity level obtained. The lowest value of noise intensity level is $\beta = 61.41 \text{ dB}$. Meanwhile, the highest noise intensity level value for train arrivals is $\beta = 96.66 \text{ dB}$. And the lowest noise intensity level value is $\beta = 83.75 \text{ dB}$. So if compared with the threshold value of noise intensity level set by the Indonesian Government ($\beta = 70 \text{ dB}$), the value of noise intensity level at the city railway station Medan has exceeded the threshold and can be harmful to the surrounding environment.

Factors that affect the high value of this noise intensity level were also identified from the results of the research in Medan City railway station. These factors are the friction that occurs between the train wheels and rails, the high number of passengers, speaker notifications for departures and train horns. Further research can be done efforts to reduce the intensity of noise.

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