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Environmental noise impact assessment from mass rapid transit to the adjacent community

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Abstract. Due to the extension of the Mass Rapid Transit (MRT) network throughout the years, the noise generated from MRT had increased and this environmental noise tends to cause annoyance to the adjacent community. The aim of this research is to measure the environmental noise level generated by MRT at one of the MRT stations in Kuala Lumpur, Malaysia, compare the permissible limit and community annoyance response to the measured noise impact to the surrounding community. A total of 4 monitoring points were selected for environmental noise impact assessment. After that, a sound level meter was set up at these monitoring points to measure the sound level. For each monitoring point, the noise level was measured for 6 hours continuously from 7:00 am to 1:00 pm. Based on the results, the noise levels at critical monitoring points exceeded 9.23 % in Taman Midah MRT Station. Little community annoyance is caused in the study areas and this will affect the quality of life of the adjacent community. In conclusion, the environmental noise impact assessment was carried out to safeguard the noise level to be within the noise limit and to enhance the quality of life of the community alongside MRT.

1 Introduction

Noise is a sound that is undesirable and it will cause disruption. Environmental noise means an unintended sound that is produced in our surroundings. Many electronic sound devices produce noise such as amplifiers, speakers, and types of machinery. In developing countries especially industrialised societies, human beings will expose to different kinds of environmental noise. High doses of sound exposure in daily life will eventually affect human health. Nowadays, noise pollution has reached an annoying level and it becomes one of the major concerns across the planet that impacts the quality of human life in urban areas [1]. This problem causes the community to prefer to have their residences staying far away from noisy sources.

Besides, different levels of noise exposure will lead to a wide range of health effects. Primary exposure to environmental noise will cause some acute effects on human beings such as sleep disturbance, annoyance, cardiovascular health, birth and reproductive outcomes, cognition, mental health, well-being, and quality of life [2]. With continuous high

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environmental noise exposure in daily life, it will annoy the community and also bring out additional health effects to individuals.

In developing countries such as Malaysia, the rapid development of railway construction will cause environmental noise pollution. The noise produced by Mass Rapid Transit (MRT) will impact the adjacent community, especially some sensitive receptors such as residential areas, schools, hospitals, and shop lots. These sensitive receptors will be forced to receive daily environmental noise pollution generated by MRT. Moreover, the community nearby the MRT station will receive significant noise and vibration. Daily exposure to railway noise will be harmful to human health. Malaysia's MRT Project comprises the construction of a city railway network together with the existing Keretapi Tanah Melayu (KTM), Light Rail Transit (LRT), and monorail and this will be the backbone of the public transport system in Kuala Lumpur. The MRT project is the largest transport infrastructure project under the national key economic area (NKEA) in Malaysia [3] and the MRT Line 3 circle line is the critical final piece to complete Kuala Lumpur's urban rail network is and expected to be fully operational by the year 2030.

There are some studies related to railway noise [4,5,6,7] were carried out to explore their adverse effects. Railway vehicles always generate a large number of noise and vibration and it is important to have a low noise for the design of railway vehicles because it will affect the comfort of the passengers. In 1996, around 20 % of the population of Western Europe was exposed to environmental noise levels exceeding 65 dB and 60 % of it was exposed to noise levels above 55 dB. Railways are one of the major sources of noise in the world. 1.7 % of the population is exposed to rail traffic and the noise level is over 65 dB [7]. The rolling noise is the main source whereas traction noise is only effective at lower speeds and it is less dependent on the train speed. The roughness of the rail and wheel causes airborne and structure-borne noise and this noise will propagate around and along the vehicle while the structure-borne noise propagates to the car body. Relating to the rolling noise, there is a range of 5 to 500 mm of the wavelength of roughness [7]. This vibration will be transmitted to the wheel and track structures and causes sound radiation.

This study will mainly focus to measure the environmental noise level generated by MRT at one of the MRT stations in Kuala Lumpur, Malaysia, and compare the permissible limit and community annoyance response to the measured noise impact. To mitigate the environmental noise impact, there are some guidelines provided by the Department of Environment Malaysia (DOE) to check the noise level with the allowable environmental noise limits. Organizations have the responsibility to design the town or infrastructure with minimum impact of noise so that it can avoid annoyance to the community and conserve public health at the same time. In this research, guidelines for the measurement and control of environmental noise limits [8, 9] were used. This guideline will be used in environmental noise impact assessments, in quantifying noise disturbance, and also in environmental noise control.

2 Methodology

2.1 Site selection

In this research, one site was selected and four monitoring points were indicated for the site. So, the noise measurement has to be carried out at a total of four monitoring points. For environmental noise impact assessment, it is better to choose some noise-sensitive receptor sites such as residential areas and shop lots. Thus, the selected site is the Taman Midah MRT Station in Kuala Lumpur, Malaysia. There are residential areas, shop lots, and roadways surrounding the Taman Midah MRT Station. Four monitoring points were chosen surrounding the Taman Midah MRT Station as shown in Fig.1. Monitoring points A1, A2, and A3 are shop lots whereas monitoring point A4 is a residential area. All of these monitoring points except A1 are considered near enough to the noise source and it is the noise-sensitive area in this study.

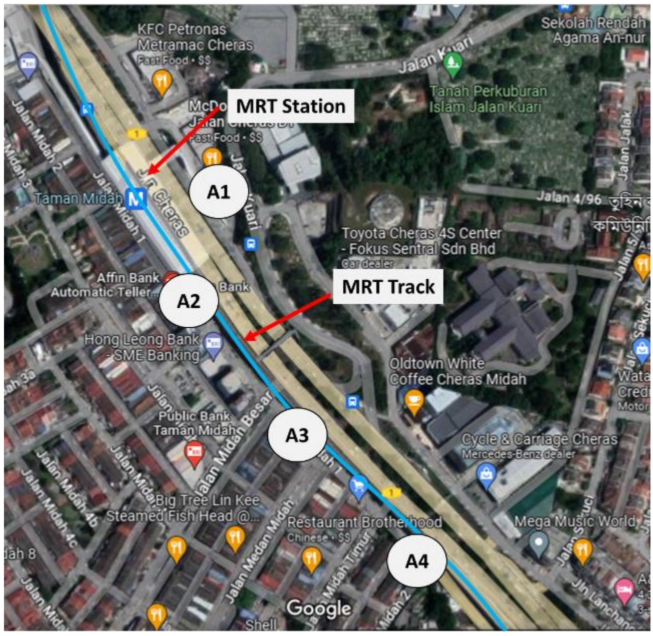


Fig. 1. Monitoring Points at Taman Midah Station

2.2 Equipment

The sound level meter that will be used during the field measurement is the Class 1 Entry Level Sound Level Meter and it is named SoundTrack LxT. A tripod is needed to hold the sound level meter in place for the noise measurement. To set up the tripod on site, the tripod is mounted with the tripod attachment screws and the sound level meter main unit is attached to the tripod directly.

A distometer named Sndway Hand-Held Laser Distance Meter was used during field measurement to measure the distance between two points. The laser distance meter is much faster and more efficient than a measuring tape because it is just one click away from the targeted point, and at the same time the distance can be measured while the far end of the measurement is not accessed. A battery-operated calibrator is used for the calibration of the sound level meter. Calibration must be carried out every time before a new noise level measurement to improve the accuracy of the measuring device.

2.3 Data collection

After the site and monitoring points were investigated and selected, with the equipment being fully prepared, data collection was carried out. In this research, the data will be collected during day time which is within the range from 7:00 am to 1:00 pm. According to DOE guidelines, the tripod with the microphone from the sound level meter has to be mounted at least 1.2 m above the ground level and at least 3.5 m from sound-reflecting structures for measurement [9]. Under some special conditions, the measurement location can be set at a greater height. During the noise measurement, additional care has to be taken to avoid unwanted sounds such as wind or noise from incidental sources. Apart from that, it is not recommended to carry out the noise measurement in intense climate conditions when the noise source is at a far distance. The noise parameters measured are L_{Aeq}, L_{max}, L_{min}, L_{10}, L_{50}, and L_{90}. The train pass-by noise level was also recorded.

2.4 Data analysis

In this research, after measuring the environmental noise level, the measured value needs to compare with the permissible limit given in DOE guidelines as shown in Table 1. Table 1 shows the permissible sound level (L_{Aeq}) for railways including transits. The site measurement L_{Aeq} values that are collected during field measurement will be computed using software and then the final L_{Aeq} will be used to compare with the permissible noise limit level.

Table 1. L_{Aeq} for Railways Including Transits [8].

Receiving Land Use Category	**Day Time 7.00 am – 10.00 pm**	**Night Time 10.00 pm – 7.00 am**	**L_{max} (Day & Night)**
Noise sensitive areas Low density and suburban residential areas	60 dBA	55 dBA	75 dBA
Urban residential areas	65 dBA	60 dBA	80 dBA
Commercial, mixed development	70 dBA	65 dBA	80 dBA
Industrial	75 dBA	75 dBA	NA

Apart from the comparison of permissible sound limits, there is an assessment of community annoyance response needed for the research, and there are some procedures to compute the community annoyance response. The equivalent of the fast response of “A” weighted sound level, L_{eq} will be adopted for evaluation. Corrections have to be done to the measured sound level according to the sound with different types of characteristic features. According to DOE [9], for noise which has an audible tone, a +5 dB tonal correction shall be added to the offending sound in the determination of the level difference for assessment. As for impulsive noise, a +5 dB impulsive correction shall also be added to the rating level.

After the value is corrected, it is called the normalised sound level and this normalised sound level produces the rating sound level called L_r. The benchmark of noise from the adjacent community is the current surrounding sound level at the property boundary without the offending sound source. Thus, the existing surrounding sound level is represented as the mean minimum sound level, and it is denoted as 90 % “A” weighted fast response level, L_{90}.

Furthermore, if there is any exceedance of the noise level, the exceedance of the noise level can be calculated using equation (1).

$$\text{Exceedance of sound level} = (L_r - L_{90})\ \text{dBA} \qquad (1)$$

Thus, the anticipated community response to the noise can be interpreted based on the exceedance of the amount of sound level as shown in Table 2.

Table 2. Anticipated Community Response to Noise [9].

Amount in dB(A) by which the rating sound level L_r exceeds the noise criterion	**Anticipated community response**	
	Impact	**Description**
0	None	No observed reaction
5	Little	Sporadic complaints
10	Medium	Widespread complaints
15	Strong	Threats of community action
20	Very Strong	Vigorous community action

3 Results and discussions

The overall noise levels at 4 monitoring points indicated as A1, A2, A3, and A4 around Taman Midah MRT Station were summarized in Table 3. Monitoring points A1, A2, and A3 were set around shop lots while monitoring point A4 was set around residential areas. For instance, A1 was set in front of McDonald's, monitoring point A2 was set in front of Affin Bank, and A3 was set in front of FORD company. To get a consistent result, the noise level measurement for four monitoring points was measured every Monday so that the traffic flow is steady during each time of the sample collection.

The measured equivalent sound level and maximum sound level were compared with the DOE guidelines as DOE in Malaysia had recommended limiting sound level and maximum permissible sound level generated from railways [9]. Based on the DOE guidelines, the limiting sound level in day time for urban residential areas is 65 dBA whereas the limiting sound level for business land use in the daytime is 70 dBA. And the maximum sound level given by the guidelines is 80 dBA. From Table 3, both A1 and A2 have similar equivalent sound levels and the highest equivalent sound level of 72.7 dBA was generated at A2. On the other hand, both equivalent sound levels measured at A3 and A4 also very much alike with the lowest equivalent sound level of 71.0 dBA was generated at A4. Furthermore, monitoring point A2 created a maximum sound level of 93.1 dBA, which is the highest among the 4 monitoring points.

Table 3. Summary of Noise Levels at Taman Midah MRT Station

Day Time 7.00 am – 1.00 pm				
Noise Parameter	**Monitoring Point**			
	A1	**A2**	**A3**	**A4**
L_{Aeq} (dBA)	72.6	72.7	71.1	71.0
L_{max} (dBA)	89.4	93.1	92.1	87.0
L_{min} (dBA)	66.7	64.6	61.9	62.0
L_{10} (dBA)	74.4	74.4	73.3	73.5
L_{50} (dBA)	71.5	71.6	69.7	69.6
L_{90} (dBA)	69.0	69.6	66.4	66.8

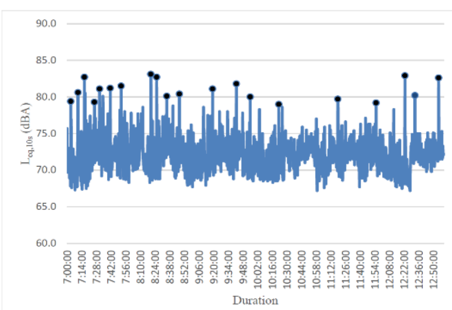
The percentage of exceedance of noise levels compared to the permissible sound level for 4 monitoring points was calculated and tabulated in Table 4. From Table 4, all 4 monitoring points exceeded both the limiting sound level and maximum sound level provided by DOE guidelines. Monitoring point A4 showed the highest exceedance of the equivalent sound level among the 4 monitoring points which is 9.23 %. While for the maximum sound level, both monitoring points A2 and A3 exceeded 16.38 % and 15.13 % respectively.

From the observations during sample collection, the major noise was generated by the road traffic noise followed by railway noise. Monitoring point A2 showed the highest percentage of exceedance of maximum sound level due to this monitoring point being set around the pick-up point of MRT. Thus, the MRT will stay longer at this particular point and more noise will be generated. On the other hand, monitoring point A4 showed the lowest percentage of exceedance of the maximum sound level because the noise barrier was constructed at this point at the very beginning of the construction of MRT. Although there was a noise barrier set up at this point, the effectiveness of the noise barrier has reduced throughout the years due to poor maintenance.

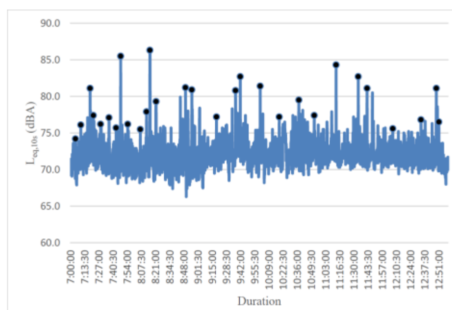
Table 4. Percentage of Exceedance of Noise Levels

Monitoring point	**A1**	**A2**	**A3**	**A4**
L_{Aeq} (dBA)	72.6	72.7	71.1	71.0
Limiting sound level (dBA)	70.0	70.0	70.0	65.0
Percentage of exceedance (%)	3.71	3.86	1.57	9.23
L_{max} (dBA)	89.4	93.1	92.1	87.0
Maximum sound level (dBA)	80.0	80.0	80.0	80.0
Percentage of exceedance (%)	11.75	16.38	15.13	8.75

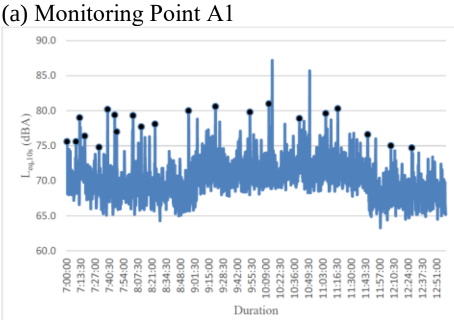
Noise levels for 4 monitoring points were collected in day time starting from morning 7.00 am until 1.00 pm, a total of 6 hours continuously by using the sound level meter. All the data collected for 4 monitoring points A1, A2, A3, and A4 were plotted in graphs of L_{eq},10s versus duration as shown in Fig. 2.



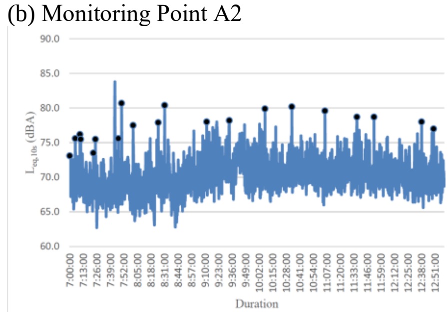
(a) Monitoring Point A1



(b) Monitoring Point A2



(c) Monitoring Point A3



(d) Monitoring Point A4

Fig. 2. Noise Level Graph of Monitoring Point A1 to A4.

As shown in the graphs, the black dot markers indicated the noise generated when MRT passed by the monitoring point. But, these were some of the significant noises generated by MRT as the train frequency was high during day time, especially from 7:00 am to 9:00 am. The train frequency from Monday to Friday was summarized in Table 5. From 7:00 am to

9:00 am, the MRT will reach every 4 minutes whereas the MRT will only reach every 7 minutes from 9:00 am to 5:00 pm.

Table 5. Train Frequency on Monday to Friday.

Time	Frequency (minutes)
6:00 am – 7:00 am	10
7:00 am – 9:00 am	4
9:00 am – 5:00 pm	7
5:00 pm – 7:00 pm	4
7:00 pm – 10:00 pm	8
10:00 pm – 12:00 am	15

Based on Fig. 2, the overall results showed that the area around shop lots and residential areas exceeded the noise permissible limit at day time from 7:00 am to 1:00 pm. As the road traffic noise at these four monitoring points was significant, the noise level at these points was much higher than the MRT noise generated. For monitoring points A1 and A2, most of the noise generated were in the range of 70 dBA to 75 dBA, which is slightly higher than the noise permissible limit, of 70 dBA provided by DOE guidelines. While for monitoring points A3 and A4, the noise generated was in the range of 65 dBA to 75 dBA, and it also exceeded the noise permissible limit.

Monitoring point A1 was set across the traffic road and near the bus stop, so the noise received from the MRT is less significant and most of the noises were mainly influenced by road traffic noise. When the MRT passed by, it cannot prove that the noise received by the sound level meter was affected by the railway noise. The noise level measured at this point when the MRT passed by was included with the road traffic noise such as motor vehicles, ambulances, and heavy trucks. Thus, the community around this area were not only affected by railway noise but also the road traffic noise in a more significant way. Moreover, monitoring A3 was set nearby the shop lots such as the FORD car showroom and car repair shop and this noise was mainly generated from the road traffic. Although the MRT noise can be heard when it passed by but the traffic noise is more disturbing to the adjacent community. So by comparing both railway and traffic noise, the railway noise becomes less significant.

Besides, monitoring point A2 is the nearest point that was set beside the MRT. Since the monitoring point, A2 was located near the MRT pick-up point, and this point is further from the road traffic, the railway noise can be measured and recorded clearly by the sound level meter when MRT passed by. Apart from that, the rolling noise generated by the MRT can be heard clearly with the automated door operating sound added in the background. The MRT noises were increased when two MRT were arriving at the same time at both platforms.

On the other hand, only monitoring point A4 was set around the residential area and the noise level measured was mainly due to the railway noise. Although there is some noise barrier constructed to reduce the noise, but from the community response during sample collection, the effectiveness of the noise barrier was reduced throughout the years and now, the noise generated by MRT was annoying and caused disturbance to the adjacent community.

Based on the overall sample collection, other noises were affecting the population adjacent to Taman Midah MRT Station other than railway noise such as noises generated from cars, buses, motorcycles, trucks, and ambulances. Different kinds of vehicles generate a different sound levels. For road traffic noises, the highest level of noise was produced by ambulance. Throughout the 6 hours of continuous measurement, it was observed that an ambulance passed through this road around 7 to 8 times every Monday as there is a hospital located 2.6 km away from the MRT station. The noise detected when the ambulance with an emergency alarm passed by can raise to 80 dBA, which is 10 dBA exceeding the noise permissible limit. All of these instantaneous noises greatly impact the adjacent community.

Table 6 shows the results of the anticipated community response to the noise around Taman Midah MRT Station. With the reference provided by DOE guidelines, the impacts of environmental noise from Taman Midah Station to the adjacent community were determined. From Table 6, it was observed that no community response at four monitoring points, where $L_r - L_{90}$ was below 5 dBA. This is because the background noise at Taman Midah is higher than usual due to the road traffic noise, so when there are noises generated by MRT, it becomes less significant and it only gives some additional noise to the existing background noise that was already annoying the adjacent community.

Table 6. Anticipated Community Response to Noise.

Monitoring point	**A1**	**A2**	**A3**	**A4**
L_{Aeq} (dBA)	72.6	72.7	71.1	71.0
Correction, K (dBA)	0	0	0	0
L_r (dBA)	72.6	72.7	71.1	71.0
L_{90} (dBA)	69.0	69.6	66.4	66.8
$L_r - L_{90}$ (dBA)	3.6	3.1	4.7	4.2
Anticipated community response	None	None	None	None

4 Conclusions

The noise levels were measured for 6 hours continuously at eight monitoring points near the MRT Station and adjacent community. For the case study at Taman Midah MRT Station, all four monitoring points exceeded the noise permissible limits where A1, A2, A3, and A4 exceeded 3.71 %, 3.86 %, 1.57 %, and 9.23 % respectively. But, no impact was found within the four monitoring points due to the higher background sound level at Taman Midah MRT Station. In the future study, it is recommended to study the effective way to reduce the sound level from the MRT station as well as the background sound level.

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