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Assessing the Impact of Traffic Noise in Residential Areas: A Case Study of Taman Koperasi Bahagia, Batu Pahat, Johor, Malaysia

Chua Chee Yung[1], Toh Yoke Teng[1,*], Muhamad Shahril Mohd Abdullah[2], Viknheswar Chandira Segaran[3]

[1] Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400 Batu Pahat, Johor, Malaysia
[2] Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400 Batu Pahat, Johor, Malaysia
[3] Teambuild Construction Group, 9 Defu South Street 1, 533844 Singapore

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ABSTRACT

Noise is a by-product of various human activities and traffic noise is considered the second leading environmental cause of adverse health effects. The increase in road transportation negatively impacts residents' quality of life over time, affecting both health and property values. To assess this, a noise mapping grid was created in a residential area, with data collected over one week during peak hours (7:00 a.m. to 9:00 a.m. and 5:00 p.m. to 7:00 p.m.) to capture maximum traffic noise levels. This data was compared to the standards set by the Department of Environment Malaysia to determine compliance. The results indicated that evening traffic noise levels were higher than morning levels, showing a greater impact on residents in the evening. Additionally, traffic noise during weekdays was higher than on weekends. These findings provide actionable insights for city planners and authorities to develop effective noise control regulations and strategies, ultimately enhancing residents' overall life satisfaction.

1. Introduction

Today, environmental noise has emerged as a significant concern. Sound is a complex phenomenon involving alternating compression and expansion of air, radiating in all directions from its source [1]. Essentially, it can be described as a minor fluctuation in local atmospheric pressure. Noise pollution, characterized by excessive sound, poses potential detrimental effects on human health. Over 20% of the population is exposed to noise levels exceeding the recommended guideline value of 55 dB [2]. According to the European Environment Agency [3], traffic noise has been identified as the second most significant environmental factor contributing to adverse health effects in Western Europe. The Ministry of Transportation Malaysia reports that the number of registered vehicles has increased by 2.0%, from 1.16 million in 2020 to 1.19 million in 2021 [4]. This increase in the number of vehicles on the road has substantial effects on society over time, including noise

* *Corresponding author*
E-mail address: toh@uthm.edu.my

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pollution, which can negatively affect the standard of living for residents such as blood pressure, increased of stress level, anxiety and cardiovascular diseases [5].

The speed of the vehicle and traffic volume are the main causes that contribute to the increases of noise level where a 50 % drop in traffic volume led to a 3 dBA reduction in overall noise [6]. Decrease of 50 % and 75 % in traffic speed led to a noise reduction of 3 dBA and 6 dBA, respectively [7]. We are exposed to a variety of sound levels in our everyday lives and experts have determined that the acceptable range for maximum sound intensity falls between 75 and 85 decibels [8]. Lan *et al.,* [9] shown that a 10 dBA increase in daytime or night-time of traffic noise was linked to a 9 % higher likelihood of experiencing anxiety. Another study also resulted that noise could lead to a reduction in cortical thickness and activate stress pathways in the brainstem and hypothalamus, resulting in an increase in the release of neurotransmitters like noradrenaline and dopamine [10]. Apart from the detrimental health impacts, traffic noise pollution can also adversely affect property values and overall community satisfaction. Residential properties that exposed to noise pollution had a 3.1% lower rental value compared to properties that were unaffected by the traffic noise pollution [11]. In a study done by Kuehnel *et al.,* [12], it is found that a Noise Sensitivity Depreciation Index (NSDI) of 0.4, meaning that a 1 dBA increase in noise levels corresponded to a 0.4 % reduction in rental costs. The study also identified that high transportation usage and congestion were contributing factors in the continual depreciation of housing values. In addition, prolonged exposure to noise can also damage an animal's reproductive capabilities, long-term survival due to chronic stress and energy balance [13]. There was evidence that traffic noise negatively affected social and motor learning, as well as inhibitory control, which could have harmful indirect consequences on animals living close to roads [14]. An experiment was done by Giordano *et al.,* [15], speakers was applied to emitted noise at approximately 62 dB. The result showed that road noise led to a decrease in small mammals' risk perception of predation, resulted in increasing food consumption and negatively affecting their foraging efficiency and alertness.

Previous studies have demonstrated that traffic noise significantly impacts daily life [16], physical health [17] and mental health [18,19]. Prolonged exposure to traffic noise has even been linked to increased mortality rates [20]. The objective of this is to assess the impact of traffic noise in residential areas. Poor urban planning and limited space have led to the construction of many residential areas adjacent to busy traffic lanes, exposing the general population to potential health hazards. The lack of buffer zones and soundproofing in these areas has exacerbated the issue of noise pollution caused by road traffic. This study aims to address this problem by focusing specifically on residential areas, highlighting a significant gap in current research. The findings of this research will provide recommendations for implementing noise reduction measures to ensure community health and safety and to ensure that noise levels comply with the latest guidelines specified by the Department of Environment [21]. This study are in line with Wang *et al.,* [22] that explained the importance of assessing noise pollution levels to provide both theoretical and data-driven foundations for noise prevention and control measures. Therefore, conducting a detailed assessment of traffic noise level is crucial in determining the actual extend of noise pollution in residential area. In this case study, the level of traffic noise will be evaluated and assess to determine whether it exceeded the permissible sound level specified by Department of Environment, Malaysia [21]. The Department of Environment's regulation specifies that developed falling under the Suburban and Urban Residential, Mixed Development classification should maintain a permissible noise level of L_{Aeq} , which should be at 65 dBA during the day and 60 dBA at night shown in Table 1.

Table 1
Recommended permissible sound level (L_{Aeq}) for category in second schedule

Receiving land use category	L_{Aeq} Day 7.00 am – 10.00 pm	L_{Aeq} Night 10.00 pm – 7.00 am
Low density residential, noise sensitive receptors, institutional (School, hospital, worship)	60 dBA	55 dBA
Suburban and urban residential, mixed development	65 dBA	65 dBA
Commercial business zones	70 dBA	70 dBA
Industrial zones	75 dBA	75 dBA

2. Methodology

This section will describe the various stages of case study which is the description of the study area, preparation of instrument, collection of data and process of data analysis. The study area was focused on the residential area at Taman Koperasi Bahagia with longitude 1.859724° N and latitude 102.949601° E that located in Batu Pahat, Johor, Malaysia. The residential area is constructed near to the main road, which connects Batu Pahat, Ayer Hitam and Jemaluang. In this section, it will be discussing on the instrument that will be applied, measurement procedure that need to implement and data measurement record during the collection of data to ensure that accurate data is obtained for further action.

2.1 Measurement Equipment

A sound level meter with an attachment of microphone windbreak shown in Figure 1(a) is an instrument that measures the sound level of noise. This equipment should undergo calibration prior to measurements at the beginning, periodically during the measurement and at the end of the measurements. In Figure 1(b), it is an acoustic calibrator or a sound level calibrator that should be applied according to the standards established to make sure that the sound level value recorded is accurate. The laser meter that is shown in Figure 1(c) was applied during the data collection. Laser meter was chosen because it offers a simple and effective way to measure distance. Additionally, it protects privacy and avoids any intrusion into personal property while allowing data collection for the study.

(a) (b) (c)

Fig. 1. (a) SLM25TK sound level meter (b) Acoustic calibrator (c) Laser meter

2.2 Data Measurement Record and Procedure

The data collected will be recorded by using a sound level meter with the time interval of total 6 minutes at different points. Based on the interval, the sound produced from the traffic noise towards the residential area will be collected. The data collection will be carried out for one week and a total of 4 hours per day during peak hours, which is 7.00 a.m. to 9.00 a.m. and 5.00 p.m. to 7.00 p.m. This is to ensure the maximum traffic noise level is collected. The gridline will be formed at the residential area to create a noise contour map so that it can visualize the spatial distribution of noise.

In this study, the assessment of traffic noise impact on the residential area was conducted by utilizing AutoCAD software, integrating the principles of noise contour mapping. The contouring technique that has been employed within AutoCAD facilitated the visualization of varying noise levels that created from the traffic noise across the study area, which is the Taman Koperasi Bahagia, providing a more thorough comprehension of the potential impact towards the residents. By applying contour mapping principles, the resulting noise maps not only offer a spatial representation of noise intensity but also contribute to a more understandable and insightful communication of the research findings.

3. Results and Discussion

In this case study, the result will be categorized into two parts for discussion. The first part of the discussion will be discussing about the comparison between morning and evening traffic noise level for a week during the peak hours. Another part of the result will be discussed about the comparison of traffic noise produced for morning and evening during weekdays and weekends.

3.1 Traffic Noise Level Measurement

The traffic noise level obtained in residential area at Taman Koperasi Bahagia, Batu Pahat from Wednesday to Tuesday (total 7 days of investigation) for two sessions which are morning (7.00 a.m. to 9.00 a.m.) and evening (5.00 p.m. to 7.00 p.m.) peak hours. There are a total of 20 stations marked at the residential area to visualize the impact of traffic noise towards it.

The data was collected for 6 minutes and a total of 360 raw data was collected at each station. The data is then analyses for each station and it is calculated using the Eq. (1) below to get the A-weighted equivalent continuous noise level, which expressed in dB (A) unit:

$$L_{Aeq} = 10log10\ [(\ 10^{\frac{x1}{10}} + 10^{\frac{x2}{10}} + 10^{\frac{x3}{10}} + \ldots\ldots 10^{\frac{xn}{10}})\ /\ \mathrm{n}\ ] \quad (1)$$

Where,
x_1, x_2, x_3 = Traffic Noise Level
n = Total number of Observation

3.2 Comparison of Traffic Noise Level

Figure 2 revealed the traffic noise mapping in the morning throughout the week. It clearly shows that only a small part of the area is recorded 65 dBA and above which located between S1 and S2. It exceeds the standard recommended limit set by the DOE which is 65 dBA but it is not impacting the residential area. Likewise, the residential area is mostly covered with traffic noise levels ranging from 55 dBA to 60 dBA. The station from S1 to S5 is recorded fall within range of 60 to 64 dBA. This is due

to the nearer distance to the main road; higher road usage will lead to a higher traffic noise to be generated. Thus, residents living around that area would be facing higher risk of traffic noise exposure which would lead to series of negative impacts to the environment as well as the health of the residents from Taman Koperasi Bahagia.

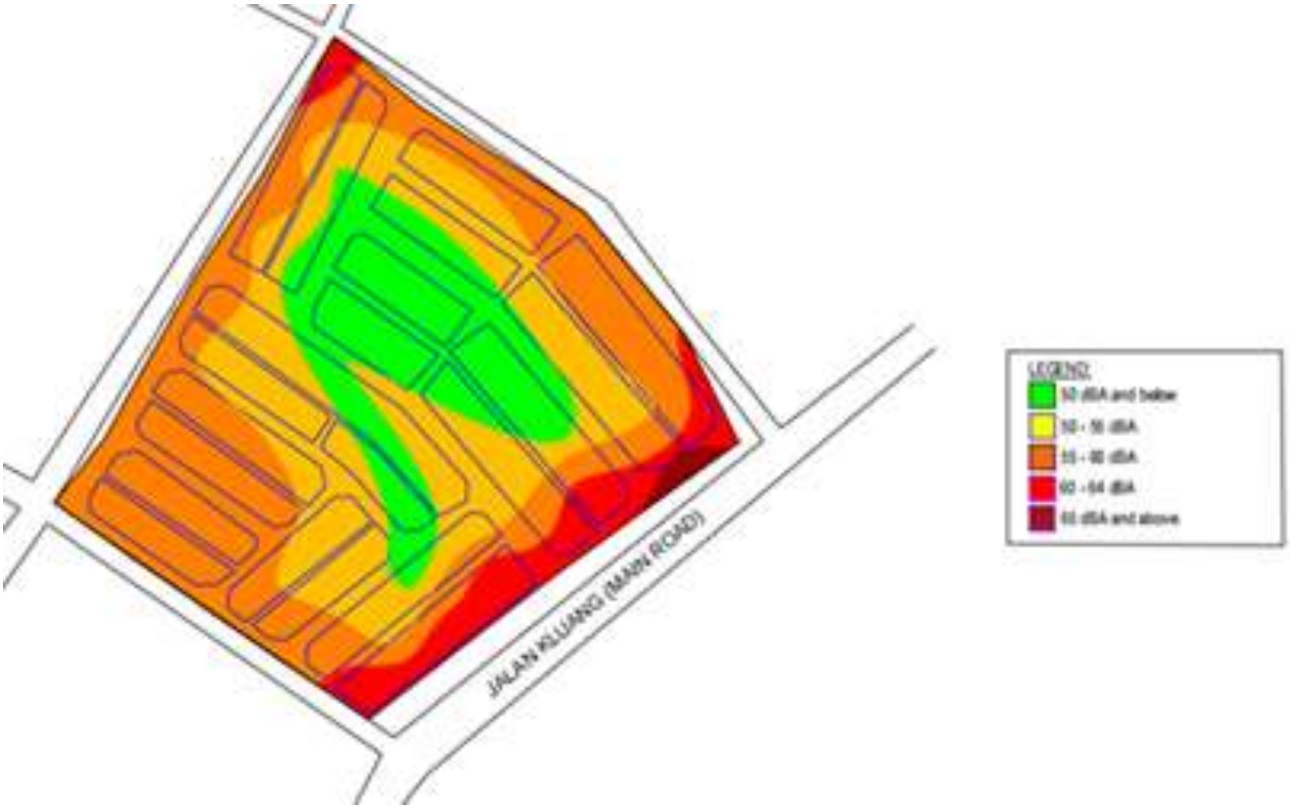

Fig. 2. Noise map of Taman Koperasi Bahagia in the morning throughout the week

According to Figure 3, the traffic noise level recorded in the evening is much higher than the traffic noise level recorded in the morning. It is shown significantly that the coverage of A-weight continuous sound pressure level that falls under category 60 to 64 dBA whereby only a small region from the overall residential area is recorded under 50 dBA. The area that falls within the range of 60 to 64 dBA which was the station from S1 to S5 was the mainly exposing to the road that road user uses it daily for travelling. Hence, by comparing the noise mapping in the morning and evening throughout the week, it revealed that the residential area at Taman Koperasi Bahagia has greatly affected by traffic noise in the evening and it is also shown that the station that has higher traffic noise level was found located near to the main road, as which all the vehicles would speed up due to a space which is wide and free of obstruction and likewise the others driver behaviour such as honking. Based on the results, it likewise revealed that the road usage was higher during the evening session compared to the morning session.

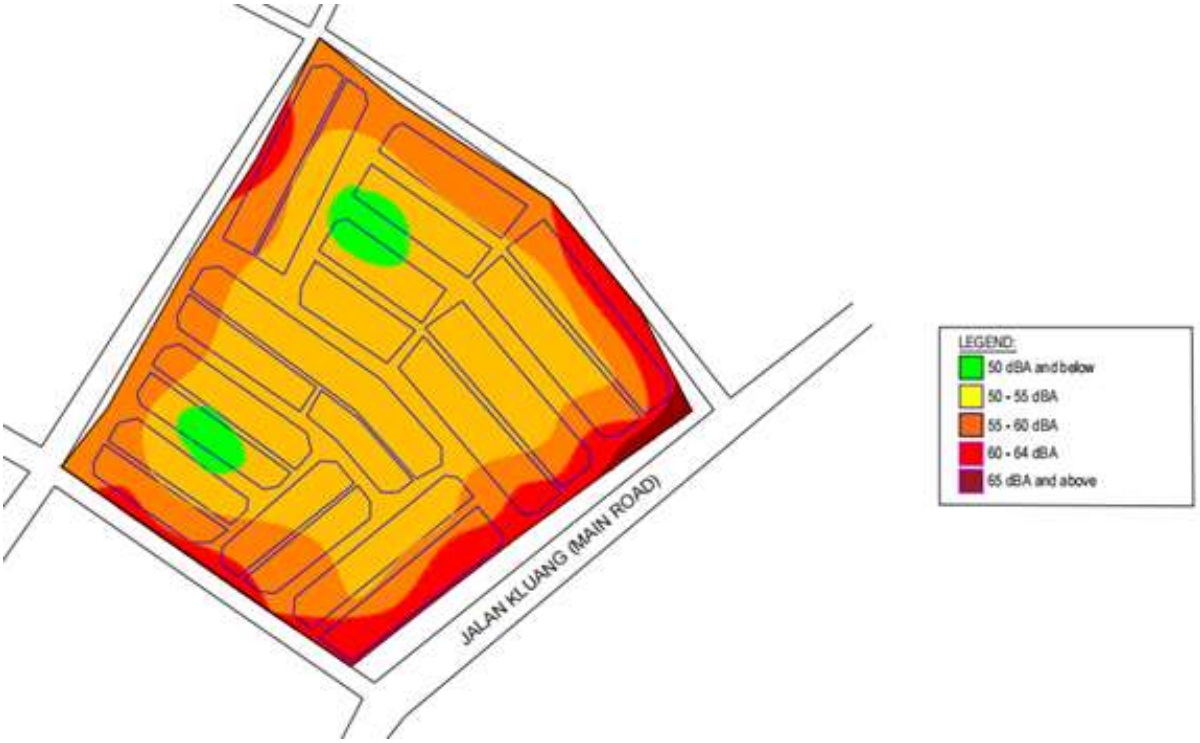

Fig. 3. Noise map of Taman Koperasi Bahagia in the evening throughout the week

Figure 4 shows the noise mapping of the residential area in the morning during weekdays. It shows that only a small area between S1 and S2 is facing high traffic noise levels that are brought by the traffic noise. The result recorded that the highest traffic noise level recorded in the morning is 65.4 dBA. It has exceeded the recommended limit that has been set by the DOE. By comparing the same station which is S20 recorded in the morning and evening during weekdays, the traffic noise level recorded in the morning is slightly higher than in the evening, which is 62.0 dBA and 60.5 dBA, respectively. This is because morning sessions were known as the peak hours of which most of the vehicles were passing by the highway as well as the others nature noise disruption obtained around the site area.

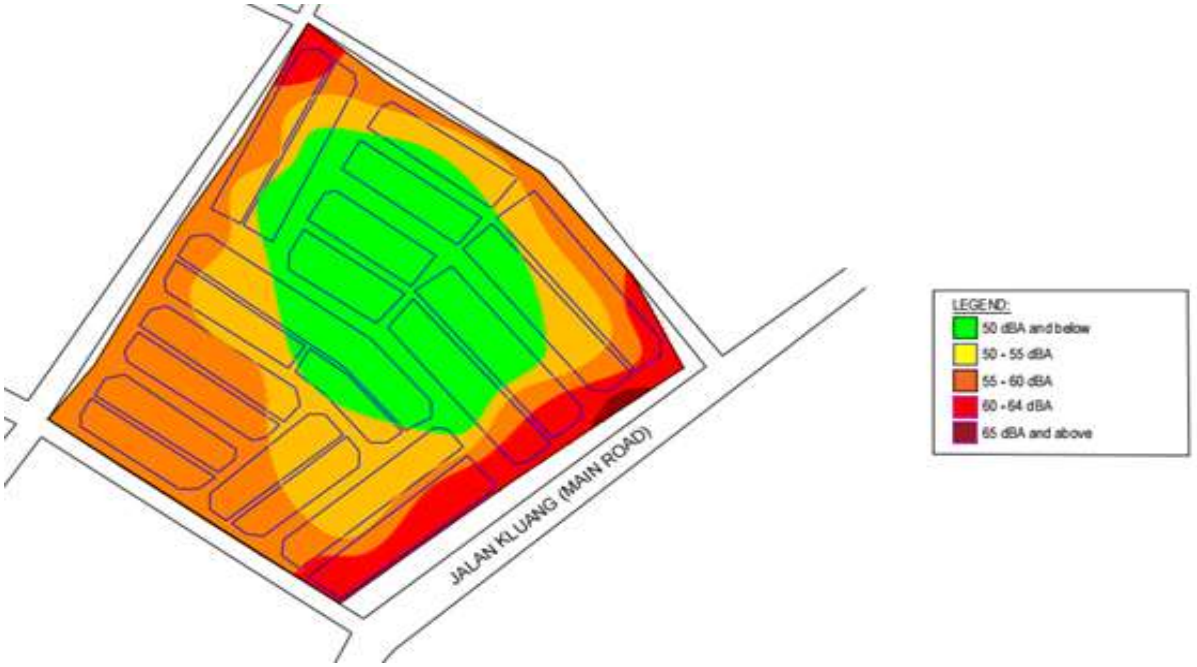

Fig. 4. Noise map of Taman Koperasi Bahagia in the morning during weekdays

In Figure 5, the traffic noise level recorded in the evening during weekdays. The result shown that the highest traffic noise level recorded was at S1 with value 64.8 dBA. There is no data recorded that the traffic noise level exceeds the recommended permissible sound level that set by the DOE. The lowest traffic noise level recorded in the evening is 49.5 dBA and 47.2 dBA in the morning. The residential area is mostly exposed to the sound pressure level at the range between 50 to 55 dBA in the evening. This has shown that the residents are not exposed to any risk in the evening due to traffic noise, especially for those who are live near to the main road as it was still fall under the recommended permissible limits of sound level. This is mainly due to a lower road usage during the evening session as it already passed with the working hours and most of the transportation services would not be held evening onwards. Hence, it was relatively reducing the road usage which posses with lesser impacts and traffic noise towards the residential area.

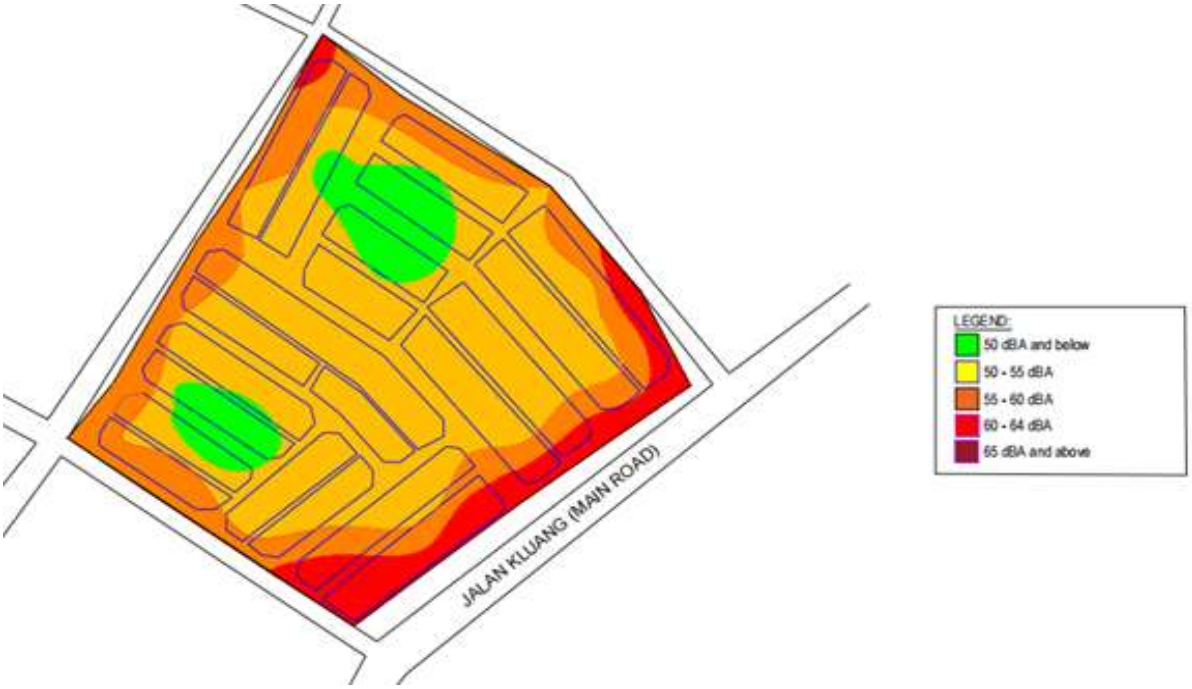

Fig. 5. Noise map of Taman Koperasi Bahagia in the evening during weekdays

Based on Figure 6, it revealed the traffic noise level observed at Taman Koperasi Bahagia, during the weekend morning. S2 was obtained with the highest traffic noise level which was 65.8 dBA which slightly exceeded the recommended permissible sound level set by DOE, 65 dBA. Therefore, residents lived near to S2 is expected to be exposed with health risks or any environmental impacts caused by the traffic noise. However, the overall region from the residential area was found exposed to traffic noise level ranging from 50 to 55 dBA and the range of 50 dBA and below was noticed from part of the residential area and the lowest traffic noise level was observed at S12 which was 47.4 dBA. Hence, it was known that traffic noise possessed a lower risk to the residential area during the weekend as compared to the weekday as lower traffic noise level was obtained from the research. This could be due to lower road usage during the weekend which in turn resulted in a lower sound level to be generated from the traffic noise.

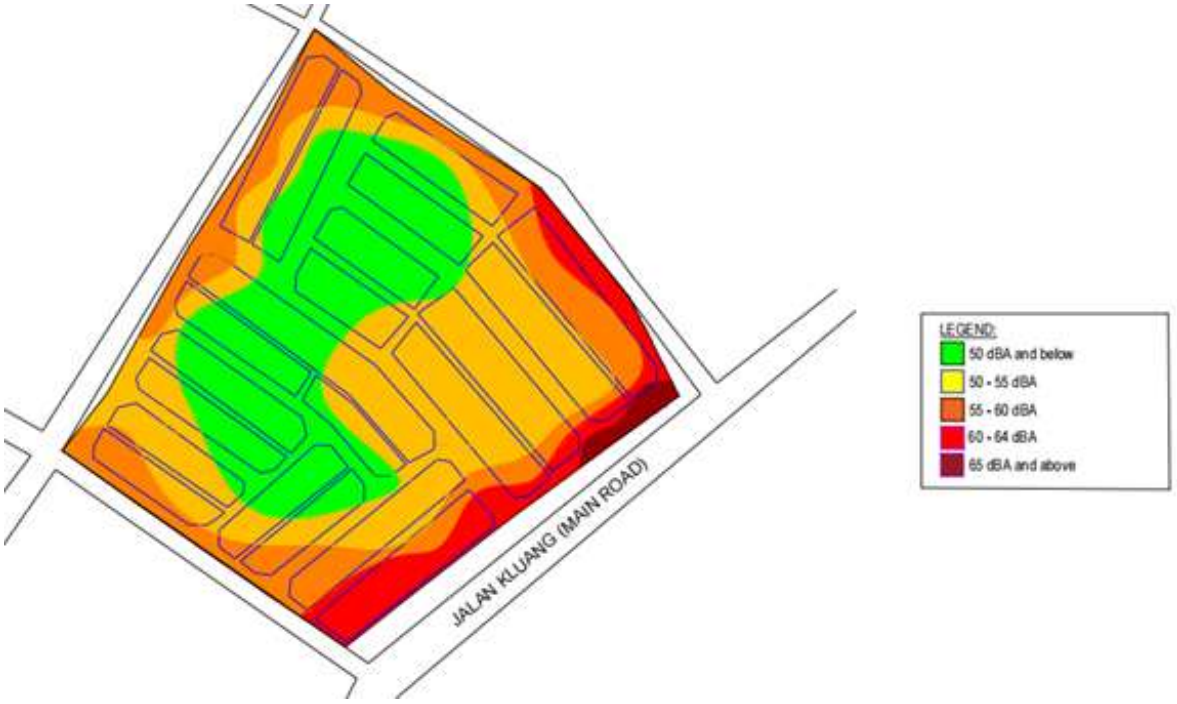

Fig. 6. Noise map of Taman Koperasi Bahagia in the morning during weekend

Figure 7 shows the traffic noise level recorded around Taman Koperasi Bahagia during weekend, in the evening session. It was observed that both S1, S2 and S5 are exposed to the sound level ranging from 65 dBA and above. While the highest sound level was found at S1 which was 68.5 dBA which has greatly exceeded the recommended permissible sound level limit regulated by DOE, 65 dBA. One of the reasons these stations found to be exposed with greater sound level was due to a walking distance from the residential area to the highway which greatly affected the residents lived nearer to these stations. Besides, in comparison with the sound level obtained from the morning session, evening session was observed with higher traffic noise level as more stations were exposed to sound level ranging from 65 dBA and above and the sound level recorded from overall region of residential area was mostly fall within the range of 50 to 55 dBA. Whereas only a small part of residential area obtained with lower traffic noise level, 50 dBA and below and the lowest sound level was observed at S13 which was 49.4 dBA. Hence, it was concluded that Taman Koperasi was exposed to a higher sound level in the evening than the morning during the weekend. As most of the activities planned on weekend were mainly conducted from evening onwards, which in turns increasing the road usage and eventually raising the sound level that to be observed.

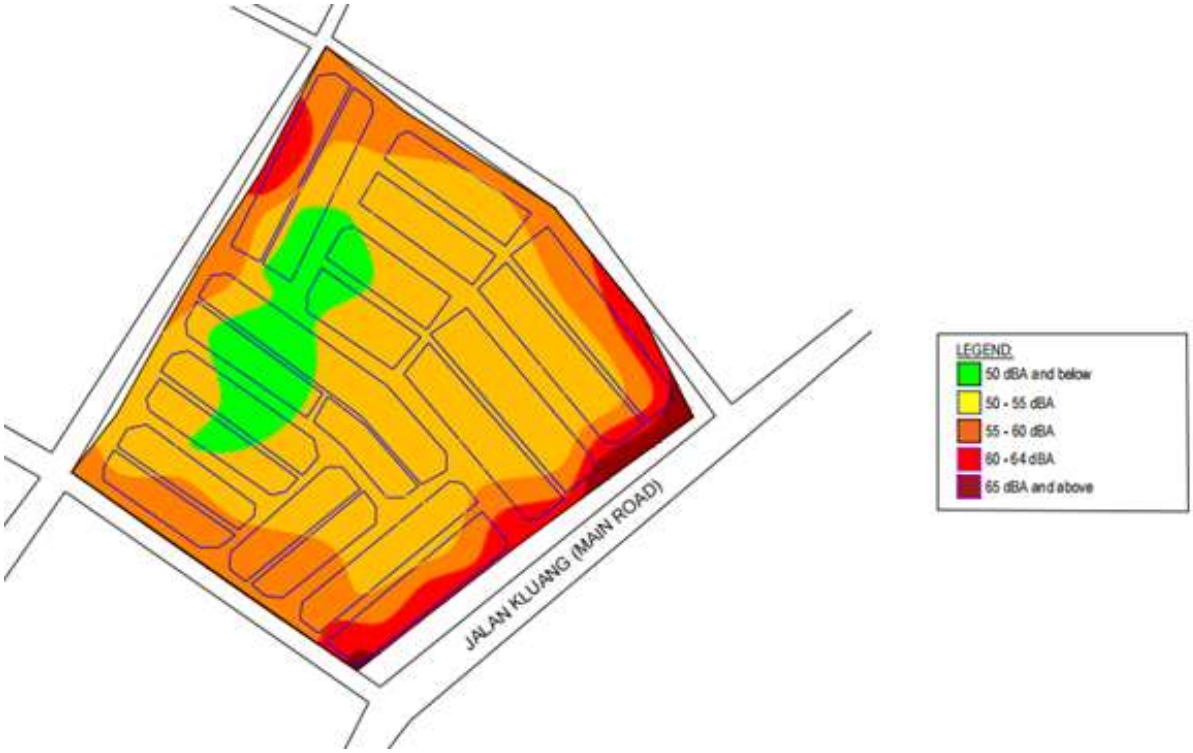

Fig. 7. Noise map of Taman Koperasi Bahagia in the evening during weekends

3.3 Comparison of Traffic Noise Level in the Morning and Evening

During the weekdays, it was obtained that the traffic noise level observed in the evening session was higher than the morning session. By comparing the most impacted stations which were S1, S2, S3, S4, S5, S6 and S10, results in the morning were recorded as 64.5 dBA, 65.4 dBA, 63.8 dBA, 63.6 dBA, 64.4 dBA, 57.2 dBA as well as 60.2 dBA respectively. In contrast, the results were recorded as 64.8 dBA, 64.7 dBA, 63.2 dBA, 62.8 dBA, 63.4 dBA, 60.4 dBA and 62.4 dBA respectively when it comes to the evening session. Based on this result, it was known that the traffic noise level obtained was higher for these stations in the morning than the evening. Thus, the peak hours of the major road near to the Taman Koperasi Bahagia were found in the evening hours in which the vehicles on road may start to increase due to after-work hours. Likewise, since the results recorded for the morning session had already passed the working hours. Therefore, the road usage may be reduced as most of the transportation services and most of the vehicles were excluded during the measurement.

On the weekend, the central region of the residential area which were the stations S8, S9, S12 and S13, traffic noise level in the morning was recorded as 51.4 dBA, 53.5 dBA, 47.4 dBA and 49.3 dBA respectively. Whereas it was recorded as 51.7 dBA, 54.7 dBA, 50.1 dBA and 49.4 dBA respectively in the evening. Hence, it was concluded that the findings were the same as reported during the weekdays as these stations were more impacted by the traffic noise in the evening than in the morning.

Based on the results recorded for the most impacted region, which were stations S1, S2, S3, S4, S5, S6 and S10, the results were recorded as 65.6 dBA, 65.8 dBA, 63.8 dBA, 63.8 dBA, 63.8 dBA, 59.6 dBA and 60.6 dBA respectively in the morning. While the results were recorded as 68.5 dBA, 66.5 dBA, 63.4 dBA, 63.9 dBA, 65.8 dBA, 58.2 dBA and 61.4 dBA respectively in the evening session. Based on the analysis, it was known that results obtained in the evening session were higher compared to the morning session as the traffic noise had a greater impact on the residents in the evening. Hence, contributed to a higher traffic noise level for the residents living near to these stations.

3.4 Comparison of Traffic Noise Level in Weekdays and Weekend

In comparison of the traffic noise level between weekdays and weekends, the data recorded for weekdays' morning and weekends' morning are taken into considerations. Based on the results abovementioned, the overall traffic noise level obtained from the weekdays was higher than the weekend as most of the stations had found being exposed to the traffic noise level in the range of 60 dBA to 64 dBA which was close to the permissible limit set by DOE. Noise level fall within these range may highly contribute to series of chronic impacts to the residents and environment even though not exceeding the DOE permissible limits. However, stations S1 and S2 were exposed to noise level higher than 65 dBA on the weekend which considered unsafe as it had exceeded the permissible limit for an existing residential area. While only station S2 was recorded exposing to traffic noise level that was higher than 65 dBA on the weekdays. This can be concluded that, although the overall results had revealed that the traffic noise level obtained during the weekdays was higher than weekends, the affected stations or region might still be deviated as it might have the existence of some external noise disruption or heavier traffic happened on the weekend that eventually makes some stations to experience a higher traffic noise level.

Based on the data obtained, stations S1 to S5 were known as the main affected region by traffic noise as it was highly exposed to sound level. Although only a small region at S1 and S2 that had exceeded the permissible noise level limit set by DOE, but S3, S4 and S5 also exposing to a high-risk situation because the traffic noise level recorded was within 60 to 64 dBA. This is because the main road, Jalan Kluang is located right near to these stations, which highly contributed to series of negative impacts to the residential area such as noise pollution through severe traffic noise generated during the peak hours.

However, during the field measurement, it was observed that a row of trees is planted along the street near to stations S1 to S5 where supposedly act as a good sound absorber or sound barrier. The trees that planted next to the main road where it should be act as the noise absorber. As the trees or any plants tends to absorb or diminish sound by detecting the sound waves and alter the behaviour of sound concurrently. Whereas different types of plant possessed with different physical characteristics, thus it will absorb, refract or deflect the sound waves differently.

Sound absorption by the trees is mainly working by its structure of trees. For instance, structures of branch, density and shapes of the leaves as well as the texture of the trees. Previous researcher had revealed that the trees owned with a rough texture possessed with better sound absorption. In contrast, it was found that trees planted along the stations S1 to S5 showed a poor performance in sound absorption as it was not helped in traffic noise reduction during the site data collection. This may be due to the trees are planted by a random arrangement as sound waves may be travel through the empty spaces and eventually reaching the residential areas. Besides, it may likewise be due to the structure of the trees which substantially reduces its ability in sound absorption.

4. Conclusions and Recommendations

In conclusion, the results have revealed the impact of the traffic noise towards the residential area for a week and noise mapping has been produced to visualize and assessed the equivalent A-weighted sound level of traffic noise at the residential area. The objective of this study was achieved successfully by determining the traffic noise level results obtained in this study by using the sound level meter at selected stations and comparing the data collected with the standard of Department of Environment, Malaysia. It was concluded that the residential area that built up next to the main road, Jalan Kluang are impacted the most by the traffic noise no matter in the morning or afternoon

during weekday and weekend. It is almost exceeded the permissible sound level that has been set in the Guidelines for Environmental Noise Limits and Control by the Department of Environment Malaysia. Although the limit of the traffic noise has not exceeded the standard, but the residents are still exposed to the high-risk situation where prolonged exposure to traffic noise could lead to issue such as health and mental problems. The finding of the study provides actionable insights that can inform city planner or the authorities in implementing and creating the effective noise control regulations and strategies to provide the overall life satisfaction for the residents.

There are few recommendations that arise from the finding of this study which could benefit the future planning as per below:

i. Installation of sound barrier to reduce the noise level arises from traffic noise can be implemented. It works through the process of absorption, wavelength modifications, diffraction as well as reflections to minimize the impact of traffic noise.
ii. Continuous monitoring of traffic noise level or regular reassessment of traffic noise level at the high-risk area by the relevant authorities should be implemented. The possible impacted area should be monitored continuously to track the trends and the potential fluctuations of the traffic noise towards the residential area.
iii. Policy makers should also collaborate with the Department of Town and Country Planning and Department of Landscape to strategically revisit the selection and the placement of trees that plant along the road. This will not only help to reduce noise pollution but also contribute to a visually appealing and harmonious landscape.
iv. Stakeholders should enforce stricter guidelines on the vehicle noise emissions and modifications, policy makers can curb excessive noise generated by the vehicles, especially those fitted with loud exhaust systems or aftermarket modifications that amplify noise levels. A regular inspection on road by the traffic police to the road users should be done to ensure the vehicles are comply with the guidelines.

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