Traffic Noise Assessment among Residential Environment in Batu Pahat, Johore, Malaysia

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Abstract. Noise pollution arises as a severe problem to the community and ground transportation has highly impacted noise environment of the neighbourhood. In the present study, six stations were selected from three different locations in order to assess the traffic noise impact among residential area along Jalan Kluang, Batu Pahat. The objectives of this study focused on two main stages: (1) determination of noise indices; and (2) assessment of traffic noise impact. The noise indices such as equivalent continuous noise level (LAeq), noise level exceeded 10% (L10), 90% (L90) and the maximum noise level (LAFmax) of peak hours measurement time were determined using sound level meter (SLM) at all six stations. Besides, traffic noise index (TNI) and noise pollution level (LNP) were calculated based on the measured noise indices to expose the traffic noise impact. Overall, the result of the present study showed that residential area faces traffic noise disturbance partially whereby 50% of the stations exceeded the DOE standard which was 55dBA. Nevertheless, the residents living nearby Jalan Kluang are commonly facing traffic noise nuisance, but stations located further inside residential areas tend to have more residential background noises apart from traffic influence.

1. Introduction
The rising number of ground transportation due to the development of cities and population daily demands has directly been associated to urban noise pollution in terms of elevated traffic noise levels [1]. The traffic noise mainly occurs from the frictional effect between road surface and tires which causes high negative impact to the urban communities and the surrounding environment [2-3]. Dominance of traffic noise level in the surrounding environment affects the sleeping, resting, studying and communication among population and together with traffic noise annoyance, they constitute threatening impacts to human health in long term [4].

2. Traffic Noise Limits
Noise pollution has become a serious problem for humans and has been officially announced as the second threatening pollution in the world by World Health Organization (WHO). Noise pollution inducement from transportation varies into several sources such as traffic noise, aircraft noise, marine noise and railway noise. Traffic noise can be defined as an unwanted sound generated from vehicles while operating on roadways. Traffic noise is known as the most pervasive and serious among transportation form of noise sources [5]. According to the European Environment Agency (EEA) in year
2014, urban noise has been categorized as major environmental health threats in overall Europe [6]. From the report, road traffic is the significant source of environmental noise with an estimated 125 million people affected by noise level greater than 55 decibels dBA which is about 40% from the entire population living among Europe.

In Asia, developing countries such as China, India and Vietnam are facing serious problem of traffic noise pollution in their cities [7]. Malaysia is one of the developing countries included in this problem due to the development pace that constantly occurs with the increasing number of road transportation networks in supporting the development process. Noise pollution awareness is not a new scenario as it has received the attention of the authorities in Malaysia as early as 1979 [8]. The Star Online (2016) stated that 132 noise pollution complaints have been reported to the Department of Environment, Malaysia in 2015. Most of the complaints were reported due to the noise from the commercial and construction sites. Other noise pollution complaints were reported regarding the noise that came from industrial and transportation system. Although traffic noise annoyance is not the major source of nuisance, the expert has highlighted that road traffic noise is the most pervasive noise pollution over the world [9].

Based on the environmental control limits set by the Malaysian Department of Environment (2007) at suburban and residential areas, the maximum permissible noise level outside the low density residential areas should not exceed 55 (dBA) in order to protect the community from this urban noise. However, the noise limit varies according to the sensitivity of area, type of location and different regulations set by the countries. Table 1 shows noise limit level among the selected countries which are classified into daytime and night-time noise level which are compared to WHO noise limit [10-12]. Hence, specific evaluation of traffic noise level will help to understand the actual condition of noise pollution in residential environment. Furthermore, the obtained results contribute in identifying enough precautions to control traffic noise annoyance in residential areas along Jalan Kluang Batu Pahat.

Table 1. Noise level standard by WHO and selected countries [10-12].

| Noise Level Limit                  | Noise level, L_{eq} dBA |
|-----------------------------------|-------------------------|
|                                   | Daytime     | Night-time |
| WHO                               | 55          | 45         |
| Malaysia (DOE Low Density)        | 55          | 50         |
| Germany (Noise level guidelines)  | 45          | 35         |
| Australia (Recommended outdoor background noise level) | 45 | 35 |
| Japan (Environmental quality standards) | 45 | 35 |
| Korea (Environmental quality goal) | 50          | 45         |
| Philippines (Environmental quality noise standards) | 50 | 40 |
| Iran (Residential area)           | 55          | 45         |
| (Commercial area)                 | 65          | 55         |
| (Industrial area)                 | 75          | 65         |

Thus, the present study was conducted to evaluate traffic noise indices and to assess the traffic noise impact towards nearby residents of Jalan Kluang. The assessment of traffic noise pollution at these areas was also compared with the noise limit and control that has been set by Malaysian Department of Environment.
3. Methodology

The main objectives of the present study were divided in two main stages: (1) determination of noise indices; and (2) assessment of traffic noise impacts. The details of each stage are described in the following sections.

3.1. Study area

In recent years, Batu Pahat has become a rapidly growing township due to several establishments of colleges, institutions and universities. In the recent year of 2015, about 41632 number of vehicles were recorded using Jalan Kluang daily according to data from Transport Statistic Malaysia [13]. The noise assessment of this study was specifically conducted on the residential areas which are directly located along Jalan Kluang Batu Pahat. A total of three main residential locations were chosen in this study to evaluate the traffic noise effects to the population surrounding. Two respective stations were chosen for each location to effectively identify the traffic noise level and the details are shown in Table 2 and Figure 1. All the observed stations were chosen by considering similar basic criteria as according to DOE guidelines which are being at least 75 meters away from intersections, traffic signal and other noise source such as schools, stadium, mosque and playground.

Table 2. Measurement locations.

| Location       | Stations | Coordinates                  |
|----------------|----------|------------------------------|
| Taman Lundang  | L1       | 1.8571° N 103.1000° E        |
|                | L2       | 1.8477° N 103.0717° E        |
| Taman Arked    | L3       | 1.8664° N 103.1168° E        |
|                | L4       | 1.863216°N 102.955564°E      |
| Taman Gading   | L5       | 1.863159°N 102.958450°E      |
|                | L6       | 1.859886°N 102.949631°E      |

Figure 1. Map of study areas.
3.2. Determination of noise indices

The field measurement in this study was conducted to evaluate the noise indices using sound level meter of Bruel & Kjaer 2250 band class 0 which complies to the guidelines set by Malaysian Department of Environment [12]. Sound level meter (SLM) was configured with 1/3 octave band and A-weighted units to capture sound measurement in the present study. SLM was approximately placed on level ground about 1.5 meters high and 70 degrees to noise source with the aid of tripod. The microphone of SLM was protected by windshield cover and the stations were located by avoiding any reflective sources nearby as shown in Figure 2. The traffic noise assessments were conducted during weekdays. Noise surveys were taken during the peaks hours which consist of morning peak hours (7-9 am) and evening peak hours (5-7 pm).

![Traffic Noise Measurement Locations](image)

**Figure 2.** On-site traffic noise measurement locations for (a) Taman Lundang, L1, (b) Taman Arked, L3, and (c) Taman Gading, L6.

3.3 Assessment of traffic noise

The noise data were recorded in SLM and analysed using logging software BZ5503-Measurement Partner Suite to generate the equivalent continuous noise level (L\text{Aeq}) for respective period, percentile of noise exceedance, maximum and minimum sound level. The field measured data were analysed and converted to traffic noise index (TNI) and noise pollution level (LNP) to identify the noise pollution experienced by the residents in the targeted residential areas [14-15]. The analysed noise indices such as L\text{Aeq}, noise level exceeded 10\% (L\text{10}) and noise level exceeded 90\% (L\text{90}) were used to derive the TNI and LNP values. The traffic noise index (TNI) has an input of L\text{10} and L\text{90} as un-linear noise variability to make the respective allowance and it was derived as shown in Equation 1 [16]. On the other hand, combination of noise indices L\text{Aeq}, L\text{10}, and L\text{90} derived the noise pollution level (LNP) as shown in Equation 2. In overall, the TNI and LNP values should not be more than 74dBA and 88dBA respectively as to be a good indicator to evaluate healthy noise environment for residential areas.

\[
\text{TNI} = 4 (L_{10} - L_{90}) + L_{90} - 30 \\
\text{LNP} = \text{L\text{Aeq}} + (L_{10} - L_{90})
\]
4. Results and discussion

Field measurements on different time interval were observed to evaluate the seriousness of the traffic noise pollution in Batu Pahat. Overall, the measured equivalent continuous noise level (LAeq) was analysed using 2-hour period as shown in Table 3. In addition, noise parameters such as noise level exceeded 10% (L_{10}), 90% (L_{90}), maximum noise level (LAFmax), traffic noise index (TNI) and noise pollution level (LNP) were calculated to determine the traffic noise pollution rate among the observed residential areas. Analysed noise indices and parameters were presented in chart for better illustration as in Figure 3 and 4.

Overall, the field measurement result of LAeq was satisfactory whereby 50% of the observed stations were under the recommended DOE standard which is 55dBA. Each location consists of two different stations. The setup for the first station was chosen to be nearer to the road than the second station which provided the variability of distance to the noise source. The variation in distance to the main road or the targeted noise source plays a major role in determining the noise level. Thus, the nearer stations of L1, L3 and L5 recorded higher LAeq than the other stations. Apart from the distance variation to noise source, the locations layout and quantity of traffic vehicle service played more important roles in determining the noise level. For instance, location such as Taman Arked and Taman Gading recorded higher LAeq than Taman Lundang. Although the distance to noise source in all three locations were similar, the quantity of traffic vehicles at Taman Arked and Taman Gading were slightly higher. The respective two locations had similar capacity of road users since the locations were nearer to Bandar Penggeram Batu Pahat. The highest equivalent noise level was obtained in station L3 and L5 which is 57.1dBA both respectively. Both of those respective stations have similarities in term of the location’s layout and the capacity of road users.

The field measurement obtained the maximum noise level (LAFmax) to identify the characteristic of noise produced in the respective residential areas. The results recorded about 71.6dBA as the lowest and 92.2dBA as the highest for LAFmax. The lowest LAFmax value obtained in this study is higher than 60dBA which like an outside environment of residential area possibly cause discomfort but only physically related effects to humans occurs during 110dBA or higher according to WHO guidelines [17]. The LAFmax has very short term presence, yet the higher noise has increased the impacts towards humans in psychology and physiology ranging from discomfort up to mortality [18]. The LAFmax is totally the case depending variable factor in each residential area. The objective is to obtain those parameters in order to identify the ongoing noise circulation in a residential area. Each station has independent level of LAFmax based on the exposure and ongoing daily events in the respective location. For instance, residential layout consists of housing area, shop lots, free ground, public utility area and playgrounds. Each different area has independent noise emission which is totally uncontrollable. This scenario shows that the arising background noise level is strongly associated with some of the resident behaviours such as honking from the vehicles, speeding of the vehicles, producing intense noise emission from heavy engine of their vehicles and other modifications of the vehicles. Apart from daily human activity, their nature noise disruption also occurs in each of the observed area such as dog barking, bird and crickets chirping which highly impacted the background noise level during the field measurement.

From table 3, it can be noticed that the traffic noise index (TNI) values and noise pollution level (LNP) were analysed to measure the physiological and psychological impact to residents living at the residential area along Jalan Kluang Batu Pahat. According to the result in table 3, it shows that all the assessed residential location recorded lesser TNI values than 74dBA. Thus, this proves that these sampling locations were not affected by traffic noise. The noise pollution levels (LNP) at the respective 3 residential areas were under 88dBA even though the LAFmax and certain LAeq values exceeded the DOE standards. Since Jalan Kluang is the main road that connects Ayer Hitam, Parit Raja and Batu Pahat, the drivers tend to speed their vehicles especially toward Parit Raja where the road is straight and wide. More detailed studies in the future are necessary to identify the extent of factors that affect the level of noise along Jalan Kluang. Besides that, other qualitative factors that may affect communication, sleepless disturbance, teaching and living environment of these areas also need to be taken into consideration as well.
Table 3. Summary of traffic noise assessment.

| Location      | Station | Time   | LAeq | LAFmax | L10  | L90  | TNI | LNP |
|---------------|---------|--------|------|--------|------|------|-----|-----|
| Taman Lundang | L1      | AM     | 52.4 | 83     | 53.2 | 42.9 | 54.1| 62.7|
|               |         | PM     | 55   | 83     | 55.8 | 44.5 | 59.7| 66.3|
|               | L2      | AM     | 51.9 | 76.5   | 53.4 | 45.4 | 47.4| 59.9|
|               |         | PM     | 51.1 | 83.85  | 51.1 | 42.7 | 46.3| 59.5|
| Taman Arked   | L3      | AM     | 57.1 | 83.8   | 58.5 | 49.1 | 56.7| 66.5|
|               |         | PM     | 56.1 | 81.2   | 57.8 | 49.3 | 53.3| 64.6|
|               | L4      | AM     | 51.3 | 76.1   | 52.1 | 42.6 | 50.6| 60.8|
|               |         | PM     | 47.5 | 71.6   | 49.1 | 43.5 | 35.9| 53.1|
| Taman Gading  | L5      | AM     | 57.1 | 92.2   | 56.7 | 48.2 | 52.2| 65.6|
|               |         | PM     | 54.4 | 75.4   | 56.9 | 47.9 | 53.9| 63.4|
|               | L6      | AM     | 52.2 | 82.6   | 54.1 | 44.1 | 54.1| 62.2|
|               |         | PM     | 55.1 | 78.1   | 57.3 | 47.7 | 56.1| 64.7|

Figure 3. A-weighted equivalent continuous noise level (LAeq) for 2 hours (AM) Morning peak hours; (PM) Evening peak hours.

Figure 4. Traffic Noise Index (TNI) values and Noise Pollution Level (LNP) for (AM) Morning peak hours; (PM) Evening peak hours.
5. Conclusion and recommendation

In the present study, field measurements were carried out at 6 locations to assess the traffic noise impact at 3 different residential areas along Jalan Kluang Batu Pahat. From the results, two stations exceeded the DOE limits were found to be L3 and L5 over six stations by clocking the largest LAeq at about 57.1dBA. The largest LAmax value acquired was 92.2dBA, which has a greater tendency for people living with discomfort alongside Jalan Kluang, Batu Pahat. The stations which exceeded the recommended standard have helped the researcher to understand the sound characteristics and real life scenarios throughout the field measurements. The largest traffic noise index (TNI) and noise pollution rate (LNP) were achieved at 59.7dBA, 66.5dBA respectively, which remains below the recommended boundaries. In a nutshell, resident houses near Jalan Kluang commonly face more traffic noise nuisance, while the houses further inside residential areas faces higher background noise from natural factors. The field measurement has exposed that background noise in residential area has to be considered severely for further researchers to specify the traffic noise related field of study.

Further research on traffic noise impact can be carried out more precisely which focuses on the targeted traffic nuisances to reduce the disruption of mentioned uncontrollable variables in study area. More detailed studies in the future are necessary to identify the extent to which factors affect the level of traffic noise along this busy road together with traffic characteristics data such as speed and volume of vehicles. Besides, other factors that may affect communication, sleepless disturbance, teaching and learning environment of these areas can also be included in the investigation.

6. References

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