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# Road Traffic Noise Levels at Different Types of Residential Areas in Nibong Tebal, Penang

**Herni Halim[1,*], Nur Fatin Najiyah Hamid[1], Mohamad Firdaus Mahamad Yusob[2], Nur Atiqah Mohamad Nor[1], Nur Hanani Farhah Mohd Hilmi[1], Nur Sabahiah Abdul Sukor[1], Noorhazlinda Abdul Rahman[1], Zaiton Haron[3], Faridah Wahab[4]**

[1]School of Civil Engineering, Engineering Campus,
Universiti Sains Malaysia, 14300 Pulau Pinang, MALAYSIA

[2]School of Electrical and Electronic Engineering, Engineering Campus,
Universiti Sains Malaysia, 14300 Pulau Pinang, MALAYSIA

[3]Department of Structure and Materials, Faculty of Civil Engineering,
Universiti Teknologi Malaysia, 81310 Johor, MALAYSIA

[4]School of Environmental Engineering,
Universiti Malaysia Perlis, 02600 Perlis, MALAYSIA

*Corresponding Author

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**Abstract:** Traffic vehicles on the road networks during their movement create noise that has greater impact on environment. The sources, the receivers and the place of transition, where the sound wave propagates, are the three vital parameters for the field of noise acoustics. For this research, the aim of this study is to assess traffic noise levels between different types of residential areas in Nibong Tebal, Penang. The study is carried out in order to achieve the following three main objectives, which are to assess the level of traffic noise at selected residential areas, to characterize the traffic flow composition nearby study areas, and to compare noise levels between low density and terraced house residential areas. The noise levels measurements were carried out periodically in the morning (from 0700 to 1100), evening (from 1600 to 1900), and at night (from 2200 to 2300) for 15 minutes using a sound level meter. The traffic characteristics were measured simultaneously during noise levels measurements. The highest equivalent continuous noise levels for the low density residential areas was at Kampung Batu 2 in the evening with 65.9 dB(A), while for the medium density residential areas, Taman Sri Acheh contributed 68.60 dB(A) during the morning. The lowest equivalent continuous noise levels were obtained at Kampung Simpang Tiga in the morning that contributed 54.9 dB(A) for low density residential areas. However, the minimum equivalent continuous noise levels obtained for the medium density residential areas was at Taman Ilmu Indah in the morning with 63.10 dB(A). The results obtained, clearly show that the equivalent continuous noise level for all study sites exceeded the maximum permissible sound level for medium density areas during daytime (from 7.00 am to 10.00 pm), which is 55 dB(A), while at night time (from 10.00 pm to 7.00 am) is 45 dB(A), and for low density residential areas during daytime (from 7.00 am to 10.00 pm) is 55 dB(A), while at night time (from 10.00 pm to 7.00 am) is 45 dB(A), respectively. These values are based on the guidelines for environmental noise limits and control by the Department of Environment, Malaysia.

**Keywords:** Road traffic noise, traffic composition, medium density population, residential areas

*Corresponding author: ceherni@usm.my

## 1. Introduction

Environmental noise pollution produced by road traffic differs across geographical space depending on the receiver, the interceding impediments such as buildings, barriers and terrain and identifying the number of individuals in a particular location that will be influenced by excessive noise levels [1]. The area of global mass transportation and urbanization, traffic noise has become a critical issue in modern time [2].

The occurrence of noise that is mostly heard by the people is usually execrable, coincidental and causes a variety of health problems such affecting children's cognition and hypertension [2]. The consequence of noise can be psychological as well as physiological as it will lead to reduce of quality sleep, and annoyance which affect the quality of health [3]. Prolonged exposure to the traffic noise levels exceeded 70 dB (A) could cause hypertension, high stress levels, sleep disturbance and other harmful effects [4]-[6].

Over 24 million people subjected to noise levels above 65 dBA of $L_{eqDEN}$ (Day Evening Night Sound Level) and over 103 million people are subjected, above 55 dB (A) of mean daily noise [7]. Studies have found that the traffic noise exposure is associated with stroke, ischemic disease and hypertension on human being [8]. According to the Löbig and Weber [9], the environmental noise is the cause of sleep disturbance, triggering the release of stress hormone level, induced annoyance and developer of hearing impairment on human well-being. People that are living close to the roadway will notice frequently noise events occurring in the traffic streams and tend to get sleep disturbance [10].

In recent studies conducted in Malaysia by Halim et al. [11], the noise levels obtained at residential areas are greater near Sungai Besi Expressway compared to traffic flow at Duke Highway and KESAS Highway. Sungai Besi Expressway has a greater traffic flow compared to the other two highways. During the peak hour, the highest noise level was 75.7 dB (A). During off-peak hour was 73.4 dB (A), while 73.8 dB (A) and 72.6 dB (A) were the lowest equivalent continuous noise levels ($L_{Aeq}$) obtained in Sungai Besi Expressway. These noise levels obtained at residential areas located near highways revealed that highway noise levels in Malaysia are exceeding the outdoor noise limit by Malaysia guidelines (DOE, 2007) (the permissible noise limit of continuous sound pressure level ($L_{Aeq}$) for urban residential area is 60 dB(A) for daytime and 50 dB(A) for night time as in Table 1). The noise levels measured also exceeded the World Health Organization (WHO, 2000) which stated that outdoor noise levels obtained in dwelling areas should not surpass 55 dB (A) during daytime and 45 dB (A) during night time. The noise limits aims to protect the dwellers from being seriously annoyed during daytime and night time. Dwellers are categorized in three types of residential areas as shown in Table 2. The study highlighted that noise has become significant environmental problems of Malaysia and need further mitigation in order to overcome it.

**Table 1 - The maximum permissible sound level ($L_{Aeq}$) by receiving land use for planning and new development [14]**

| Receiving Land Use Category | Day Time (7.00 am – 10.00pm) | Night Time (10.00pm – 7.00am) |
|---|---|---|
| Noise Sensitive Areas, Low Density Residential, Institutional (School, Hospital), Worship Areas. | 50 dB(A) | 40 dB(A) |
| Suburban Residential (Medium Density) Areas, Public Spaces, Parks, Recreational Areas. | 55 dB(A) | 45 dB(A) |
| Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential-Commercial). | 60 dB(A) | 50 dB(A) |
| Commercial Business Zones | 65 dB(A) | 55 dB(A) |
| Designated Industrial Zones | 70 dB(A) | 60 dB(A) |

**Table 2 - Classification of residential area based on planning guidelines for environmental noise and control [14]**

| Density | Person per acre |
|---|---|
| Low | < 75 |
| Medium | 75 -200 |
| High | > 200 |

Previous study on assessment of traffic noise pollution in Penang was carried out by Aziz et al. [12]. However, the study only covers Bukit Mertajam as study sites. In order to implement effective noise control measures and to boost

the quality of noise environment [13], more data is needed on noise emission by vehicles especially in areas with receivers live nearby the roads. Therefore, this study was carried out with the objectives; to assess the level of traffic noise at selected residential areas; to characterize the traffic flow composition nearby study areas; and to compare noise levels between low density and terraced house residential areas. The findings from this study will provide a clear insight into the noise level of road traffic between high density and medium density population and assist proper planning in selected residential areas in Nibong Tebal, Penang.

## 2. Materials and Method

Noise descriptors were examined in this research to investigate the different type of noise level percentiles that were measured. Noise produced was not steady as noise level changed with time. The energy equivalent levels of road traffic streams have a pattern of fluctuation of noise levels over time that they associated with annoyance and other circumstances, depending the noise emission vehicles on the road traffic stream and the volume of the traffic flow [10].

In the analysis, $L_{Aeq}$ data were used to describe the traffic noise in the study sites, $L_{Aeq}$ a widely used noise descriptor is commonly adopted in many developed countries to explain noise level. The indices used such as $L_{10}$, $L_{50}$ and $L_{90}$, imply as the spatial intrusive noise level, the spatial median noise level and the spatial background noise level, respectively.

### 2.1 Description of Study Sites

This research was conducted in Nibong Tebal, Penang at six residential areas comprised of Taman Seri Acheh, Taman Pekaka and Taman Ilmu Indah which represents suburban residential areas with medium density of population. For rural residential areas, Kampung Batu 2, Kampung Sungai Bakau and Kampung Simpang Tiga were selected as study sites. A selective analysis was carried out on the traffic capacity on the suburban and rural road network near the study sites. The reasons of choosing these study sites are due to different density of population in the study sites. Density of population is calculated based on assumption of 5 persons in a house divided by the total area of a study site in acre unit.

Fig. 1 shows the location and Table 3 detailed out the coordinates, length of stretch of study sites from the roadside nearby and density of population, respectively.


**Fig. 1 - The locations of the study sites in Nibong Tebal, Penang**

**Table 3 - Coordinates, length of stretch and density of population of the study sites in Nibong Tebal, Penang**

| Study Sites | Coordinates | Length of Stretch (m) | Density Population |
|---|---|---|---|
| 1. Taman Ilmu Indah | 5.164,100.500 | 150 | 100(medium) |
| 2. Taman Pekaka | 5.138,100.492 | 150 | 99(medium) |
| 3. Taman Sri Acheh | 5.144,100.469 | 150 | 124(medium) |
| 4. Kampung Batu 2 | 5.129,100.467 | 100 | 60(low) |
| 5. Kampung Sungai Bakau | 5.126,100.419 | 100 | 70(low) |
| 6. Kampung Simpang Tiga | 5.141, 100.465 | 80 | 55(low) |

## 2.2 Noise Level Measurement

The noise levels were collected at the residential areas with duration sampling on two weekdays (Tuesday and Wednesday) and two weekends (Saturday and Sunday) by using the sound level meter (Cirrus (UK) – CR:1710). The measurement of the data using sound level meter was taken at 1 minute interval for 15 minutes morning, afternoon and night so that variations of noise can be obtained. The noise levels measurements were carried out periodically in the morning (from 0700 to 1100), evening (from 1600 to 1900), and at night (from 2200 to 2300) for 15 minutes. This method follows the noise measurement method in The Planning Guidelines for environmental Noise Limits and Control [14]. The sound level meter was held 1.50 m above the ground surface on the highway shoulder at a distance of 5 m from the pavement edge [14]. A calibrator was used to routinely calibrate the sound level meter before and after the measurement session. The sound level meter was calibrated in 93.7 dB (A).

Traffic composition was recorded using manual count and speed gun with 15 minutes observation to identify the percentage of traffic composition. The manual count was used to measure traffic volume on the road while the speed gun was shot at different types of vehicles several times in order to compute the average speed of each type of vehicles.

The types of vehicles should be classified into several classes to ease the evaluation of the vehicles that pass through the road. The classification of every class was followed as Arahan Teknik Jalan (8/86). The different types of vehicles will affect the exposure level of noise levels. In this study, the vehicles are classified into four classes which are car, motorcycle, light vehicle and heavy vehicle as per shown in Table 4.

**Table 4 - Vehicle classification into several classes**

| Class | Type of Class |
|---|---|
| 1 | Car |
| 2 | Motorcycle |
| 3 | Medium lorries |
| 4 | Heavy Vehicle (Bus, Big Lorry, Trailer) |

The PCU vehicle classification is summarized in Table 5 and it shows the conversion factors to PCU's from Arahan Teknik (Jalan) 8/86, A Guide on Geometric Design of Roads.

**Table 5 - PCU vehicle classification**

| Type of Vehicle | Equivalent Value (PCU) |
|---|---|
| Passenger cars | 1.00 |
| Motorcycles | 0.33 |
| Medium lorries | 1.75 |
| Heavy lorries | 2.25 |
| Buses | 2.25 |

## 3. Results and Discussion

Based on the guidelines for environmental noise limits and control by the Department of Environment [14], the maximum permissible sound level ($L_{Aeq}$) for medium density areas during daytime from 7.00 am to 10.00 pm is 55 dB(A) while at night time from 10.00 pm to 7.00 am is 45 dB(A). The the maximum permissible sound level ($L_{Aeq}$) for low density areas during daytime from 7.00 am to 10.00 pm is 50 dB(A) while at night time from 10.00 pm to 7.00 am is 40 dB(A).

Fig. 2 and Fig. 3 show the sound pressure level during weekdays and weekends, respectively. According to Fig.2, the highest $L_{Aeq}$ obtained at low density residential areas was 66.10 dB(A) at Kampung Sungai Bakau in the morning. The lowest $L_{Aeq}$ obtained was at Kampung Sri Acheh in the evening with 55.80 dB(A). Furthermore, in medium density residential areas, Taman Sri Acheh recorded the highest $L_{Aeq}$ with a value of 67.8 dB(A) at night while the lowest $L_{Aeq}$ was recorded at Taman Ilmu Indah at night with a value of 62.0 dB(A). The results obtained for all the $L_{Aeq}$ values show that all the values exceeded the maximum permissible sound level ($L_{Aeq}$) by the guideline of Malaysia for day time and night time either for medium density residential areas or low density residential areas. The maximum and minimum $L_{10}$ obtained were at Taman Sri Acheh (70.80 dB(A)) and Kampung Sri Acheh (58.2 dB(A)) during morning and evening, respectively. The highest and lowest $L_{50}$ measured was at similar study sites and measurement period as $L_{10}$ with values of 63.70 dB(A) and 49 dB(A), respectively. For $L_{90}$, Taman Pekaka recorded the highest value with 55.9 dB(A) while Kampung Sungai Bakau recorded the lowest value with 44.10 dB(A). $L_{max}$ is the maximum value recorded throughout the measurement. The highest $L_{max}$ value recorded was 91.4 dB(A) while the lowest was 72 dB(A), both at low density residential areas; Kampung Sungai Bakau (morning) and Kampung Sri Acheh(night),

respectively. This $L_{max}$ values show instantaneous events occurred during the noise measurement. However, $L_{max}$ is rarely used to describe the traffic noise level because it only explains a very short period of noise level from the traffic.

Referring to weekends noise levels in Fig.3, the highest $L_{Aeq}$ obtained at low density residential areas was 67.5 dB(A) at Kampung Sungai Bakau in the morning. The lowest $L_{Aeq}$ obtained was at Kampung Sri Acheh in the morning with 61 dB(A). Furthermore, in medium density residential areas, Taman Sri Acheh recorded the highest $L_{Aeq}$ with a value of 67.8 dB(A) in the evening while the lowest $L_{Aeq}$ was recorded at Taman Pekaka in the morning with a value of 62.1 dB(A). The results obtained for all the $L_{Aeq}$ values on weekends show that all the values exceeded the maximum permissible sound level ($L_{Aeq}$) by the guideline of Malaysia for day time and night time either for medium density residential areas or low density residential areas. The maximum and minimum $L_{10}$ obtained were at Taman Sri Acheh (70.7 dB(A)) and Kampung Sri Acheh (63.5 dB(A)) during evening and night, respectively. The highest and lowest $L_{50}$ measured was at Taman Sri Acheh and Kampung Sri Acheh with values of 66 dB(A) and 50.6 dB(A), respectively. For $L_{90}$, Kampung Sri Acheh recorded the highest value with 58.4 dB(A) while Kampung Sungai Bakau recorded the lowest value with 41.3 dB(A). The highest $L_{max}$ value recorded was 93.1 dB(A) while the lowest value was 76.5 dB(A), both at low density residential areas; Kampung Sungai Bakau (morning) and Kampung Sri Acheh(night), respectively. The results were at similar study sites during weekdays.

It can be concluded that, according to the recorded data and the observation while measuring the noise levels, for the low density residential areas, Kampung Sungai Bakau repeatedly gave the highest $L_{max}$ value compared to the other study sites. The adhan, that summons people in the living area by using amplifier from the mosque five times a day, noise generated from the engine sound of motorcycles and vehicles and high frequency of misuse horns by the driver were contributed to the high value of $L_{max}$. In the medium density residential areas, Taman Sri Acheh contributed to the highest $L_{max}$ obtained during the measurements periods. During the measurement at Taman Sri Acheh, it can be noticed that there was a high number of heavy vehicles that used the main route of Taman Sri Acheh, mostly of large trucks were back and forth from the Eppor Pack Sdn Bhd factory that located nearby the study site. Besides, the main route of Taman Sri Acheh moderately congested with vehicles and motorcycles. In addition, drivers that used this main route tend to honk their vehicles due to their own reasons. All in all, it can be concluded that low density residential areas featured considerably lower noise levels compared to medium density of residential areas mainly due to the movement of road traffic vehicles by the residents. This finding is in line with Pathak et al [19] as their study found that noise levels at housing areas located at the edge of the city are lower compared to in the middle of the city.

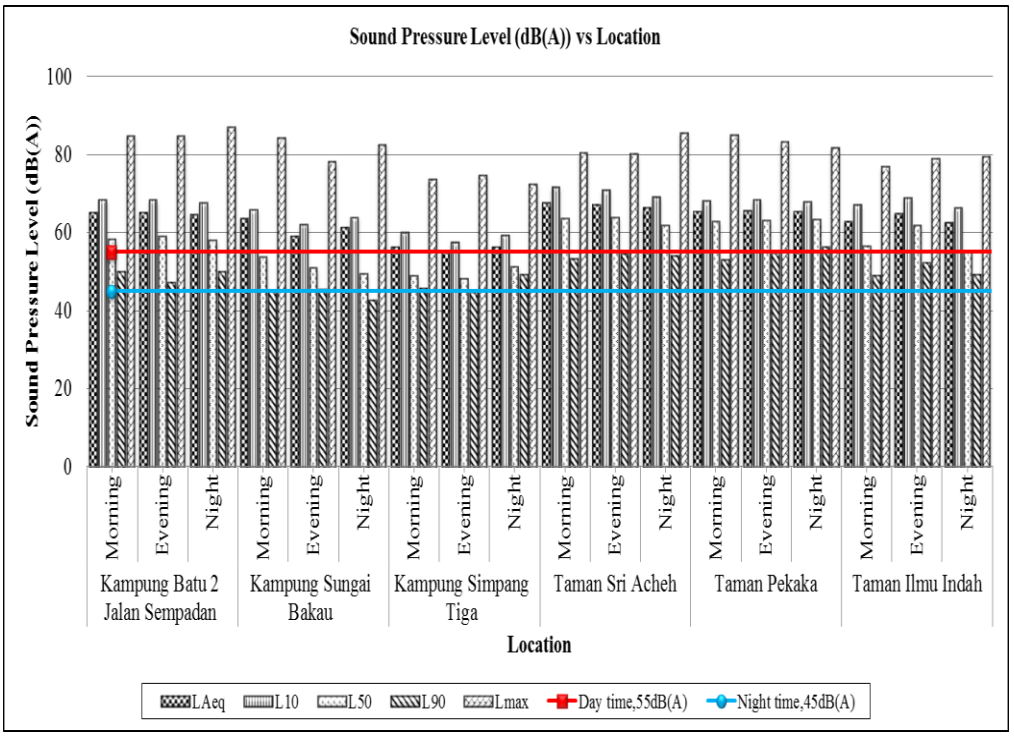


**Fig. 2 - Noise level at study sites during morning, evening and night measurements periods for the weekdays**

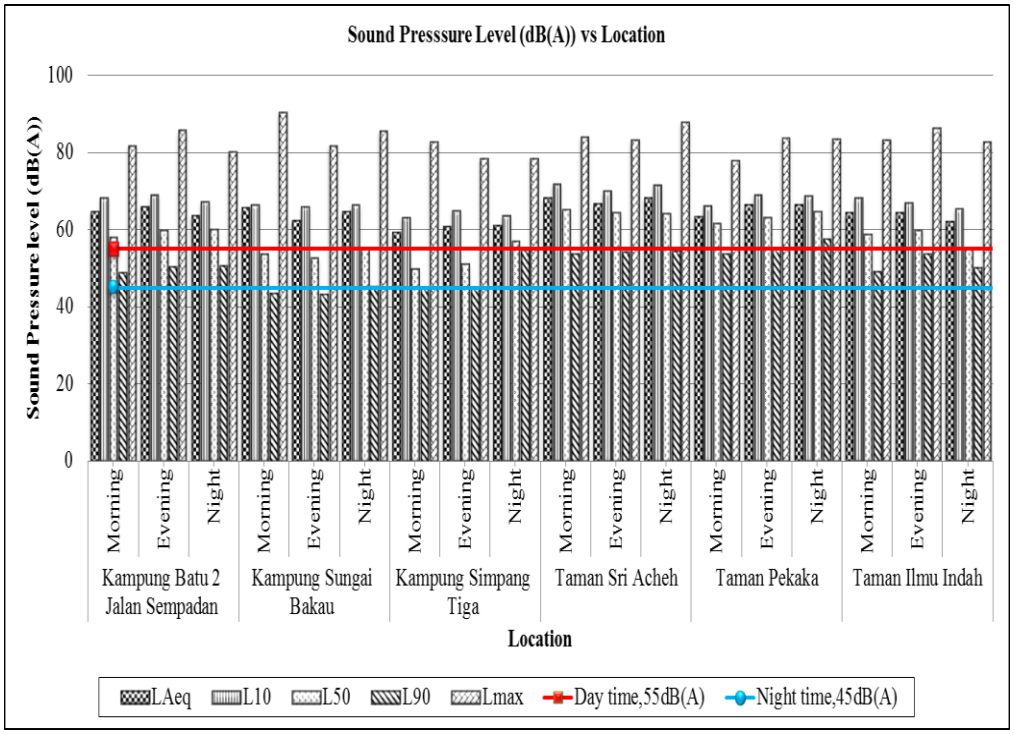


**Fig. 3 - Noise level at study sites during morning, evening and night measurements periods for the weekends**

Based on Table 6, the range of average speed obtained for all the study sites on weekdays during the period of measurements for car obtained between 41.4 km/hr to 70.73 km/hr, for van obtained between 46.67 km/hr to 74 km/hr, for motorcycles obtained between 40.43 km/hr to 65.08 km/hr, for medium lorries obtained between 42 km/hr to 67 km/hr and for heavy vehicles obtained between 41 km/hr to 57 km/hr during weekdays. Furthermore, based on Table 7, the range of average speed obtained for all the study sites on weekends during the period of measurements for car obtained between 47.21 km/hr to 68.21 km/hr, for van obtained 42 km/hr to 83 km/hr, for motorcycles obtained between 44.2 km/hr to 63.62 km/hr, for medium lorries obtained between 30 km/hr to 63.5 km/hr and for heavy vehicles obtained between 41 km/hr to 65 km/hr during weekends.

**Table 6 - The measurement average speed on weekdays**

| Location | Average Speed (km/hr) | | | | | |
|---|---|---|---|---|---|---|
| | Time | Car | Van | Motorcycles | Medium Lorries | Heavy Vehicles |
| Kampung Batu 2 Jalan Sempadan | Morning | 70.73 | 65.00 | 55.24 | 64.50 | 0.00 |
| | Evening | 63.50 | 74.00 | 55.95 | 57.00 | 41.00 |
| | Night | 59.86 | 58.00 | 52.93 | 0.00 | 0.00 |
| Kampung Simpang Tiga | Morning | 64.60 | 49.00 | 49.00 | 42.50 | 0.00 |
| | Evening | 54.64 | 0.00 | 49.00 | 62.00 | 0.00 |
| | Night | 41.40 | 0.00 | 45.44 | 0.00 | 0.00 |
| Kampung Sungai Bakau | Morning | 59.89 | 50.33 | 46.31 | 42.00 | 0.00 |
| | Evening | 53.17 | 58.00 | 48.55 | 49.50 | 0.00 |
| | Night | 50.63 | 0.00 | 40.43 | 0.00 | 0.00 |
| Taman Sri Acheh | Morning | 67.33 | 58.00 | 56.27 | 55.25 | 49.00 |
| | Evening | 58.41 | 54.38 | 56.27 | 52.73 | 53.83 |
| | Night | 58.22 | 49.00 | 60.55 | 48.33 | 46.67 |
| Taman Pekaka | Morning | 47.81 | 49.00 | 49.41 | 43.46 | 50.50 |
| | Evening | 48.08 | 46.67 | 51.45 | 44.67 | 0.00 |
| | Night | 45.56 | 0.00 | 46.19 | 0.00 | 0.00 |
| Taman Ilmu Indah | Morning | 68.74 | 0.00 | 65.08 | 52.50 | 57.00 |
| | Evening | 62.62 | 54.00 | 55.41 | 58.50 | 0.00 |
| | Night | 66.26 | 0.00 | 54.60 | 67.00 | 46.00 |

**Table 7 - The measurement average speed on weekends**

| Location | Average Speed (km/hr) | | | | | |
|---|---|---|---|---|---|---|
| | Time | Car | Van | Motorcycles | Medium Lorries | Heavy Vehicles |
| Kampung Batu 2 Jalan Sempadan | Morning | 68.21 | 0.00 | 63.62 | 63.50 | 0.00 |
| | Evening | 59.95 | 54.80 | 55.52 | 52.50 | 0.00 |
| | Night | 55.60 | 55.00 | 53.71 | 0.00 | 0.00 |
| Kampung Simpang Tiga | Morning | 54.86 | 0.00 | 44.20 | 0.00 | 0.00 |
| | Evening | 58.89 | 61.00 | 50.00 | 0.00 | 0.00 |
| | Night | 53.08 | 0.00 | 45.55 | 57.00 | 0.00 |
| Kampung Sungai Bakau | Morning | 47.95 | 0.00 | 55.62 | 0.00 | 0.00 |
| | Evening | 52.84 | 57.00 | 43.41 | 0.00 | 0.00 |
| | Night | 50.44 | 50.00 | 44.37 | 0.00 | 41.00 |
| Taman Sri Acheh | Morning | 63.50 | 61.67 | 52.53 | 54.00 | 53.50 |
| | Evening | 64.92 | 63.50 | 55.56 | 59.50 | 65.00 |
| | Night | 59.72 | 55.50 | 54.24 | 30.00 | 55.00 |
| Taman Pekaka | Morning | 48.30 | 49.00 | 47.89 | 40.00 | 0.00 |
| | Evening | 47.21 | 43.25 | 45.19 | 51.50 | 50.50 |
| | Night | 46.10 | 0.00 | 46.98 | 0.00 | 0.00 |
| Taman Ilmu Indah | Morning | 67.12 | 83.00 | 58.93 | 53.00 | 0.00 |
| | Evening | 66.93 | 72.00 | 63.00 | 54.00 | 0.00 |
| | Night | 63.04 | 42.00 | 58.00 | 39.50 | 0.00 |

Table 8 to Table 9 show the Pearson correlation for noise level, average speed and number of vehicles in pcu for low density residential areas and medium density residential areas during weekdays and weekends.

**Table 8 - Pearson correlation coefficients for noise level, average speed and number of vehicles (pcu) for low density residential area during weekdays**

| | Noise Level | Average Speed | Number of Vehicles (pcu) |
|---|---|---|---|
| Noise Level | 1 | 0.901 | 0.77 |
| Average Speed | 0.901 | 1 | 0.971 |
| Number of Vehicles (pcu) | 0.770 | 0.971 | 1 |

**Table 9 - Pearson correlation coefficients for noise level, average speed and number of vehicles (pcu) for medium density residential area during weekdays**

| | Noise Level | Average Speed | Number of Vehicles (pcu) |
|---|---|---|---|
| Noise Level | 1 | 0.466 | 0.495 |
| Average Speed | 0.466 | 1 | -0.539 |
| Number of Vehicles (pcu) | 0.495 | -0.539 | 1 |

Based on Table 9, noise level was very strongly correlated with average speed of vehicle (r = 0.901) and number of vehicles in pcu (r = 0.77). On the other hand, average speed of vehicle was very strongly correlated with number of vehicles in pcu (r = 0.971). When the number of vehicles in pcu increases, thus the average speed of vehicles decreases.

Based on Table 10, noise level was strongly correlating with average speed of vehicles (r = 0.466) and number of vehicles in pcu (r = 0.495). On the other hand, average speed of vehicle was strongly correlating with number of vehicles in pcu (r = -0.539). Average speed was inversely proportional to number of vehicles in pcu.

Based on Table 11, noise level was very strongly correlating with average speed (r = -0.892) and number of vehicles in pcu (r = 0.986). Noise level was inversely proportional to average speed of vehicles in pcu. On the other hand, the average speed of vehicles was very strongly correlating to the number of vehicles (r = -0.806). Average speed of vehicles was inversely proportional to the number of vehicles in pcu. When the number of vehicles in pcu increases, thus the average speed of vehicles decreases.

Based on Table 11, noise level was less strongly correlating with average speed of vehicle (r = 0.139). Noise level was strongly correlating with number of vehicles in pcu (r = 0.555). On the other hand, average speed of vehicles was

very strongly correlating with number of vehicles in pcu (r = -0.747). Similarly, average speed was inversely proportional to the number of vehicles in pcu.

**Table 10 - Pearson correlation coefficients for noise level, average speed and traffic density (pcu) for low density residential area during weekends**

| | Noise Level | Average Speed | Number of Vehicles (pcu) |
|---|---|---|---|
| Noise Level | 1 | -0.892 | 0.986 |
| Average Speed | -0.892 | 1 | -0.806 |
| Number of Vehicles (pcu) | 0.986 | -0.806 | 1 |

**Table 11 - Pearson correlation coefficients for noise level, average speed and number of vehicles (pcu) for medium density residential area during weekends**

| | Noise Level | Average Speed | Number of Vehicles (pcu) |
|---|---|---|---|
| Noise Level | 1 | 0.139 | 0.555 |
| Average Speed | 0.139 | 1 | -0.747 |
| Number of Vehicles (pcu) | 0.555 | -0.747 | 1 |

Based on the Fig. 2 and Fig. 3, regarding the noise levels obtained during weekdays and weekends, for the low density residential areas, Kampung Batu 2 shows the highest average noise levels obtained at evening time that were exceeded the maximum permissible sound level ($L_{Aeq}$) according to the Planning Guidelines for Receiving Land Use for Planning and New Development [14]. From Fig. 4 and Table 6, it can be seen that the motorcycle with 21% and 20 pcu were obtained as the highest traffic density at Kampung Batu 2 with average speed of motorcycle 55.65 km/hr.

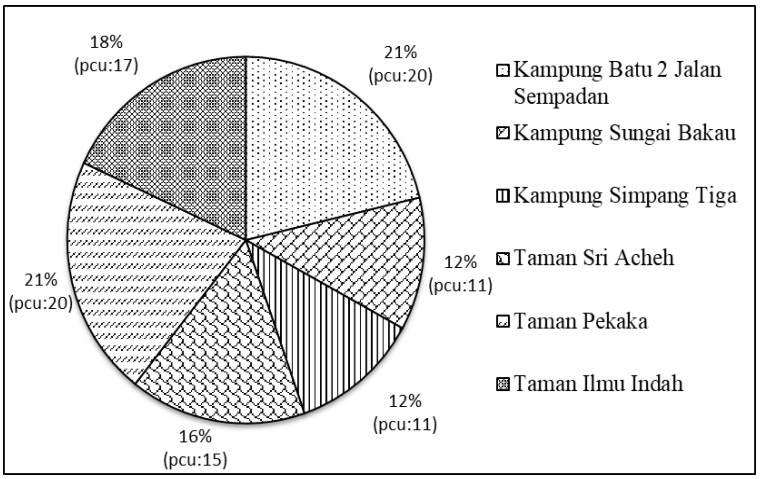


**Fig. 4 - Percentage and pcu of motorcycle during evening time on weekdays**

According to Table 6 and Fig. 5, medium lorries with 15% and 2.5 pcu with average speed 57.00 km/hr were observed to pass by the road at the Kampung Batu 2 during evening time. The presence of high density of variations vehicle types that produces sound power level affected to the noise levels attained at the study site.

Based on Fig. 6 and Table 7 for traffic characteristics on weekends, the medium lorries that passed by the road were 28% with 5 pcu at the average of speed of 52.50 km/hr for Kampung Batu 2. Can and Aumond [15] stated that, for every road segment, the mean speeds will affect the emissions of sound power level of the vehicles.

For the medium density residential areas, Taman Sri Acheh shows the highest average noise levels obtained at morning time during weekdays and at night time during weekends which were exceeded the maximum permissible sound level ($L_{Aeq}$) according to the Planning Guidelines for Receiving Land Use for Planning and New Development [14]. During weekdays, Fig. 7 and Table 6 shows the highest traffic density of medium lorries obtained at 18% and 42.50 pcu with average speed 55.25 km/hr.

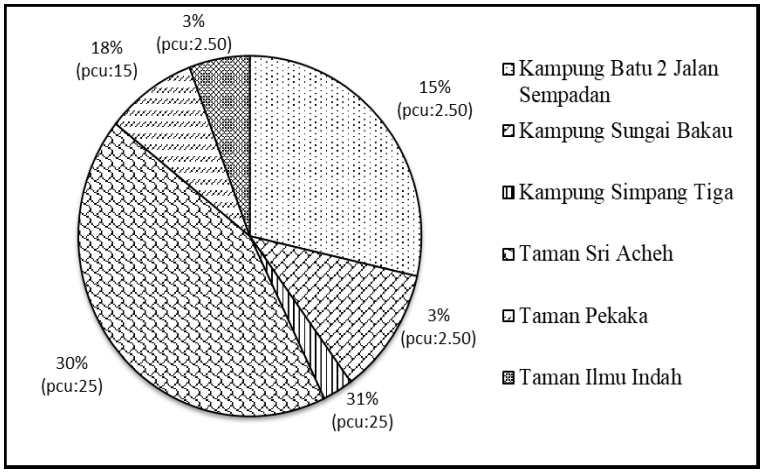


**Fig. 5 - Percentage and pcu of medium lorries during evening time on weekdays**

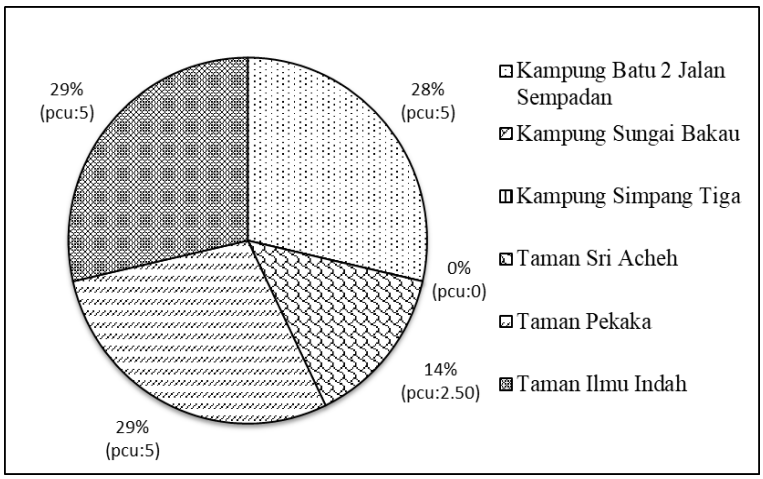


**Fig. 6 - Percentage and pcu of medium lorries during evening time on weekends**

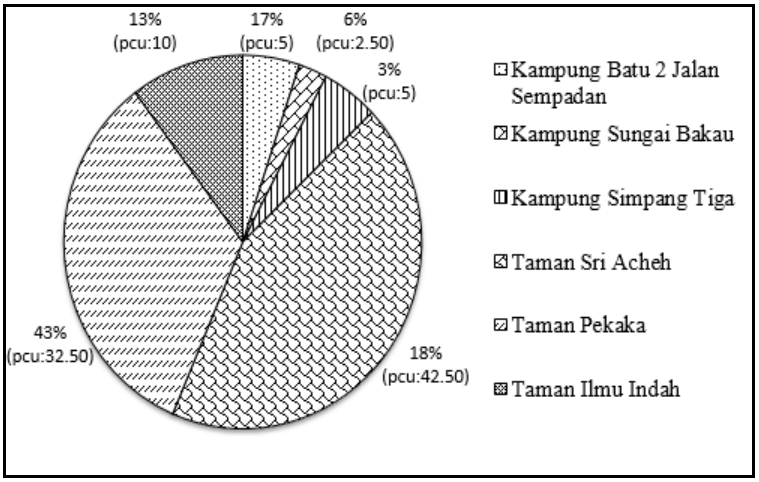


**Fig. 7 - Percentage and pcu of medium lorries during morning time on weekdays**

In Fig. 8, the heavy lorries obtained was at 70% and 21 pcu with average speed 49.00 km/hr. During weekends, Taman Sri Acheh showed the highest average noise levels produced that was exceeded the maximum permissible sound level ($L_{Aeq}$) according to the Planning Guidelines for Receiving Land Use for Planning and New Development [14] at night time.

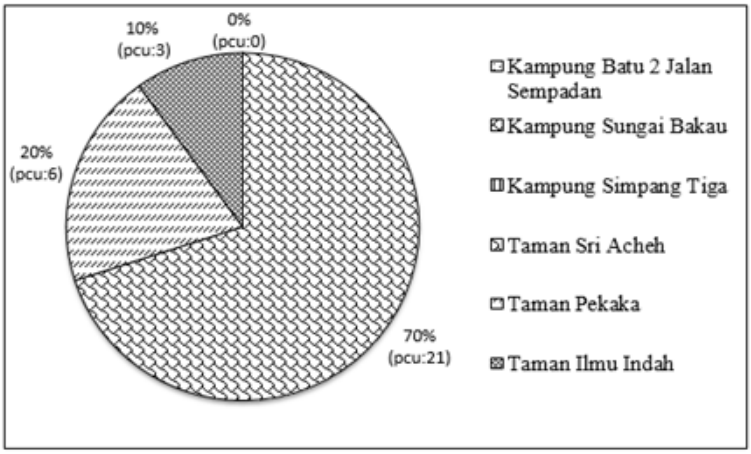


**Fig. 8 - Percentage and pcu's of heavy lorries during morning time on weekdays**

From the Table 6 and Fig. 9, 24% with 94 pcu of car and van were observed to pass by the road at Taman Sri Acheh with average speed 59.72 km/hr for car and 55.50 km/hr for van.

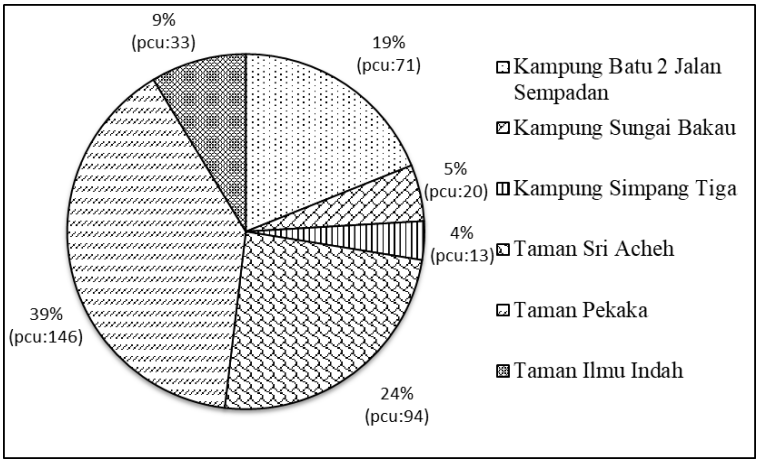


**Fig. 9 - Percentage and pcu's of car and van during night time on weekends**

From the Fig. 10, traffic density of medium lorries at 50% with 10 pcu was the highest traffic density obtained at Taman Sri Acheh with average speed 30 km/hr.

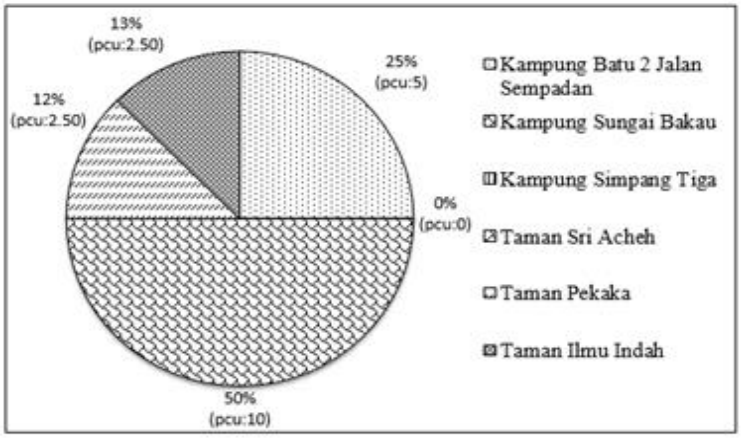


**Fig. 10 - Percentage and pcu's of medium lorries during morning time on weekends**

In addition, based on the Fig. 11, Taman Sri Acheh obtained the highest traffic density of the heavy vehicle at 67% with 6 pcu during morning time with average speed of the heavy lorries obtained was at 65 km/hr.

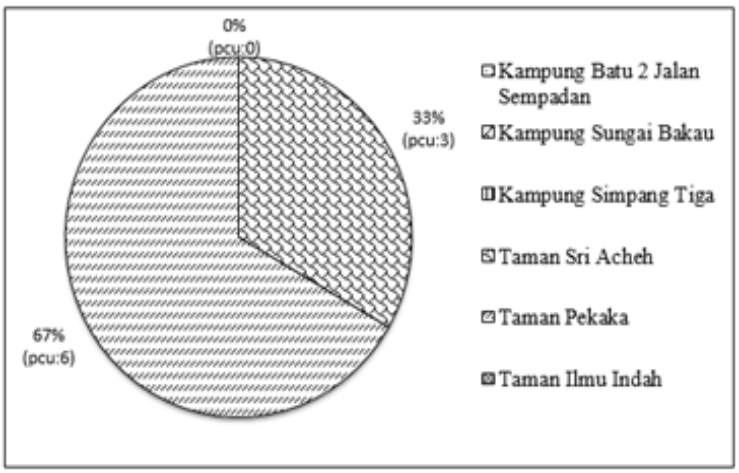


**Fig. 11 - Percentage and pcu's of heavy lorries during evening time on weekends**

Furthermore, based on the Fig. 12, Taman Sri Acheh dominated the high density of heavy lorries during night time with 67% and 6 pcu at 55 km/hr.

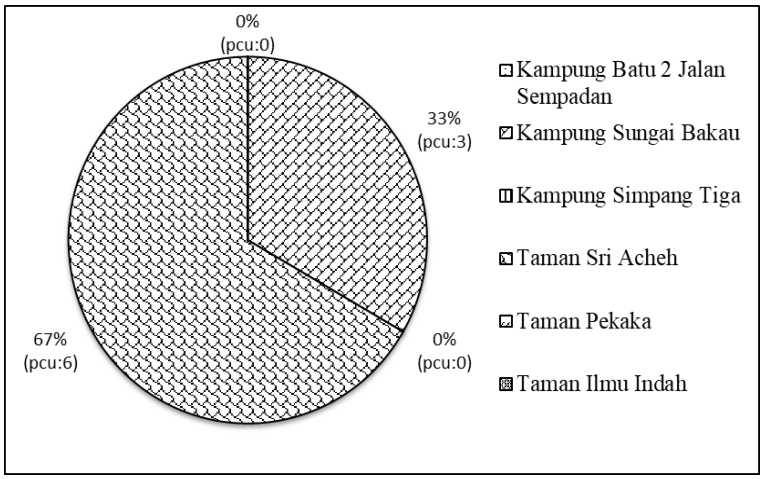


**Fig. 12 - Percentage and pcu's of heavy lorries during night time on weekends**

Medium and heavier vehicles tend to emit noise emissions due to the acceleration values that evolve at higher speed than light vehicle under free traffic regime. Rolling noise and engine noise that due to air pumping noise emission in tyre grooves, friction and contact between the tyres and street may increases the emission of the noises during speeding of the vehicles [16]. Furthermore, at speeds higher than 30 km/hr for cars and 45 km/hr for heavy duty vehicles, rolling noise will prevail at this speed range. Ryu et al. [17] mentioned that, the speed, type of passing vehicle, area, height of building and traffic volume will influence the road traffic noise emission. These findings noise levels exposed to the residents may help the policy makers of this country to provide most efficient counter-measures as stated by Jakovljevic et al. [18].

## 4. Summary

Based on the results and analysis obtained from this research, it can be concluded that all the recorded equivalent continuous level ($L_{Aeq}$) for low density residential areas and medium density residential areas were exceeded the maximum permissible sound level ($L_{Aeq}$) according to the Planning Guidelines for Receiving Land Use for Planning and New Development for medium density residential areas during day time from 7.00 am to 10.00 pm is 55 dB(A) while at night time from 10.00 pm to 7.00 am is 45 dB(A) while for low density residential areas is 50 dB(A) during day time and 40 dB(A) during night time. Furthermore, the other noise descriptors obtained, such as L10, L50 and L90 were recorded at very high levels. Among the six residential areas investigated in this study for traffic noise measurement, Kampung Batu 2 showed the highest average noise level obtained for the low density residential areas with number of vehicles ranges for car van (2 pcu–69 pcu), motorcycle (14 pcu–29 pcu), medium lorries (2.5 pcu–5 pcu) and heavy lorries (12 pcu) with average speed ranges between car and van (54.80 km/hr–70.73 km/hr), motorcycle (52.93 km/hr–63.62 km/hr), medium lorries (52.50 km/hr–64.50 km/hr) and heavy lorries (41 km/hr). For the medium

density residential areas, Taman Sri Acheh showed the highest average noise levels attained with number of vehicle ranges car van (4 pcu–86 pcu), motorcycle (10 pcu–17 pcu), medium lorries (2.5 pcu–10 pcu) and heavy lorries (3 pcu–21 pcu) with average speed ranges between car and van (49 km/hr–67.33 km/hr), motorcycle (52.53 km/hr–60.55 km/hr), medium lorries (30 km/hr–59.50 km/hr) and heavy lorries (46.67 km/hr–65 km/hr). In the study, the relationship between noise level, average speed of vehicles and number of vehicles were investigated. From Pearson correlation coefficient analysis, when the number of vehicles in pcu increases, thus the average speed of vehicles decreases and noise levels increases.

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