ASSESSMENT OF ROAD TRAFFIC NOISE AT RESIDENTIAL AREA IN NIBONG TEBAL, PULAU PINANG

NUR FATIN NAJIYAH BINTI ABDUL HAMID

SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA
2018

ASSESSMENT OF ROAD TRAFFIC NOISE AT RESIDENTIAL AREA IN NIBONG TEBAL, PULAU PINANG

By

NUR FATIN NAJIYAH BINTI ABDUL HAMID

This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfilment of requirement for the degree of

BACHELOR OF ENGINEERING (HONS.)
(CIVIL ENGINEERING)

School of Civil Engineering,
Universiti Sains Malaysia

June 2018

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2014/2015

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title: ASSESSMENT OF ROAD TRAFFIC NOISE AT RESIDENTIAL AREA IN NIBONG TEBAL, PULAU PINANG

Name of Student: NUR FATIN NAJIYAH BINTI ABDUL HAMID

I hereby declare that all corrections and comments made by the supervisor(s) and examiner have been taken into consideration and rectified accordingly.

Signature:

____

Date :

Approved by:

____

(Signature of Supervisor)

Name of Supervisor :

Date :

Approved by:

____

(Signature of Examiner)

Name of Examiner :

Date :

ACKNOWLEDGEMENT

All praises to Allah, for giving me robustness throughout this journey to complete the final year research project with success. I would like to express my greatest thanks to those people who involved in completing this research project. Special thanks to my supervisor, Dr. Herni Binti Halim for the guidance, knowledge and support she has provided.

Deepest appreciation and thankful to my family for the support and to all residents that living in between my research study areas for giving a good cooperation during the research.

ABSTRAK

Kajian ini memberi tumpuan kepada pengukuran bunyi bising di dua jenis kawasan kediaman di Nibong Tebal, Pulau Pinang. Kawasan kediaman tersebut berkepadatan rendah (Kampung Batu 2 Jalan Sempadan, Kampung Sungai Bakau dan Kampung Simpang Tiga) dan berkepadatan sederhana (Taman Sri Acheh, Taman Pekaka dan Taman Ilmu Indah). Meter pengukur tahap bunyi digunakan untuk merakam paras bunyi selama 15 minit untuk setiap kawasan kajian dan diulangi sebanyak dua hari untuk hari bekerja dan hujung minggu. Paras bunyi dirakamkan pada waktu pagi (0800-0930), petang (1400-1530) dan malam (2200-2330) untuk setiap hari pengukuran bunyi. Pengiraan secara manual kepadatan trafik juga diukur serentak dengan pengukuran bunyi. Pengukuran kelajuan kenderaan juga direkodkan secara serentak untuk mendapatkan purata kelajuan setiap jenis kenderaan mengikut Arahan Teknik Jalan (8/86), Panduan Rekabentuk Geometri Jalan (kereta, motorsikal, lori kecil dan kenderaan berat). Pengukuran kelajuan menggunakan pengesan perangkap laju jenis laser. Paras bunyi L_{Aeq} yang direkodkan di kawasan kediaman berkepadatan sederhana adalah antara julat 61.8 dB(A) hingga 69 dB(A) manakala untuk kawasan kediaman berkepadatan penduduk rendah, paras bunyi L_{Aeq} yang direkodkan adalah dalam julat 54.9 dB(A) hingga 66.2 dB(A). Kesemua data bunyi L_{Aeq} yang direkodkan melebihi nilai maksimum yang dibenarkan mengikut Garis Panduan Penggunaan Tanah untuk Perancangan dan Pembangunan Baru Bagi Had dan Kawalan Bunyi Alam Sekitar oleh Jabatan Alam Sekitar Malaysia.

ABSTRACT

This study focuses on the measuring noise levels at two residential areas in Nibong Tebal, Penang. The residential areas are low density residential areas (Kampung Batu 2 Jalan Sempadan, Kampung Sungai Bakau and Kampung Simpang Tiga) and medium density residential areas (Taman Sri Acheh, Taman Pekaka and Taman Ilmu Indah). The sound level meter is used to record noise levels for 15 minutes for each residential area and is repeated for two days on weekdays and weekends. The noise level measurements were monitored in the morning (0800-0930), evening (1400-1530) and night (2200-2330). The traffic density was manually counted simultaneously with noise level measurement. The measurement speed of vehicles were also recorded simultaneously to obtain the average speed of each type of vehicle according to Arahan Teknik Jalan (8/86), A Guide on Geometric Design of Roads (cars, light vans, motorcycle, small lorries and heavy lorries) by using speed laser gun. The average sound level (L_{Aeq}) obtained at the medium density residential areas ranges from 61.8 dB (A) to 69 dB (A) while for low density residential areas ranges from 54.9 dB (A) to 66.2 dB (A). All the sound level (L_{Aeq}) recorded were exceeded the maximum permissible sound level (L_{Aeq}) according to the Planning Guidelines for Receiving Land Use for Planning and New Development for Environmental Noise Limits and Control by the Department of Environment.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

L_{10}	Noise level exceeded for 10% of the time
L_{50}	Noise level that exceeded for 50% of the time
L_{90}	Noise level exceeded for 90% of the time
L_{Aeq}	Equivalent Continuous Sound Level
L_{max}	Maximum Sound Level

CHAPTER 1

INTRODUCTION

1.1 Background

One of the environmental noise pollution is produced by road traffic and it differs across geographical space depending on the receiver, the interceding impediments such as buildings, barriers and terrain (Murphy and Douglas, 2018). The area of global mass transportation and urbanization, traffic noise has become a critical issue in modern time. The occurrence of noise that mostly hears by the people usually is execrable, coincidental and causes a variety of health problems such affecting children's cognition and hypertension (Chew and Wu, 2016).

During at the time of holidays and work, particularly at night, noise creates diverse obstacles caused by the air flow of movements of vehicles, the vehicle's engine mechanism and pneumatic street action. When a vehicle stopped, the noise level clearly plummets and it will increase when the vehicle starts to accelerate. Ongel and Sezgin (2016) mentioned that the pavement surface characteristics, environmental condition, type of tire, vehicle type, aerodynamic noise, and vehicle speed contribute to the vehicle noise. For example, the event due to friction and contact between pavement and tire for the rolling noise causes the rolling noise increases with driving speed while engine noise will influence over during acceleration, at lower speed and correspond to low noise frequencies of about 100Hz (Löbig and Weber, 2017).

Furthermore, road infrastructures such as branches of lanes, the architecture of crossroads, construction of road pavement, traffic flow and the number of vehicles direction and number of road lanes have major impact for the generation of noise level (Kyçyku et al., 2016). Han et al. (2018) stated that with different urban functional areas that are generally made up with different intensities in land-use forms in large areas such as residential, industrial, commercial, education land by different anthropogenic activities will generate acoustic environment with different noise intensity. The predictions between in the range of 55 to 70 dB(A) are classified for the noise exposure onto the buildings along the secondary roads (Morley and Gulliver, 2016).

Cited sources of most frequently noise are coming from aircraft noise, neighbour's noise and mainly from the traffic noise. The consequence of noise can be psychological as well as physiological as it will lead to reduce the quality of the sleep and annoyance which affect the quality of health (Dreger et al., 2015). To mitigate noise pollution, the traffic management, which mainly focused on road traffic, is crucial to the noise reduction in order to lower the decrease the volume of the composition traffic, generate better traffic flow and to reduce the speed of vehicles (Ruiz-Padillo et al., 2014). In addition, the policy makers must indicate intense traffic carrying capacity under the environmental limitation to guarantee the performance of management measures (Feng and Timmermans, 2014). A selective analysis need to be done on the traffic capacity on the urban and rural road network, to boost the quality of noise environment (Huang et al., 2015).

1.2 Problem Statement

Exposure to environmental noise can have a number of adverse health effects (WHO, 2011). Studies also indicate that the significance of quietness and quiet areas benefit human health (Yu and Kang, 2017). Furthermore, the European Union 6th Action Program ‘‘Environment 2010: Our Future, Our Choice” stipulated that the number of people regularly affected by long-term high levels of noise, estimated at 100 million people in the year 2000, should decrease by around 10% by 2010 and by 20% by 2020. The difficulty to attain those targets is that 54% of people live in urban areas (WHO, 2014), where transport infrastructures represent the most important source of noise.

In urban areas, noise is influenced by pavement and traffic typologies (Freitas et al., 2012), by street dimension (Tang and Wang, 2007), by urban shape and by the presence of public transport (Paunovic´ et al., 2014). The same noise source could produce a different annoyance, depending on the area – urban or rural (Knall and Schuemer, 1983) – but both areas, if people show high noise sensitivity, are mainly associated with high annoyance (Fyhri and Klaeboe, 2009; Miedema and Vos, 1999). Aziz et al. (2012) conducted an assessment of traffic noise pollution in Bukit Mertajam, Malaysia that was taken at two locations which were at Arumugam Pillai road and Permatang Batu road. The average noise level measured were between 75.8 dB(A) and 76.3 dB(A) for Arumugam Pillai road and for Permatang Batu road, the average noise level ranged between 73.8 dB(A) and 74.9 dB(A), which exceeded The Planning Guidelines For Environmental Noise Limits and Control by the Malaysian Department of Environment (DOE, 2007) states that the L_{Aeq} for suburban residential areas should not exceed 55 dB(A) at day time and 45 dB(A) at night time.

In Meng and Kang (2014) study, based on field measurements and questionnaire surveys about road traffic noise with 13 typical villages in the northeast of China, it was found that the village residents would feel uncomfortable when the average sound pressure level of main road traffic noise is too high (≥60 dB(A)) or too low (<50 dB(A)). The rural area is commonly related to have less traffic noise, thus the rural area has peaceful environment compared to the urban area. In addition, the rural area is offering better benefits for the settlement purpose. Based on the guidelines of Environmental Noise Limits and Control by the Malaysian Department of Environment (DOE, 2007) states that the L_{Aeq} for medium density residential areas should not exceed 55 dB(A) at day time and 45 dB(A) at night time while for low density residential areas should not exceed 50 dB(A) at day time and 40 dB(A) at night time. As there is no study carried out on measuring traffic noise in rural area, therefore this study want to bridge the gap in literature. The benefit that can be obtained of this noise level measurement conducted in this research area is to determine or mitigate civilian noise exposure in small town (median density of population) and rural areas (low density of population).

1.3 Objectives

The aim of this study is to assess traffic noise levels at medium density and low density residential areas in Nibong Tebal, Penang. The study is carried out in order to achieve the following three main objectives:

a) To assess the level of traffic noise at selected residential areas.
b) To characterize the traffic density nearby the selected residential areas.
c) To evaluate relationship between noise levels and traffic density at selected residential areas.

1.4 Scope of Work

In rural areas, the single and double storey terrace houses and wooden houses in types of detached and semi-detached houses were developed. (EPU JPM, 2015; Abd. Shatar et al. 2017). This research is conducted at six residential areas which consist of three areas of the terrace houses and three areas of detached houses in Nibong Tebal, Pulau Pinang. The scope of works focuses on collecting data of traffic noise and the traffic density of the vehicles on the road network at the residential areas. The scope of work includes the site visit to the study area to determine a suitable location for the research. Furthermore, the duration of sampling were taken on two weekdays (Tuesday and Wednesday) and weekends (Saturday and Sunday).

By using sound level meter, the measurements of the data were taken 15 minutes during each sampling period (morning, evening and night). The time of collection was carried out in the morning, evening and night so that variations of noise level can be obtained. Based on the Planning Guidelines For Environmental Noise Limits and Control (DOE, 2007), the Maximum Permissible Sound Level (L_{Aeq}) by Receiving Land Use for Medium Density Residential Areas are 55 dB(A) on day time and 45 dB(A) on night time while for Low Density Residential Areas are 50 dB(A) on day time and 40 dB(A) on night time. The traffic density data were recorded using the manual count to measure the traffic volume on the road by the presence of passenger cars, motorcycle, light vans, medium lorries and heavy lorries. The number of vehicles obtained was converted to equivalent passenger car unit (PCU) according to the Arahan Teknik Jalan (8/86), A Guide on Geometric Design of Roads. Furthermore, the speed laser gun was aimed at different type of vehicles several times at one point to compute the average speed of each type of vehicles within 15 minute noise measurement.

1.5 Justification of the Research

The study of traffic noise between different types of residential areas helps to improve the guidelines and regulations in order to know the acceptable noise level at study area, the immediate and long term control that can be suggested to help solve the noise problem. In some cases, national norms establish rules to preserve the acoustic quality in specific areas for example parks, hospitals and schools and to reduce people's noise exposure, recommending the adoption of noise indicators and setting thresholds to comply with (Camusso and Pronello, 2016).

Moreover, the study produces and assesses the descriptive statistics of road traffic noise level that consists of noise descriptors, range of noise level measured, mean and standard deviation of the noise level for each monitoring session during weekdays and weekends. In addition, temporal variation of noise level was examined at each study site to determine whether the mean samples obtained in the measurement session differ from each other.

1.6 Thesis Outline

Chapter 1: Introduction – General description of study that includes problem statement, objectives to achieve and scope of work to be carried out.

Chapter 2: Literature Review -The content of this chapter is discussing about previous research that are related to traffic noise on the road network in the urban and rural residential areas.

Chapter 3: Methodology - Explaining all steps taken in preceding research. This chapter consists of introduction of the study area and the description to the sample analysis.

Chapter 4: Results and Discussion - The results of the study are discussed in this chapter including assessment level of traffic noise measured at the residential areas, characteristic of traffic density as well as evaluating the relationship between noise levels and traffic density.

Chapter 5: Conclusion and Recommendation - This chapter concludes the findings in this study and provides suggestion to mitigate the environmental problem.

CHAPTER 2

LITERATURE REVIEW

2.1 Traffic Noise Pollution

Traffic vehicles on the road networks during their movement create noise that has greater impact on environmental. The sources, the receivers and the place of transition where the sound of sound wave propagates are the three vital parameters for the field of noise acoustics (Bouzir and Zemmouri, 2017). Acoustic environment can be divided into natural sounds and environmental sound. The natural sound such as wind and thunder sound emerging from the geophysical environment while the environmental sounds are generated from mixed human activities. Accompanied by the rapid urbanization over past few decades are affecting the impact on biodiversity, biogeochemical cycle, earth's environments as well as human health and environmental noise (Han et al., 2018). The densification of the road network causing the traffic flow become the main culprit of noise annoyance which need to be exactly treated by road traffic mitigation and has to be precisely estimated (Can and Aumond, 2018).

Considering of traffic parameters such as type of vehicles, speed and vehicle composition (Ryu et al., 2017) with the interaction of several types of pavements, the annoyance of the noise is analysed for the road traffic noise generation (Soares et al., 2017). The noise emission of real traffic streams that has different vehicles such as cars and trucks might be overlapping considerably The increasingly annoyance will interfere human daily activities such as leisure, rest, study, work and it might affect the human health (De Coensel et al., 2016).

The construction of new roads and growth of road traffic streams lead to an expanding of traffic noise pollution (Ow and Ghosh, 2017) causing the areas situated along the main road become noisier areas. Chew and Wu (2016) mentioned that, mean level of 62.3 dB(A) over a mean range of 840 Hz to 970 Hz could lead to be the main source of annoyance to people. Particularly hazardous noise will occur during the night time as the night time at normal levels will be between 45 – 65 dB(A) which can be related to reduce the sleep quality of the people thus decreasing the human health (Monrad et al., 2016). The sources of noise pollution which are mobile sources such as air and ground transportation while stationary sources such as construction and demolition, commercial, recreational, industrial and domestics. The exhaust system and engine of automobiles, buses, trucks and motorcycles a crucial source of noise on the real traffic streams, which constitutes main environmental traffic pollution impact (Quiñones et al., 2016).

2.2 Worldwide Traffic Noise Pollution

In terms of environmental noise policy and related legislation, the European Union, the EU becomes the world leader. Since 1970s, legislative instruments have been evolved in order to reduce noise levels of automotive vehicles. From focussing on the source, the developed legislation has transitioned to mitigate at the point of receiving of the environmental noise (Murphy and Douglas, 2018). According to the WHO (2009), noise exposure above 55 dB(A) during night-time period will give significant impact on human health in the resident population. Those residents that lived facing the road are likely to be conscious about the influence of road traffic noise. Huang et al. (2015) wrote that, almost 30% populations in China are exposed to noise levels more than 55 dB(A). Due to greater population exposure to environmental noise, the Standard of Environmental Noise of Urban Area was formulated in order to guarantee the quality of environmental noise for residents in daily life.

Furthermore, more than 44% of the population living in Europe are constantly exposed to noise levels more than 55 dB(A) that can affect the efficiency of people during their daily life due to getting effects such as sleep disturbances and health problem (Bouzir and Zemmouri, 2017). In order to mitigate the transportation noise, most industrialized countries have already performed regulation about the maximum permissible environmental traffic noise. Therefore, abundance of highway agencies applying noise abatement measure that can be categorized into three which are along the propagation path, at the source and at the receiver in order to decrease the noise levels (Ongel and Sezgin, 2016). Based on the Table 2.1, it shows the summary of literature review regarding noise levels attained at different countries.

Table 2.1: Summary of literature review regarding noise levels attained

Author	Research on:	Country	Location	Noise Levels Attained
Bąkowski et al. (2017)	Assessment of Uncertainty in Urban Traffic Noise Measurements. Procedia Engineering.	Poland	Krakowska Street in Kielce	During night time obtained 64.78 dB(A) and during day time obtained 70.42 dB(A)
Murphy et al. (2018)	Population exposure to road traffic noise: Experimental results from varying exposure estimation approaches. Transportation Research Part D: Transport and Environment.	Republic of Ireland	Dublin Agglomeration	Above 40 dB(A)
Camusso and Pronello (2016)	A study of relationships between traffic noise and annoyance for different urban site typologies. Transportation Research Part D: Transport and Environment.	North-west of Italy	Torino	Above 60 dB(A)
Löbig et al. (2017)	Using ambient noise measurements to model urban particle number size distributions at a traffic site. Atmospheric Pollution Research.	Germany	Street Canyon site,City of Braunschweig	Ranging between 68 dB(A) and 72 dB(A)
Fiedler et al. (2015)	Evaluation of noise pollution in urban traffic hubs—Noise maps and measurements. Environmental Impact Assessment Review.	Southern Brazil	City of Curitiba	Above 55 dB(A)
Abbaspour et al. (2015)	Hierarchal assessment of noise pollution in urban areas – A case study. Transportation Research Part D: Transport and Environment.	Southeastern Tehran	District 14	Above 70 dB(A)

2.3 Traffic Noise in Malaysia

Accelerated development of cities, soaring circulation of automotive vehicles and mechanization will be associated with the rising levels of noise pollution. Exposure to the long-term noise and to the impermissible an ambient noise level could affect to human health problem (Abbaspour et al., 2015). The type of a continuous sound which produce fluctuates sound over time in irregular trend is drastically influenced by the road traffic noise. In recent studies conducted in Malaysia by Halim and Abdullah (2014), the noise levels obtained is greater in traffic flow in Sungai Besi Expressway with number of vehicles more than 500 for every 15 minutes when compared to traffic flow in Duke Highway that attained less than 500 numbers of vehicles that pass by the road for every 15 minutes. During the peak hour, it shows the highest noise level was 74.9 dB(A). During off peak hour, the noise level was 73.4 dB(A) while 73.8 dB(A) and 72.6 dB A) where the lowest L_{Aeq} respectively. These noise levels reveals that highway noise levels in Malaysia is exceeding the outdoor noise limit by Malaysia guidelines (DOE, 2000) as well as the World Health Organization (WHO, 2000) which stated that noise levels obtained should not surpass 55 dB(A) during daytime and 45 dB(A) during night time. This study highlighted that noise has become significant environmental problems in Malaysia and need further mitigation in order to overcome it. Table 2.2 shows The Planning Guidelines For Environmental Noise Limits and Control by the Malaysian Department of Environment (DOE, 2007) that defines the low density residential areas as areas with a population of less than 75 persons per acre, suburban residential (medium density) areas as areas with a population of 75 to 200 persons per acre while the urban residential (high density) areas as areas with a population exceeding 200 persons per acre. Table 2.3 shows Conversion Factor to

Passenger Car Equivalent (PCU) according to the Arahan Teknik Jalan (8/86), A Guide on Geometric Design of Roads.

Table 2.2: The Maximum Permissble Sound Level (L_{Aeq}) by Receiving Land Use for Planning and New Development (DOE, 2007)

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 2.3: Conversion Factors to p.c.u's from Arahan Teknik (Jalan) 8/86, A Guide on Geometric Design of Roads

Type of Vehicle	Equivalent Value in p.c.u's for Rural Standards
Passenger Cars	1.00
Motorcycle	1.00
Light Vans	2.00
Medium Lorries	2.50
Heavy Lorries	3.00
Buses	3.00

2.4 Effect of Traffic Noise on Human

According to the environmental agency, over 24 million people subjected to noise levels above 65 dB(A) and over 103 million people are subjected to daily mean noise level above 55 dB(A) (Díaz, 2017). Noise pollution creates adverse of negative effects on well-being as it will activate hypothalamus-pituitary-adrenal (HPA) axis and autonomic nervous system that related to human hormones such as increase levels of cortisol (Christensen et al., 2017) which might affect human metabolism (Murphy and Douglas, 2018).

Furthermore, traffic noise will increase the environmental pollution (Kyçyku et al., 2016) as the road traffic produces a greater number of gaseous pollutants and generate ultrafine particles of atmospheric pollutants between 10mm-500mm diameter range (Morelli et al., 2015) and affecting the quality of life (Abbaspour et al., 2015). The pollutants produce due to road traffic made up of carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (HC) in European Union with each pollutant contribute 58%, 50% and 75%, respectively to the road traffic (Liu et al., 2017) and generate vast pollution in SO_2 and Particulate matter (Borrego et al., 2016).

Studies have found that the traffic noise exposure will be associated with stroke, ischemic disease and hypertension on human being (Monrad, 2016). According to the Löbig and Weber (2017) wrote that the environmental noise is the cause of sleep disturbance, triggering the release of stress hormone level, induced annoyance and development 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 (De Coensel et al., 2016).

Sleep disturbances will cause the sleep duration to become shorter, thus it will give a negative impact on the well-being physical activity, thus impaired the recovery. Physical inactivity is considered as a significant threat to the human health in both children and adults as it will cause varies disease to occur between the public people such as diabetes, colorectal cancer and cardiovascular disease (Roswall et al., 2017).

In addition, due to road traffic noise, if the adults are prolonged exposed to traffic noise; most likely they will have irrevocable negative effects on their health (Dreger., 2015) as the noise is correspond with mood disorder, neurodegenerative disease and neurocognitive function for the long-term exposure (Tzivian et al., 2015).

2.5 Noise Descriptors

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 has 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 **(**De Coensel., 2016).

In the analysis, L_{Aeq} data was used to describe the traffic noise in the study sites. L_{Aeq} is a widely used noise descriptor is commonly adopted in many developed countries to explain noise level. It is constant noise level, which under a given situation and time, the noise descriptor contains the same acoustic energy as the actual-time varying noise level. Therefore, a different percentage of time during noise measurement is called noise descriptors.

The commonly used values of noise descriptors are L_{10}, L_{50}, L_{90} and L_{Aeq} (Kumar and Goswami, 2013). The indices used such as L_{10} presented as the level in dB(A) exceeded over 10% of the time, L_{50} defined as noise level exceeded for 50% of time, L_{90} is often referred to background noise level and L_{Aeq} is the constant level that built up the same quantity of energy during measuring period as the actual fluctuating level (Gupta and Ghatak, 2011).

Based on The Planning Guidelines For Environmental Noise Limits and Control by the Malaysian Department of Environment (DOE, 2007), it states that the Maximum Permissible Sound Level (L_{Aeq}) by Receiving Land Use For Planning and New Development for Medium Density Residential Areas are 55 dB(A) during Day Time between 07:00 to 22:00 and 45 dB(A) during Night Time between 22:00 to 07:00 while for the Low Density Residential areas are 50 dB(A) during Day Time and 40 dB(A) during Night Time.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains the method used to carry out the study and measurement traffic noise data before analysis of the data can be made. Several steps were taken in preparing and implementing the scope of works in order to carry out this study. The steps involve to achieving all of the objectives of the study are as shown in the Figure 3.1.

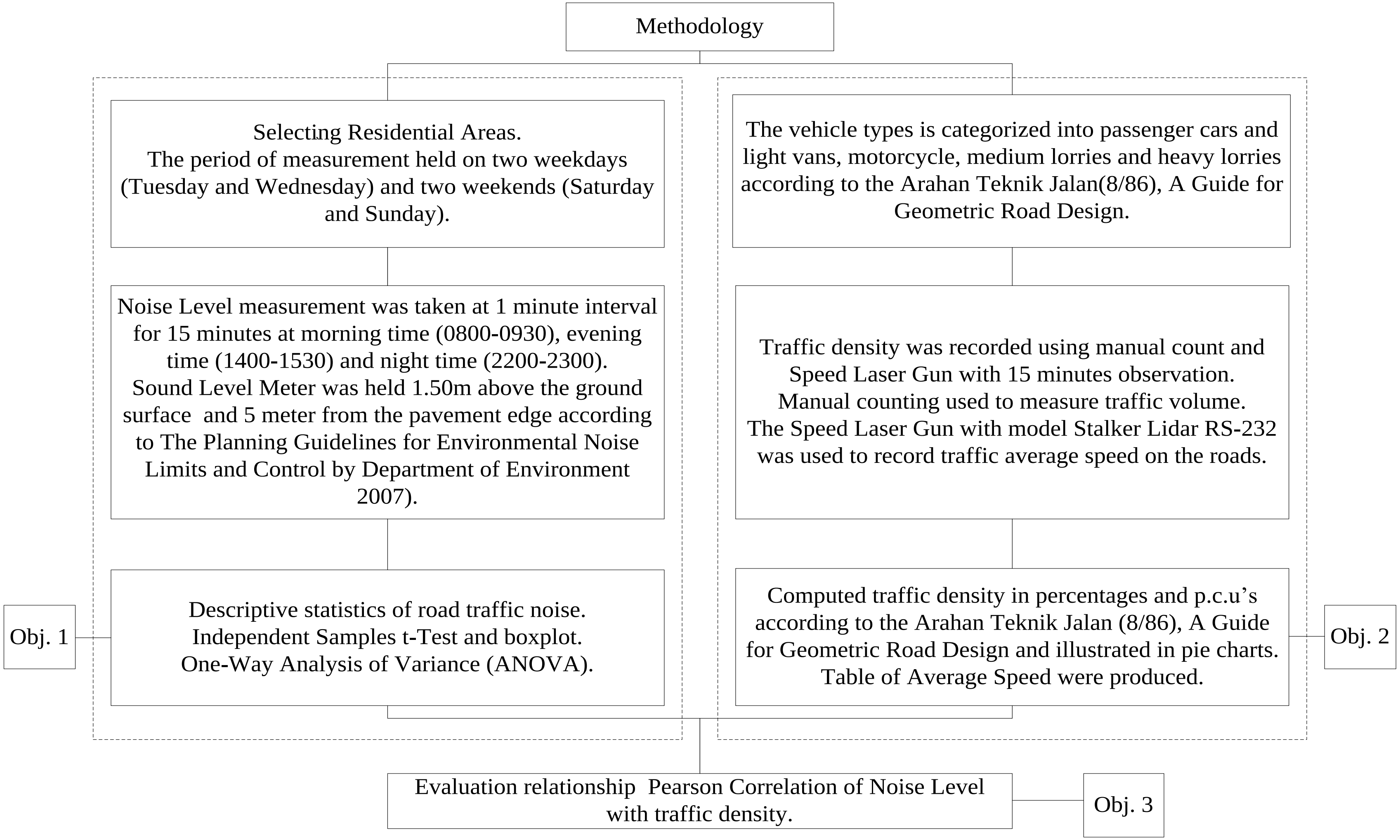

Figure 3.1: Research Flow Diagram

3.2 Description of the Study Area

This study is conducted at six residential areas which comprised of different types of residential areas such as terrace houses and detached houses that represent medium density and low density residential areas respectively (EPU JPM, 2015; Abd. Shatar et al., 2017) in Nibong Tebal, Pulau Pinang as shown in Table 3.1:

Table 3.1: Types of Residential Areas

Medium Density Residential Areas	Low Density Residential Areas
Taman Seri Acheh	Kampung Batu 2 Jalan Sempadan
Taman Pekaka	Kampung Sungai Bakau
Taman Ilmu Indah	Kampung Simpang Tiga

These residential areas were chosen due to the location of the areas that are next to main roads, the availability and accessibility to carry out the study. Furthermore, the distance of these areas from Engineering Campus, Universiti Sains Malaysia are also the selection factors to carry out this study. Based on the Table 3.2, the total housing unit were manually counted from google maps at the study areas with assumption be made that one housing unit equivalent to five (5) residents.

Table 3.2 : The Density Population of the Residential Areas

Location	Total Housing Unit	Density Population	Area (m^2)	Area (Acre)	Density (Person/Acre)	Type of Density
Kampung Batu 2 Jalan Sempadan	22	110	39380.05	9.73	11	Low Density
Kampung Sungai Bakau	20	100	17483.74	4.32	23	Low Density
Kampung Simpang Tiga	25	125	32734.65	8.09	15	Low Density
Taman Sri Acheh	112	560	18197.98	4.50	125	Medium Density
Taman Pekaka	77	385	13493.44	3.33	115	Medium Density
Taman Ilmu Indah	56	280	11487.21	2.84	99	Medium Density

Figure 3.2 shows the locations of the study sites on the map for the detached houses in Nibong Tebal, Penang that represent low density residential areas.

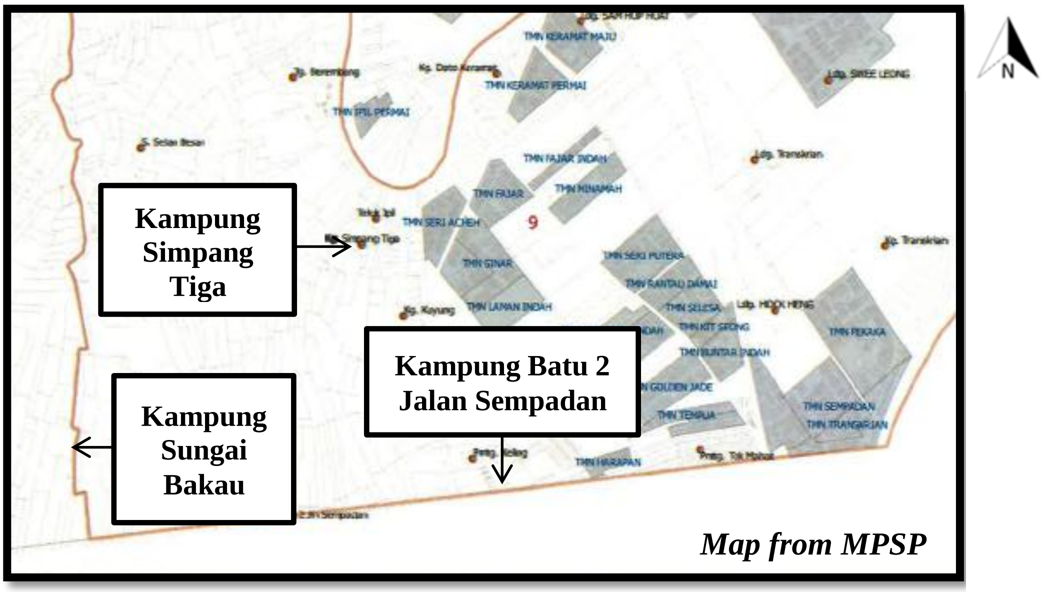

Figure 3.2 : The locations of the study sites on the map for detached houses that represent low density residential areas

Figure 3.3 and Figure 3.4 show the location of the study sites on the maps for the terrace houses in Nibong Tebal, Penang.

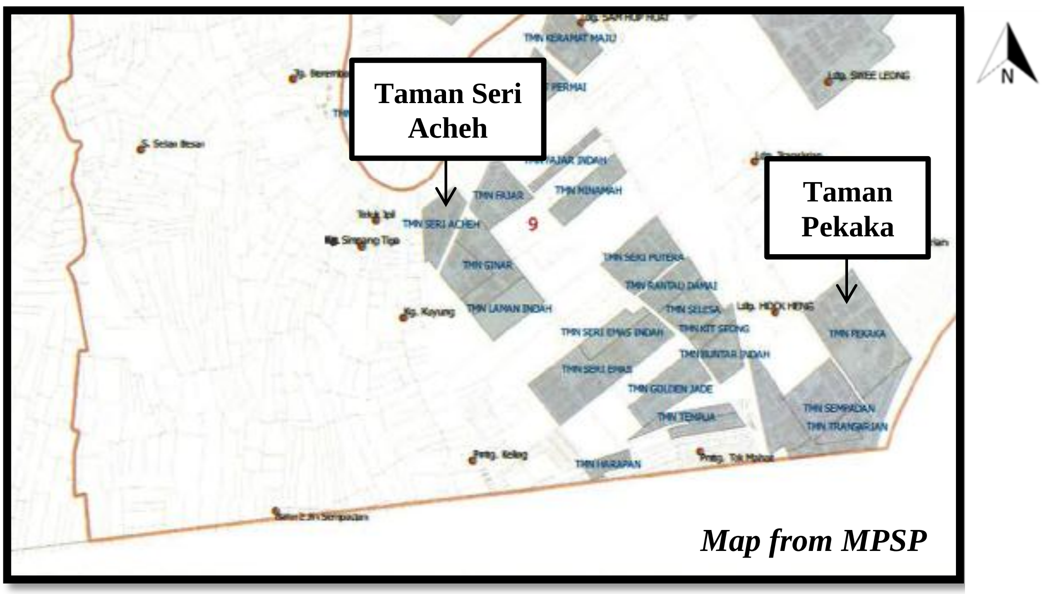

Figure 3.3: The locations of the study sites on the map for terrace houses that represent medium density residential areas

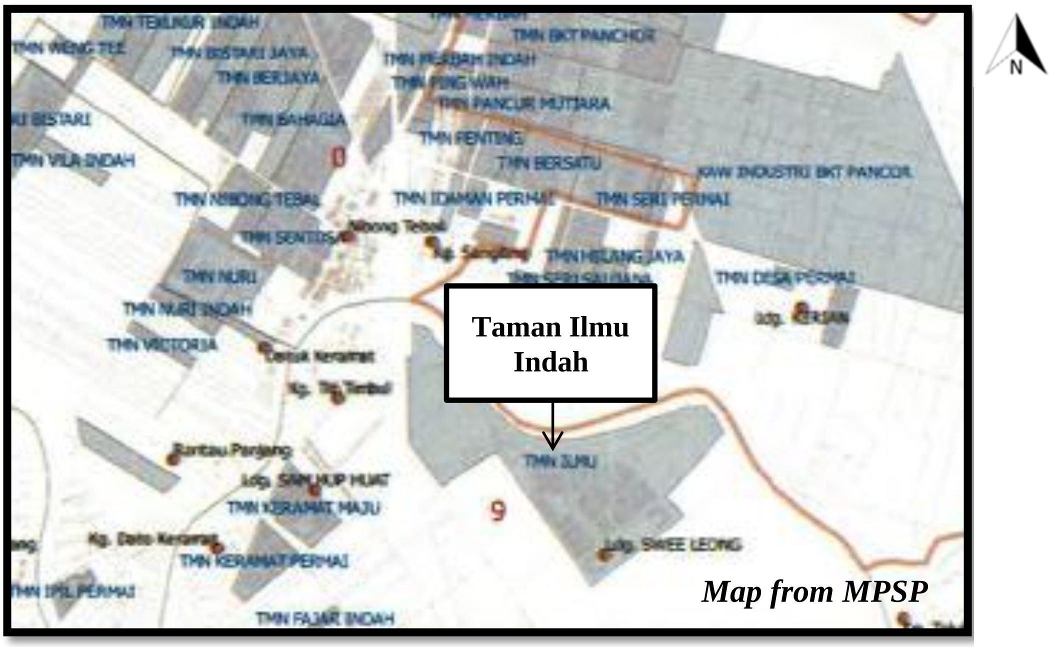

Figure 3.4 : The locations of the study sites on the map for terrace houses that represent medium density of residential areas

3.3 Noise Levels Measurement

The noise levels were collected at three terrace houses, residential areas and three detached houses, residential areas with duration sampling on two weekdays (Tuesday and Wednesday) and two weekends (Saturday and Sunday) by using the sound level meter. The measurement of the data by using sound level meter was taken at 1 minute interval for 15 minutes morning (0800-0930), evening (1400-1530) and night (2200-2330) so that variations of noise can be obtained from different period of a day.

The primary objective of noise level measurement is to determine the existing noise levels at the selected sites. The noise level monitoring is conducted using a sound level meter. In this study, 15 minutes (the sound level meter recorded every 1 minute noise level) recorded data were averaged as the counted traffic density were recorded for every 15 minutes.

The justification of 1 minute data interval is that, the noise levels were recorded as detail as possible to represent the reality of noise level at the studied sites without missing any noise variation. Therefore, any extreme event during the measurement can be detected. Noise measurement was conducted both on weekdays which on Tuesday and Wednesday, while weekends on Saturday and Sunday. The data were used to provide a noise profile of each location, including the quietest and noisiest hours. This method follows the noise measurement method in The Planning Guidelines for Environmental Noise Limits and Control (DOE, 2007). 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 (DOE, 2007). A calibrator was used to routinely calibrate the sound level meter before and after the measurement session. The sound level meter was calibrated at 93.7 dB(A).

Traffic density data in this study is categorized into four types, which car and van, motorcycle, medium lorries and heavy lorries according to the Arahan Teknik Jalan (8/86), A Guide on Geometric Design of Roads. Heavy lorries involves a vehicle with more than 2 axles such as lorry and buses. For the purpose of the study, the traffic density were recorded using manual count and speed gun with 15 minute observation to identify the percentages and p.c.u's of vehicles. The number of vehicles obtained will be converted to equivalent passenger car unit (PCU) according to the Arahan Teknik Jalan (8/86), A Guide on Geometric Design of Roads. The instrumentation for real time traffic recording included manual count and speed gun. The manual count was used to measure traffic volume on the road. The speed gun was used for measuring traffic speed of varying types of vehicles on the road. The speed gun was shot at different type of vehicles several times in order to compute the average speed of each type of vehicles.

The Figure 3.5 shows the equipment used was sound level meter manufactured by Cirrus Research plc with instrument type CR 1710 and series number G080259. This sound level meter was classified as the Class 1 sound level meter that has the greatest level of accuracy and tolerance limit for Class 1 is at +/- 1.9 dB(A) at the frequency level of 1 kHz. The Figure 3.6 shows the speed laser gun with model Stalker Lidar RS-232 and series number LD080272 that used to compute the average speed of vehicle. The Figure 3.7 shows the manual traffic counting activity besides the road to manually count the passing by vehicle on a road.

Figure 3.5: Sound Level Meter

Figure 3.6 : Speed Laser Gun

Figure 3.7 : Manual Count of passing by vehicle on a road