Traffic noise pollution level at selected cities in Kelantan

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Abstract. In densely populated areas where the communities strive, noise pollution has become a critically alarming problem and must be addressed accordingly. The World Health Organization also recognizes it as a concerning public health issue in the urban areas. More often, the effects of noise towards the residents living in the vicinity areas can include the worsening of life quality and result in physiological effects, among others. We hypothesize that the increasing traffic results in higher noise pollution levels. The aim of this study was to quantify traffic noise pollution using noise pollution level (NPL) and traffic noise index (TNI) at selected cities in Kelantan, namely Tanah Merah and Pasir Mas. A sound level meter (TENMARS TM102) was used to record the noise level, and the traffic volumes were determined by using tally counts. The noises were measured during four different peak hours from 08:00 to 22:00. The recorded noise levels were compared with the Department of Environment (DOE) recommended limit of 60 dB(A) during daytime. The traffic noise pollution level was confirmed to be higher when the traffic volume counts increased. The results suggest proper mitigation measures such as enforcing zoning regulations and promoting public awareness campaigns were needed to reduce the noise pollution level.

Introduction

Traffic noise was deemed as the most pervasive community sound source, given the increase in vehicle quantity, especially in urban areas. Although noise pollution has taken the interest of urban residents, it is still frequently underestimated and received little attention to action because it is viewed as a local issue [1]. Despite gaining little attention, traffic noise is proven to be the most frequent and hazardous noise source [2]. Among the contributing factors for noise pollution sourced from traffic are aerodynamic friction, vehicle-road system contact, vehicle-vehicle interaction and vehicle noise from exhaust systems and engines [3].

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Noise pollution emerged as a growing concern in urban areas, significantly impacting the health, well-being and overall quality of life of residents [4]. While other urban pollutions are constantly being researched, the study of noise pollution plays an integral role in understanding and addressing the challenges of urban and industrialized environments, contributing to the broader field of urban design and planning [5].

Individual vehicles and overall volume of traffic are the components that make up traffic noise. Individual vehicle noise is comprised of the combination of sounds from the engines, transmission, exhaust, interaction between tyres and pavement, air turbulence and body and load rattles. In addition to this, traffic noise also depends on several factors such as traffic volume, speed, composition, as well as road gradient and road surface and texture type [6].

The negative effects of noise pollution towards humans are categorized as auditory and non-auditory. It is important to note that because noise exposure includes non-auditory effect, this may be the reason for lack of concern about noise among the residents. Non-auditory effects, however, incorporate some of the most serious health issues, such as cardiovascular disease and psychiatric disorders [7]. It was also shown in previous study that exposure to environmental traffic noise is associated with an increased risk of developing hypertension and preeclampsia in pregnant women [8].

This paper discusses the levels of traffic noise pollution at two cities in Kelantan (Tanah Merah and Pasir Mas). The number of registered passenger vehicles in Malaysia increased by 12% from 2022 to 2023 [9]. Moreover, transportation demand is predicted to increase as the population is reckoned to grow from 28.6 million in 2010 to 41.5 million in 2040 [10]. Therefore, it is pivotal to address traffic noise pollution in Malaysian cities given these concerns. The noise levels recorded in this study were then compared with the permissible limit determined by the Department of Environment (DOE) Malaysia and the World Health Organization (WHO). Traffic noise level (TNI) and noise pollution level (NPL) was then calculated.

2 Materials and Method

2.1 Study Area

Four locations were selected for this study and these locations are located in Tanah Merah and Pasir Mas districts. All locations were selected based on the proximity of the roads to nearby residential areas, schools and other sensitive areas. In addition, these areas are the main roads commute by the locals for the purpose of travelling to work, schools and others. The description of the study locations is shown in Table 1 below.

Table 1. Study locations description

District	Location	Coordinate	Area description
Tanah Merah	Jln Klinik	5°48'14"N 102°08'37"E	Area consist of 2 schools which are SK Seri Suria 1 and SK Seri Suria 2
	Jln Ismail Petra	5°48'42"N 102°08'03"E	Area is a mixed between residential and commercial areas

Pasir Mas	Jln Masjid Besar	6°02'50.8"N 102°08'21.7"E	2 schools are located within the area which are SMK Pasir Mas andSK Sultan Ibrahim 2 along with a mosque (Masjid Sultan Muhammad III)
	Bandar Baru Pasir Mas	6°00'23.01"N 102°05'46.29"E	Main road that connects Pasir Mas to Rantau Panjang with scattered residential areas

2.2 Noise measurement

The work was done in accordance to DOE's guideline to environmental noise limit and control [11]. The equipment used in this study was a TENMARS TM102 sound level meter. This sound level meter is equipped with A and C weightage. Sound level meters must be mounted with a pole or tripod at least 1.2 to 1.5 m above the ground [11] as shown in Figure 1. In order to minimize errors, the installed equipment must be made sure that it has a significant distance of approximately 3.5 m from any reflective surface other than the ground.

The sampling period was done in June 2024. Noise measurements were taken every 5 minutes over a period of 2 hours, and this was done during four different peak hours; 08:00 to 10:00, 12:00 to 14:00, 16:00 to 18:00 and 20:00 to 22:00. This measurement time was taken based on [11] daytime noise threshold limit, second schedule. This schedule represents recommended permissible sound level (L_{Aeq}) by receiving land use for existing built up areas where the limit is 60 dBA at day time for low density residential, noise sensitive receptors, institutional (school, hospital worship). Average noise was then calculated in dBA [12].

Fig. 1. Sound level meter positioned at the study location

2.3 Traffic measurement

Among the factors that are included in traffic measurement are traffic volume, density, vehicle classification and traffic flow. However, our study only focuses on traffic volume and vehicle classification. In this study, we categorized vehicles into 2 main categories; light and heavy vehicles. Light vehicles are typically defined as vehicles with a Gross

Vehicle Weight Rating (GVWR) ≤4,536 kg, while heavy vehicles are those with GVWR around 11,793 kg or more. The examples for each category are shown in Table 2.

Table 2. Vehicles categories

Light (≤ 4,536 kg)	Heavy (≥ 11,793 kg)
Passenger cars	18 wheels trucks
SUVs and Crossovers	Cement mixers
Small pickup trucks	Bus
Van and minivan	Fire trucks
Motorcycles and scooter	Construction equipment (backhoe, bulldozer)
	Tankers

Traffic volume refers to the count of vehicles or pedestrians passing a particular point over a specified time frame. In this study, we focus solely on vehicles, as pedestrians are not considered a significant source of traffic noise pollution. Traffic volume was measured concurrently with noise levels using a sound level meter. In this context, traffic volume is denoted by Q, while the percentage of heavy vehicles is represented by P. Traffics were categorized based on vehicles types and their engine power.

2.4 Parameters for noise measurement

To describe the distribution of noise levels over a period of time we use the common statistical metrics which are L_{10}, L_{90} and L_{50}. L_{10} is commonly used as an indicator of peak noise levels in an environment and it is especially useful in assessing the impact of intermittent loud noises. L_{90} is used to assess the background noise and to understand the typical noise environment providing a balance between peak and background noise level, L_{50} is often used. All of these metrics represent the noise level that exceeds their respective percentage of the measurement period (e.g., L_{10} is the noise level that exceeds 10% of the measurement period).

Traffic noise index (TNI) and noise pollution level (NPL) are the tools that are utilized for assessing and quantifying noise the effects of noise, particularly in urban and transportation settings. The formula for calculating both TNI and NPL are as follows.

$$TNI = 4\,(L_{10} - L_{90}) + (L_{90} - 30) \quad (1)$$

$$NPL = L_{eq} + (L_{10} - L_{90}) \quad (2)$$

3 Results and Discussion

Our study considers noise pollution permissible limits set by DOE as the main reference for noise threshold. The result clearly shows that noise levels at all locations exceeded the limit by DOE. Figure 2 shows L_{max} at Jln Klinik was recorded as 68.1 dBA at 20:00 – 22:00, L_{max} for Jln Ismail Petra was recorded as 78.7 dBA at 12:00 – 14:00, L_{max} for Jln Masjid Besar was recorded as 72.8 dBA at 08:00 – 10:00 and L_{max} for Bandar Baru Pasir Mas was recorded as 69.4 dBA at 12:00 – 14:00.

The result also brings us to the highest LA_{eq} recorded at all locations, which was 83.8 dBA at Jln Ismail Petra during peak hours 08:00 – 10:00. The other three locations' LA_{eq} ranged from 76.2 dBA to 79.3 dBA. Figure 3 shows the LA_{eq} for noise levels recorded at all locations with the DOE permissible limit (in dashed line), which is 60 dBA during daytime. Among all locations, Jln Ismail Petra has the highest noise level for all time intervals done during this study.

Although every location's noise levels exceeded DOE limit, the findings however were in line with the data recorded in all states around Malaysia. A work by [6] stated that the DOE recorded yearly day and night noise levels throughout the country and the noise levels were ranged between 56 dBA to 82 dBA during daytime. These readings too, have similar intensity with other ASEAN cities specifically Ho Chi Minh and Hanoi [13].

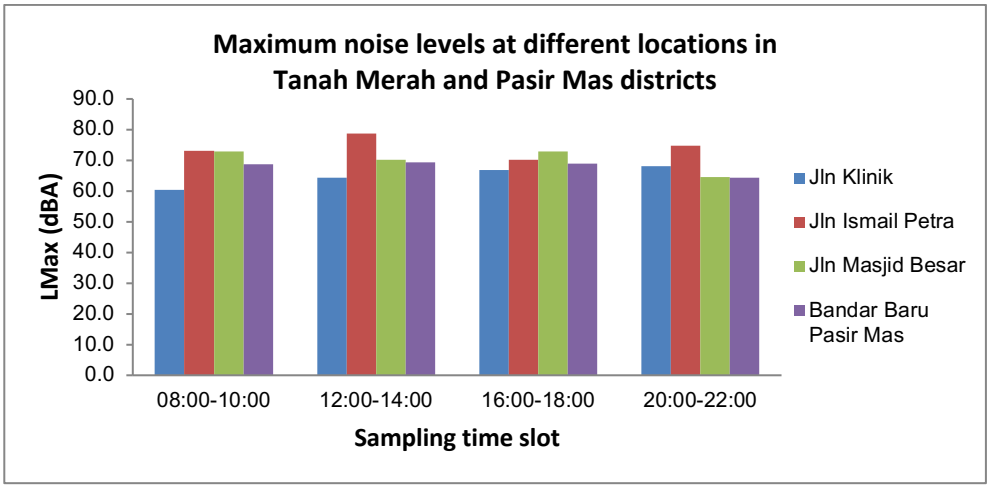
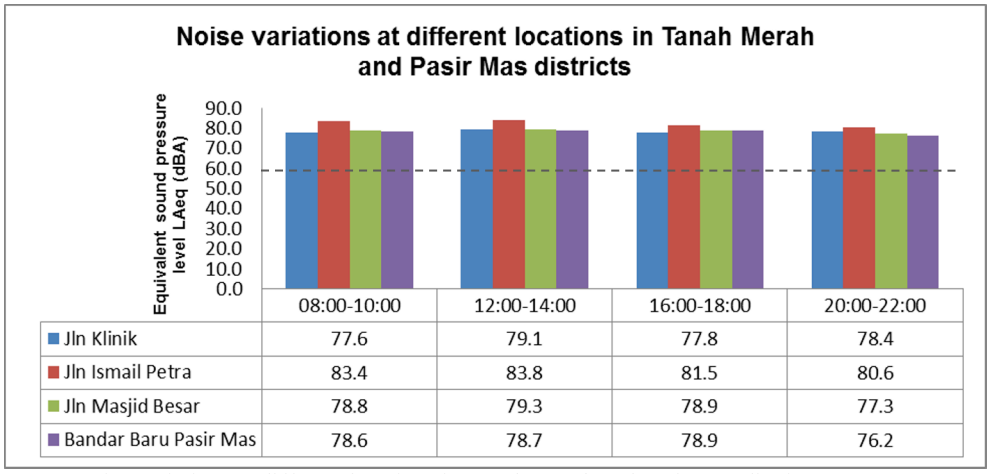


Fig. 2. Maximum noise levels at different locations in Tanah Merah and Pasir Mas districts



	08:00-10:00	12:00-14:00	16:00-18:00	20:00-22:00
Jln Klinik	77.6	79.1	77.8	78.4
Jln Ismail Petra	83.4	83.8	81.5	80.6
Jln Masjid Besar	78.8	79.3	78.9	77.3
Bandar Baru Pasir Mas	78.6	78.7	78.9	76.2

Fig. 3. Noise variations at different locations in Tanah Merah and Pasir Mas districts

Table 3 shows the variations of the values for TNI and NPL for all locations. The highest TNI and NPL were recorded at the same location and at the same time of recording; Jln

Ismail Petra recorded during a morning session at 08:00 to 10:00. The TNI was 91.5 dBA and 97.2 dBA for the NPL.

The lowest TNI and NPL values recorded in this study still exceeded the limit set by DOE with 85.2 dBA and 92.5 dBA, respectively. All the data recording sessions in this study fell under the daytime category (07:00 – 22:00) according to [10] in its second schedule. As mentioned before, the permissible limit by DOE standard is 60 dBA during day time.

TNI and NPL are metrics that often correlate. We found that as TNI increased, indicating higher levels of annoyance due to traffic noise, NPL also increased, reflecting a higher overall noise pollution level. Our result confirmed this and showed that at Jln Klinik, the TNI increased from 84.9 dBA at 08:00 – 10:00 to 85.2 dBA at 12:00 – 14:00, the NPL also increased from 91.2 dBA to 92.2 dBA. As for Jln Ismail Petra at 08:00 – 10:00, the TNI was decreasing from 88.0 dBA to 8.6 dBA at 12:00 – 14:00 and the NPL also decreased from 93.1 dBA to 92.8 dBA respectively.

Table 3. TNI and NPL values at all locations

Districts	Locations	08:00 - 10:00		12:00 - 14:00		16:00 - 18:00		20:00 - 22:00	
		TNI	NPL	TNI	NPL	TNI	NPL	TNI	NPL
Tanah Merah	Jln Klinik	84.9	91.2	85.2	92.2	85.2	91.4	85.0	91.7
	Jln Ismail Petra	91.5	97.2	89.9	96.9	87.6	94.6	86.0	93.4
Pasir Mas	Jln Masjid Besar	88.0	93.1	86.6	92.8	87.1	92.8	86.2	91.5
	Bandar Baru Pasir Mas	87.2	92.6	86.0	92.2	86.8	92.6	85.0	90.3

There are various factors that influence and contribute to the levels of traffic noise in specific areas. It is stated by [14, 15] that the main source of traffic noise comes from the interaction between vehicle tyres and road surface, which eventually plays a major role in the overall noise produced by traffic. It is also apparent that traffic noise is significantly influenced by underlying factors such as traffic volume, flow, velocity, road features, vehicle types, speed limits, driving skill, road intersection types and many more [16].

However, the result found that traffic volume alone did not solely contribute to high noise measurement. Indeed, the percentages of heavy P vehicles passing by also contribute to traffic noise. Table 4 and Table 5 show the traffic volume (Q) vs percentage of heavy vehicles (P) and traffic volume (Q) vs LA_{eq} at all locations, respectively.

Jln Ismail Petra at 08:00 – 10:00 had the highest P compared to other locations (14.4%), with 1807 as the total number of vehicles. Its LA_{eq} was 83.4 dBA. The highest LA_{eq} of all locations was also recorded at Jln Ismail Petra at 12:00 – 14:00 (83.8 dBA); the P value was 9.8%. Despite having a lower P value than the prior, the total number of vehicles was the highest of all locations ($Q = 2769$). This shows that total vehicles and/or a higher percentage of P alone did not influence noise level measurement. According to [17], their study recorded a drop in noise level when the vehicle volume increased. Their findings attributed this to the low-speed movement of the traffic with less acceleration at that particular time interval [18, 19].

Table 4. Total vehicle (*Q*) and percentage of heavy vehicles (*P*) at all locations

Districts	Locations	08:00 - 10:00		12:00 - 14:00		16:00 - 18:00		20:00 - 22:00	
		Q	P(%)	Q	P(%)	Q	P(%)	Q	P(%)
Tanah Merah	Jln Klinik	688	0.9	1120	0.5	697	1.6	891	0.6
	Jln Ismail Petra	1807	14.4	2769	9.8	1772	5.1	1665	1.4
Pasir Mas	Jln Masjid Besar	633	8.4	951	4.1	742	5.9	484	4.8
	Bandar Baru Pasir Mas	661	6.4	844	2.8	787	4.9	403	2.2

Table 5. Total vehicle (*Q*) and LA_{eq} (dBA) at all locations

Districts	Locations	08:00 - 10:00		12:00 - 14:00		16:00 - 18:00		20:00 - 22:00	
		Q	LA_{eq}	Q	LA_{eq}	Q	LA_{eq}	Q	LA_{eq}
Tanah Merah	Jln Klinik	688	77.6	1120	83.4	697	78.8	891	78.6
	Jln Ismail Petra	1807	79.1	2769	83.8	1772	79.3	1665	78.7
Pasir Mas	Jln Masjid Besar	633	77.8	951	81.5	742	78.9	484	78.9
	Bandar Baru Pasir Mas	661	78.4	844	80.6	787	77.3	403	76.2

All locations in this study had high traffic counts. The minimum number of vehicles were counted at Bandar Baru Pasir Mas during 20:00 – 22:00, with a record of 403 vehicles passing by. The highest vehicle count was recorded at Jln Ismail Petra during the afternoon 12:00 – 14:00. This was expected, given the nature of the busy road itself.

Excessive noise exposure could lead to a variety of health issues, including sleep disturbances, increased stress levels, cardiovascular problems, impaired cognitive function, and reduced overall well-being. The effects of traffic noise can be divided into four categories: biological reactions, such as elevated blood pressure, hearing impairments, depression, which can cause irritability and insomnia, and influence on task execution, which can lead to decreased efficiency and communication problems [20]. Therefore, by being aware of the specific noise impacts, noise-related health hazards could be reduced.

In the future, suitable mitigation measures must be applied to locations with high risk of traffic noise pollution. Noise barriers can be a bit expensive and ineffective depending on the situation, hence natural barriers [6] can be considered by utilizing plants such as shrubs. These plants proved to potentially reduce noise levels by 4-8 dB [21].

4 Conclusion

This study shows that all locations experienced high noise levels that exceeded the limit according to Malaysian guidelines. As the traffic count at all locations was high, the result was anticipated. The highest noise level recorded was 83.8 dBA at a location where the total traffic count was also the highest, with 2769 vehicles at 12:00 – 14:00. However, it was noted that the percentage of heavy vehicles (*P*) also attributed to the increase of noise level at Jln Ismail Petra. In addition, we suggest factors contributing to traffic noise to be explored more in future studies. This would be a huge benefit for the decision makers, especially in town planning and noise management.

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