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Original Article

The Effects of Night-Time Road Traffic Noise on Discomfort - a Case Study in Dungun, Terengganu, Malaysia

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Abstract

Background: Sound produced by the passing traffic contributes to noise pollution. Noise pollution affects the residents of both city and suburban areas. The noise produced does not only disturb the community living nearby the main road during the day but becomes worse during the night. The purpose of the study is to perform noise level measurement and subjective evaluation on the noise produced at night in a residential area along Paka Road, Dungun, Terengganu.

Methods: Data of the noise level produced at night in the residential area were taken at three different locations using SoundTrack LxT sound level meter. These locations determined the effect of distances to the noise being heard. Data were recorded to produce L_{Aeq}, L_{max}, L_{10} and L_{90}. Noise pollution levels (LNP) and traffic noise index (TNI) were also reported. A subjective evaluation was conducted to investigate residents' perception of the effects of traffic noise at night in their daily life routine. This study employed a questionnaire specially constructed for the study based on related literature review.

Results: The noise levels inside and outside of the residences exceeded the noise level permitted by Department of Environment (DOE) and World Health Organization (WHO). The noise level in the residence was 66.4 dBA which is much higher than the level proposed by DOE. While the highest L_{Aeq} of the traffic noise measured inside the residence was 57.5 dBA which is also considered as high. Moreover, the maximum noise level inside the residences could reach up to 85.3 dBA at night during the weekends.This study also showed that from 114 respondents who were selected randomly, 61% felt that their residential area is noisy at night.

Conclusion: The noise produced by the traffic at Paka Road, Dungun at night is considerably high and affects the residents' quality of life.

Keywords: Malaysia, Traffic, Noise

Introduction

Like most of the adverse effects of other types of pollutions in the urban environment, exposure to noise constitutes health risks (1, 2). Research regarding urban noise pollutions have divulged that road traffic is usually the highest contributor to urban noise (3, 4). Ising and Kruppa (5) reported that road traffic noise is the most biggest source of environmental noise as compared to other sources (6). The main sources of road traffic noise are from the engine and frictional contact between

the vehicle and the ground and air, traffic flow rate which depends on the speed of the vehicles and the nature of the road surface (7).

Nowaday living environment in many residential areas has been deteriorating among others is because of the increase in traffic volume and noise annoyance that resulted from it (8). Noise annoyance is a feeling of discomfort, dissatisfaction or displeasure (2). Annoyance to noise is the most widely studied and analyses indicate that there is no simple relationship between noise exposure and reaction to noise (9). There are big differences in the annoyance response of people exposed to the same noise level and they may be affected through health, work performance and comfort(10). With increasing number of vehicles both in the urban and suburban areas, traffic noise is no longer experienced in urban areas only. For example, in the east coast of the peninsular of Malaysia,Terengganu motor vehicle ownership has increased from 13.4 people per car in 1970 to 2.9 people per car in 1992 (11). Although there are noise barriers that can be seen alongside the roads in major cities in Malaysia, there are not enough effort to lessen the traffic noise at suburban residential areas. One of the run in suburban area is Paka Road at Dungun Terengganu. It is a very long and busy road however it is not a gazetted highway. Nevertheless, it is the main road connecting Pahang and Kelantan (two neighboring states) through Dungun Terengganu, if one chooses not to use the highway. According to the Malaysia Ministry of Transport (12), the average daily traffic from Terengganu-Dungun-Kuantan reached to more than 27,000 vehicles in 2012.

The objective of this case study was to investigate the noise level from inside and outside the residence nearby Paka Road, Dungun, Terengganu. It aslo aimed to understand the residents' perceptions on the effects noise, especially at night time.

Materials & Methods

This study was done at residential areas along 3km stretch of Paka Road as shown in Fig. 1. Along this road, there are many residential areas, few schools, shop houses and also colleges.

Fig. 1: The area of study

Figure 2 shows the locations of six noise measurement stations labeled as A-F. The locations of the stations were selected based on the distances from the source of the noise, i.e. the Paka Road immediate road side to the location of the selected houses (13). Measurements at these six stations and subjective evaluation at the surrounding residential areas were carried out in a month's duration.

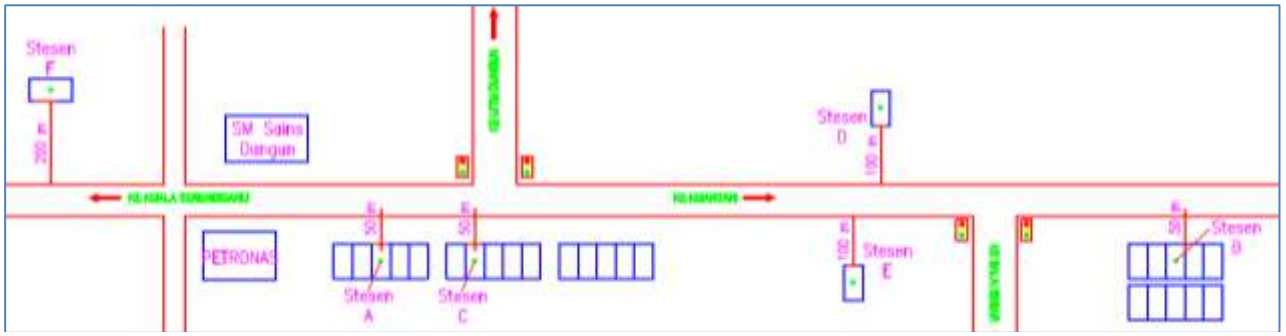

Fig. 2: Locations of noise measurement stations labeled as A to F

The first measurement was for less than 50 meters from noise. Station A and Station B were located outside of a residence while Station C was in a room inside the residence. Both Station D and Station E were located outside a residence which is more than 50 meters but less than 100 meters to the noise source. Meanwhile, only Station F was located inside a residence at a distance of more than 100 meters but less than 200 meters.

Measurement procedure

Measurement was carried out using *SoundTrack LxT* sound level meter. This instrument was calibrated and then installed on a tripod at 1.2 to 1.5 meter in height and 1 meter of distance from the wall. The noise measurement from the road was carried out on weekday nights from Sunday to Thursday; and weekend nights from Friday to Saturday, according to time duration as shown in Table 1. The distances were chosen with respect to the location of the residences from the roadside. The measurement was only done when it was not windy or rainy, and for 40 minutes at each locations.

Table 1: Time duration for noise observation

Time duration	Time
I	7.00 p.m – 9.00 p.m
II	9.00 p.m – 11.00 p.m
III	11.00 pm – 1.00 a.m
IV	1.00 a.m – 3.00 a.m
V	3.00 a.m – 6.00 a.m

The *SoundTrack LxT* was set up at the house compound for the data observation outside of the residence. Meanwhile, for the observation inside the residence, the instrument was set up in the living room for time duration I and II, and in the bedroom for time duration III, IV and V. The recordings were executed using A weighting (dBA) and L_{Max} (Maximum Sound Level), L_{Min} (Minimum Sound Level), L_{Aeq} (Equivalent continuous A-weighted sound pressure level) and percentile sound pressure level at L_5, L_{10}, L_{50} and L_{90}.

Subjective evaluation

Subjective evaluation was also conducted to the residents who live at the residential areas, whereby their houses are immediate to the main road. A structured questionnaire was prepared to obtain the physiological reactions and responses on annoyance caused by the noise pollution. The questionnaire was established with reference from literatures (7,14,15) comprising of four sections including the demographic background of the respondents, noise annoyance degree, noise sensitivity score and effects of noise annoyance. There are 38 questions altogether and the questions were closed-ended with possible fixed answers to be chosen by the respondents. Most of the questions related to the effects of noise annoyance that the residents perceived consisted of Likert scales with five categories which are: "noticed but not annoyed", "slightly annoyed", "moderately annoyed", "very annoyed", and "extremely annoyed" and categories for frequencies are: "never", "sometimes", "once a week" , "a few time a week" and "every night". This questionnaire rated the discomfort or annoyance level that the residents experienced from Paka Road night traffic noise. A total of 114 adult respondents were selected randomly and each of the respondent represented one household.

Results

Noise level

Table 2 shows the road noise level at stipulated locations and time. For the stations with less than 50 meter distance to the noise source, the noise level outside of the residence showed a higher L_{Aeq} value which was within 51.0 dBA to 66.4 dBA. L_{max} readings obtained at Station A and B were almost the same which was 85.8 dBA and 85.3 dBA. Station B showed a higher L_{Aeq} than Station A. Mean value for 30 readings of noise average level, L_{Aeq} obtained for all Stations A, B and C is 57.3 dBA (SD 4.723).

Table 2: Noise level at the distance of less than 50 meters from road

Station	Location	Night	Time duration	Noise level/ Sound Index (dBA)			
				L_{Aeq}	L_{maxs}	L_{10}	L_{90}
A	Outside the residence	Weekday	I	59.8	79.3	61.7	48.2
	(Less than 50 meters)		II	63.5	80.3	61.7	48.2
			III	56.3	73.3	58.8	45.2
			IV	51.0	67.2	57.6	42.7
			V	54.9	70.9	57.8	44.0
		Weekend	I	60.2	75.6	67.4	53.5
			II	57.0	74.3	59.3	47.0
			III	63.5	74.1	63.4	46.1
			IV	65.4	85.8	67.4	54.1
			V	54.1	76.7	59.7	46.7
B	Outside the residence	Weekday	I	59.5	79.1	61.7	47.2
	(Less than 50 meters)		II	63.5	80.3	66.2	51.4
			III	55.5	64.9	57.9	47.8
			IV	53.1	67.2	57.6	42.7
			V	57.1	76.9	55.8	37.4
		Weekend	I	65.3	85.3	67.4	53.5
			II	56.7	72.0	59.0	46.7
			III	64.3	75.6	67.4	54.1
			IV	66.4	81.8	63.9	47.0
			V	53.1	62.9	57.0	44.5
C	Inside the residence	Weekend	I	56.3	85.3	67.4	53.5
	(Less than 50 meters)		II	53.3	79.1	61.7	47.5
			III	56.0	74.3	58.2	45.9
			IV	57.5	74.4	59.9	46.2
			V	53.1	62.9	57	44.5
		Weekday	I	51.9	64.1	56.2	40.1
			II	53.1	73.0	56.7	40.1
			III	51.0	55.7	58.7	51.4
			IV	52.7	76.9	55.8	37.4
			V	54.0	67.2	57.6	42.7

Station A recorded the minimum noise level reading at 58.6 dBA with the highest median value. Besides, the lowest mean value between these three stations was at Station C with 53.8 dBA with 53.2 dBA median value (SD 2.07). Pearson correlation for noise level between the noise inside and outside the residences showed a weak correlation. Moderately high Pearson correlation values were obtained between Station C and Station A was -0.618 (P=0.057); and between Station C and Station B was -0.678 (P= 0.031). The same procedure was conducted at Station D and Station E. The noise level recorded for Station D and Station E for a distance less than 100 meters from road was at a moderate level with the minimum reading value L_{Aeq} of 44.6 dBA. The maximum value of L_{max} recorded was 73 dBA at Station E. Station D recorded 49 dBA for its highest noise value level with L_{max} is 62.2 dBA. Meanwhile for Station E, the minimum noise value level obtained was 43.8 dBA and the highest value obtained was 45.2 dBA with L_{max} is 60 dBA. L_{Aeq} reading for Station E showed lower reading from Station C. Noise level for both stations did not have a significant difference (t = 2.59, P<0.05) and the correlation between both stations carried out with Pearson test (0.596), showed a moderate correlation.

The sound level readings obtained for station F for the distance of between 100 and 200 meters were almost the same for time duration I to V, hence the value of mean and median readings measured was 40.2 dBA with max noise level L_{max} is 59.0 dBA. Pearson correlation test showed that the noise level correlation was weak which is -0.168 (value $P = 0.832$). Mean difference for noise level between Station C and Station F was 15.6 dBA.

Noise level was also measured during different types of night: weekdays versus weekends and at different time duration. The mean value difference at Station A using *t*-test was 0.82 ($P = 0.46$) for weekend nights and weekday nights. The highest noise level measured at weekday nights was at time duration II, with the same reading value for Stations A and B, which was 63.5 dBA. Besides, the lowest noise level measured was at time duration IV with 12.5 dBA noise level difference for Station A and 10.4 dBA for Station B. The highest noise level reading, L_{Aeq} outside the residence obtained at weekend nights at time duration IV which was 66.4 dBA. The most disturbing noise level inside the residence for residents was at time duration IV, which was during weekend nights with the highest value L_{Aeq}, 57.5 dB. The respondents experienced most noise during their bed time at time duration III to IV. The t-test for the mean value difference (t = 3.14, $P = 0.035$) showed that there were differences for noise level readings which were measured at weekday nights and weekend nights. The positive t-test result showed the L_{Aeq} at weekend nights were higher than weekday nights for four time durations from duration I to IV.

The LNP and TNI for L_{Aeq} values were measured to identify noise pollution experienced by the residents at Paka Road, Dungun. The mean value difference obtained from t-test for LNP value of weekend and weekday nights showed the t value was 2.21 (P= 0.04) where the mean value LNP at weekend nights was higher than weekday nights. The residents who do activities outside their houses were exposed to the noise pollution at noise level as high as 83.3 dBA with TNI value of 84.6 dBA in time duration IV at Station B. Table 3 shows the LNP value level and TNI outside the residence on weekday and weekend nights.

Table 3: LNP value level and TNI outside the residence on weekday and weekend nights

Station	Time duration	Noise level/ Sound index (dBA)			
		Weekday night		Weekend night	
		LNP	TNI	LNP	TNI
A	I	73.3	72.2	74.1	79.1
	II	77.0	72.2	69.3	66.2
	III	69.9	69.6	80.8	85.3
	IV	65.9	72.3	78.7	77.3
	V	68.7	69.2	67.1	68.7
B	I	74.1	79.1	79.2	79.1
	II	69.3	66.2	69.0	65.9
	III	80.8	85.3	77.6	77.3
	IV	78.7	77.3	83.3	84.6
	V	67.1	68.7	65.6	64.5
D	I	48.8	29.3	57.0	45.5
	II	50.6	32.5	50.6	32.3
	III	45.9	29.0	54.6	42.7
	IV	57.0	45.5	54.7	45.6
	V	50.6	32.3	54.4	43.2

Based on Table 3, it could be seen that the night time LNP level outside the residence at Station A and Station B were both much higher than the suggested values by DOE and WHO with readings between 65.6 dBA to 83.3 dBA during weekends. Meanwhile on weekday nights, the LNP values for both stations were a bit lower than weekend nights with LNP value between 65.9 dBA to 80.8 dBA. The LNP mean value for both stations with a distance of less than 50 meters, had a higher mean value than a station with a distance less than 100 meters. Station D showed a higher LNP level on weekend nights than weekday nights, and the LNP mean value difference was 3.7 dBA. TNI mean value for Station A and Station B showed almost the same reading for both weekday and weekend nights. The highest mean value obtained was at Station A with TNI value 75.3 dBA on a weekday, and the highest TNI value was 71.1 dBA obtained at Station A. Pearson correlation value in Table 4 showed that there was a significant correlation between the TNI values; between Station D with Stations A and B.

It could be concluded that road noise pollution was experienced by the residents. This could be seen from the LNP and TNI value levels as shown in Table 5. Table 5 shows the LNP and TNI value levels inside the residence on weekend nights.

Table 4: Pearson correlation between TNI value at Station D and, Stations A and B

		Station A	Station B
Station D	Pearson correlation	0.626	0.654
P-value		0.258	0.231

Table 5: LNP and TNI value level inside residence on weekend nights

Station	Time duration	Noise level/ Sound index (dBA)	
		LNP	TNI
C(less than 100 meters)	I	70.2	79.1
	II	67.5	74.3
	III	68.3	65.1
	IV	71.2	71.0
	V	65.6	64.5
E(more than 50, less than 100 meters)	I	48.8	27.2
	II	53.0	42.5
	III	53.2	37.8
	IV	46.5	22.0
F(more than 100, less than 200 meters)	I	48.6	36.8
	II	49.1	40.1
	III	47.8	36.4
	IV	44.1	25.5

From Table 5, a high level of LNP pollution was experienced by the residences at bed time and early at night. The value of LNP and TNI at the residence from a distance at Station E (less than 100 meters) and Station F (more than 100 meteres and less than 200 meters) showed moderate readings. The TNI mean value between Station C and Station E was 40 dBA (t = 6.52, value $P < 0.05$). From the t-test, the mean value difference for LNP level outside the residence (Station B) and

inside residence (Station C) for a same distance, showed that the difference in mean value outside the residence was higher than LNP mean value inside the residence (t = 2.69, P = 0.05). There was significant correlation with 0.95 correlation value between the two stations (B&C). This just proved that noise pollution outside the residence has effects to the noise pollution inside the residence. Meanwhile, the difference of mean for TNI value showed slight difference where the TNI value was 3.48 dBA.

Subjective evaluation

The descriptive data were analyzed using a model of reliability and the Cronbach Alpha value is 0.761. Respondents are residents of 114 chosen residences in this study. Table 6 below shows the demographic information about the respondents.

Table 6: Percentages on demographic data

Category		Frequency (n)	Percentage (%)
Gender	Male	53	46.5
	Female	61	53.5
	Total	114	100.0
Age	less than 25 years old	57	50.0
	25 - 35 years old	38	33.3
	36-45 years old	12	10.5
	more than 45 years old	7	6.1
	Total	114	100.0
Length of residence	Less than 1 year	49	43.0
	1 - 5 years	32	28.1
	6 -10 years	33	28.9
	Total	114	100.0
House position whether house is facing street	Yes	85	74.6
	No	29	25.4
	Total	114	100.0

A total of 53 males (47%) and 61 females (53%) participated in this study. Respondents' age distribution showed that the majority of the respondents are from the young age group; 50% of them were less than 25 years old. The study showed that the age group of 25 - 35 years old was the most affected by the traffic noise with 11.4% of them selected "extremely annoyed". Majority of the respondents's house positions face the street, hence perhaps that explains the highest annoyance level reported was at the fourth Likert scale "annoyed".

The level of disturbance experienced by the respondents in the evening was higher than during the day. The subjective evaluation shows that the majority of respondents felt they were "extremely annoyed" and "very annoyed" by noise in their residences at night than during the day. The largest percentage of the respondents (37%) declared that they were very annoyed during the night and only 7% of respondents were very annoyed during the day.

Self-reported respondents' disturbance and depression of the level of traffic noise were also measured in this study. Most respondents reported that noise was extremely high in their residences at night and they felt disturbed and depressed about it every day. A huge number of respondents (44.7%) declared "sometimes" they were distracted and depressed with traffic noise heard from inside their homes. However, only a few respondents (1.8%) felt that they were "never" disturbed and depressed by "traffic noise". This study also revealed that respondents perceived that they were disturbed by

the traffic noise in many ways as catergorized and shown in Fig. 3.

A strong correlation could be seen between sleeping difficulty and waking up easily at night (0.762) and sleeping difficulty with headache (0.542). The relationship between emotional disturbances also indicated a significant correlation with feeling tired when waking up and indirectly could affect individuals' mood during the day (0.513).

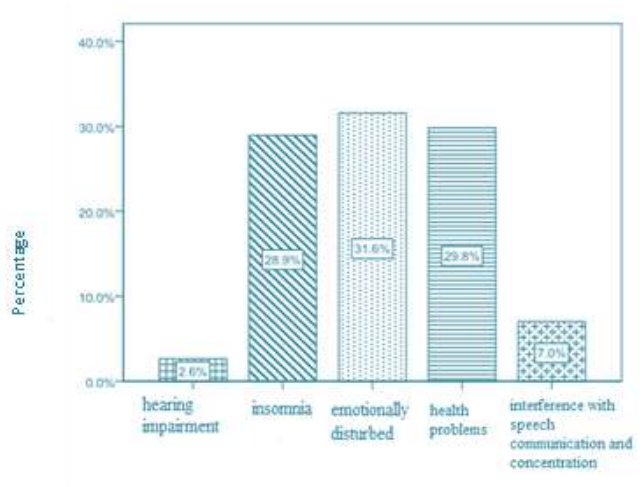

Fig. 3: Respondents'perceptions on disturbance from traffic noice

Discussion

From the results, it is shown that the more the distant of stations from the noise source, the lower the noise level. It was also shown that the mean values for weekend nights were higher than weekday nights. This trend used to be a problem only in the urban areas (6-8) but it seems that from this study, similar trend can be seen even in the suburban areas. It was observed that these high LNP and TNI during night time were mainly caused by express busses and also heavy industrial vehicles that travel mostly very late at night. On the other hand, the high values during weekends night time were contributed mainly from youngters involved in illegal street racings.

Noise annoyance is a feeling of resentment, discomfort or offense. Although Marjan and Majid (7) showed that there was a correlation between respondents' age and noise level, it was not shown with this data. It is also said that the noise level in the evening and at night has more interference than during the day even at the same level of noise (16). There are previous studies conducted by Ohrstrom (17) that showed several psychosocial well-beings of subjects exposed to the high noise levels were not caused by road noise exposure during the day but because of exposure at night which was disturbing to sleep quality (2). Furthermore, the traffic noise at the residential area could lead to sleeping disorders which could induce disturbances of sleep in terms of difficulty to fall asleep, and waking up suddenly from sleep. Night time noise could induce disturbances to sleep and other negative effects such as increased blood pressure (7). This study found that 48% of respondents considered noise pollution as a serious issue in their residential areas. However, there were only a few respondents who took actions to solve the noise they are experiencing. Most of them just ignored the noise and considered it as a normal situationas it did not give any negative effects to their health and lives.

The disturbance experienced by the respondents were mostly reported as emotionally disturbed (31%), health problems (30%) and insomnia (2). The study carried out by Mohammadi (18) also indicated that insomnia and emotionally disturbed were the main types of disturbances experienced by the community in the city of Kerman, Iran. Emotional disturbance could cause people to be depressed and indirectly will affect their mood.

Conclusion

The highest traffic noise level was obtained inside and outside the residence on weekend nights between 1.00 am to 3.00 am. The highest L_{Aeq} obtained for inside and outside residence were 57.5 dBA and 66.4 dBa, respectively. Almost all the stations recorded very high noise level which exceeded the standard set by DOE and WHO;which should be at 45 dBA and 50 dBA around residential areas.The subjective evaluation showed that the main effects of night-time noise in the residence were emotional disorders (31.6%), health problems (29.8%) and insomnia (28.9%).

Respondents were emotionally disturbed by noise pollution and this has a significant correlation with tiredness and respondents mood are affected the next day (0.513). It can be concluded that there is traffic noise disturbance along Paka Road Trengganu. The pollution influenced the quality of life of the people staying at the nearby residential areas. This study would like to suggest further investigations in controlling, reducing, and diminishing noise pollution at suburban areas as it affects the well-beings of residents.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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The authors declare that there is no conflict of interest. The researcher was supported by Politeknik Sultan Mizan Zainal Abidin, Teren-gganu, Malaysia.

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