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The relationship between road traffic noise and annoyance level in Phuket province, Thailand

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Abstract

Road traffic noise generates unpleasant sounds in communities, which not only makes enormous noise pollution in road areas but also disrupts the quality of buildings located near these roads. The aim of this study was to determine the relationship between road traffic noise and annoyance level in Phuket, Thailand. Traffic noise level was measured during day and night time on nine roads in Muang Phuket, Thalang, and Kathu Districts. The annoyance levels of 253 people living in these areas were determined using questionnaires. Noise annoyance level was estimated using the ICBEN method which classified annoyance level into a five-point verbal scale (extremely, very, moderately, slightly, and not at all annoyed). The results showed that traffic noise levels (Leq 24hr) were in the range of 70.0-70.9, 72.7-74.7, and 74.6-74.8 dB(A) in Muang Phuket, Thalang, and Kathu Districts, respectively, exceeding 70 dB(A) for the ambient noise standard of Thailand. Moreover, L_{dn} ranged from 74.0-75.8, 77.5-78.1, and 79.7-80.1 dB(A) in Muang Phuket, Thalang, and Kathu Districts, respectively. The average annoyance scores of traffic noise in Muang Phuket, Thalang, and Kathu were found to be 1.78, 2.52, and 2.75, respectively. Thus, the average annoyance score of Phuket Province was 2.24. The annoyance responses of residents in surveyed areas indicated that people in Muang Phuket were more sensitive to road traffic noise than those in Talang and Kathu. Moreover, the result showed a significant positive correlation between road traffic noise and annoyance level (Pearson correlation coefficient= +0.733, P=0.025).

Keywords: Road traffic noise, Noise annoyance, Dose-response relationship

1. Introduction

Traffic noise produces unpleasant or unwanted sounds in communities, which not only makes enormous noise pollution in road areas but also detracts from the living and occupational quality of the buildings and land located near these main roads and highways [1].

In developed countries, road traffic noise is considered to be the worst environmental problem and leading damage to health and well-being in the community [2]. In 2000, more than 24 million people in the European Union were highly annoyed by road traffic noise higher than 55 dBA for 24 h (L_{dn}) [3 & 4]. From rapid urbanization, noise annoyance might increase among urban populations in both developed and developing countries. Although road traffic noise has not been recognized as a serious problem in developing countries, several studies conducted in some of countries have shown the potentially adverse effects of noise in communities where road traffic noise is very intensive [4 - 6].

Phuket is one of the most popular tourism provinces attracting many visitors around the world. In 2015, 12.52 million visitors travelled to Phuket [7]. Accordingly, numbers of vehicles in Phuket are increasing every year as shown in Figure 1. In addition, road traffic noise may impact people who live in the community areas in Phuket. This problem leads to annoyance and may affect the quality of life. Therefore, this study aimed to investigate road traffic noise and determine the relationship between road traffic noise and annoyance level in Phuket Province, Thailand.

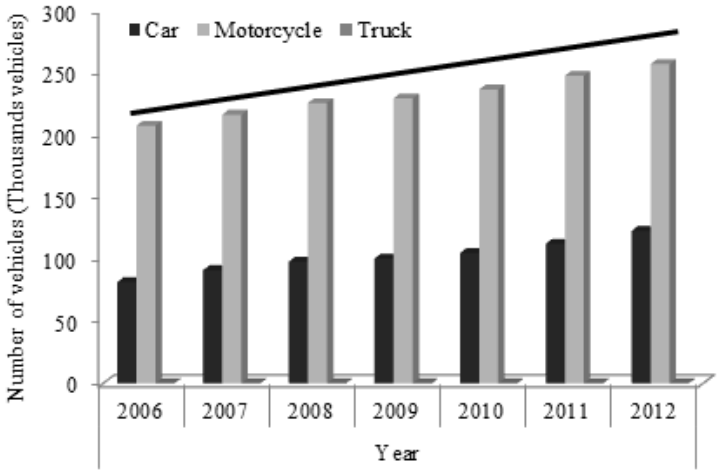

Figure 1 Number of registered vehicles in Phuket Province

2. Methods

2.1 Goal and scope of research

The goal of this study was to determine the relationship between road traffic noise and annoyance level in Phuket, Thailand. This work was designed as cross-sectional study by measuring road traffic noise and collecting annoyance data in residence areas near roadsides. This work was conducted during the tourist high season in Phuket Province from April 2 to June 1, 2015.

2.2 Study areas

The investigated areas for nine points of noise measurement along roadsides in Muang Phuket, Thalang, and Kathu Districts are shown in Figure 2. Pathipat, Ratsada, Yaowarat, and Montri Roads were measurement points in Muang Phuket District. Thepkasattri Road in Baan Muangmai, Baan Kain, and Baan Lipon were measurement points in Thalang District while Vichitsongkram and Baramee Roads were measurement points in Kathu District.

2.3 Road traffic noise measurements

Traffic noise was measured at selected points in each road as shown in Figure 2. These measurement points were located in the middle of areas approximately 1 to 5 meters from the road edge. Each point was measured 3 times for 24 hours weekdays and weekends. In addition, traffic volume and speed of vehicle were counted manually during rush hours. Vehicle types were divided into motorcycle, personal car, truck, and heavy truck.

2.4 Social survey

Sample size was calculated using the formula of Daniel [8] as shown in Equation (1). Data was collected using questionnaires to obtain all necessary information from 253 respondents.

$$n = \frac{Z^2 pq}{e^2} \tag{1}$$

Where;

n is the sample size Z is the selected critical value of desired confidence level (1-α equals the desired confidence level, e.g. 95%)

e is the desired level of precision

p is the estimated proportion of people who feel annoyed to total number of people in the preliminary survey (26/30).

q is 1-p.

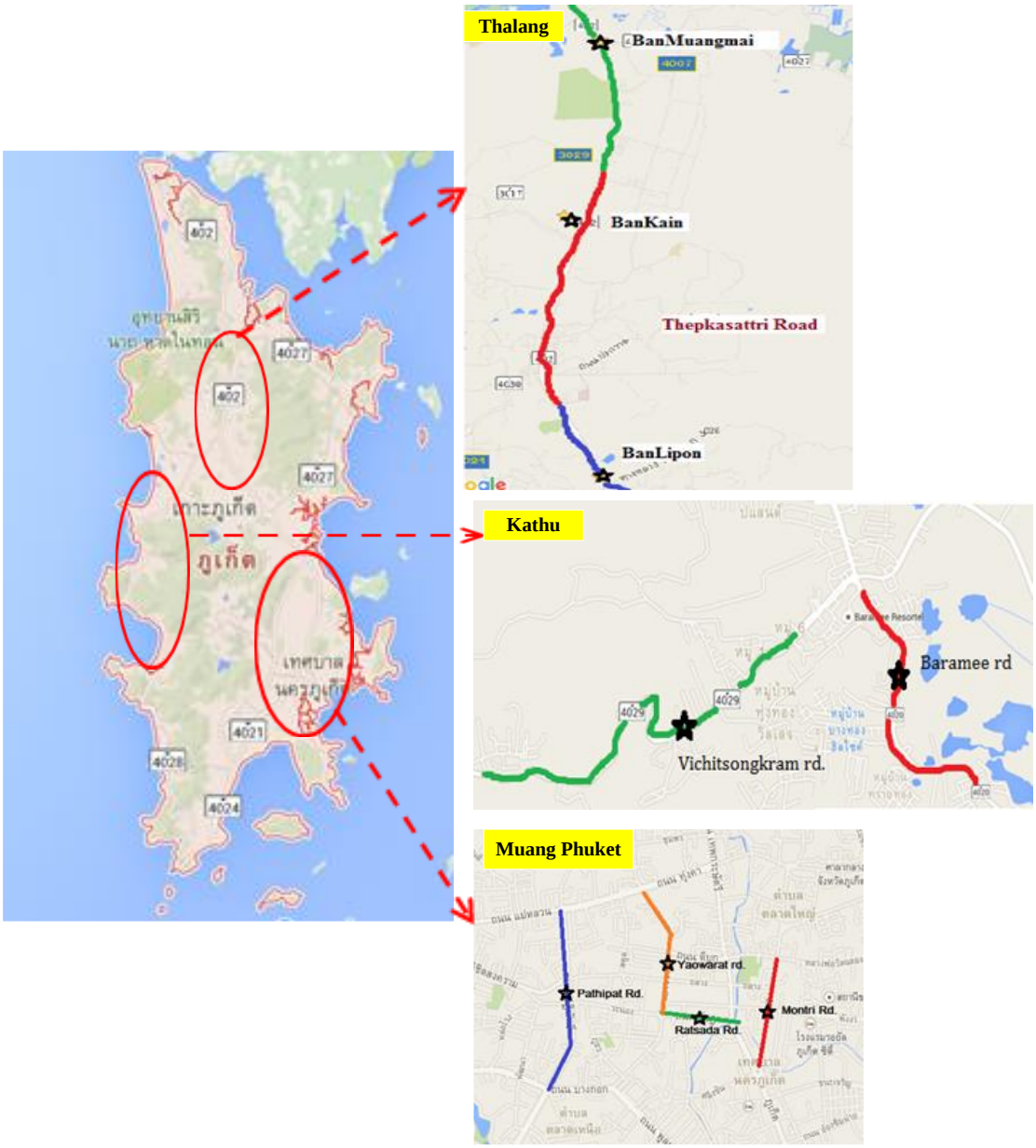

Figure 2 Investigated areas for noise measurement
Remark: ★ are measurement points (Source: https://www.google.co.th/maps/place/)

Therefore, p(0.86), q(0.14), Z(1.96), and e(0.05) are used to calculated sample size. The sample size calculated using the formula of Daniel is equal to 185 people. However, total sample size of annoyance survey of this study was 253 people to prevent data loss and increase validity. Using proportional ratio between total number of people lives along the road around measurement points of traffic noise and calculated sample size, total number of respondents was 126, 103, and 24 people in Muang Phuket, Thalang, and Kathu, respectively. Respondents were people who lived around the measurement points of traffic noise for more than 1 year. General characteristics of selected areas and annoyance levels were gathered. Noise annoyance was estimated using a verbal annoyance Likert scale (1 to 5 graded "not at all", "slightly", "moderately", "very", and "extremely") according to recommendations of the International Commission on Biological Effects of Noise (ICBEN) [4].

2.5 Exposure-response relationships

A dose-response relationship was established between the day-night noise level (L_{dn}) and percentage of highly annoyed respondents (including "very" and "extremely" annoyed) taken from the 5-point verbal scale of the ICBEN. Noise exposure in the community was reported as "yes" and "no". The subjects were also asked to point out the most important sources of noise in their environment.

L_{dn} is a weighted equivalent sound level for a 24-hour period with 10 dBA compensation for nighttime noise level (10.00 pm.-07.00 am.) to take into account increasing noise annoyance of overnight sleep hours. L_{dn} was defined as shown below.

$$L_{dn} = 10\log[\frac{1}{24}[15\left[10^{\frac{Ld}{10}}\right] + 9[10^{(Ln+10)/10}]]] \quad (2)$$

Where;
L_{dn} day-night sound level (dBA)
L_d daytime equivalent sound level (dBA)
L_n nighttime equivalent sound level (dBA)

3. Results and discussion

3.1 Road traffic noise level

The results of noise measurement in Phuket Province showed that average noise levels (Leq, 24 h) in Muang Phuket, Thalang and Kathu Districts were in the range of 70-70.9, 72.9-74.7, and 74.6-74.8 dBA, respectively. Moreover, L_{dn} was found in the range of 74.0-75.8, 77.5-78.1, and 79.7-80.1 dBA in Muang Phuket, Thalang and Kathu, respectively. Results indicated that traffic noise level in Kathu District was higher than that in Thalang and Muang Phuket Districts. This is because many famous tourism attractions are located in Kathu District such as Patong and Kamala Beaches. As a result, numerous cars transport tourists from downtown Phuket to the beach. Therefore, traffic noise levels in Kathu were higher than in other areas in Phuket. Traffic noise levels in each area of Phuket Province are presented in Table 1.

Table 1 Traffic noise level in each area of Phuket Province

District	Road	Traffic noise level (dBA)	
		Leq, 24 h [(a)]	Ldn [(b)]
Muang Phuket	Yaowarat Rd.	69.3-70.8	73.7-74.2
	Ratsada Rd.	70.5-71.1	75.4-76.1
	Montri Rd.	70.0-70.5	74.3-75.2
	Pathipat Rd.	70.0-70.5	75.5-75.9
Thalang	Ban Muangmai	74.4-75.1	77.1-78.7
	Ban Kain	72.4-75.0	76.2-78.9
	Ban Lipon	72.6-73.3	77.3-77.6
Kathu	Baramee Rd.	73.7-75.4	77.8-81.5
	Vichitsongkram Rd.	74.2-74.9	79.4-80.0

Remark:
(a) The ambient noise standard of Thailand is set at 70 dBA
(b) Ldn value are not set as standard

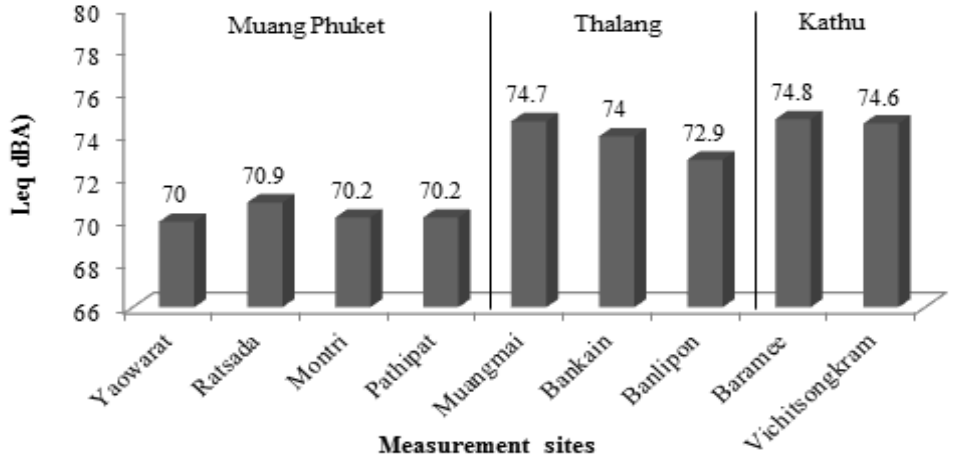

Figure 3 A-weighted sound pressure levels (LAeq 24 hr) in Muang Phuket, Thalang, and Kathu Districts

Moreover, the results of noise measuring in Muang Phuket showed the Lmin, Lmax, L_{10}, and L_{90} were 66.9, 74.7, 73.7, and 64.0 dBA, respectively. In addition, Lmin, Lmax, L_{10}, and L_{90} in Thalang District were 67.4, 78.1, 80.0, 67.1 dBA, respectively. Lmin, Lmax, L_{10}, and L_{90} in Kathu District were 70.8, 76.8, 77.5, and 70.4 dBA, respectively. The results indicated that L_{eq24hr} of all districts was higher than the Ambient Noise Standard of Thailand set at 70 dBA. Therefore, people living in these areas may risk exposure to traffic noise. Average noise levels of all surveyed sites are presented in Figure 3. L_{day}, L_{night} and L_{dn} equivalent noise levels are presented in Figure 4. It indicated that daytime and nighttime equivalent noise levels of all areas surveyed in Phuket exceeded the Environmental Noise Standard of Japan for residential areas, set at 55 and 45 dBA for daytime and nighttime, respectively [9].

Comparing road traffic noise in Phuket with Hanoi and Ho Chi Minh City, the $L_{Aeq,\ 24h}$ were 73-79 and 71-77 dBA, respectively. This indicated traffic noise levels in both cities of Vietnam were higher than Phuket Province. In addition, traffic noise level in Phuket was less than that in Bangkok. Comparison of road traffic noise in Phuket Province and other cities is shown in Table 2.

3.2 Annoyance levels

The total numbers of respondents was 126, 103, and 24 in Muang Phuket, Thalang, and Kathu Districts, respectively. The results of the survey indicated that most respondents were 25 to 35, and 35 to 50 year old, contributing to 34.4 and 28.1 % of total respondents, respectively. In addition, duration times at home of respondents ranged from 1 to 5 years. The result showed that 50.2% of respondents were annoyed from road traffic noise.

The result found that the average annoyance scores in Muang Phuket, Thalang, and Kathu Districts were 1.77, 2.52, and 2.75, respectively, as presented in Table 3. These indicated that levels of annoyance from road traffic noise of respondents in Muang Phuket were in the range of “not at all” to “slightly” annoyed. Annoyance level of respondents in Thalang and Kathu were in the range of “slightly” to “moderately” annoyed. Moreover, annoyance score of Phuket’s respondents were extremely, very, moderately, slightly, and not at all annoyed at 5.1, 17.4, 26.9, 0.8, and 49.8%, respectively. The significant sources of traffic noise came from motorcycle and personal car, contributing to 40.2 and 20.0 % of total respondents, respectively.

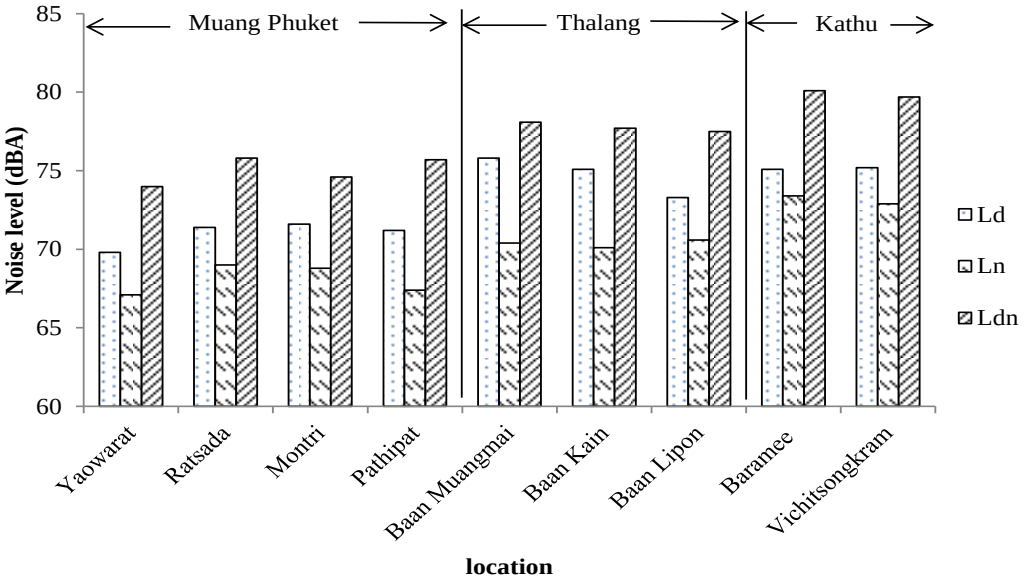

Figure 4 L_d, L_n and L_{dn} equivalent noise level in Muang Phuket, Thalang, and Kathu Districts

Table 2. Comparison of road traffic noise in Phuket Province and other areas

Area	Road traffic noise ($L_{Aeq, 24h}$) (dBA)
Phuket Province, Thailand	70-74 [(a)]
Bangkok City, Thailand	75-81 [(b)]
Hanoi City, Vietnam	71-77 [(c)]
Ho Chi Minh City, Vietnam	73-79 [(c)]

Remark: data derived from [(a)]field survey, [(b)]Pochanajan [10], [(c)] Phan Thi et al. [11]

Table 3 Annoyance score in Muang Phuket, Thalang, and Kathu Districts

District	Measurement points	L_{dn} (dBA)	Annoyance score
Muang Phuket	Yaowarat Rd.	74.0	1.80
	Ratsada Rd.	75.8	1.40
	Montri Rd.	74.6	2.00
	Patipat Rd.	75.7	1.90
		Average	1.77
Thalang	Baan Muangmai Rd.	78.1	3.20
	Baan Kain Rd.	77.5	1.94
	Baan Lipon Rd.	77.7	2.43
			2.52
Kathu	Baramee Rd.	80.1	3.00
	Vichitsongkram Rd.	79.7	2.50
		Average	2.75

Table 4 Traffic noise level and %HA in Muang Phuket, Thalang, and Kathu Districts

District	Measurement points	L_{dn} (dBA)	%HA
Muang Phuket	Yaowarat Rd.	74.0	13.9
	Ratsada Rd.	75.8	6.80
	Montri Rd.	74.6	20.0
	Patipat Rd.	75.7	42.0
Thalang	Baan Muangmai Rd.	78.1	66.7
	Baan Kain Rd.	77.5	9.10
	Baan Lipon Rd.	77.7	21.6
Kathu	Baramee Rd.	80.1	50.0
	Vichitsongkram Rd.	79.7	25.0

Remark: HA is highly annoyed (including "very" and "extremely" annoyed)

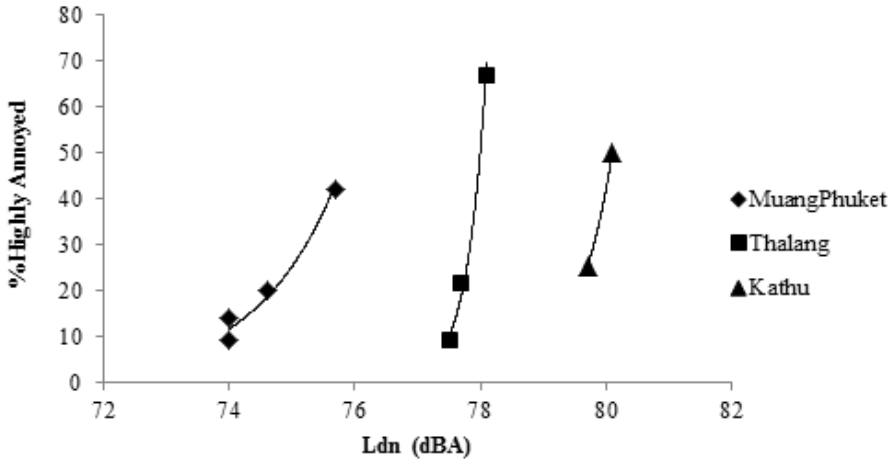

Figure 5 Dose-response curves relationships for road traffic noise annoyance in Muang Phuket, Thalang, and Kathu Districts

In addition, Ali and Tamura (2003) reported that 81.7% of respondents in the Greater Cairo Area of Egypt were annoyed by road traffic noise. The types of vehicles that produced most noise annoyance were identified as bus and heavy truck. Moreover, 53.5% of respondents declared to be "highly annoyed" from road traffic noise [12]. This annoyance was less than that in London, Paris and Pamplona, Spain. Moreover, the study of noise annoyance in Ghent, Belgium for 105 respondents reported that 8% of respondents were very annoyed, 19% were moderately annoyed, 47% were slightly annoyed, and 53% were not annoyed [13]. Whereas, 21% of respondents of Clamart Cedex, France were very annoyed [14]. Therefore, annoyance of respondents in Phuket was higher than that in Clamart Cedex, France.

3.3 Community response to road traffic noise in Phuket

Traffic noise level and %HA in each area are presented in Table 4. These results indicated that the number of extremely and very annoyed respondents were quite high in Baan Muang Mai, contributing to 66.7% of total respondents. However, the highest L_{dn} was found on Baramee Road in Kathu District. A dose response relationship was established between the percentage of highly annoyed respondents and the L_{dn}.

The dose response curve between the percentage of highly annoyed respondents and the L_{dn} of Muang Phuket, Thalang, and Kathu are presented in Figure 5. It indicated that the percentage of highly annoyed respondents in Muang Phuket were lower than Thalang and Kathu. In addition, L_{dn} level in Kathu was higher than Thalang and Muang Phuket with a minimum L_{dn} value of 79.7 dBA. Therefore, the results of this study confirmed that road traffic noise annoyance in Kathu was lower than in Thalang and Muang Phuket. Conversely, respondents in Muang Phuket were more sensitive than those in Thalang and Kathu. At 20% HA from dose-response curve in Muang Phuket, Thalang and Kathu, L_{dn} was 74.5, 77.6, and 79.6 dBA, respectively. Moreover, L_{dn} was found to

be 74.8 dBA at 20% HA from dose-response curve in Phuket Province. Results indicated that traffic noise annoyance of Phuket was higher than Hua and Da Nang City [14]. Therefore, Thais in Phuket were less tolerant to traffic noise than Vietnamese in Hua and Da Nang City.

Moreover, the correlation between annoyance levels and road traffic noise levels were obtained using Pearson correlation coefficient. There was a significant positive correlation between annoyance and traffic noise level ($r=+0.733$, $p=0.025$). The result of this study indicated that an important relationship exists between traffic noise and annoyance level which conforms to the result of several studies [15-21].

From the results of this study, the alternative ways to reduce traffic noise level in Phuket Province should be suggested to also reduce annoyance level. Traffic volume and vehicles speed should be controlled. Additionally, noise barriers can be applied between the main road and respondent's home.

4. Conclusions

Traffic noise level (LAeq 24 hr) in Muang Phuket, Thalang, and Kathu Districts were 70.0-70.9, 72.7-74.7, and 74.6-74.8 dBA, respectively. This indicated that average equivalent noise level of all investigated areas exceeded the Ambient Noise Standard of Thailand, set at 70 dBA. In addition, the result of the social survey found that more than 50% of respondents were annoyed by road traffic noise. The significant annoyance levels found in Phuket Province were moderately annoyed, contributing to 26.9% of total respondents. The average annoyance score of road traffic noise in Muang Phuket, Thalang, and Kathu were 1.78, 2.52, and 2.75, respectively. Moreover, average annoyance score in Phuket Province was 2.24. This indicated that the feeling of annoyance by road traffic noise of residents in Phuket were in the range of slightly annoyed to moderately annoyed. Accordingly, dose-response relationship between L_{dn} and percentage of highly annoyed respondents indicated that people in Kathu were more tolerant to road traffic noise than that in Thalang and Muang Phuket. Moreover, the result showed a significant positive correlation between road traffic noise and annoyance level.

5. Acknowledgements

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