Community response to environment noise: A preliminary soundscape assessment of highland environment

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ABSTRACT

Highland rich in natural resources encourages economic and development growth, hence, altered the sound and landscape of the highland environment. Noise pollution in developing highland area could intrude the ability to comprehend of natural and environmental sounds. In accordance with the previous research conducted on physical noise assessment and psychological assessment of audio and visual lab-test, this paper presented the soundscape assessment of in-situ using questionnaire at selected green area. As preliminary, the main objective of this research is to identify respondents' preferences and perceptions that characterise the soundscape on highland environment. At the first stage of survey, 53 respondents were participated to evaluate the existing soundscape condition. Next, the existing soundscape environment with additional sound intervention was created to examine the preference and perception of acoustic comfort in selected green area. The questionnaire is based on the people's perception towards the perceived sound and landscape. In general, people preferred nature-based sound, therefore, the dominance of the perceived nature sound along with the congruence aspects of landscape and context at selected green area influence their preference level.

INTRODUCTION

Schafer [1] initiated the term 'soundscape' and believed that soundscape is alternative approach to understand the sound in a different dimension from the context of 'noise' thus creating a better quality of life. The soundscape research may require more holistic character [2], and has started to be discussed in order to improve the quality of city life [3], in consideration to the urban nature. On the other hand, numerous studies on soundscape assessment in public spaces including noise assessment have been performed [4, 5, 6, 7] and various analyses regarding community responses to environment noise i.e. traffic noise, have also been studied [8, 9]. Commonly, the perception of sound that direct to the term 'noise', widely imply negative impression and have possibility to create anxiety and other problems [10, 11]. The movement of reduction or elimination of noises by introduced the rules and regulations may need hard implementation for the rapid development of the urban environment. Therefore, the integration between quantitative and qualitative approaches for evaluating the variety interpretation on urban soundscape quality is needed. Meanwhile,

Nasar [12] recognized from the environmental assessments and their aesthetics factors will contribute meaningful judgments for community satisfaction.

Various studies on soundscape interrelate with human involvement through psychological assessment. Among the reports in the relevant literature, Carles *et. al.* [13] and Viollon *et. al.* [14] focused on the relationship between landscapes and sounds through audio and visual. Carles [13] looked into preferences through combination of different sounds and landscapes. He found out that the congruence of both stimuli influence people's preferences. Viollon [14] focus on the use of images and sound that differ in the degree of urbanization. The presented images influence the human response towards the sound environments.

However, most of soundscape studies in public spaces are concentrated in the urban areas. There are less specific soundscape assessment studies that have been focused in highland areas. Highland is one of the popular tourist spots consists of natural environment with high level of sensitivity. The rapid development growth of highlands gave potential effect on surrounding environment. Noise pollution in developing highland area could intervene to the quality in preserving the natural and environmental sounds. Hence, the negative impact of rapid development toward the activities in highland area is needed to take into consideration.

To inquire that situation, the authors conducted an extensive physical measurement for assessing the soundscape and landscape influence on highland environment [15]. The higher sound level are mainly generated by the vehicles but the sites location and landscape features also contributed significant influence to the sound levels. Furthermore, the authors extended the study to identify factors and elements that characterize the soundscape in three selected green areas on highland environment by using audio-visual experiment in laboratory [16]. It was clearly found that natural ambience sound elements attributed more attention on preferences and perception of the soundscape in highland environment.

Considering the potential expansion of this research, the authors attempt to utilize the preferred sound elements found in previous study to the real condition. In this paper addresses in-situ assessment of the human preferences and perceptions of soundscape of public space in highlands by using sound masking technique as a preliminary study.

METHODOLOGY

In this study, Cameron Highlands is one of well-known highlands in Malaysia and having identities of cultural heritage and nature-based attraction. However, due to rapid urbanization, it is being exploited for the needs of the socio-economy activities.

As preliminary, township of Tanah Rata in Cameron Highlands was chosen to be focus for the soundscape study area based on its important role as the administrative center and tourist main attraction. Being the center of development, the provision of recreational areas is situated in close proximity, with easy access and open to the public. Several landscape areas exist in the center of development were outdoor open spaces that provide recreational activities through its natural and man-made setting.

One of prominent open spaces in Tanah Rata is Taman Pertabalan (Figure 1). Taman Pertabalan (Site A) is an open public park that consists of seating and table area, children playground, and open green area where people conduct recreational activities such as picnic, skateboarding, walking, jogging and playing. The features of Taman Pertabalan incorporated with the landform that makes certain area of the park partly as sunken landscape. This landscape area located near to the primary road as well as the secondary road. Variety of vegetation can be seen throughout the park that includes trees, pines, palms, shrubs and groundcover.

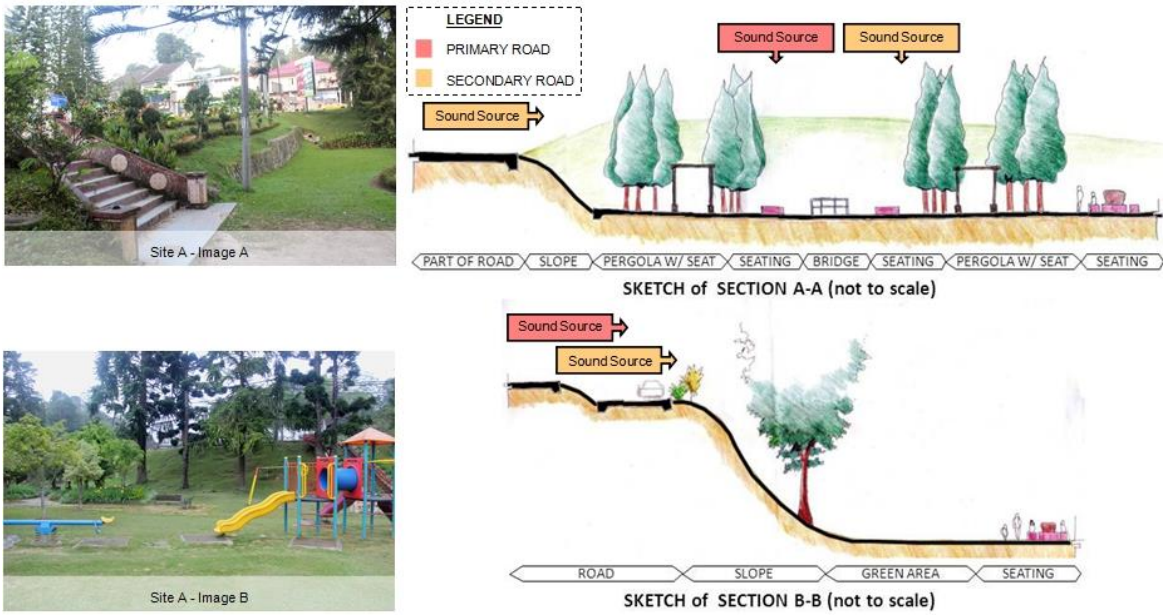

Figure 1: Site A (Taman Pertabalan): Images and sketch of sections (not to scale)

Audio-visual test (Lab-test)

In previous study [16], the audio-visual test or lab-test was performed to identify the human preferences and experience towards the original and artificial sounds of selected landscape areas in Cameron Highlands. Video (audio-motion image) was recorded with covering natural and activities scenes for representing site study i.e. Site A. Then, sample of video was insert three types of sound elements i.e. birdsong, water and natural ambience, into original sound using VSDC Free Video Editor ver. 2.2.1.319 as illustrated in Table 1. Total number of sample using for stimulation test is four and the test took around 30 seconds. The participants were placed at same row at a distance two meters from the screen to watch the video sample projected from the projector (EPSON EB-1965) and will be given one monitoring headphone (Shure SRH-840) as depicted in Figure 2. Volume range was adjusted at computer (Apple MacMini), video software (VLC Media ver. 2.1.5) and headphones amplifier (Behringer Pro-8 HA8000) to ensure the similar volume will be heard by the participants. However, due to limitation of calibration method or chamber, the calibration only performed by using the experienced acoustics experts to control the sounds to be similar as real conditions. The noise level and temperature conditions of the room also were controlled using within the range of 43 ±2 dBA and 22 ±2 °C.

Before video sample is projected, the participant is asked to indicate their preferences towards 18 sound elements. Then, the participant needs to answer of five subjects in term of perceptions on a five-scale as presented in Table 2 after projection of video samples.

Table 1: Sample combination for audio-visual test

Site	Legend	Sounds
Site A	A1	Original
	A2	Original with birdsong
	A3	Original with water
	A4	Original with natural ambience

Figure 2: Photo of condition when conducting audio-visual test

Table 2: Subject preference for evaluation of each sample

	Preference Scale				
	1	2	3	4	5
Subject	Unpleasant Uncomfortable Chaotic Boring Unfavorable	Slightly	Neutral	Slightly	Pleasant Comfortable Calm Exciting Favorable

Noise assessment

Noise measurement was performed using Class 1 sound level meter (SLM) Cirrus 'Optimus Green' con-currently with in-situ assessment in Day 1 and Day 2. One point of reference was located at Site A. SLM attached with wind protector was placed at a height of 1.2 m above the ground. The parameters measured were L_{Aeq}. Measurements were taken during daytime only from 0900 to 1500 (six hours) due to rain in evening session.

In-situ assessment

Questionnaire with corresponding subjects used in lab-test was distributed to the participants for both days at Site A. The questionnaire was distributed with existing original sound around the Site A in Day 1. Next, based on outcome from previous section, the artificial sound of natural ambience used previously in lab-test was selected and generated in Day 2. The artificial sound was amplified by using outdoor environmental speaker, Bose® Free Space® 51 Environmental Speakers. The speakers were located purposely hide-inside the bushes as shown in Figure 3 to avoid any distracting views for the participants. The artificial sound was controlled and adjusted between 2-3 dBA higher than the averaged L_{Aeq} produced in Day 1.

Figure 3: Photo of condition when conducting in-situ assessment; O outdoor speaker

RESULTS AND DISCUSSIONS

Audio-visual test (Lab-test)

Questionnaires are distributed to a group of students that are age around 20s years old. The number of respondents is 78 undergraduate students participated in 20 sessions for two days. 47% of the respondents are male and 53% are female participated in the test. In addition, 64% of respondents previously have been to the Tanah Rata, Cameron Highlands.

At first stage, the subject evaluation on preferences of 18 sound elements was conducted as shown in Figure 4. Water flowing sound element shows highest weighted mean with 4.59. In addition, leaves rustling, birds chirping and wind blowing sound elements can be observed as having almost similar weighted average. In contrary, result also shows noticeable tendencies that majority respondents are rated other sound elements below than 3-scale weighted averages which can be considered as less favorable or unfavorable to the subjects.

In general, majority of respondents have highest preferences with the sound element related to natural sound environment while the sound elements on machinery and human activities have been identified as most significant contributing factor to less favorableness.

Next, the evaluation of audio-visual test has been carried out as shown in Table 3 of Site A. In The averaged mean scores of perception rating for Site A were A4 which original sound with natural ambient sound element. However, the pleasantness and quietness subjects were rated lower than others subjects. The survey results rated critically both human preference and pleasantness subjects on water sound element but in general, natural sound setting or natural ambience sound elements were positively dominated.

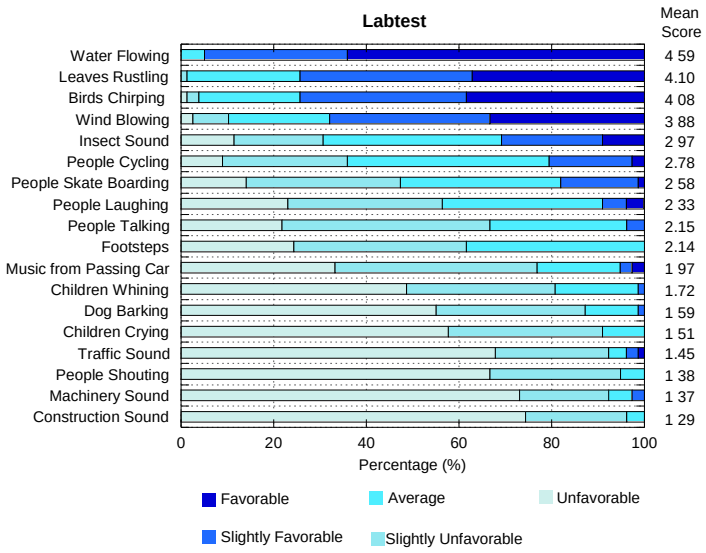

Figure 4: Lab-test evaluation on human preferences of 18 sound elements.

Table 3: Comparison of weighted mean on the quality attributes of lab-test soundscape assessment for Site A

Scene	Quality Attributes (Lab-test)						
	Pleasant	Comfort	Calmness	Excitement	Quietness	Favorable	Average
A1: Existing Sound	3.01	2.97	2.78	3.14	2.71	2.94	2.835
A2: Water Sound	3.46	3.35	3.05	3.33	2.60	3.26	3.175
A3: Bird Sound	3.08	3.10	3.01	2.87	2.78	2.88	2.953
A4: Natural Ambience	3.44	3.36	3.85	3.37	2.54	3.40	3.267

Noise assessment

The sound levels for Site A during two days (Day 1 and Day 2) are shown in Figure 5. In general, there is noticeable differences of higher noise level during Day 2 can be observed due to adjustment of sound level of artificial sound was set higher than averaged noise level from previous day. However, distinct fluctuations can be found in certain time of measurement cause by significant activities and traffic noises from surrounding.

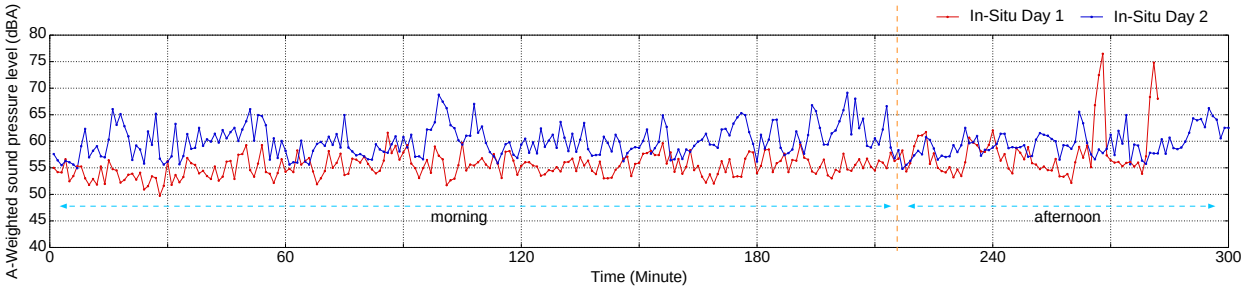

Figure 5: Sound pressure level (dBA) during in-situ assessment at Site A

In-situ assessment

The total number of respondents' participated in-situ assessment for Day 1 and Day 2 are 53 and 83 respondents, respectively. 54.5% of the respondents are male and 45.5% are female participated in questionnaires session. In addition, 88% of respondents are tourist and the remainder of respondents are currently local people of Cameron Highlands.

Similar as lab-test, the subjects' evaluation on preferences of 18 sound elements was conducted. As shown in Figure 6, birds chirping and wind blowing sound elements show highest weighted mean score for both days. Four sound elements i.e. wind blowing, birds chirping, water flowing and leaves rustling sound elements can be observed as having almost similar weighted mean score. Insect sound, people laughing, cycling and skateboarding sound elements were become acceptable compared to lab-test results. It is suggested that those sound elements frequently can be observed in-situ and their direct experience in current situation during the questionnaire session might influence to their response. In contrary, results in both two days also show significant indicator that majority respondents are rated people shouting, dog barking, traffic, construction and machinery sound elements below than 2-scale weighted averages which can be considered as most significant contributing factor to less favorableness. Majority of respondents have highest preferences with the sound element related to natural sound environment for both days as similarly obtained in lab-test findings.

On the other hand, the comparison of quality attributes towards the perception subjects on soundscape and landscape between Day 1 and Day 2 were depicted in Figure 7 and Table 4. On soundscape perception, the results shows identical characteristics that majority respondents are rated all quality attributes' subjects over than 3-scale weighted averages which can be considered as mean in favorable except quietness subject in Day 2. In addition, weighted mean scores of each subjects of Day 1 were higher compared to Day except pleasantness subject. In general, the artificial sound added into the existing soundscape in this assessment was less effective based on the maximum dispersion less than 0.2.

Furthermore, the same basic tendency can be observed in landscape perception. Even though no change has been made on landscape situation for both days but there is noticeable different in dispersion. The results of weighted mean score of Day 1 were higher compared to Day 1. The maximum mean deviation found on landscape perception being below than 0.3 and can be considered less significant on the human perception.

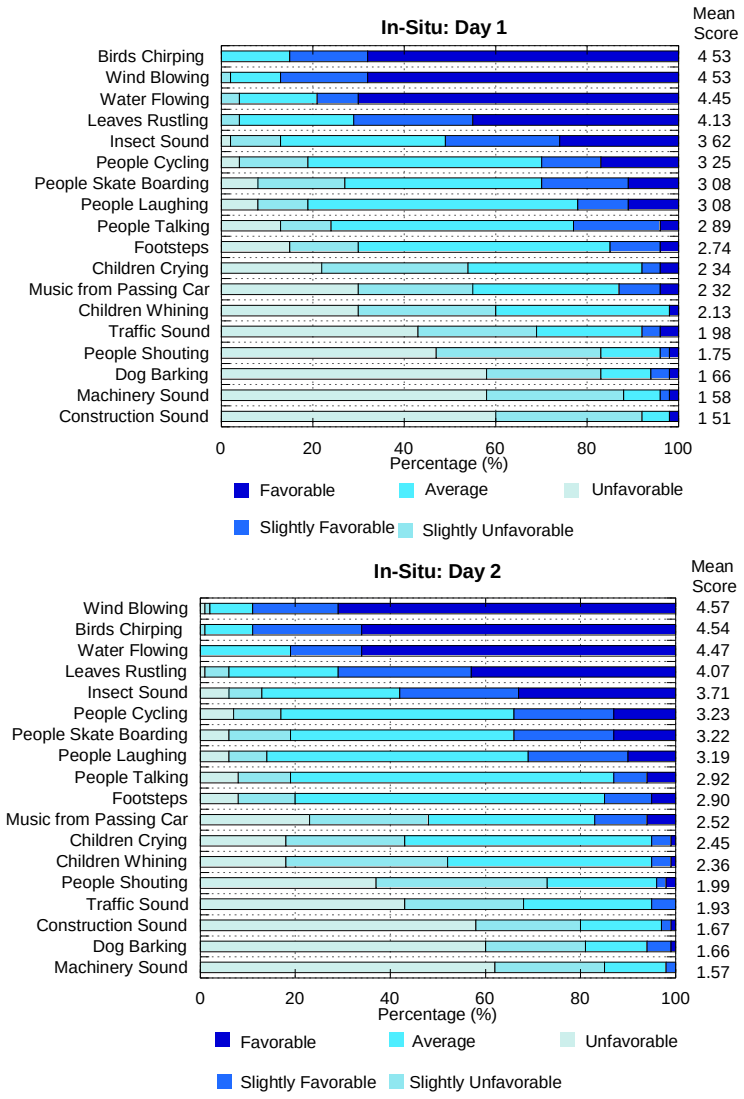

Figure 6: In-situ evaluation on human preferences of 18 sound elements.

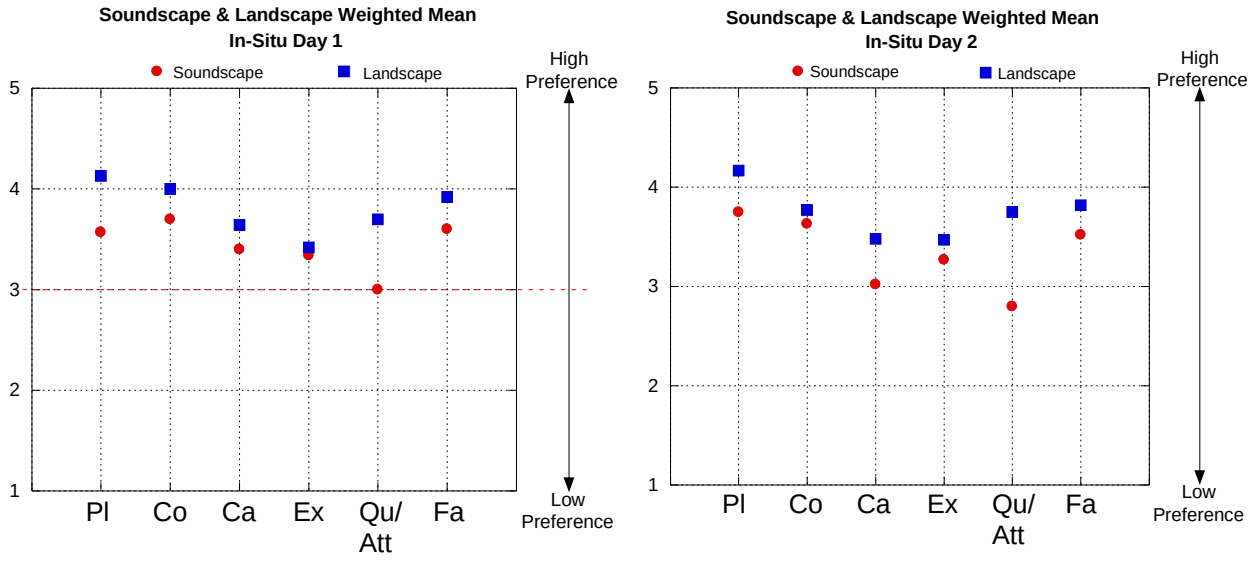

Figure 7: Quality attributes on human perception in-situ for both Day 1 and Day 2.

Table 4: Comparison of weighted mean on the quality attributes of in-situ assessment for soundscape and landscape of Site A

Site A: Sound of Environment

Scene	Quality Attributes (In-situ)						
	Pleasant	Comfort	Calmness	Excitement	Quietness	Favorable	Average
Day 1: No artificial sound	3.57	3.70	3.40	3.34	3.00	3.60	3.435
Day 2: With artificial sound	3.75	3.63	3.02	3.27	2.80	3.52	3.332

Site A: Landscape

Scene	Quality Attributes (In-situ)						
	Pleasant	Comfort	Calmness	Excitement	Attractive	Favorable	Average
Day 1: No artificial sound	4.13	4.00	3.64	3.42	3.7	3.92	3.802
Day 2: With artificial sound	4.17	3.77	3.48	3.47	3.75	3.82	3.743

CONCLUSIONS

The preliminary stage of this study, both in lab-test and in-situ surveys of acoustical environment in landscape area in Tanah Rata, Cameron Highlands have been presented. Based on the results from questionnaire surveys, both lab-test and in-situ assessment revealed that human preferences towards selected sound elements having similar characteristics. It was also clearly found the combination of original sound with the selected artificial sound elements in lab-test reflected to the total evaluation and perceptions of the quality of sound environment. However, the combination of artificial sound (natural ambience) with existing in-situ sound environment gave less effective towards human perception. Further investigations on different types of artificial sounds are now being pursued intensively.

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REFERENCES

[1] Schafer, R. M. (1977). *The Soundscape: Our sonic environment and the tuning of the world*: New York: Destiny Books.

[2] De Coensel, B. and Botteldooren, D. (2007). *Models for soundscape perception and their use in planning.* Proceedings of the 36th International Congress and Exhibition on Noise Control Engineering, Istanbul, Turkey.

[3] Yang, W. and Kang, J. (2005). Soundscape and sound preferences in Urban Squares: A case study in Sheffield. *Urban Design,* 10(1), 61-80.

[4] Zannin, P. H. T., Coelho Ferreira, A. M. and Szeremetta, B. (2006). Evaluation of noise level in urban parks. *Environmental Monitoring and Assessment,* 118, 423-433.

[5] Gidlof-Gunnarsson, A. and Ohrstrom, E. (2007). Noise and well-being in urban residential environments: The potential role of perceived availability to nearby green areas. *Landscape and Urban Planning,* 83(2), 115-126.

[6] Urban, J. and Maca, V. (2013). Linking traffic noise, noise annoyance and life satisfaction: A case study. *Environmental Research and Public Health,* 10, 1895-1915.

[7] Lam K. C., Ng S. L., Hui W. C. and Chan P. K. (2005). Environmental quality of urban parks and open spaces in Hong Kong. *Environmental Monitoring and Assessment*, 111, 55-73.

[8] Phan, H. Y. T., Yano, T., Phan, H. A. T., Nishimura, T., Sato, T. and Hashimoto, Y. (2010). Community reponses to road traffic noise in Hanoi and Ho Chi Minh City*, Applied Acoustics*, 71, 107-114.

[9] Sato, T., Yano T., Bjorkman, M. and Rylander, R. (1999). Road traffic noise annoyance in relation to average noise level, number of events and maximum noise level, *Journal of Sound and Vibration,* 223(5), 775-784.

[10] Raimbault, M. and Dubois, D. (2005). Urban soundscape: Experiences and knowledge, *Cities.* 22, 339-350.

[11] Kang, J. and Zhang, M. (2010). Semantic differential analysis of the soundscape in urban open public spaces, *Building and Environment,* 45, 150-157.

[12] Nasar, J.L. (1989). *Perception, cognition and evaluation of urban places*: I. Altman & E.H. Zube (Eds) Public Places and Spaces: New York, US: Springer.

[13] Carles, J.L., Barrio, I.L., and De Lucio, J.V. (1999). Sound influence on landscape values. *Landscape and Urban Planning*, 43, 191-200.

[14] Viollon, S., Lavandier, C. and Drake, C. (2002). Influence of visual setting on sound ratings in an urban environment. *Applied Acoustics*, 63, 493-511.

[15] Mastura, E., Hussein, H. and Nazli, C. D. (2014). *Soundscape assessment of Cameron Highland environment for sustainable development.* Paper presented at the Intenational Conference on Sustainable Urban Design for Liveable Cities, Kuala Lumpur, Malaysia.

[16] Nazli, C. D., Mastura, E. and Hussein, H. (2015). *Investigation on the soundscape preference and perception of highlands environment: A preliminary study.* Proceedings of the 22nd International Congress on Sound and Vibration, Florence, Italy.