ASSESSMENT OF TRAFFIC NOISE AND ANNOYANCE RESPONSE IN MADURAI CITY

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ABSTRACT

This paper attempts to substantiate the assessment of vehicular traffic noise or 'traffic noise' in Madurai city, Tamilnadu State, India. For this, the traffic noise data were analyzed in 21 regions covering 3 school zones, 3 hospital zones, 3 commercial zones, 3 residential zones, 6 signalized intersections, and 3 bus terminals .Based on the umpteen PCU/h data collected during the past, at six critical locations, the PCU/h data varied between 344 (at B1, weekday-evening) and 6303 (at I6, weekday-evening). Owing to the expected significant growth of traffic in Madurai city, although the recent past (August, 13 – February, 14) and previous (December, 09 – May, 10) traffic noise data indicated the slight variations between the respective L_{eq}s at few locations, but a maximum deviation of about 8.3 dBA was noticed at Kalavasal intersection. On the other hand, the annoyance response of public exposed to traffic noise was assessed through the appropriate psychometric-based questionnaire-type social survey conducted during August, 2013 to February, 2014.

Keywords: Annoyance Response, PCU/H, Traffic Noise.

I. INTRODUCTION

Traffic noise is a public vital noise source in the urban environmental noise. Strictly speaking, "vehicular traffic noise" is considered as "traffic noise" (from now onwards in this article) and is a serious chronic environmental issue not only in several Indian cities like Delhi [1], Asansol [2], Chidambaram [3], Kolhapur [4], and others; but also in other cities like Beijing (in China) [5], Osho and Drammen (in Norway) [6], Mashaad (in Iran) [7], and others in the world. Owing to its diversified effects like physical, physiological, psychological, socio-well being, socio-economic, and performance-based on human beings, several national and international organizations have set an equivalent sound level-based (L_{eq}), a specific limit of 70 dBA (day-time) in UK and China [8] and 45 dBA (night-time) in Siberia and USA [9]. Even though India is considered as one of the fastest developing country in South East Asia, due to the rapid growth of population in several metropolitan and major cities traffic noise seems to be the vital environmental pollution which is posing potential threat to majority of humans. Hence, substantial effects have been exercised in assessing the traffic noise pollution in many metropolitan and major cities from past 15 years. Therefore, it is highly necessary not only to understand or to assess the level of traffic noise prevailing in the urban environment, but also to effectively and efficiently mitigating it by planning and design methods. In this direction, this investigation was undertaken to assess the traffic noise annoyance in Madurai city, Tamilnadu state, India, based on the frequency spectra of traffic noise

data collected during December, 2009 to May, 2010, and validated the same during August, 2013 to February, 2014.

II. FIELD INVESTIGATION AND EVALUATION OF TRAFFIC NOISE ANNOYANCE

2.1 Field Investigation

2.1.1. Study Location and Measurement of Noise

The essential demographic and geographic aspects of Madurai city during the study period were: population as per 2011 census=10.17 lakh, geographical area=248km^2, latitude=9º56'0" N, and longitude=78º7'0" E. Also, the sampling locations for monitoring of traffic noise pollution in Madurai city consisted of six typical zones such as school (with three locations), commercial (with three locations), residential (with three locations), hospital (with three locations), signalised intersections (with six locations), and bus terminals (with three locations).

Noise levels were appropriately measured in 'A' weighting network using sound level meter (RTA 824 model, Larson and Davis make, USA). The meter was held 1.3 to 1.5 m above the ground surface and 3 to 3.5 m away from reflecting surface, if any. For each sampling location, noise measurements were carried out intermittently for two weekdays and one weekend-day (i.e., Sunday) with three typical peak hours of traffic noise monitoring per day. The selected schedule in a particular day was as follows: morning 8-9 am (or 8.30-9.30 am or 8.45-9.45 am), afternoon 12-1 pm (or 12.30-1.30 pm or 12.45-1.45 pm), and evening 4.30-5.30 pm (or 5-6 pm or 5.30-6.30 pm. However, the traffic noise levels at various locations were measured randomly, during September, 2013, to February, 2014, in view of understanding the current levels of noise in Madurai city.

2.2 Assessment of Traffic Noise

2.2.1 Assessment of Vehicular Traffic Noise

In view of assessing the vehicular traffic noise in Madurai city, 21 locations covering 6 categories of zones were selected. In concise 198 data sets (189 data sets corresponding to peak morning, afternoon, and evening traffic: and 9 data sets corresponding to continuous 1 h based data) were obtained.

2.3 Assessment of Traffic Noise Annoyance

The traffic noise annoyance was primarily assessed through socio-acoustic survey (i.e., by distributing appropriate questionnaire forms). The objective-type questionnaire pertaining to "Traffic Noise Pollution Feedback Form" was prepared, based on psychrometric tests and standard marketing survey procedures. The traffic noise pollution feedback consisted of Parts A and B, in which Part-A had thirty questions and Part-B had one major (i.e., objective) and another minor question. Further, Qs in Part-A and Q2 of Part-B were coupled with appropriate five alternative choices, except Q1 of Part-B which had four options. Further, the survey was performed at almost all the urban regions of Madurai city by considering the critical factors like sex, profession, age, traffic noise pollution awareness, and educational background. The filled-in feedback forms were collected within the duration of 24 h from the public. The peak ratings of traffic noise annoyance were categorised under five classes, based on the total weights taken from Qs both in Part-A and Part-B (except Q2). The various rating categories were: tolerable (0-26), moderately noisy (27-44), noisy (45-62), very noisy (63-79), and hazardous (80-88).

III. RESULTS AND DISCUSSION

Table 1 Variations in Typical Categories of Vehicles at Specific Locations

Zone	Location	Vehicle category(per hour)											
		Motorised Two-wheeler		Car		Bus		Lorry/ Truck		Auto rickshaw		Van	
		min	max	min	max	min	max	min	Max	min	max	min	max
School	Sethupathy school (S1)	---	2778 (6.5.10) Thu, En	---	564 (7.5.10) Fri, An	---	225 (7.5.10) Fri, Mn	---	---	---	---	---	---
	Sourashtra school (S2)	---	---	193 (11.5.10) Tue, Mn	---	96 (12.5.10) Wed, En	---	4 (12.5.10) Wed, En	130 (11.5.10) Tue, An	---	810 (30.5.10) Sun, An	19 (11.5.10) Tue, Mn	---
	Thiruparakundram school (S3)	712 (9.5.10) Sun, Mn	---	---	---	-	---	---	---	189 (5.5.10) Wed, Mn	---	---	65 (4.5.10) Tue, En
Commercial	Anna nagar (C1)	1071 (25.4.10) Sun, Mn	---	---	---	30 (11.3.10) Thu, An	---	---	---	254 (12.3.10) Fri, En	---	4 (11.3.10) Thu, Mn	---
	Yanaikal (C2)	---	2820 (8.3.10) Mon, An	---	567 (8.3.10) Mon, En	---	194 (4.3.10) Thu, En	10 (4.3.10) Thu, En	---	---	628 (8.3.10) Mon, En	---	55 (8.3.10) Mon, En
	Therkuvasal (C3)	---	---	137 (2.3.10) Tue, Mn	---	---	---	---	134 (3.3.10) Wed, An	---	---	---	---
Residential	Villapuram (R1)	---	---	139 (4.4.10) Sun, En	---	---	---	---	---	---	586 (15.3.10) Mon, Mn	---	54 (15.3.10) Mon, Mn
	Pasumalai (R2)	832 (28.3.10) Sun, An	---	---	468 (9.3.10) Tue, En	---	175 (10.3.10) Wed, Mn	---	140 (9.3.10) Tue, An	158 (28.3.10) Sun, Mn	---	---	---
	Chokkikulam (R3)	---	2272 (17.3.10) Wed, En	---	---	27 (21.3.10) Sun, An	---	3 (21.3.10) Sun, An	20 (17.3.10) Wed, An	---	---	9 (21.3.10) Sun, An	---
Hospital	Rajaji hospital (H1)	---	1956 (18.2.10) Thu, An	---	537 (18.2.10) Thu, An	---	186 (18.2.10) Thu, En	---	94 (18.2.10) Thu, En	---	---	---	54 (19.2.10) Fri, An
	Christian mission hospital (H2)	---	---	120 (14.2.10) Sun, Mn	---	---	---	6 (12.2.10) Fri, En	---	---	2748(15.2.10) Mon, An	8 (14.2.10) Sun, Mn	---
	Apollo hospital (H3)	834 (11.4.10) Sun, Mn	---	---	---	36 (8.5.10) Mon, Mn	---	---	---	101 (11.4.10) Sun, Mn	---	---	---
Signalised Intersection	Palanganatham (I1)	1842 (7.12.09) Mon, En	---	---	---	---	---	---	---	280 (6.12.09) Sun, En	---	---	---
	Kalavasal (I3)	---	---	---	---	---	---	---	351 (11.2.10) Thu, An	---	---	---	218 (9.2.10) Tue, En
	Keelavasal (I4)	---	---	---	---	96 (4.2.10) Thu, An	---	9 (3.2.10) Wed, En	---	---	---	---	---
	Therkuvasal (I5)	---	---	180 (28.12.09) Mon, Mn	---	---	---	---	---	---	---	---	---
	Goripalayam (I6)	---	4428 (8.2.10) Mon, Mn	---	1272 (5.2.10) Fri, En	---	467 (8.2.10) Mon, En	---	---	---	1155 (8.2.10) Mon, En	24 (28.2.10) Sun, Mn	---
Bus Terminals	Mattuthavani (B1)	---	---	2 (8.4.10) Thu, En	---	111 (8.4.10) Thu, En	---	---	---	7 (8.4.10) Thu, En	78 (8.8.10) Sun, En	---	---
	Aarapalayam (B2)	---	287 (18.5.10) Tue, An	---	53 (6.6.10) Sun, En	---	---	---	7 (6.6.10) sun, Mn	---	243 (18.5.10) Tue, An	1 (17.5.10) Mon, Mn	14 (17.5.10) Mon, En
	Periyar (B3)	3 (5.4.10) Mon, En	---	---	---	---	196 (5.4.10) Mon, Mn	---	---	2 (2.5.10) Sun, Mn	---	---	---

Table 2 Variations in PCU/h Data at Specific Locations

3.1 Assessment of Traffic Volume Data

The manual method of collection of field traffic data was adopted in this investigation, in order to count different categories of vehicles like motorised two-wheeler, car, bus, lorry/truck, and others, at all locations on all typical days. From huge available data sets it is seen that the number of two-wheelers, cars, auto-rickshaws, vans, and other categories in morning session of all days are significantly more than the respective numbers in the evening session of the respective days. But, on the other hand, the corresponding data pertaining to bus, and lorry/trucker showed more in the evening when compared to morning session.

In order to understand the variations (both maximum and minimum) in various vehicle categories, at all six zones and specific locations, Table 1 was prepared. On the other hand, Table 2 was prepared, based on equivalence factors as per IRC: 2000, 19, [10] for the variations in PCU/h data at specific locations. From the fair comparison between Tables 1 and 2, it is seen that the location S1 (among school zones), the location C2 (among commercial zones), the location H1 (among hospital zones), and the location I6 (among signalised intersections) are seems to be critical in view of both aspects like vehicle categories and PCU/h values at all the typical days (both the week and week-end days). Lastly, from the bulk traffic volume data sets, the PCU/h was expected to vary between 344 (at the location B1 among 3 bus terminals, on 8.4.10: Thursday, evening) and 6303 (at the location I6 among 6 signalised intersections, on 8.2.10: Monday, evening).

Zone	Location	PCU/h (with date, day and session)	
		Minimum	Maximum
School	Thiruparakundram (S3)	1503 9.5.10, Sun, En	- - -
	Sethupathy (S1)	- - -	2896 7.5.10, Fri, An
Commercial	Anna nagar (C1)	1417 11.3.10, Thu, An	- - -
	Yanaikal (C2)	- - -	3371 4.3.10,Thu, An
Residential	Chokkikulam (R3)	1120 21.3.10, Sun, En	- - -
	Villapuram (R1)	- - -	2334 15.3.10, Mon, Mn
Hospital	Apollo hospital (H3)	913 11.4.10, Sun, Mn	- - -
	Rajaji hospital (H1)	- - -	2780 18.2.10, Thu, An
Signalised Intersection	Keelavasal (I4)	1432 7.4.10, Sun, Mn	- - -
	Goripalayam (I6)	- - -	6303 8.2.10, Mon, En
Bus terminals	Mattuthavani (B1)	344 8.4.10, Thu, En	- - -
	Periyar (B3)	- - -	5028 6.4.10, Tue, Mn

3.2 Current Assessment of Traffic Noise

As per R. Sivasubramanian [11], the L_{eq} data were measured at seven critical locations on specific weekdays

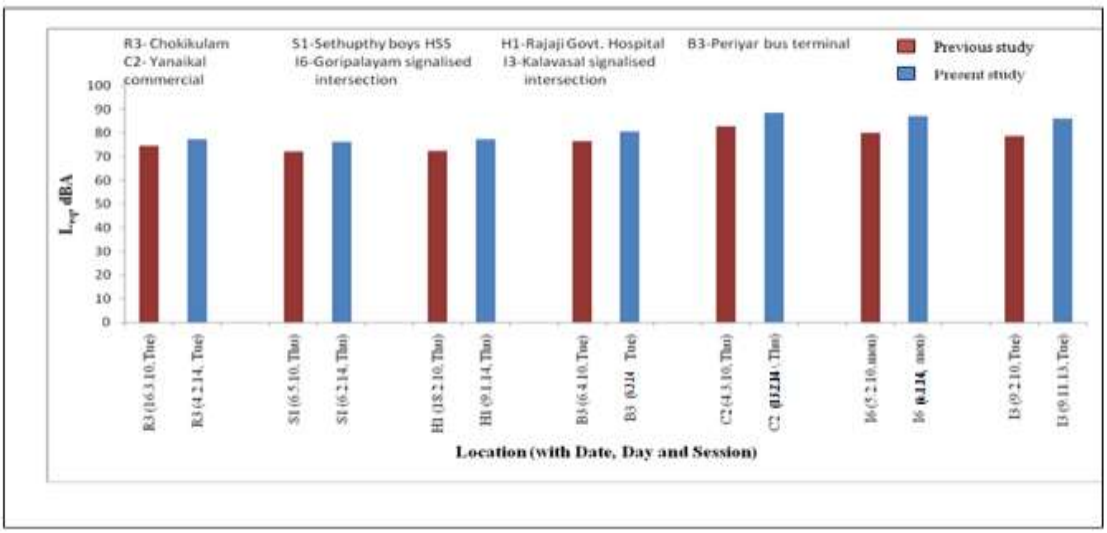

Figure 1 Comparison of Traffic Noise Levels between Past and Present Studies (Evening Time)

(both at morning and evening peak times). Fig. 1 shows the L_{eq} values for the past and present studies, at different critical locations in evening times. As expected, the variations between the L_{eq} values for the past and present studies were only slight at few locations. But, a maximum deviation of about 8.3 dBA could be noticed at Kalavasal intersection. This is due to the significant growth of traffic in Madurai city from the past three years.

3.2 Assessment of Traffic Noise Annoyance

Before compiling and processing of feedback responses, in each location, the truthfulness of the data was verified based on fourteen pairs of antagonistic Qs. Based on the number of pairs of antagonistic Qs, the responses were classified as: irrelevant (if > 10 pairs), antagonistic (if between 6 and 10 pairs), and slightly ambiguous (if ≤ 5 pairs).

Table 3 Different Categories of Public Responses towards Annoyance

Category	Madurai (300)	
	Male (133)	Female (167)
Irrelevant	4	18
Ambiguous	0	0
Slightly ambiguous	78	69

Figures Within The Parenthesis Refer The Total No. Of Feedback Forms Given For Survey

These data were used to compare the peak traffic noise ratings given by the public in Q2 of Part-B. Figs. 2 and 3 shows the distribution of overall socio-acoustic responses, in Madurai city, considered with irrelevant and

irrelevant responses (based on the total weightage assessed as per Questionnaire). From Figs. 2 and 3, the distribution curves corresponding to Madurai, are approximately normally distributed between tolerable response (0-26) and hazardous (80-88). Moreover, the weightage-based overall response in Madurai city is centered at noisy response. Comparing Fig. 4 (which is solely based on the single response as per Q2 of Part-B) and Figs. 2-3, similar opinion could be observed. However, the majority of the responses in all the cities were coinciding with the noisy state of traffic noise.

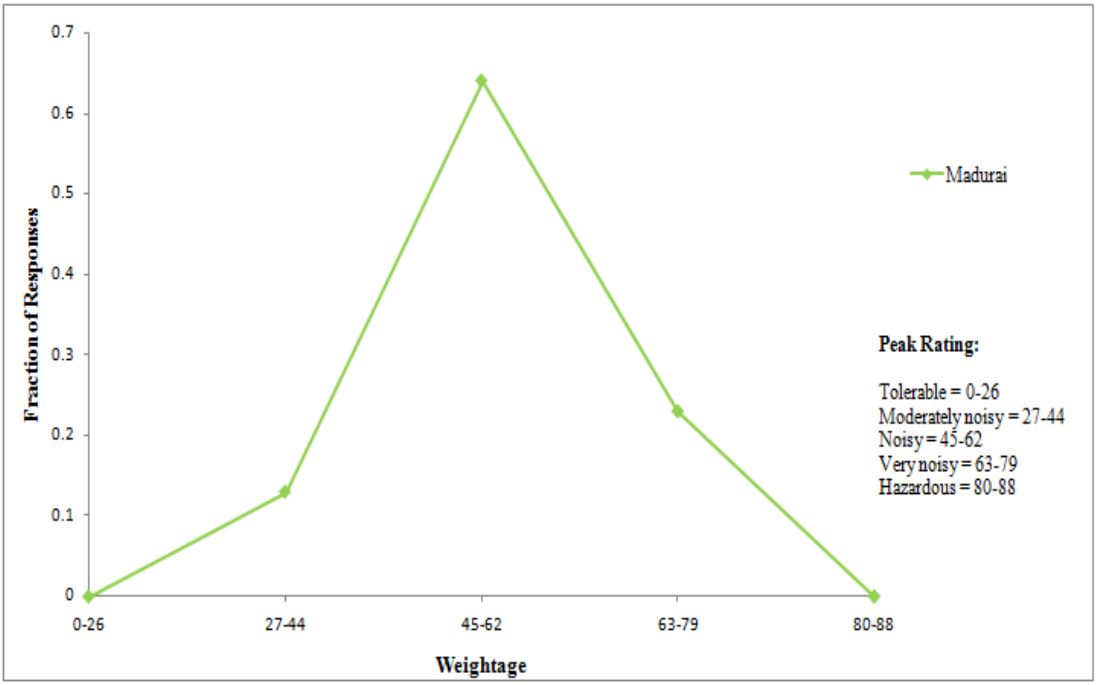

Figure 2 Socio-acoustic Noise Response Distribution Curves (with Irrelevant Forms)

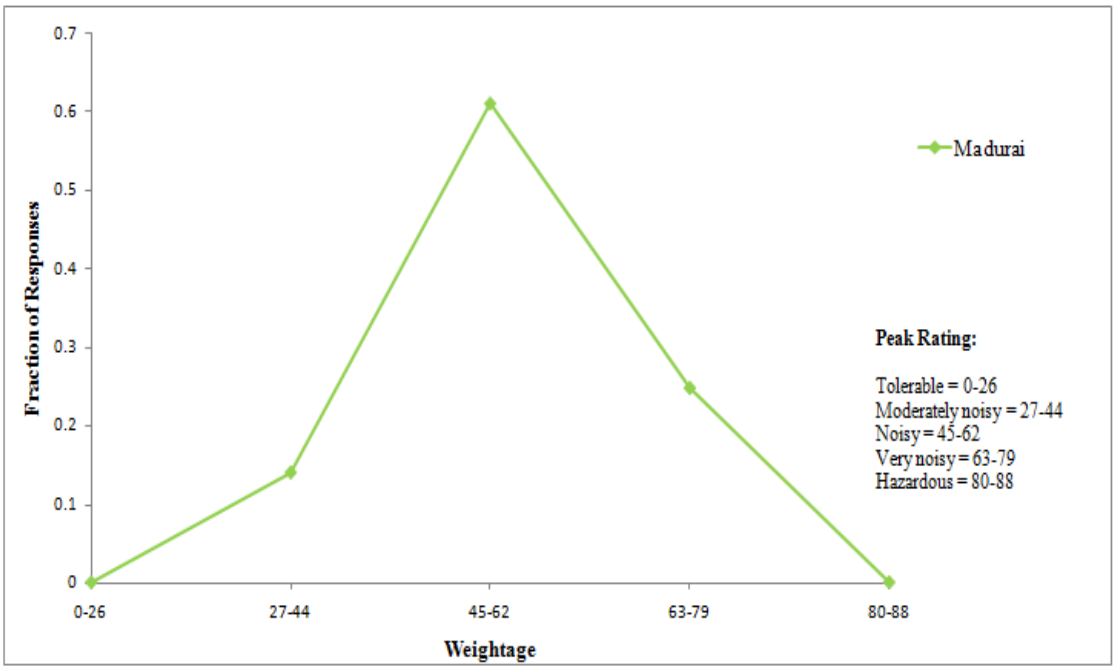

Figure 3 Socio-acoustic Noise Response Distribution Curves (without Irrelevant Forms)

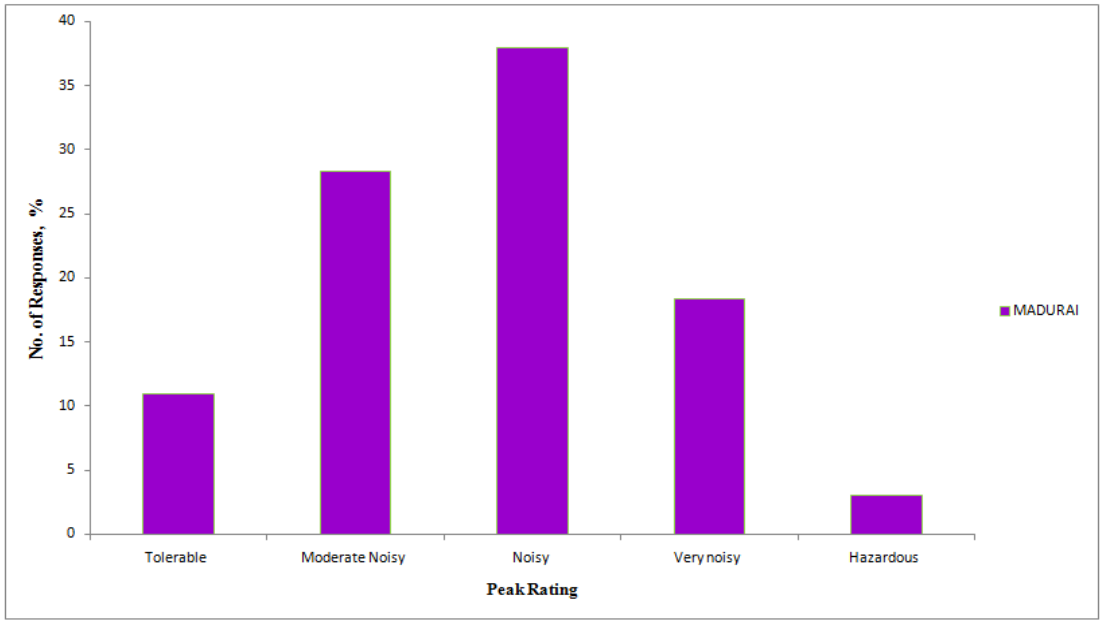

Figure 4 Individual Weightage Responses about Peak Rating of Traffic Noise

IV. CONCLUSION

The present level of traffic noise in Madurai city is significantly higher than the past assessment. Among the various locations in Madurai city, Sethupathy school, Yanaikal-commercial zone, Rajaji hospital, Goripalayam signalised intersection, Villapuram-residential zone, and Aarapalyam bus terminal are highly critical from the noise pollution point of view, under the preview of the present study. The mixed-mode traffic pattern prevails in Madurai city with substantially higher motorised two-wheelers, when compared to other categories of vehicles. The socio-acoustic survey conducted at Madurai confirms as noisy traffic environment. The socio-acoustic responses substantiate psychological and physiological effects on human beings.

REFERENCES

[1] Tyagi V., Krishnakumar, and Vinothkumar Jain, A study of the Spectral Characteristics of Traffic Noise Attenuation by Vegetation Belts in Delhi, Applied Acoustics , 67, 2006, 926-935.

[2] D. Baneerjee, S.K. Charkaboorthy, S. Bhattacharrya, and Gangopadhyay A., Attitudinal Response towards Road Traffic Noise in the Industrial Town of Asansol, Int. J. Environ. Res. Public Health, 5 (3), 2008, 165-171

[3] P. Balashanmugam, Ramanathan A.R., Nehrukumar V., and Balasubramnaiyan K., Assessment of Noise Pollution in Chidambaram Town, Int.J.Research in Engineering and Technology, 02, 2013, 85-93

[4] Hunashal B., and Patil B., Assessment of Noise Pollution Indices in the City of Kolhapur, India, Procedia-Social and Behavioural Sciences, 37, 2012, 448-457

[5] Bengang Li, Shu Tao, and Dawson R.W., Evaluation and Analysis of Traffic Noise from the Main Urban Roads in Beijing, Applied Acoustics, 63, 2002, 1137-1142

[6] Klaboe R., Amumdsen A.H., Fyhri A., and Solberg S., Road Traffic Noise-The Relationship between Noise Exposure and Noise Annoyance in Norway, Applied Acoustics, l65, 2004,893-912

[7] Rahmani S., Mousavi S.M., and Kamali M.J, Modelling of Road Traffic Noise with the use of Genetic Algorithm, Applied Soft Computing, 11, 2011, 1008-1013

[8] China EPA, Conspectus of Environmental Protection in 21st Century in China, Beijing: Publishing House of China Environmental Sciences, 1995.

[9] Directive 2002/49/EC of the European Parliament and of the Council of June 25, 2002 relating to the assessment and management of environmental noise, Official Journal of European Communities, 1, 189/12.

[10] Kadhyalli L, Traffic Engineering and Control (Khanna Publishers, 1995)

[11] R. Sivasubramanian, S.K.Krithiga, S. Dhivya, and Dr.S.Keerthinarayana, Assessment and Evaluation of Traffic Noise Response in Madurai city: Proc. 21st Recent Trends in Civil and Environmental Engineering, Anna University, Trichy, 2014, 29-34.