

# Traffic-Generated Noise Pollution: Public Perception and Modelling Under Jordanian Conditions

Khair S. Jadaan

Department of Civil Engineering, University of Jordan, Queen Rania Street, Amman, Jordan

Email: Kjadaan@hotmail.com

Hala F. Gammoh, Rami A. Ammoura, Zeina S. Al-Nabulsi, and Abdelqader A. Okasha

Department of Civil Engineering, University of Jordan, Queen Rania Street, Amman, Jordan

Email: Gammohhala@yahoo.com, Rami.ammourah@gmail.com, Zeinanabulsi@hotmail.com, Abd.okasha@gmail.com

**Abstract**—Road traffic noise along the Jordanian road network is drawing an increasing attention due to its growing magnitude and various impacts as a result of the high increase in vehicular traffic. This study investigates the issue with the aim of providing an understanding of its social impact on residents of Amman, the capital of Jordan and developing a noise level prediction model under local conditions. Thirty four sites along urban arterials, representing different characteristics, were included in the study and used for model development. Traffic noise levels were measured at the selected locations and a social survey was performed, using a pre-designed questionnaire, to examine the reactions and attitudes of the neighbouring residents towards these levels of traffic noise. The results of the study revealed that the impact of traffic noise on people can cause annoyance while performing daily activities to the extent that 65% of the respondents think of moving to a quieter place, and about 54% were willing to pay for attenuation measures. The resulting prediction model incorporated variables describing traffic and site conditions. The developed model was validated by comparing its predicted noise levels with those measured and found to be valid under local conditions.

**Index Terms**—traffic noise, noise level, survey, social impact, noise modelling

## I. INTRODUCTION

Road traffic noise is an environmental pollutant that is encountered in daily life creating interference in communication and health. It can cause hearing loss, tension, anxiety, anger, Sleeplessness and other serious health problems. The nuisance is caused by the accumulation of sound of individual vehicles in the traffic stream in addition to other contributory factors related to driver's behaviour, vehicle and weather conditions. It is particularly annoying in the vicinity of noise sensitive areas such as hospitals, mosques and churches, and schools.

The issue of traffic noise in Jordan has been drawing an increasing attention over the last few years, due to its increasing magnitude calling for the need to perform studies assessing this problem and trying to find solutions to alleviate it, but only few fruitful studies were performed in this regard.

This study further investigates the issue in order to provide better understanding of the present and future magnitude of the problem and its anticipated impact on residents.

Subsequently, a survey was performed which examined the reactions and attitudes of residents towards this problem in each of the roads that were taken into consideration. The survey included social characteristics of individuals, and their attitude towards traffic noise, and how it impacted their daily activities, analysed with the help of questionnaire survey.

## II. LITERATURE REVIEW

A large number of studies into the various aspects of traffic noise and its impacts were carried out in various countries. An Indian study [1] showed that more than half of the surveyed residents expressed annoyance by traffic noise during daily activities, while also causing them headaches and nervousness. A more recent study [2] reviewed the noise-related research in India and established similar facts. A Swedish study [3] showed a significant decrease in subjective sleep quality, and the average time required to fall asleep was about 12 minutes longer. Finally, a significant increase in tiredness during the day was found after nights with noise exposure.

Various studies in Europe showed that that health of millions of Europeans is affected by traffics noise, and the social cost of it is over 40 billion Euros yearly.

Hedonic price models have been widely used to estimate implicit noise values and produced significant declines in values due to traffic noise. A Korean study evaluating the monetary effect of traffic noise on property values in Seoul Korea [4] showed that with every 1% increase in traffic noise a 1.3% decline in land value was

---

Manuscript received March 12, 2016; revised June 5, 2016.

<sup>1</sup> Currently visiting professor, University of Auckland, New Zealand

associated. The literature also handled the economical evaluation of noise reduction including the benefits and costs of noise attenuation measures [5], [6].

Many noise prediction models have been developed in the past few decades for traffic noise assessment and predictions. The most common models are the American Federal Highway Administration (FHWA) model and the British Calculation of Road Traffic Noise (CRTN) model. Some of the developed models were of general nature and treated the general traffic conditions [7] while others treated specific traffic conditions such as noise during daytime [8], under interrupted traffic flow conditions [9], for stationary and mobile sources [10] and considering the impact of honking on traffic noise [11]. The various models and their performance has also been evaluated [12].

In Jordan, few studies have been carried out to evaluate the present, future magnitude of traffic noise, its cost and the potential countermeasures [13]-[18] while nothing has been done towards the development of traffic noise prediction models under Jordanian conditions.

### III. METHODOLOGY

Noise levels were measured at each of the selected sites. A Bruel and Kjaer type 2215 Precision sound level meter was used for measuring L10 (1hr) noise level. Readings were taken at 34 sites along urban arterials in Amman during two 1-hour periods between 7:00 and 8:00 and between 19:00 and 20:00. The two periods which are 12 hours apart aimed to cover the morning and evening traffic conditions.

Classified manual traffic volume counts were conducted at the selected locations while speed data measured with 2km/h accuracy, were provided by the Jordanian Traffic Institute. Data related to road geometry at the selected sites were obtained from the Ministry of Public Works and Housing.

A social survey using a pre-designed questionnaire was carried out as a part of this study in order to evaluate the effect of traffic noise on the daily activities of residents along the studied sites. The questionnaire consists of fifteen questions and was distributed to a random sample of 100 citizens residing along the urban arterials where noise levels were measured. The home-interview survey method was used to ensure full understanding of questions in a way that satisfies the purpose of the study.

In developing the mathematical relations between the different factors and the level of traffic noise, the site readings were grouped into categories of similar conditions in order to correctly and separately identify the effect of each factor on noise level.

### IV. RESULTS AND DISCUSSION

The results of noise measurements shown in Table I illustrates that the noise levels at all locations are significantly high and exceed the maximum allowable noise level adopted in Jordan which is 63 dB(A). The environmental effects of traffic noise are obvious among Jordanians where 80% of respondents consider traffic

noise an environmental pollutant. Also 79% consider traffic noise a public health problem which reflects the public awareness to this issue as shown in Table II.

TABLE I. MEASURED DAY-TIME AND NIGHT-TIME LEVEL L10 (1 HR) AT 34 LOCATION IN THE CITY OF AMMAN

Location Number	Identification	L10 (night time)	L10 (day time)
1	Interior circle	73	71
2	First circle	56	64
3	Second circle	61	66
4	Third circle	64	67
5	Fourth circle	67	66
6	Fifth circle	68	70
7	Sixth circle	67	67
8	Seventh circle	65	68
9	Eighth circle	70	73
10	Sport city circle	68	78
11	Abdoun circle	66	66
12	Swieleh circle	70	71
13	Gardens Street	70	72
14	Safeway-Gardens junction	73	71
15	Princess Basma street	61	69
16	Allstiqlal street	73	79
17	Abu Nsair Street	73	75
18	Al-Madina Al-Munawara street	67	70
19	Airport Highway	78	80
20	Al-Sakhra Almosharafa street	66	73
21	Queen Rania street	72	72
22	King Abdullah II street	76	78
23	Prince Ali Bin Hussien street	70	71
24	Prince Shaker street	71	66
25	Al-Sinaa' street	70	73
26	Jordan street	74	77
27	Al-Mahatta street	72	80
28	King Hussien street	74	76
29	Khalil Alsaket street	69	68
30	Cairo street	70	70
31	Khalid Bin Alwaleed street	66	71
32	Zahran street	80	79
33	South buses terminal	71	710
34	Raghdan buses terminal	73	79

The results of the social survey shown in Table III reveal that a significant portion of community seems to be negatively affected by road traffic noise during daily life.

The social impact of traffic noise in the city of Amman as perceived by the general public depicted in Table II

highlight the facts that 63% of respondents reported that they get annoyed by traffic noise, 55% of them said that they close the windows always or most of the time due to traffic noise and a total of 65% of respondents consider moving to a quieter neighbourhood.

TABLE II. PERCENTAGE OF PEOPLE WHO ARE AFFECTED BY TRAFFIC NOISE

%	
63	annoyed by traffic noise
80	environmental pollutant
79	health problem
65	prefer moving away
63	classify noise very high and high
55	close windows
57	think TN reduce the cost of building
31	would sell house at reduced cost
59	consider attenuation measures necessary
54	willing to pay for attenuation measures

The results of the study also revealed that traffic noise can cause annoyance while performing daily activities where 24% of respondents get annoyed by traffic noise while working, 49% of them get annoyed while resting, 34% get annoyed while talking to others, 31% get annoyed while talking on the phone, 39% get annoyed while reading, 38% get annoyed while watching TV and 53% of respondents get annoyed while sleeping (Table III).

TABLE III. THE PERCENTAGE OF PEOPLE WHO GET ANNOYED BY TRAFFIC NOISE DURING DAILY ACTIVITIES

%	Activity
24	annoyed while work
49	annoyed while rest
34	annoyed while talk to others
31	annoyed while talk on the phone
15	annoyed while eating
39	annoyed while reading
38	annoyed while watching TV
53	annoyed while sleeping

The respondents have also pointed out that traffic noise causes twist in mood (53%), headache (36%), and difficulty in concentration (40%). About 57% of respondents think traffic noise reduces the cost of their buildings and a total of 31% of them are willing to sell their house at reduced cost due to traffic noise.

As a result, 59% of respondents consider attenuation measures necessary, and in order to reduce the noise, 54% of respondents were willing to pay for attenuation measures which reflect the public awareness to this issue.

A model representing the noise levels under traffic conditions of Jordan was established by combining the different factors and their coefficients. The relationship was developed on the basis that relations between different factors and noise levels is linear.

It should be noted that the base noise L0 (that is the level of noise when no vehicles are present) is the minimum noise level expected and each factor causes an increase on that base level.

The final model was found to have the following form,

$$L_{10} = L_0 + 0.208 \left( S \pm \frac{1}{5} \sin(\Theta) \right) + 0.00291V + 0.4546P - 0.65D$$

where,

L0: Base noise level (dBA)

S: Traffic speed (Km/h)

L: Length of inclination/declination (generally considered 15 meters)

Θ: Road Slope

V: Traffic volume (Vehicles/hour)

P: Percentage of heavy vehicles

D: distance from observer (M)

The mathematical model was tested by gathering data points and comparing actual values to model results. The model produced very encouraging results. About 70% of the points were predicted with very high accuracy of ±3 dB, 15% of the points had an acceptable accuracy of ±6 dB, and 15% of the points had major errors of almost ±10 dB.

## V. CONCLUSION

Noise measurements along Amman’s arterial roads show that noise levels at all sites exceeded the maximum acceptable limit adopted in Jordan, The results of the social study reflect high public awareness of the road traffic noise problem and its impacts on residents of Amman as 80% of the interviewed people consider it an environmental pollution and a public health problem. The social survey results reveal that 63% of the neighbouring residents are annoyed by road traffic noise during their daily activities to the extent that 65% of respondents considering changing their place of residence. Calling for the need to apply necessary noise mitigation measures.

A model describing the relationship between a number of traffic and site variables and noise level was developed, and presented in this study for assessment and prediction of traffic noise under Jordanian conditions. The model is validated with measured noise levels and found to be valid under local conditions.

## REFERENCES

- [1] D. R. Nandanwar, D. K. Parbat, and S. K. Deshmukh, “Study on residents perception and attitudes towards urban traffic noise in Nagpur city,” in *Proc. International Conference on Emerging Trends in Engineering and Technology*, Dec. 2009, pp. 585-588.
- [2] D. Banerjee, “Research on road traffic noise and human health in India: Review of literature from 1991 to current,” *Noise and Health*, vol. 14, no. 58, pp. 113-118, 2012.
- [3] E. Ohrstrom, “Effects of low levels of road traffic noise during the night a laboratory study on number of events, maximum noise levels and noise sensitivity,” *Journal of Sound and Vibration*, vol. 179, no. 4, pp. 603-615, 1995.
- [4] K. S. Kim, S. J. Park, and Y. J. Kweon, “Highway traffic noise effects on land price in an urban area,” *Transportation Research Part D: Transport and Environment*, vol. 12, no. 4, pp. 275-280, 2007.
- [5] H. A. Nijland, E. E. M. M. Van Kempen, G. P. Van Wee, and J. Jabben, “Costs and benefits of noise abatement measures,” *Transport Policy*, vol. 10, no. 2, pp. 131-140, 2003.

- [6] N. Becker and D. Lavee, "The benefits and costs of noise reduction," *J. Environ. Plann. Manage.*, vol. 46, no. 1, pp. 97-111, 2003.
- [7] F. Cirianni and G. Leonardi, "Environmental modeling for traffic noise in urban area," *Am. J. Environ. Sci.*, vol. 8, no. 4, p. 345, 2012.
- [8] E. C. Da Paz and P. H. T. Zannin, "Urban daytime traffic noise prediction models," *Environmental Monitoring and Assessment*, vol. 163, pp. 515-529, 2010.
- [9] S. Agarwal, B. L. Swami, and A. B. Gupta, "Development of a noise prediction model under interrupted traffic flow conditions," *Noise and Health*, vol. 11, no. 45, pp. 189-93, 2009.
- [10] A. Sharma, R. Vijay, V. K. Sardar, R. A. Sohony, and A. Gupta, "Development of noise simulation model for stationary and mobile sources: A GIS-based approach," *Environmental Modeling and Assessment*, vol. 15, no. 3, pp. 189-197, 2010.
- [11] A. Sharma, G. L. Bodhe, and G. Schimak, "Development of a traffic noise prediction model for an urban environment," *Noise and Health*, vol. 16, no. 68, pp. 63-67, 2014.
- [12] C. Steele, "A critical review of some traffic noise prediction models," *Applied Acoustics*, vol. 62, no. 3, pp. 271-287, 2001.
- [13] Q. Banihani and K. S. Jadaan, "Assessment of road traffic noise pollution at selected sites in Amman, Jordan: Magnitude, control and impact on the community," *Jordan Journal of Civil Engineering*, vol. 6, no. 2, pp. 267-278, 2012.
- [14] K. Jadaan, H. Gammoh, A. Okasha, E. Breizat, and T. Hadidi, "Evolution of traffic noise impacts in Amman, Jordan," *International Journal of Automotive Engineering and Technologies*, vol. 4, no. 1, pp. 7-11, 2015.
- [15] A. Al-Dakhlallah and K. Jadaan, "Attitudes of Jordanian population towards traffic noise," *Int. J. Appl. Sci. Eng.*, vol. 3, no. 2, pp. 145-150, 2005.
- [16] J. Goussous, A. Al-Dakhlallah, K. Jadaan, and M. Al-Zioud, "Road traffic noise in Amman, Jordan: Magnitude and cost investigation," *Journal of Traffic and Logistics Engineering*, vol. 2, no. 2, pp. 104-107, 2014.
- [17] K. Jadaan, A. Al-Dakhlallah, J. Goussous, and H. Gammoh, "Evaluation and mitigation of road traffic noise in Amman, Jordan," *Journal of Traffic and Logistics Engineering*, vol. 1, pp. 51-53, 2013.
- [18] A. Jamrah, A. Al-Omari, and R. Sharabi, "Evaluation of traffic noise pollution in Amman, Jordan," *Environmental Monitoring and Assessment*, vol. 120, pp. 499-525, 2006.



**Khair Jadaan** born in 1948 earned his Ph.D. degree in traffic engineering and planning in 1975 from the University of Bradford, U.K.. Khair working experience covers a variety of positions in both private and public sectors in various developed and developing countries including New Zealand, Germany, U.K., U.S.A., Kuwait, Iraq and Jordan. He is currently a PROFESSOR of transportation engineering at the University of Jordan. He published over 120 papers in international journals and conferences.

Prof. Jadaan is a Fellow of IHTE (U.K), member of IPENZ (New Zealand), member of ASCE (USA) and Jordan Engineers Association and been awarded a number of honoraries.



**Hala Gammoh** born in 1992 is a civil engineer graduated in June, 2015 from University of Jordan. She is a MEMBER of the junior research team of the department. Her research interests include traffic safety and environmental impact of transport. Currently she works with a consultancy firm.



**Rami Ammourah** born in 1991 is a civil engineer and a MEMBER of the junior research team of the civil engineering department, University of Jordan. He was trained in the USA during summer 2011. His research involvement and interests are in the broad field of transportation engineering with emphasis on the environmental and safety issues.



**Zeina Al Nabulsi** born in 1991 is a newly graduate of the civil engineering department, University of Jordan. She is a MEMBER of the junior research team of the department. Her research activities and interests include traffic safety and environmental impacts of transport.

**Abdelqader Okasha** born in 1992 is has graduated from civil engineering department in June, 2015. He is a MEMBER of the junior research team of the civil engineering department, University of Jordan. He works with a local consultancy firm. His research involvement and interests are in the broad field of transportation engineering.