Noise exposure inside of the Kerman urban buses: measurements, drivers and passengers attitudes

Ghorbanali Mohammadi *

Department of Industrial Engineering, College of Engineering, Qom University of Technology, Qom, Iran, 3718146645

**Author for Correspondence: ghorbanalim@yahoo.co.uk*

Received:26 Nov. 2014, Revised: 22 Dec.. 2014, Accepted: 27 Dec. 2014

ABSTRACT

A comprehensive study was conducted with the objectives of evaluation of noise exposure in the workplace of bus drivers, and to find attitudes of passengers and drivers. This study consisted of two phases. In the first phase, Noise levels were measured in fifty buses. The evaluation of noise levels in the workplace of bus drivers was performed according to the Iranian legislation`s. Twenty four buses with noise levels above 85 dB (A) consider as an "unsafe" workplace. In the second phase, the attitude of 50 male drivers and 500 passengers concerning the annoyance and impact of noise on health was also surveyed. Second phase showed that 70% of drivers and 86.4% of passengers were nervousness from high level noise inside the buses. Eighty four percent drivers and 80% passengers felt noise had affected on their hearing. This study also affirmed that out of every seven drivers, six reported headache.

Key Words: Hearing loss; Occupational noise; Bus drivers and passengers; health impact; urban buses

INTRODUCTION

Noise is a well-known environmental problem associated with major cities worldwide. In both the industrialized and non-industrialized world traffic noise is a major environmental concern for residents of cities [1]. Increased knowledge of the health effects of noise and increased community awareness of environmental noise has a higher expectation for governments at all levels to reduce noise levels [2]. Noise in large cities is considered by the World Health Organization to be the third most hazardous type of pollution [3].

In recent years, the impact of noise on wildlife also has increasingly become concern [1].

A review of related literature shows that over the years numerous studies of urban traffic noise have been conducted. Several studies have addressed the quantification of outdoor noise pollution levels [4-9].

The impact of urban traffic noise on the health and welfare of exposed individuals has also been studies by researchers' worldwide [10-12].

Urban bus operation appears to be an especially stressful occupation because of the array of potentially noxious physical and psychological stressors acting on the drivers and passengers. Physical stressors abound, in particular traffic congestion, safety hazards, fluctuations in temperature with the opening and closing of doors, vibration and noise [13-14]. However, a limited number of studies have also been carried out on the noise levels inside vehicles [15, 16and 17]. This research represents the first study of noise inside bus transit vehicles in Iran.

Kerman is one of the 30 provinces of Iran. Kerman city had an estimated population of 580, 000 in 2008. The city of Kerman embraces about 80% of the urban population, being the most developed and largest city of the province. The city transportation is made up of 295 buses, which run along different lines across the city. This study consisted of two phases, which are described separately.

MATERIALS AND METHODS

PHASE I

In this phase, Noise levels in 50 buses were equally sampled in five separate sub-samples: (1) 10 Mega trance buses, (2) 10 Benz 457 buses, (3) 10 Benz 355 buses, (4) 10 Benz 457buses with CNG and (5) 10 Renault buses. Mega trance buses stop at specific stations for loading and unloading passengers, and can carry up to 50 passengers; gasoline is the kind of fuel used in this bus. Benz 457 and Benz 355 buses can carry up to 38 passengers. The manufacturing year is 2004. The position of the engine in all type buses is rear mounted engine. Benz 457 with CNG fuel buses operates in regular streets across the city; can carry up to 38 passengers. The manufacturing year is 2005 and used CNG gas. Renault buses are carrying 38 passengers and used gasoline fuel.

Measurements have been carried out in 50 buses in several lines during the whole ride, from starting station to finish station. During measurements, buses were loaded with passengers at the normal working hours. Measurements performed when meteorological conditions were ideal, no wind and no rain during the study period.

Measurements have been carried out inside several types of buses that operate in the city, to identify the levels of noise pollution during commuting hours in Kerman buses and also to show the drivers and passengers attitudes of annoyed inside vehicle noise. The acoustical parameter used in this evaluation was the noise exposure level expressed in dB (A), according to ISO 1999 (1990) Acoustics: - Determination of occupational noise exposure and estimation of noise-induced hearing impairment and Iranian noise exposure (85dB (A)).

Noise levels were measured using the BK 2238 and the B and K investigator 2260 types one integrating and logging sound level meters. The instrumentations and calibration of equipment were performed in accordance with manufacturers` recommended procedures. The microphone of the sound level meter was placed 20cm from the external ear of the bus driver. Noise exposure level was normalized to a nominal eight hours working day calculated from the measured equivalent sound pressure level normalized exposure levels were calculated according to;

$$L_{EX,8h} = L_{eq,T_e} + 10\log\frac{L_e}{L_0}(dBA)$$

Where:

L_{eqL_e} is the equivalent continuous A-weighted sound pressure level.

L_e is the effective duration of a working day and equal to 8h.. The 9 hours working day is a minimum hour for Kerman bus drivers (L_e =9).

L_o is the reference duration of the working day (8h).

For comfortable working condition the L_{eqL_e} according to Iranian laws should be 85 dB (A). Uncomfortable workplace shows the value more than 85 dB (A).

The noise pollution level, which accounts for short-term noise variability, was computed from the following equation:

$$L_{NP} = L_{eq} + 2.5\delta$$

Where δ is the standard deviation (SD) of noise level.

PHASE Π

In the second phase of the study, the standard questionnaire was used [10 and 12]. The questionnaire elicited three types of information from bus drivers and passengers: their socio-demographic characteristics information such as age, educational, experience, accidents last five years prior to being interviewed. The questionnaire also includes questions regarding their levels of annoyance with inside-vehicle noise, and their attitudes/awareness concerning the health and welfare impacts of noise. Each subject was interviewed individually in one-on-one interview. A total of 500 (passengers) and 50 (Male drivers) completed questionnaires were collected, from passengers and drivers respectively. There were no refusals among subjects selected. In the city of Kerman there was no female driver. The study was carried out in the city of Kerman, capital of provinces of Kerman.

The analyses were performed by using Statistical Package for Social Science SPSS 16.0 software (SPSS Inc. Chicago, ILL, USA). Student t-test and ANOVA test with $\rho \langle 0.05$ was used to test the annoyance and awareness of the long-term health impacts of noise on drivers and passengers during daily rides. Chi-square test was used to assess the relationship between the annoyance and health impact of noise and independent variable. The independent variable included age, accidents, experience and bus noise. The study was carried out in the city of Kerman, capital of provinces of Kerman.

RESULTS

Noise Measurements

Normalized exposure sound levels are obtained from the workplace of the bus drivers shown in Tables 2-7. These tables display the type of bus, year of manufacturer and the normalized exposure levels. Tables 2-7 shown that the year of Mega trance buses were assembled between 2004 and 2005, Benz 475 and 355 buses were in year 2002, Benz 475 buses with CNG were assembled in year 2003 and finally Renault buses were assembled in year 2007. Benz 475 and Benz 355 buses operate in Kerman transport network were the oldest among those buses we surveyed. As shown in Tables 2-7 the Mega trance buses exposed drivers and passengers to noise levels of $83 \le L_{EX,9h} \le 76$. The Benz 457 buses exposed noise levels $90 \le L_{EX,9h} \le 78.6$ to their drivers and riders. The Benz 355 buses offered noise levels $99.5 \le L_{EX,9h} \le 98.5$ and the Benz 457 buses with CNG noise levels was $91.0 \le L_{EX,9h} \le 87.6$. Finally, the Renault buses noise levels to their drivers was $85.4 \le L_{EX,9h} \le 79.2$.

A total of 37% drivers and 81.6% of passengers were annoyed with the noise level inside the bus. Seventy six percent of the drivers and 87.4% of the passenger were felt fatigue, 84%,79.6%, 76%, 82.4% of the drivers and passenger were had hearing impaired and headache respectively (see Table 1).

Forty four percent of the drivers with five to ten years' experience and twenty eight percent with the more than ten years' experience were indicated that noise levels inside the buses are very high.

Analysis of the coefficients of correlation between annoyances, perceived impacts of noise and

measured equivalent noise levels also supported the above findings. The correlation statistics between L_{eqL_e} and Fatigue, Hearing impair, Headache, Annoyance and Nervousness were 0.736, 0.707, 0.736, 0.748 and 0.776 for drivers, 0.424, 0.678, 0.686, 0.683 and 0.713 for passenger respectively. A t-test and ANOVA was also employed to test the null hypothesis. Results indicated that the null hypothesis was rejected for perceived drivers and passengers' annoyed as well as long-term health impacts at the 95% significance level.

Table 1: Socio-demographic characteristics and attitude of drivers and passengers levels

Variable(Drivers)	Frequency	Percent	Variable(passengers)	Frequency	percent
Age groups	50		Gender	500	
20-30 years	10	20	Male	385	77.0
31-39 years	15	30	Female	115	23.0
40-50 years	18	36	**Age Groups**		
More than 50 years	7	14	18-30 years	156	31.2
Education			31-39 year	125	25.0
Elementary	20	40	40-50 year	158	31.6
Secondary	17	34	>50	61	12.2
High school (Diploma)	13	26	**Education**		
Experience			None	128	25.6
1-5 years	14	28	Elementary	92	28.4
5-10 years	22	44	Secondary	145	29.0
More than 10	14	28	High school		
Accidents			(Diploma)	117	23.4
1-3 accidents	18	36	college Graduate	18	3.6
4-6 accidents	23	46	**Bus noise**		
> 6 accidents	9	18	very High	245	49.0
Bus noise			High	210	42.0
Very high	28	56	Normal	15	10.0
High	17	34	Unknown	30	6.0
Normal	5	10	**Air Conditioning**		
Air conditioning			yes	115	23.0
Yes	2	4	No	385	77.0
No	48	96	**Fatigue**		
Fatigue			yes	437	87.4
Yes	38	76	No	63	12.6
No	12	24	**Hearing Impaired**		
Hearing Impaired			Yes	398	79.6
Yes	42	84	No	102	20.4
No	8	16	**Headache**		
Headache			Yes	412	82.4
Yes	38		No	88	17.6
No	12	76	**Annoyed**		
Annoyed		34	Yes	408	81.6
Yes	37		No	92	18.4
No	13	74	**Nervousness**		
Nervousness		36	Yes	432	86.4
Yes	35	70	No	68	13.6
No	15	30			

Table 2: Normalized exposure levels were inside Mega trance buses.

Manufacturing year	$L_{EX,8h}$	**Manufacturing year**	$L_{EX,8h}$
2004	83.0	**2005**	77.0
2004	81.0	**2005**	76.8
2004	80.0	**2005**	76.5
2004	79.0	**2005**	76.0
2004	78.5	**2005**	

Table 3: Normalized exposure levels were inside Benz 475 bus

Manufacturing year	$L_{EX,8h}$	**Manufacturing year**	$L_{EX,8h}$
2002	90.0	**2002**	79.2
2002	88.5	**2002**	79.0
2002	88.5	**2002**	79.0
2002	79.5	**2002**	78.8
2002	79.3	**2002**	78.6

Table 4: Normalized exposure levels were inside Benz 355 bus

Manufacturing year	$L_{EX,8h}$	**Manufacturing year**	$L_{EX,8h}$
2002	99.5	**2002**	98.8
2002	99.2	**2002**	98.6
2002	99.0	**2002**	98.5
2002	99.0	**2002**	98.4
2002	98.9	**2002**	98.2

Table 5: Normalized exposure levels were inside Benz 457 buses with CNG

Manufacturing year	$L_{EX,8h}$	**Manufacturing year**	$L_{EX,8h}$
2003	91.0	**2003**	88.7
2003	90.8	**2003**	88.5
2003	89.4	**2003**	88.2
2003	89.2	**2003**	88.0
2003	89.0	**2003**	87.6

Table 6: Normalized exposure levels were inside Renault buses

Manufacturing year	$L_{EX,8h}$	Manufacturing year	$L_{EX,8h}$
2007	85.4	**2007**	81.2
2007	84.2	**2007**	80.0
2007	83.0	**2007**	79.8
2007	82.5	**2007**	79.4
2007	82.3	**2007**	79.2

Table 7: Summary noise pollution indicator inside sample transit buses in Kerman

Bus types	L_{NP}	Mean	SD	Min	Max
Mega trance	84.3	78.4	2.34	76	83
Benz 475	93.86	81.99	4.75	78.6	90
Benz 355	99.86	98.81	0.39	98.2	99.5
Benz 457 with CNG	91.77	89.07	1.08	87.9	91
Renault	86.95	81.70	2.13	79.20	85.40

DISCUSSION

Noise pollution has been stated as a serious health hazard [18], with noise-related damage to humans ranging from annoyance to insanity and death [19]. Maschke [20] treated the impact of noise as a stress inductor, and stated that induced stress by noise has a psychosocial component. Nelson 21] reported that long term exposure to high occupational noise can result in permanent hearing loss. Additionally, commonly experienced noise effects may include annoyance, deterioration of sleep quality, and stress-related ischemic heart disease [22-24].

In Iran as well as other countries such as United Kingdom, Switzerland, Germany, Australia, Brazil and Japan maximum permissible noise levels for occupational noise exposure is 85dB (A). Thus, according to this legislation, fifty percent of drivers in Kerman working in the workplace can be considered an "unsafe".

Noise exposure inside the bases considered in the present study is characterized by the subjective rating according to the "Salford" criterion [19]. According to this criterion, the environment inside the buses is termed Quite, Noticeable, Intrusive, Annoying and very Annoying, if the noise levels do not exceed 67 dB (A), 73 dB (A), 79 dB (A), 85 dB (A) and 91 dB (A) respectively. Therefore, the environment in Benz 355 and Benz 475 with CNG can be characterized as "Very Annoying".

The analysis of the data also indicated that during a given trip (15-25 min long), the mean noise level were, e.g. 80 dB (A) inside Mega trance buses, 84.3 dB (A) inside Benz 457 buses, 99 dB (A) inside Benz 355 buses, 89.3 dB (A) inside Benz 457 with CNG fuel and 82.3 dB (A) inside Renault buses. To serve as a comparison of noise levels inside transit vehicles, the results of Mega trance, Benz 457, Renault, and Benz 457 with CNG buses are in agreement with other studies [16and 25] performed in Kuwait and Rio de Janeiro, Brazil, which indicated that during a 5-min trip, a diesel bus averaged 82.1 dB (A), and a CNG-powered bus registered 76.9 dB (A), but the findings of the Benz 355 was 17 dB (A) higher than studies performed in Kuwait and Brazil.

This study has revealed that 84% of drivers and 80% of the passengers reported noise inside the busses affect their hearing. According to the environmental noise criterion recommended by WHO, permanent hearing loss is likely to occur if $L_{EX,8h} \geq 75\ dB(A)$ for periods up to 40 years. One carries the same risk if subjected to an hour`s exposure at $L_{eq} \geq 84\ dB(A)$ .This implies that the drivers of buses will be prone to hearing loss. Analysis of data showed that more than half of drivers and approximately half of the passengers reported noise inside buses was very high. This can cause decreasing concentration significantly and may result in increasing accident rate.

This study also confirmed that 40% of the drivers, they had accidents during daily trip prior to the study.

The study findings also indicated that 76% of the drivers and 82.4% of the passengers reported, they have headache during their daily bus trips. Analyses of the data reported in this study revealed in the 50% of the busses in the city of Kerman in working conditions are unsafe.

CONCLUSIONS

In both the industrialized and non-industrialized countries, noise in urban area is a major productivity, health and environmental concern for public as well as for bus drivers. The study finding indicated that, noise exposure levels inside buses we surveyed are greater than 85dB (A), which can cause permanent hearing loss.

The study finding also indicated that, the drivers are exposed to noise levels more than 85dB (A) for nine hours a day, six days a week, this working condition lead to a real potential health problem. At these levels of noise pollution, it is safe to conclude that the inside of transit buses during the daily commuting hours, is generally noisy, which is in agreement with other studies [6 and 9].

Results of this part of the study are in agreement with others study [14] who found that bus driving is a stressful and unhealthy activity.

Nearly four out of five drivers and riding passengers were annoyed with the noise inside the bus. The sample drivers and passengers with noise levels inside buses were related to the human noise, lack of proper maintenance, bus engine, loading and unloading passengers and the manufacturing year. Noise and lack of air conditioning in the bus were the top two ranked service deficiencies of the public transit system in Kerman, as previously reported [16].

ACKNOWLEDGMENTS

The author is deeply indebted to the administration of the bus transit in Kerman for their cooperation. The insightful comments of the reviewers are greatly acknowledged.

REFERENCES

[1] National Pollution Clearinghouse, Noise Effects on Wildlife, found at http://www.nonoise. Org/library/fctsheet /wildlife.htm, retrieved Sept. 13, 2004.

[2] Aftandilian Dave. Noise Pollution, Conscious Choice, June 1999. Found at http://www.consciouschoice.com/Note/note1206.html, retrieved Sept. 13; 2004.

[3] Khilman T. Noise pollution in cities, Curitiba and Gotenborg as examples. In; proceeding of the Seminar-Environmental Aspects of Urbanization-Seminar In honor of Dr.Mostafa kamal Tolba, Gothenburg, Sweden, in CD; 2004.

[4] Diniz F, Zannin, P.H.T. Noise impact caused by electrical energy substation in the city of Curitiba,Brazil. Science of the total Environment, 2004; 32: 23-31.

[5] Jamrah A, Al-Omari A, Sharab R. Evaluation of traffic noise pollution in Amman,. Jordan Environmentalist,2006; 120: 499-525.

[6] Koushki P, Al-saleh O, Ali S Y. Traffic noise in Kuwait: profiles and Modelling residents perceptions Journal of urban planning and Development,1999; 125:101-109.

[7] Mohammadi G. An investigation of Community Response to Urban Traffic Noise. Iranian J. Environ. Health. Sci. Eng., 2008;6: 137-142.

[8] Morillas J M V, Escobar V G, Sierra J A M, Gomes R V Carmona. An environmental noise study in the city of Caceres, Spain, Applied Acoustics,2001;63;1061-1070.

[9] Zannin P H T, Diniz F B, Ferreira J A C. A survey of urban noise annoyance in a large Brazilian city: the importance of a subjective analysis in conjunction with objective analysis. Environmental Impact Assessment Review, 2003; 23; 245-255.

[10] Alice HS. Noise and Its Effects, Administrative Conference of the United States, Nov. 1991. Found at http://www.nonoise.org/library.htm, retrieved Oct. 27, 2004.

[11] Belojevic M., and Jakovljevic B. 1997.Subjective reactions to traffic noise with regard to some personality trait. Environmental International, 1997; 23: 147-155.

[12] Patel V S and Ingle S T. Occupational noise and hearing loss among pulse processing workers.Environmentalist, 2008; 28:258-265.

[13] Ewans G W, Carrere S. The traffic congestion, perceived control, and Psycho physiological stress among urban bus drivers. Journal of Applied Psychology, 1991; 3:99-108.

[14] Rydstedt L W, Johansson G, Ewans G W. The human side of the road: Improving the working conditions of urban bus drivers. Journal of Occupational Health Psychology, 1998; 3:161-171.

[15] Jain V K, Anyogita S, Prakash A. .A study of noise in CNG driven modes of Transport in Delhi, Applied Acoustics, 2004; 65:195-20.

[16] Koushki,P , Ali M A, Chandrasekhar B P, Al-Sarawi M. Exposure to noise inside transit buses in Kuwait: measurement and passenger attitudes. Transport Reviews, 2002; 22:295-308.

[17] Zannin, PHT. Occupational noise in urban buses, International Journal of Industrial Ergonomics, 38, 232-237, special issue: Spanning the Gap from Traditional Ergo to health and safety Issue, or in the International Journal of Industrial Ergonomics: occupational noise in urban buses, 2006; 36: 901-905.

[18] Bies, D. A. and Hansen C H. Engineering Noise Control: Theory and Practice, 2nd ed., E and FN SPON, London; 1996.

[19] Mato R R, Mufuruki T S. Noise pollution associated with the operation of the Dar es Salaam International Airport, Transportation Research Part D, 1999:81–89.

[20] Maschke C P. Preventive medical limits for chronic traffic noise exposure, Acoustica, 1999; 85: 448.

[21] Nelson P M. Transportation Noise Reference Book (ed.) Butterworth & Co., London. N Netherlands Health Council. 1997. Committee on a Uniform Environmental Noise Exposure Metric, *1995:* Assessing Noise Exposure for Public Health Purposes, Report 1997/23E.

[22] Morrell S, Taylor R and Lyle D. A review of health effects of aircraft noise', Australian and New Zealand Journal of Public Health,1997; 21:221–236.

[23] Mohammadi G. Occupational Noise Pollution and Hearing protection in selected industries, Iranian Journal of Health, Safety and Environment, 2014; 1; 30-35.

[24] Bryan M.E. A tentative criterion for acceptable noise levels in passenger Vehicles, Journal of sound Vibration, 48(1976); 525.

[25] Balassiano R. and White P. Experience of compressed natural gas bus Operations in Rio de Janeiro, Brazil. Transportation Research D, 1997; 2: 147-155.