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Evaluation of road traffic noise pollution in Quetta (Pakistan)

H. U. khan*, Syed Imran Ali

Department of Physics, Balochistan University of Information Technology Engineering and Management Sciences, Quetta, Pakistan

Email address:
hamullah_khan@yahoo.com (H. U. khan)

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Abstract: Pakistan, like other developing countries, is facing the growing problem of traffic noise pollution of the modern world. It is a notable problem of urban areas of the country including Quetta city. The basic cause of this problem is the tremendous increase in traffic volume and lack of proper town planning. This study is the first proper attempt to evaluate the traffic noise level in Quetta city. To estimate the level of road traffic noise, the technique employed is a "regular grid over a map" . This technique generated 60 observation locations across the city covering almost the whole city. The different zones are classified on the standards of US Department of Housing and Urban Development. The measuring points generated so have been divided into four categories depending upon the activities carried out in that region. It is observed that mixed area i.e. "commercial and residential" are at high risk, where the L_{max} is 93.1 dB and the statistical analysis reveals the fact that the 77.1 % of the locations in residential areas are higher than the standards set by the local authority. Noise map is also designed for future use and the better understanding of the traffic noise in Quetta city. It is observed that most of the population of the city is significantly exposed to the high noise level due to the unmitigated traffic noise.

Keywords: Noise, Expose, Residential, Traffics, Measurement

1. Introduction

Noise pollution is the consequence of urbanization and industrialization and is considered as major problem of urban areas. The most important factors raising noise pollution in urban areas include vehicular traffic, neighborhood electrical appliances, TV and music systems, public address systems, and railway and air traffic. Increase in noise level, across the world, has motivated the researchers of the world to this study the problem and its impact on the environment. Also, researchers have reported that the road traffic noise is the leading source of noise in urban areas [1]. Noise pollution is not only the growing problem of developing countries but also of the developed countries. According to researchers, over 130 million people in Europe suffer from exposure to noise levels above 65 dB(A) [2].

The noise defined as a unwanted sound, either because of its effects on human or its effect on fatigue or malfunction of physical equipment, or its interference with the perception or detection of other sounds [3]. To comprehend the noise pollution in a better way we must understand the range of sound intensities for normal human. Human ear can detect the wide range of intensities, from threshold of hearing i.e. 1 x 10^{-12} W/m^2 to the threshold of pan at 10 W/m^2, this range can express in terms of decibel by the following relation [4].

$$Intensity\ Level = \beta = (10\,dB)\log_{10}\frac{I}{I_o}$$

Where
β = Is a constant defining intensity level.
I_o = Reference sound intensity.

If β becomes zero decibel (dB), no sound is heard by most people. Similarly, the sound intensity level at the threshold of pain is 130 dB.

In many research conducted worldwide, especially in developed countries, road traffic noise is considered to be the worst environmental noise offender and a leading detriment to health and well-being in the community [5]. Noise can cause speech interfere, especially when the background noise level is 50 dB (A), noise can also cause annoyance and can decrease work performance [6]. According to the World Health Organization, noise pollution is nowadays the third most hazardous environmental type of pollution, preceded only by air and water pollution [7]. Noise pollution has notable adverse impacts on the health of human beings. There is an increasing probability to heart disease among the peoples who are constantly living in the areas where the out door noise level is greater than 65-70 dB[8]. Another survey reveals the fact that traffic noise is not only the main cause of headache, high BP, dizziness and fatigue at working place but is also badly interfering in daily life activities such as resting, reading, and communications [9]. A study among the workers exposed to road traffic noise disclosed a deep relationship between the exposure of traffic noise and the noise-induced hearing loss (NIHL)[10].

2 Materials and Methods

2.1. Study Area

Balochistan is the largest province by area, Pakistan and Quetta is the largest city and capital of Balochistan. Quetta is a beautiful valley, surrounded by mountains named: Chiltan, Takatoo,Murdar, and Zarghun. The city is an important gate way to Afghanistan and Central Asia. Quetta is known as the fruit garden of Pakistan.

British government had designed new Quetta city after earthquake of 1935, only for 0.1 million people while now over two million populations is living in this city. With the increase in population, the number of vehicles has also been increased. The increase in the number of vehicles and lack of proper management has greatly increased the problem of noise pollution in Quetta city. No wonder, increase in population, lack of proper town planning and high traffic density has greatly increased traffic noise on all important roads of the city.

2.2. Experimental Procedure

Experimental procedure mainly includes method employed in taking readings from various roads of the city. Various methods are being used to study the environmental noise pollution in a city. The observation time and selection of sampling locations are the two most important aspects while taking traffic noise data.

2.3. Observation Time

While measuring road traffic noise level, different practices have been adopted, depending upon the need; the observation time may accede a continuous measurement of many years as performed in Valencia and Lanzhou city [11]. On the other hand we have the examples of measuring time of 20 and 15 minutes [12]. We have selected our observation time during working hours from 8 a.m. to 8 p.m. and noise level measured for 15 min at each location point with the interval of 2 hour. To achieve higher accuracy, sampling is done on the random day strategy. So, at each sampling point, the data is collected on more than two randomly selected days in a week.

2.4. Selection of Sampling Locations

Different strategies of the selection of sampling locations have been practiced in different parts of the world. Some important of them are summarized here,

a). By using grid over a map
b). Source - oriented sampling
c). Receptor - oriented sampling
d). by using the prior classification of the noise

a). Using grid (or mesh) over map**:** In this technique a non-regular grid is used to distribute the measurement points throughout the city. Its main draw backs include:

i. Conclusions strongly depend on gird size
ii. Time and resource consuming

b). Source oriented sampling**:** In this strategy, the measurement locations are selected randomly mainly on the basis of traffic conditions.

However, the results obtained by this method may not be utilized for any work in future. This is the main disadvantage of this strategy.

c). Receptor - oriented sampling**:** In this technique, a particular class of receptor for the exposure of noise is investigated.

d). By using the prior classification of noise**:** This classification may be based on the use of services, the density of residents, or the type of road uses.

The method selected for this work is the regular mach method (Sommerhoff, et al 2004). After the implementation of mash it has been observed that the square of the mash also indicating the area according to the particular economical and commercial activities, so the measurement sites have been divided into four different zones (table 01) according to the particular use of that area as shown in the map (figure: 01)

Table 1. *The Division of Different Urban Zone and their assigned symbols.*

S.No.	Zone	Symbol
I.	Residential	▣
II.	Residential and Commercial	◈
III.	Commercial and service	⭘
IV.	Cantonment(Residential)	⬟

2.5. Measurements

Measurements are taken under suitable climatic conditions i.e. no rain and no wind in the environment, using the digital sound level meter of type II of EXTECH Instruments, Model No.407768 ; with PC interface. The sound level meter is also calibrated before and after each reading using the calibrator of EXTECH Instruments, Model No. 407766 .

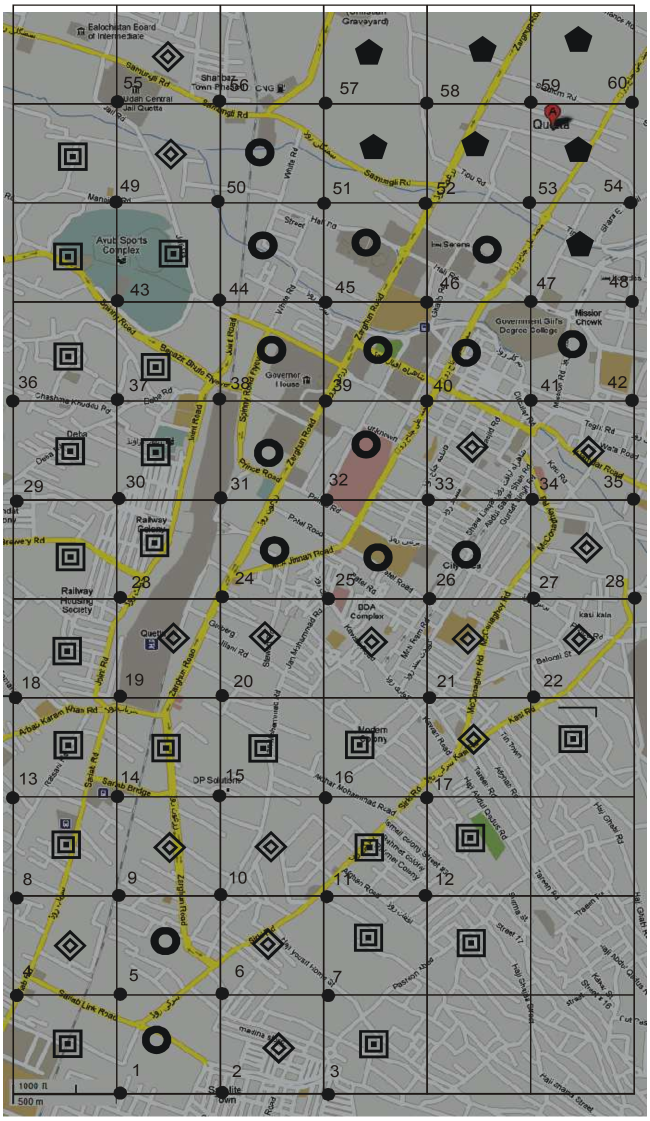


Figure 1. Map of Quetta City (From Google; 05th October 2011) with randomly superimposed mesh of 500x500m indicating the measurement points.

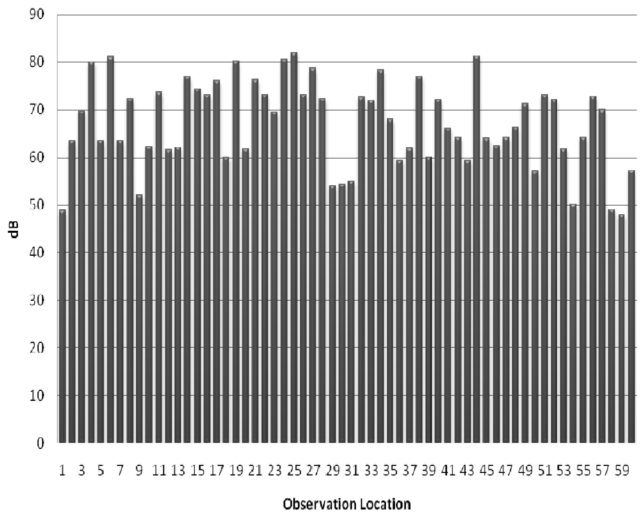


Figure 2. Variation in A-weighted equivalent sound level across the Quetta City.

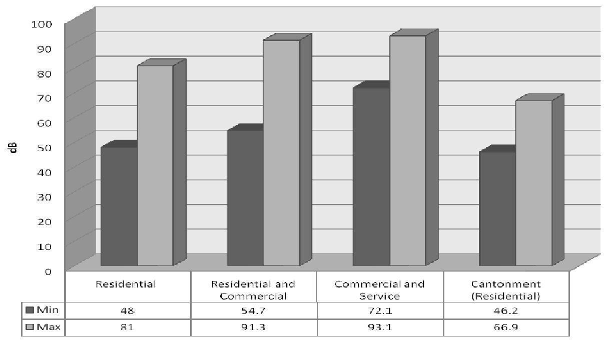


Figure 3. Comparison of Lmax and Lmin ,among the different zones of Quetta City.

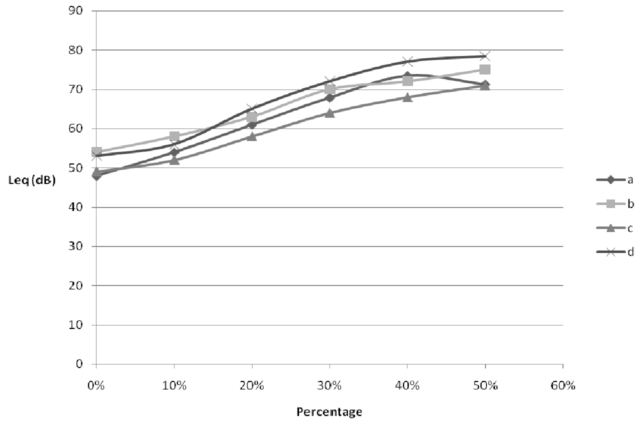


Figure 4. Percentile distribution of Leq measured values on each period, at 60 locations of the city.

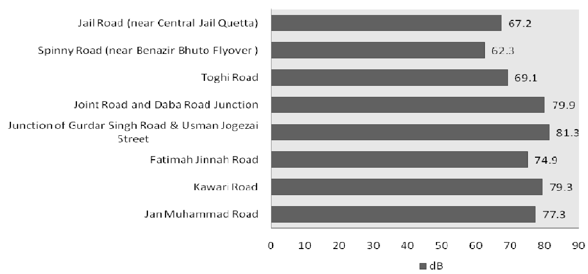


Figure 5. L10 for the eight selected areas in Quetta city.

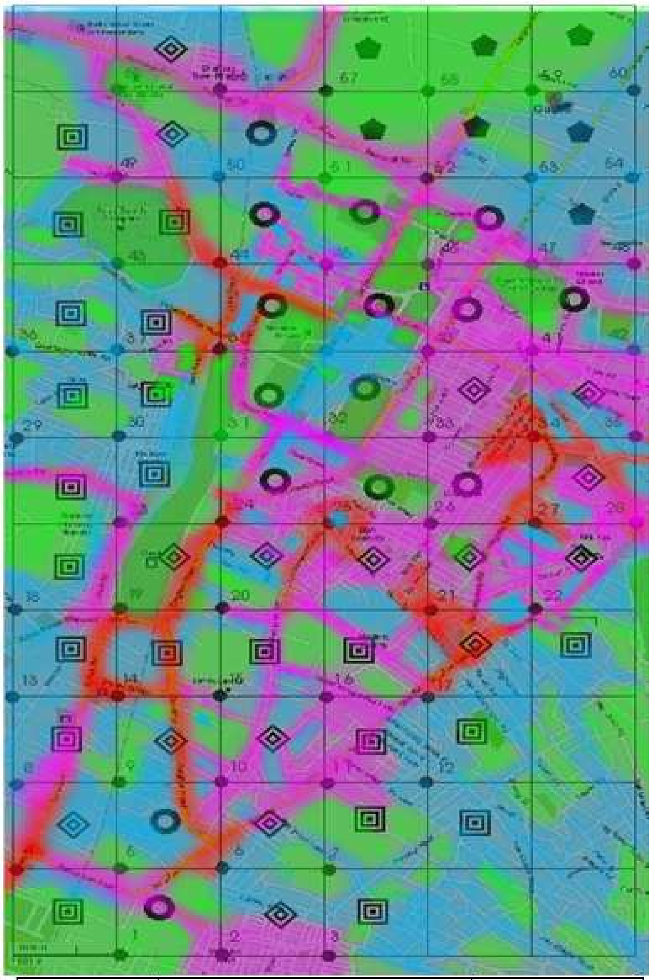
3. Results and Discussion

In this work the noise level is estimated by implementing the regular mash over the city, such that it covers the main area of the city, which includes residential, commercial, mixed (i.e. commercial and residential) and cantonment area. Mash size is selected by keeping in view that it must not be very large so that in that region the sound level (L_{Aeq}) may not vary more then ± 5 dB. These mashes contain the different urban zones indicating by the particular symbols as shown in the table. (Table: 1). The area of each mash represents the cover area of 500m x 500m, which is implemented on the city map according to the scale (Fig.08). Select the sixty corners of the imposed mash to record the observations, where as the actual readings are made very close to the locations as specified in the table, with its maximum, minimum and average values. (Table:2)

Table 2. *Data of the sixty locations obtained from the randomly superimposed mesh.*

Location Number	Location Name	Maximum (L_{max}) dB	Minimum (L_{min}) dB	Average dB
1	University of Bolochistan Hostel	62.3	47.0	48.7
2	Satellite Town (Near Police Station)	71.2	56.9	63.4
3	Satellite Town (Jilani Khan Road)	81.0	54.8	69.7
4	Sariab Road & Sariab Link Road Junction	90.0	65.3	80.0
5	Sariab Link Road (Near Sirki Road)	75.6	68.2	63.4
6	Sirki Road & Zarghun Road Junction	87.2	64.1	81.0
7	Haji Yousif Home Street(Near Sirki Road)	61.9	49.6	63.5
8	Sariab Road	80.8	67.0	72.2
9	Near Dukani Baba mizar	60.1	52.0	52.1
10	Jan Muhammad Road	82.5	54.7	62.2
11	Sirki Road (between HajiYousif St. and Afghan Road)	85.1	62.6	73.7
12	Afghan Road (Near Sirki Road)	77.4	52.1	61.6
13	Raisani Road	72.9	53.9	62.0
14	Sariab Bridge & Sariab Road Junction	90.4	71.0	76.9
15	Jan Muhammad Road	83.7	62.8	74.3
16	Faquire Muhammad Road	79.2	68.5	73.1
17	Sirki Road (Near Akhtar Muhammad Road)	86.4	68.9	76.1
18	Arbab Karam Khan Road	76.2	59.1	60.0
19	Junction of Arbab Karam Khan, Sariab & Joint Road	92.1	72.1	80.3
20	New Al-Gillani Road	72.1	54.0	61.8
21	Kawari Road(near Gurdat Singh Road)	81.2	59.5	76.3
22	Kasi Road (Tin Town)	76.3	63.8	73.2
23	Joint Road(near Railway Housig Society)	78.4	61.3	69.5
24	Zarghun Road (near M.A. Jinnah Road)	84.9	66.4	80.5
25	M.A. Jinnah Road (near Kawari Road)	93.1	64.3	82.0
26	Junction of Patail & Shahwak Shah Road	84.0	71.2	73.1
27	Prince Road (near Maconaghey Road)	91.3	66.9	78.6
28	Kasi Road (near Kasi Kala)	81.0	62.1	72.3
29	Wahadat Colony (inside; near 2nd stop)	69.2	56.0	54.0
30	Railway Colony (near Railway Ground)	65.9	55.2	54.3
31	Near Railway Police Station	64.2	56.1	55.0
32	Prince Road(near civil hospital)	85.3	67.3	72.7
33	Fatimah Jinnah Road (near 4th street from the Prince Road)	90.8	62.3	71.9
34	Junction of Gurdar Singh Road & Usman Jogezai Street	88.6	68.9	78.3
35	Alamdar Road	79.5	61.4	68.0
36	Cohashma Khudda Road (Daba)	72.9	56.2	59.3
37	Daba Road	79.0	58.6	61.9
38	Joint Road and Daba Road Junction	80.9	57.5	76.9
39	Zerghun Road(near Governor House)	69.1	53.9	60.0
40	M.A. Jinnah Road (near Iqbal Road)	89.1	57.6	72.1
41	Toghi Road (near Circular Road)	90.3	60.8	66.1
42	Dr. Ghalam Nabi Road (near Govt. Muslim Abad High School)	70.4	58.0	64.2
43	Spinny Road (near Benazir Bhuto Flyover)	77.2	56.4	59.3
44	Mir Jafar Khan Jamali Road (near Ayub Sport Complex)	85.6	65.3	81.2
45	Circular Road (near White Road)	76.7	56.2	63.9
46	Ghalib Road (near Radio Station)	79.6	58.2	62.4
47	Share-e-Gulistan Road (near Govt. Girls Degree College)	86.1	66.5	64.1
48	Near Lourds Hotel	74.2	61.3	66.2
49	Manu-Jan Road (near Jail Road)	79.8	56.9	71.3
50	Shahbaiz Town (near White Road)	68.0	54.8	57.0
51	Hali Road (near Serena Hotel)	74.9	53.2	73.1
52	Zerghun Road (near Sammungli Road)	87.1	62,7	72.1
53	Junction of Tipu & Jinah Road	72.8	52.4	61.7
54	Shara-e-Tufail (near the street which is jioning the M.A. Jinnah Road)	68.9	51.9	50.1
55	Jail Road (near Central Jail Quetta)	90.2	53.2	64.2
56	Sammungli Road (near Shahbaz Town)	78.4	64.8	72.8
57	Sammungli Road (near White Road)	80.1	62.9	70.0
58	Tipu Road (between the graveyard and the Zarghun Road)	66.9	46.2	48.9
59	Stadium Road (near Zarghun Road)	67.1	47.0	48.0
60	M.A. Jinnah Road (in Cantonment)	71.8	59.2	57.2

Due to its appropriate area of 500mx500m, each mash has become the true representative of the true predominated activities conducted in that region. On the basis of different human activities performed in different regions of Quetta city, we have divided the city into four different zones. We have assigned a particular symbol to each zone depending on the nature of human activities in that zone. Also, we have given a particular symbol to each mash depending on the nature of human activities in that particular region.



Color	Name of Color	Range
	Light Green	$L_{Aeq} \leq 49$ dB
	Light Blue	$49 < L_{Aeq} \leq 62$ dB
	Magenta	$62 < L_{Aeq} \leq 76$ dB
	Red	$L_{Aeq} > 76$ dB

Figure 6. *Noise map of Quetta City*

Quetta city can be easily divided into residential area, commercial and service area. However, due to lack of town planning, there are many locations in the city where we cannot properly differentiate between residential and commercial areas. Therefore, we have established a separate zone and named it "Residential and Commercial zone." The commercial and service area is comprised of shops, government and private offices, banks etc. The random super-position of the mash also covers the specific residential area in the cantonment. Hence, the observation locations at the corners of the mash can easily categorized into residential, residential and commercial, commercial and service or cantonment areas. The distribution of the measurement sites is uneven, with the highest percentage for residential areas as illustrated by the zone distribution. (Table: 3)

Table 3. *The distribution of the measurement sites according to the zone.*

Zone	Number of Observation Locations	Percentage(%) of the Locations
Residential	22	36.7
Residential and Commercial	18	30
Commercial and Service	15	25
Cantonment (Residential)	05	8.3

Table 4. *Distribution of the measured LAeq values at 60 different sites in Quetta City.*

A-weighted equivalent sound level L_{eq} dB	Number of Sites	Percentage (%)
$L_{Aeq} \leq 50$	02	3.3
$50 < L_{Aeq} \leq 55$	06	10
$55 < L_{Aeq} \leq 60$	06	10
$60 < L_{Aeq} \leq 65$	14	23.3
$65 < L_{Aeq} \leq 70$	06	10
$70 < L_{Aeq} \leq 75$	14	23.3
$75 < L_{Aeq} \leq 80$	07	11.7
$80 < L_{Aeq} \leq 85$	05	8.3
$85 < L_{Aeq} \leq 90$	-	-

We observed and recorded L_{min}, L_{max}, for all the sixty locations (Table: 4) besides that the noise descriptors L_{10} and L_{eq} were calculated and defined as **:** [13]

L_{10} : A specified dBA levels which is exceeded ten percent of the time during the whole period of measurement.

L_{eq} : The equivalent continuous dBA level which has the same energy as the original fluctuating noise for the same given period of time.

The A-weighted equivalent sound pressure level was computed and is defined as follows [14]. (Oyedepo, et al. 2010)

$$L_{Aeq} = 10\log_{10}\left[\frac{1}{N}\sum_{i=1}^{N}\left(anti\log\frac{L_{Ai}}{10}\right)ni\right]$$

By the analysis of the data it is observed that 77% of the locations have A-weighted equivalent sound level (L_{Aeq}) more than 60 dB (Table: 6). Where as 53.3% of the locations have A-weighted equivalent sound level (L_{Aeq}) more than 65 dB.

The Pakistan Environmental Protection Agency which is managed by the Ministry of Environment has set standard of noise in Pakistan. According to these standards the maximum day level noise is 55dB for residential area is 65dB for commercial areas (Pakistan Environmental Protection Agency). In the study, it is also observed that 77.1% of the locations in residential areas is higher than the set standards, where as 68% of the locations in commercial areas is also higher then the set standards.

There are different standards of noise across the world. The US Department of Housing and Urban Development (HUD) recommends the following standards. (Zannin, et al. 2002)

$L_{Aeq} \leq 49$ dB — Clearly Acceptable
$49 < L_{Aeq} \leq 62$ dB — Normally Acceptable
$62 < L_{Aeq} \leq 76$ dB — Normally Unacceptable
$L_{Aeq} > 76$ dB — Clearly Unacceptable

After the division of HUD standards it is also observed that mixed areas (i.e. residential and commercial) which also includes the residential areas and fall in the category of “Clearly Unacceptable” zone. (Table 5) Theses areas are highly dense for human activities.

Table 5. *Classification of different regions of Quetta City on the basis of the US Department of Housing and Urban Development (HUD) standards.*

Noise Exposure Class	Locations	Pre-dominated Uses
Clearly Acceptable [$L_{Aeq} \leq 49$ dB]	University of Bolochistan Hostel, Tipu Road, Stadium Road.	Residential
Normally Acceptable [$49 < L_{Aeq} \leq 62$ dB]	Near Railway Line, Afghan Road, Raisani Road, Arbab Karam Khan Road, New Al-Gillani Road, Wahadat Colony, Railway Colony, Near Railway Police Station, Cohashma Khudda Road (Daba), Daba Road, Zerghun Road(Near Governor House) , Spinny Road (near Benazir Bhuto Flyover), Shahbaiz Town, Junction of Tipu & Jinah Road, Shara-e-Tufail, M.A. Jinnah Road (in Cantonment).	i) Residential ii)Residential & Commercial iii)Cantonment (Residential)
Normally Unacceptable [$62 < L_{Aeq} \leq 76$ dB]	Satellite Town (Near Police Station), Satellite Town (Jilani Khan Road), Sariab Link Road, Haji Yousif Home Street, SariabRoad,JanMuhammad Road, Sirki Road, Jan Muhammad Road, Faquire Muhammad Road, Kasi Road (Tin Town), Joint Road, Junction of Patail & Shahwak Shah Road, Kasi Road (near Kasi Kala), Prince Road, Fatimah Jinnah Road, Alamdar Road, M.A. Jinnah Road, Toghi Road, Dr. Ghalam Nabi Road (near Govt. Muslim Abad High School), Circular Road (near White Road), Ghalib Road, Share-e-Gulistan Road (near Govt. Girls Degree College), Near Lourds, Manu-Jan Road, Hali Road, Zerghun Road, Jail Road (near Central Jail Quetta), Sammungli Road (near Shahbaz Town), Sammungli Road (near White Road),	i)Residential ii)Residential & Commercial iii)Commercial
Clearly Unacceptable [$L_{Aeq} > 76$ dB]	Sariab Road & Sariab Link Road Junction, Sirki Road & Zarghun Road Junction, Sariab Bridge, Sirki Road (Near Akhtar Muhammad, Junction of Arbab Karam Khan, Sariab & Joint Road Road), Kawari Road, Zarghun Road, M.A. Jinnah Road (near Kawari Road), Prince Road, Junction of Gurdar Singh Road & Usman Jogezai Street, Joint Road and Daba Road Junction, Mir Jafar Khan Jamali Road (near Ayub Sport Complex),	i)Commercial ii)Residential & Commercial

Table 6. *A-weighted Equivalent sound level (LAeq) distribution of the measurements per zone.*

A-weighted equivalent sound level L_{Aeq} dB	Residential		Residential and Commercial		Commercial		Cantonment (Residential)	
	Locations	%	Locations	%	Locations	%	Locations	%
$L_{Aeq} \leq 50$	-	-	-	-	-	-	02	40
$50 < L_{Aeq} \leq 55$	05	22.7	-		-	-	01	20
$55 < L_{Aeq} \leq 60$	03	13.6	01	5.5	01	6.7	01	20
$60 < L_{Aeq} \leq 65$	06	27.2	02	11	04	27	01	20
$65 < L_{Aeq} \leq 70$	03	13.6	03	17	01	6.7	-	-
$70 < L_{Aeq} \leq 75$	05	22.7	06	33	04	27	-	-
$75 < L_{Aeq} \leq 80$	-	-	04	22	02	13	-	-
$80 < L_{Aeq} \leq 85$	-	-	02	11	03	20	-	-
$85 < L_{Aeq} \leq 90$	-	-	-	-	-	-	-	-

The distribution analysis per zone illustrate that 11% of the residential and commercial zones have an environmental noise level greater then 80 dB and 20% of the commercial areas also possess the alarming noise level of eighty or more then 80 dB. The pure residential areas at some places also delivered the maximum noise level of 81dB (Figure: 3) due to unchecked silencers and pressure horns of the automobiles.

For the deeper and detail analysis of the noise level, we have divided the day time into the four periods.(Table : 7) It is found that percentile level on noise during the periods “b” and “d” was bit higher as compare to the period “c”, due to decrease in the traffic flux, because of less human activities. It is also noted the period “d” has the highest noise level, which is due to the increased economic activities.

Table 7. *Schedules of the four periods of the observation time.*

Period		Schedule
a	1st	8:00 — 10:00
b	2nd	10:00 – 15:00
c	3rd	15:00 – 17:00
d	4th	17:00 −20:00

The equivalent continuous noise level L_{eq} is related to the statistical noise level L_{10} by the following empirical relationship,

$$L_{10} = L_{eq} + 3.0 \text{ dB(A)}$$

The 10 percentile noise level is also evaluated and is displayed for the eight selected areas in the mixed zone.

Due to geo-economic and political situation of Quetta city, the economic activities have been dramatically decreased at night. Consequently, the traffic flux practically approaches to few vehicles per hour. Hence, all the zones almost match the standard of the silent zone. That's why our work is confined to day time only.

Noise map is an outstanding tool for controlling noise level in urban areas and thus helps greatly in town planning and is regarded as a useful tool to improve the level of environmental noise pollution. Noise map is considered as a power full tool to get the visual acoustic behavior of any geographical region, hence it is helpful to improve to environmental conditions regarding noise pollution and better town planning. So we made a noise map which is not only based on the data of that sixty location but besides that we have collected the data of thirty other locations.

Noise map is considered as a power tool to comprehend the environmental noise level as noise map can provide the following information:

- Illustrate the exposure of noise and, therefore, may serve as a reference during the process of policy making.
- It provides the path way for implementing the policies that may minimize the noise level.
- It gives the authorities an opportunity to theoretically review and examine their plans for the better environment.
- It helps in enforcing the regional as well as national plans to reduce the new noise resources and it also helps in reducing the noise levels in new areas that are noise sensitive.
- It helps the authorities to monitor the effectiveness of the schemes employed for noise reduction.
- It helps to monitor and study the changing trends in road traffic noise pollution and its impact on the environment.
- It enables the researchers to study the physical and psychology impact of nose on human beings.

4. Conclusion

This work has revealed some alarming facts regarding noise pollution in Quetta city. Our analysis shows that maximum sound level in commercial zone is 91.3dB and in commercial and service zone is 93.1dB which is very high than the limits set by authorities. The residential and commercial zones are at the most high risk because of the intense human activities in these regions; also, noise L_{10} in most of the area during specific periods of a day was about 81.3dB.

On the basis of the study it can also be predicted that the noise problem will increase with the passage of time. Therefore, it is essential to address it immediately as later mitigation will become difficult as well as expensive to implant. So the government should establish:

- Educational campaigns to create awareness among the local community
- Regular servicing and tuning of vehicles.
- Fixing of silencers to all automobiles
- Professionals; such as environmental engineers, architects etc. should propose some reasonable solutions to the growing problem of environmental noise pollution while constructing new roads and planning housing schemes.

Acknowledgement

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