ASSESSMENT OF ROAD TRAFFIC NOISE POLLUTION IN URBAN CITY BY NOISE MAPPING

MAJOR PROJECT REPORT

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OF

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IN

ENVIRONMENTAL ENGINEERING

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CANDIDATE'S DECLARATION

I, Kartik Nair, Roll No. 2K17/ENE/07student of M. Tech (Environmental Engineering), hereby declare that the Major project report titled "ASSESSMENT OF ROAD TRAFFIC NOISE POLLUTION IN URBAN CITY BY NOISE MAPPING" which is submitted by me to the Department of Environmental Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title of recognition.

Place: Delhi **KARTIK NAIR**

Date: JULY,2019

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CERTIFICATE

I hereby certify that the Minor project report titled "ASSESSMENT OF ROAD TRAFFIC NOISE POLLUTION IN URBAN CITY BY NOISE MAPPING" which is submitted by KARTIK NAIR, 2K17/ENE/07, Department of Environmental Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi

Date: JULY, 2019

Dr. RAJEEV KUMAR MISHRA

SUPERVISOR

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ABSTRACT

Traffic noise over the years has become one of the hazardous pollutants affecting the human life in urban areas. There has been an exponential growth of human population which has caused substantial rise in the vehicle ownership along with rapid urbanization and industrialization, which is known to cause high noise levels in Indian cities.

In urban areas, industrial, commercial and transportation sector contribute 75% in total noise pollution. In transportation sector itself road traffic noise contributes to 75% to the total noise pollution.

The analysis of noise levels in the city of Delhi is done by developing noise maps with the help of GIS (Geographic Information System). After data analysis, it was observed that the measured ambient noise levels at all the locations were violating the prescribed limits that has been set by CPCB. Also, the traffic noise level was observed to be much more during the evening time as compared to morning time at all the locations.

During the morning peak hours i.e. from 8 am to 10 am, the road traffic noise level was found to be maximum at Badli crossing, having noise level between 78.09 dB(A)-78.84 dB(A). Whereas, at Patel nagar chowk the noise level was found to be minimum with values between 71.35 dB(A)-72.10 dB(A).

For the off-peak hours i.e. from 12pm to 2pm, the road traffic noise level was found to be maximum at Paharganj chowk, the noise level obtained in this region has a value between

72.36 dB(A)-73.26 dB(A). Whereas at Shastri park and K.G & Tolstoy Marg the value is between 64.25 dB(A)-65.15 dB(A).

During the evening peak hours i.e. from 5pm to 7pm, the road traffic noise level was minimum at Shastri park and K.G & Tolstoy Marg respectively with the noise levels between 74.10 dB(A)-74.81 dB(A). The maximum noise level value was obtained at Peeragarhi chowk and Badli crossing respectively for the evening peak hour duration noise level obtained was between 80.42 dB(A)-81.12 dB(A).

It is observed that the vehicular noise contributes significantly in noise generation at all the locations of study. The noise levels are found to be in proportion to the vehicular population.

The ambient noise level standards have been violated at every locations during the peak and off peak hours. The noise level values obtained from the developed noise maps gives very close results to the measured values. Percentage difference between the predicted noise level and the monitored noise level is found to be between 4% to 7%.

Noise maps can be used to evaluate and observe the influence of noise effects in urban cities thus playing an important role to curb noise pollution.

Keywords: Traffic noise, GIS, Noise maps

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CHAPTER 1

INTRODUCTION

1.1 Noise

Sound can be defined as any variation in pressure (in air, water or other medium) the presence of which can easily be identified by human ear. Source of sound is the one that radiates power and this eventually leads to pressure, thus sound power is the cause and the sound pressure is its effect. The term "Noise" has been derived from Latin word "Nausea" which means "seasickness" or a cause of discomfort or annoyance, hence noise can be defined as a set of unwanted sounds that are known to threaten the health and welfare causing various auditory and non-auditory effects among living beings in the environment. How one perceives noise is totally subjective and depends upon factors such as duration, intensity, characteristics etc.

1.2 Types of Noise

The major cause of noise pollution is rapid industrialization and urbanization along with an exponential growth in human population. Noise pollution has become a significant contributor to environmental pollution particularly in urban areas. The major sources of noise can be classified as:

1.2.1 Industrial Noise

These are the noises that are generated due to various mechanized and non-mechanized work that are undertaken in an industry. The sound produced have a range from low to high frequencies and are found to have unpleasant and disruptive temporal sound patterns. It includes noise from factories, construction sites etc.

1.2.2 Transportation Noise

The source of this type of noise includes noise generated from airways traffic, roadways traffic, and railways traffic. To be specific road traffic noise depends upon the rate of flow of traffic, vehicular speed, no. of heavy vehicle and type or nature of road surface. Rail traffic noise depends upon type of engine, type of wagon and the roughness between rails and wheels. Aircraft noise are induced at the time of operations such as take-off and landing which are known to produce extreme noise which includes vibrations and rattle

1.2.3 Construction Noise and Building Services Noise

Construction activities cause a high amount of noise emissions. Variety of sounds is produced from activities such as excavation, cement mixing, hammering, welding etc. Also services such as disposal of garbage, cleaning of streets can induce noise at sensitive time of the day.

1.2.4 Domestic Noise

This type of noise is found in residential areas due to sounds from ventilation system, music from parties, lawn movers, and vacuum cleaners. Peculiar social behavior has always been a well-acknowledged problem of noise in multifamily dwellings. Also various leisure activities contribute significantly to high noise levels in the residential area.

1.3 Noise Exposure

Persistent exposure to noise is known to cause hearing loss and this hearing impairment induced, occurs at a frequency range of 3000-6000 Hz. Noise induced hearing impairment is known to be identified as an ill-health effect due to noise and is scientifically established.

In the case of temporary hearing loss, it has been found that, the threshold of hearing is temporarily elevated, known as temporary threshold shift. When the exposure towards noise is chronic, the shift in the threshold occurs which is permanent. Which actually leads to, hearing loss that may become permanent because the sensory cells which are present within the cochlea have been subjected to of irreversible damage.

Noise pollution is known to cause physiological effects such as decrease in heartbeat; variations in blood pressure levels and difficulty in breathing; cardiovascular diseases that to at a very low frequency range. Brain and the nervous system are affected by the resonance created by frequencies in the mid band level. These effects vary from individual to individual.

The psychological effects that are seen among individuals are also variable and difficult to measure. These effects include mental and physical fatigue, lack of concentration which leads to reduced efficiency of work, higher potential for injuries and accidents, sleeping disorder's (Halonen et al., 2014) which causes irritability, hypertension adding to the stress of living. Thereby requiring a need to control and regulate noise production and generation sources with the aim of maintaining the ambient air quality standards with respect to noise.

1.4 Noise Standards

The unit for measurement of noise is decibel (dB). The measurement of noise helps us to determine the detrimental sound levels and which needs to be controlled with the help of noise reduction. For noise analysis (frequency as well as amplitude) will have to be carried out to obtain noise levels using A-weighted filter, and the measurement unit is A-weighted decibels, dB(A). The frequency response of an A-weighting filter is equivalent to audibility levels of human being (about 40 dB(A). dB(A) denotes the loudness of the sound levels.

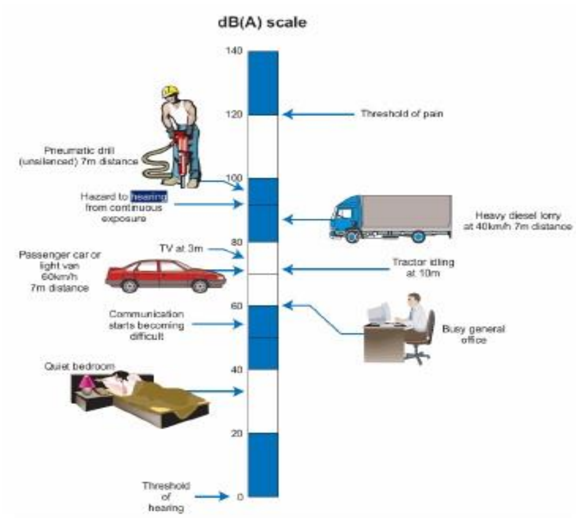

Figure 1.1 dB(A) scale showing the levels of sounds

Table1.1 Ambient noise level standards.

Area code	Zone	Limits in dB(A) for Day time	Limits in dB(A) for Night time
A	Industrial Zone	75	70
B	Commercial Zone	65	55
C	Residential Zone	55	45
D	Silence Zone	50	40

(Source: Standards of noise levels under EPA (1986), Noise Pollution (Regulation & Control) Rules, (2000)

Table 1.2 Noise standards levels of few selected countries.

Countries	Industrial		Commercial		Residential		Silence	
	Day	Night	Day	Night	Day	Night	Day	Night
Australia(dB)	55	55	55	45	45	35	45	35
India(dB)	75	70	65	55	55	45	50	40
Japan(dB)	60	50	60	50	50	40	45	35
US, EPA(dB)	70	60	60	50	55	45	45	35

Source: WHO report (2001)

Table 1.3 Recommended noise levels as given by various organizations in hospital zones

	WHO(dBA)	International Noise Council(dBA)	EPA(dBA)
Day	35	45	45
Night	30	20	35

1.4.1 Noise level in the form of (% exceeded) L_x

L_x is defined as the noise level which exceeds for x% during particular period of time or the time of monitoring. This happens due to variation in the sound pressure level with respect to time.

L_{max} = maximum noise level during monitoring time.

L_1, L_2 …. L_9 = Signifies highest noise level i.e. 1%,2%...9% of the time but these are neglected.

L_{10} = Signifies maximum noise level which exceeds 10% of the time.

L_{50} = The noise level exceeds 50% of the time. It represents the mid-point of the deviation in noise level.

L_{90} = Ambient noise level in the environment. The noise level exceeds 90% of the time.

1.4.2 L_{eq} Equivalent noise level

Equivalent noise level is defined as the mean or the average sound level which over a certain duration of time retains the same amount of the acoustic energy. The monitoring time period can be one hour, eight hours or sixteen hours.

$$L_{eq} = 10 \log_{10} \int_0^T \left[\frac{P}{Po}\right] \text{\textasciicircum} 2$$

Where, T= Total monitoring time

P= Sound pressure

P_0 = Reference pressure level ($2x10^5$ pa)

$$L_{eq} = L_{50} + (L_{10} - L_{90})^2/60$$

1.5 Effect of urbanization and population growth on noise level

Transport development is an essential component for the growth of any city. There has been an exponential growth of population which has led to an increase in the vehicle ownership along with rapid urbanization and industrialization, which is known to cause high noise levels in Indian cities.

Table 1.4 Population growth in Delhi

Year	Population(million)	Annual Growth rate(%)
1941	0.7	-
1951	1.44	7.5
1961	2.36	5.1
1971	3.65	4.5
1981	5.71	4.6
1991	9.40	6.4
2001	12.79	3.6
2010	19.00	4.8
2021	23.00	2.1

Source: Planning Department. Economic Survey of Delhi: Transport.

Table 1.5 Motor vehicles in use in Delhi (in thousands)

Year	Scooters and Motorcycles	Cars/Jeeps	Auto-rickshaws	Taxis	Buses	Freight	All motor vehicles
1971	93	57	10	4	3	14	180
1980	334	117	20	6	8	36	521
1990	1077	327	45	5	11	82	1547
2000	1568	852	45	8	18	94	2584
2010	2958	1472	103	14	39	223	4809
2020	6849	2760	209	28	73	420	10339

Source: Planning Department. Economic Survey of Delhi: Transport.

The vehicular population within the city of Delhi, increased by 135.59 % from 1999-2000 to 2015-16 and vehicular population became one crore five lakh (10567712) in May 2017, during this similar period the number of vehicles per thousand population expanded from

253 to 530. It is noticed that the road network system of the capital has expanded from 28,508 km (year 2001) to 33,663 km (year 2015) which is not sufficient, as the traffic density increases there is also increment in traffic noise level in same pattern.

In urban area Industrial, commercial activity and transportation sector contribute 75% in total noise pollution. In transportation sector road traffic noise contributes 75 % and others all contribute 25%, so that road traffic noise more affected the people.

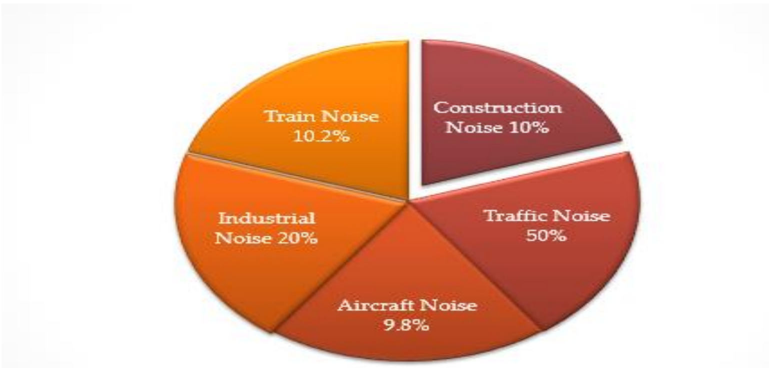

Figure 1.2 Percentage distribution of noise pollution in urban area

1.6 Application of GIS in noise mapping

Noise map graphically represents sound levels of a geographical unit for a particular time interval. These are used to analyze the sound levels and help in the pre-evaluation of action strategies and noise control methods. They are very useful for compatibility, in land-use definition, acoustic urban planning, and for the environmental impact assessment of any activity as a prelude to its implementation. To support noise effect studies a centralized spatial database management system with appropriate geographical information is required. This is developed and maintained with the help of GIS (Geographic Information System). The quality of Noise maps is improved with GIS being combined with mathematical modeling and spatial data analysis.

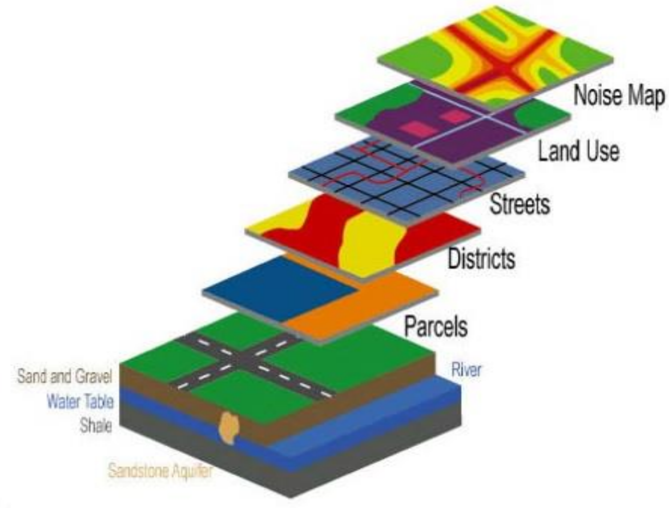

Figure 1.3: GIS based structure for noise mapping

This is done by bringing changes in data that is being used, data simplification, calculation procedures, interpolation techniques, calculation locales, other dynamics, which improve precision of results. As a result, GIS is progressively more critical in the study of the probable impact of noise pollution. GIS simplifies the graphical illustration of the noise effects and acts as a supplementary tool for analyzing the outcomes.

An integration of GIS and noise models will help in attaining noise data-models involuntarily from supporting digital geographical information. GIS database management system aids for collecting, storing, managing and governing the noise data. Noise contours are produced on the basis of various interpolation techniques available in GIS. With GIS, it is feasible to achieve a continuous spatial model of noise levels.

The quality and correctness of noise mapping is determined by the scale and also the details of the input data that is being used. At the time of noise mapping, if the concentration of information is high then accurate outcome is achieved, especially in the case where the noise levels changes quickly. The value of the outcomes of noise mapping be influenced by the nature of input data that is being used. The GIS is known to control as well as administer the kind of the outcome by considering the nature of input data into account.

Objectives

The objective of the study is as follows:

- To investigate the traffic noise at various selected locations of Delhi.
- To determine the application of ArcGIS in creating noise maps for different noise levels in the city of Delhi.
- To identify the hotspots within the city were the noise pollution level results are alarming in nature.
- To compare the noise levels with the permissible noise levels standards.

CHAPTER 2

LITERATURE REVIEW

The response of human ear to sound is logarithmic in nature rather than linear. Sound pressure is measured in units of Micro Pascal (μPa). Sound pressure of 20 μ Pa relates to the threshold hearing of an average person. It is thus known as threshold of hearing. A direct implementation of linear scales (in Pa) to the measurement of sound pressure always mains to huge numbers. As a result, the sound levels can be expressed in logarithmic scale and the logarithmic scale is called decibel or dBA.

Noise which is defined as an undesirable or an unwanted sound is the fourth pollution area after air, water and soil pollution. Noise pollution which has arisen in the recent times due to the development in technology has become one of the most important environmental problems in the world. Noise pollution has also been additionally referred to as modern plague (Goines and Hagler, 2007). Depending on factors such as duration of exposure, frequency of noise, age of the person exposed to noise, source of noise etc. it is perceived by the receiver whether noise is a disturbance or not.

Noise pollution contributes to serious psychological effects such as mental and physical fatigue, lack of concentration, sleeping disorder's etc. as reported by (Stansfeld and Matheson, 2003). It is also seen that there has also been increase in various physiological effects such as noise induced hearing loss, decrease in heartbeat; variations in blood pressure levels and difficulty in breathing as shown by (Maschke and Niemann, 2007).

In order to reduce the noise pollution, it is necessary to have evidence about the noise levels at various sites all over the city and the sources that are responsible for generating the noise, which is at the moment steered through noise mapping.

Noise map graphically represents sound levels of a site for a particular time interval. These are used to analyze the sound levels and help in the pre-evaluation of action strategies and noise control methods.

Mohammed Taleb Obaidat (2008) reported in his study that Noise maps can easily help in quantification of noise levels and their outcomes based on areas, population density and type of buildings. He has also described that Spatial noise contour maps is useful as an indicator to identify various factors that can influence road traffic noise levels, build an online traffic noise information system quantify the effects of noise over the surrounding neighborhood and developed infrastructure, manage the existing land use planning process, perform spatial queries to determine highest noise disturbance location at any time duration of the day, and control variation in land prices.

Noise map gives a deep understanding into the issues of noise control, and provides a clear, definite image of these problems. Apart from this, it also provides an in effect spatial planning and thus provide plan for noise protection of existing areas from noise sources. Noise maps are developed using a computer with software that can analyze and predict the transmission of sound in a given model. To generate a noise map, which precisely describes the current status quo it is necessary to acquire data through measurements (Jambrosic, 2011).

Noise mapping over an outsized space is produced by acting calculations that considers all, noise sources impacting a community. Noise mapping is based on simulation with the help of a computer model that aids in monitoring as well as assessing the noise effects. While assessments of noise emissions and scheming of diminution during circulation contains some inexactness, linking sample noise mapping with measured data can authorize the legitimacy of the assumptions that are used in the evaluations. However, in assessing and monitoring the noise effects of prevailing noise sources, on the basis of existing measurements overall noise mapping may be ideal if it is done efficiently, accurately and sparingly.

Giovanni Zambon et al., (2017) proposed a project that is named as Dynamic Acoustic Mapping (DYNAMAP) for developing a dynamic noise mapping system which is capable of identifying and also demonstrating inreal-time the acoustic effect of the road traffic sound levels. Noise maps were upgraded by scaling the sound levels of various pre-calculated noise maps as functions of the transformations determined between observed and calculated original grid data. The results showed that maps attained using this method can be connected with an error that will be governed by on the chosen integration time of noise levels.

Bilgehan Ilker Harman et al., (2016) for Isparta city center developed a noise map and obtained its boundary using inverse distance weighted (IDW), Kriging and multiquadric interpolation methods with four grid resolution and more than one parameters. Then, the influence of parameter selection for each procedure was investigated by considering grid resolution, namely 10 X 10 m, 50 X 50 m, 100 X 100 m and 200 X 200 m, and the performance of three methods with 50 X 50 m grid resolution were compared with each other.

Weigang Wei et al., (2015) developed a model which on the basis of measurements could dynamically update the noise maps. This model depends upon propagation models and realistic good source and a not-very-dense measurement network. For tuning model parameters, the least mean squares method (LMS) was used. The number of degrees of freedom were restricted by combination of the sources and propagation paths into different categories so as to avoid an under-determined system The efficiency of the method was corroborated in a case study in the Katendrecht district of Rotterdam, the Netherlands. The results showed that more than 75% of the LAeq predictions were nearer to the measured noise levels.

To achieve the same accuracy as standard noise mapping techniques proper implementation of participatory techniques is required as reported by (Ellie D'Hondt et al., 2013). As per the research reports an experiment for noise mapping a 1 km2 area in the city of Antwerp was selected as the area of study using Noise Tube, which is considered as a hands-on intuiting framework for monitoring environmental noise. From the data collected, noise maps of the study area with marginal errors was constructed which was as good as to that of reproduction-based noise maps.

Gaetano Licitra (2012) reviewed the procedure of noise mapping in EU and outlined that much work is to be done to standardize the noise mapping methodology so as to permit rational comparisons between regions. The report also showed that noise maps have their own restrictions but they help increase public awareness about noise exposure and soundscapes. This public alertness assists in promoting the preparation and execution of various action strategies.

Kang-Ting Tsai et al., (2009) evaluated the spatial characteristics of an environmental noise by developing noise maps acquired by data from 345 stations in Tainan, Taiwan. Noise information data were collected at flexible intervals: morning, afternoon, and evening in both summer and winter. The spatial distributions of the noise levels all through each time interval were estimated and envisioned using GIS. The analytical results showed that the maximum and minimum average noise levels were 69.6 dB(A) and 59.3 dB(A) during summer mornings and winter evenings, respectively. Assessment of monitored noise levels with respect to the standards concluded that noise standard violations, which sometimes occur during summer evenings, are as high as 23 dB(A). The results of noise exposure analysis depicted that more than 90% of the Tainan City population are open to an intolerable noise as defined by US Department of Housing and Urban Development. The study concluded that noise maps can be useful for scrutinizing noise in urban environments.

To support noise effect studies a centralized spatial database management system with appropriate geographical information is required. This is developed and maintained with the help of GIS (Geographic Information System). The quality of Noise maps is improved with GIS being combined with mathematical modeling and spatial data analysis.

In addition to being both a management system as well as a computer aided design system, GIS is a critical tool in spatial analysis and modeling. (Murphy Enda et al., 2006) had discussed the exact role of GIS in environmental noise studies in their study work. It is highly useful in environmental modeling to study ecology, atmospheric science, hydrology as well as water quality. A large number of researchers have utilized the integrated GIS traffic noise prediction model approach. However, the present linkages of GIS systems with noise models are restricted at the file-exchange level, which is both problematic as well as unsuitable. The most advantageous linkage of a noise model with GIS system would be an integrated noise-GIS system, where the noise model is produced using GIS language and all of the data are allocated. In such a system, noise modeling becomes one of the outcomes within the GIS system.

Mohammed Taleb Obaidat (2008) has talked about various use of GIS in noise effect studies like: accumulating the characteristics of the study on noise pollution, assisting environment management, forming an association among geographical, geometrical information of the surrounding environment as well as the noise prediction model, calculating the effect of noise on the environment, presenting, storing, managing, analyzing, and visualizing capabilities of the database, providing a monitoring and quantifying noise tool etc.

Bengang Li et al., (2001) developed a road traffic noise prediction model on the basis of noise emission levels of automobiles, environmental standards, and traffic conditions in Chinese cities, which can be used in urban traffic noise prediction as well as assessment.

A day and night road traffic noise maps for Guangzhou using Geographical Information Systems (GIS) and Global Positioning Systems (GPS) was developed by (Ming cai et al., 2014). An algorithm was optimized with the use of computational grids, filtering of traffic noise sources automatically and performing a quick index of the estimation objects. The correctness of the developed algorithm was supported by conducting a road traffic noise monitoring experiment within several districts of Guangzhou with respect to different road types. The results showed that the average error between the estimated and measured values is less than 2.0 dB

Alejandro Dintrans and Margarita Préndez (2013) developed a process to evaluate measures to reduce traffic noise by modeling and quantifying its bearing on the population near the main roads inside the urban outer limits. An iterative framework projection method based on the relations of a Geographic Information System (GIS) and a computational noise prediction module was suggested and applied in Santiago, Chile. The noise prediction model was able to act out the impact of diverse action plans by merging solitary measures.

Joon Hee Ko et al., (2010) developed a noise map and noise impact assessment method using GIS. After developing a road-traffic noise map for the city of Chungju, Republic of Korea, noise impact assessment was accomplished by evaluating the map. With the help of digital maps, a 3D terrain model was produced and with the use of the information from draft and digital maps building models were produced. The noise levels at 25 locations were measured and related with the expected noise levels to verify the developed noise map. An excess noise map was generated from a comparison between the road-traffic noise map and a noise-standard map. Using the surplus noise map, the areas surpassing environmental noise standards were effectively evaluated through GIS.

Noise mapping softwares are known to easily influence the quality of results. (Douglas Manvell and Erwin Hartog van Banda 2010) described the major factors that affect good practice: the user's knowledge about the software, documentation of software functions and its implementation of the standards, the user's knowledge of the standards, level of assurance of software enactment and the user's examination of the quality and influence of the input data.

Thus it is concluded that noise map provides baseline data for town planners, engineers and others for planning and execution of the projects. Spatial maps are very important for city planning and traffic engineers for the purpose of zoning, land use and traffic management. Analysis of noise maps are vital part of the town planning and traffic management as recommended by previous studies.

CHAPTER 3

INTEGRATED FRAMEWORK FOR MAPPING URBAN NOISE POLLUTION

3.1 Fieldwork and methodology

3.1.1 Study area

The city of Delhi, National capital territory of Delhi is one of the union territories of India and is bordered by the state of Haryana on its three sides and by the state of Uttar Pradesh. It comprises an area of 1428 km^2 and is the second most populous city in the country. Although conversationally Delhi and New Delhi as names are used indistinguishably to discuss with the dominion of NCT of Delhi, these are two well-defined entities, and the latter is a small part of the former. Delhi combined with cities Noida, Gurugram, Ghaziabad and Faridabad makes it the world's second largest urban area. Since the exponential growth in population, development of industrial areas, automobiles and other manmade activities, the city of Delhi has started facing noise pollution complications. Moreover, in the future this noise pollution problem will become burdensome. It is, therefore, necessary to articulate and execute suitable strategies to curb-down noise pollution from the futuristic point of view.
The location for the study includes the combination of Industrial, Commercial, Residential and silent zones within the city of Delhi as shown in Figure 3.1.

To determine the environmental noise levels and evaluate the noise pollution in the city of Delhi is predominantly due to traffic mobility within the city, the following locations along with their characteristics have been listed in the Table 3.1:

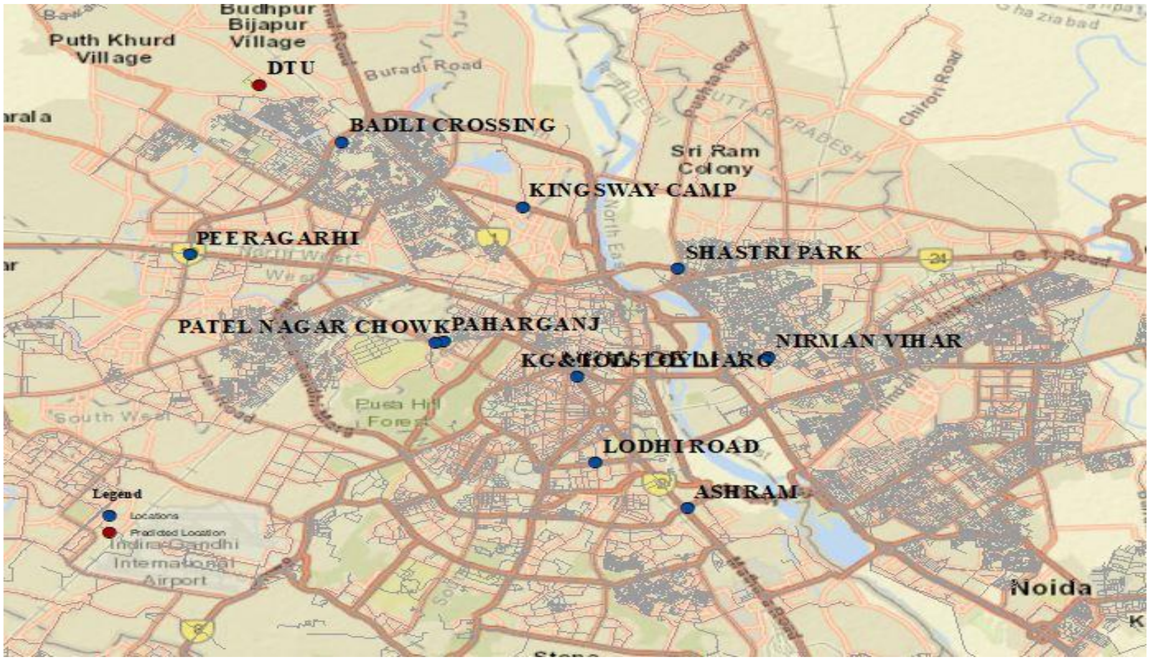

Figure 3.1: Site Locations on the map of Delhi

Table 3.1: Site locations selected in Delhi

No.	Location	Area	One side	Other side
1	Badli Crossing	Mixed	Building	Open
2	Lodhi Road	Silence Zone	Building	Open
3	Ashram Chowk	Mixed	Building	Building
4	K.G & Tolstoy Marg	Silence Zone	Building	Open
5	Kingsway Camp	Residential	Building	Building
6	Nirman Vihar	Commercial	Building	Building
7	Paharganj Chowk	Commercial	Building	Building
8	Patel Nagar	Mixed	Building	Open
9	Peeragarhi	Commercial	Building	Open
10	Shastri Park	Residential	Building	Open

3.2 Tools and Techniques

3.2.1 Sound Level Meter

A sound level meter as the one shown in Figure 3.2 is a device that is used to measure sound pressure level (SPL). It is commonly used in noise pollution studies for the quantification of different kinds of sound levels, especially for environmental, industrial and commercial. The Figure 3.3 represents the functional diagram of the sound level meter. The traffic noise level has been observed at a distance of 1m from the edge of the road and the height of the sound level meter is taken as 1.5m. It is considered as the average height for human ear. CESVA SC 260 sound level meter is the type 2 instrument based on integrating averaging sound level meter(SLM) and 1:1 and 1:3 octave band spectrum analyzers.

Figure 3.2: Sound Level Meter

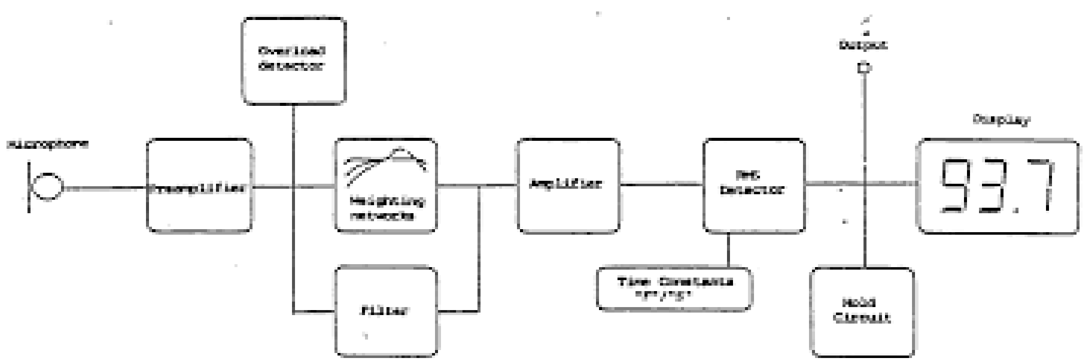

Figure 3.3: Functional diagram of sound level meter

3.2.2 Arc GIS

ArcGIS version 10.4 is a state-of-art GIS software platform established by ESRI. The software package can be used in a large space of general yet definite GIS applications and may be drawn-out simply.

To support noise-effect studies a centralized spatial database management system with admissible geographical information is essential. This is developed and maintained with the help of GIS (Geographic Information System). The quality of Noise maps is improved with GIS being combined with mathematical modeling and spatial data analysis.

This is done by bringing changes in the data being used, data simplification, calculation techniques, interpolation processes, calculation settings, other factors, which improve precision of outcomes. GIS is increasingly critical in the study of the probable impact of noise pollution. GIS aids the graphical illustration of the noise effects and acts as a supplementary tool for analyzing the results.

An integration of GIS and noise models will make it feasible to generate noise data-models automatically from existing digital geographical information. GIS database management system aids collecting, storing, managing and controlling the noise data. Noise contours are developed based on the interpolation techniques accessible in GIS. With GIS it is possible to build a continuous spatial model of the environmental noise levels.

The nature and accuracy of noise mapping depends upon the scale as well as details of the input data. During noise mapping, if the concentration of information is high then precise outcomes can be achieved, especially in the case where the noise levels changes quickly. The value of the effects of noise mapping rely on the characteristics of input data used. The GIS can influence as well as administer the quality of the results by allowing for the nature of input data into account.

3.3 Noise monitoring at different locations

3.3.1 Badli Crossing

The Badli crossing is located at a distance of 500 meters from the Haiderpur Badli Mor metro station. It is at the intersection of the outer ring road and Dr. MC Davar Marg. The land use pattern is mixed type.

Figure 3.4: Noise monitoring at Badli crossing

3.3.2 Lodhi Road

Lodhi road is the oldest road and it connects Nizamuddin village to Jor Bagh. Safdarjung's tomb and Humayun's tomb are situated on western and eastern ends of the road respectively. The land use pattern of this location is silence zone.

Figure 3.5: Noise monitoring at Lodhi road

3.3.3 Ashram Chowk

Ashram Chowk is situated at the intersection of the Mathura road and Mahatma Gandhi ring road. Its located at the south-east corner of Delhi. The land use pattern of this area is found to be mixed type. Ashram chowk is one of the busiest intersection because of link up between Uttar Pradesh and Haryana border.

Figure 3.6: Noise monitoring at Ashram Chowk

3.3.4 K.G & Tolstoy Marg

It is one of the roads to connect to Connaught Place. The road has been named Tolstoy Marg in honor of Leo Tolstoy, Russian philosopher and writer. Curzon road after independence was named as Kasturba Gandhi Marg. The land use pattern in this area is silence zone.

Figure 3.7: Noise monitoring at K.G & Tolstoy Marg

3.3.5 Kingsway Camp

Kingsway Camp is highly populated area. The land use pattern in Kingsway Camp is Residential type.

Figure 3.8: Noise monitoring at Kingsway Camp

3.3.6 Nirman Vihar

Nirman Vihar is located at the intersection of Vikas Marg and Patparganj road in east Delhi. Nirman Vihar metro station on blue line. The land use pattern in this area is Commercial type.

Figure 3.9: Noise monitoring at Nirman Vihar

3.3.7 Paharganj Chowk

Paharganj Chowk is situated at the intersection of Deshbandhu and Chitra gupta road in central Delhi. Paharganj is one of the hub for foreign and domestic tourists and is situated near New Delhi railway station. The land use pattern in this area is commercial type.

Figure 3.10: Noise monitoring at Paharganj chowk

3.3.8 Patel Nagar Chowk

Patel Nagar Chowk is located at the intersection of Shankar road and Pusa link road near the pasha harit kranti park. The land use pattern of this area is found to be of mixed type.

Figure 3.11: Noise monitoring at Patel Nagar chowk

3.3.9 Peeragarhi Chowk

Peeragarhi chowk is located at the intersection of Rohtak and outer ring road in west Delhi. The land use pattern of this area is mixed type.

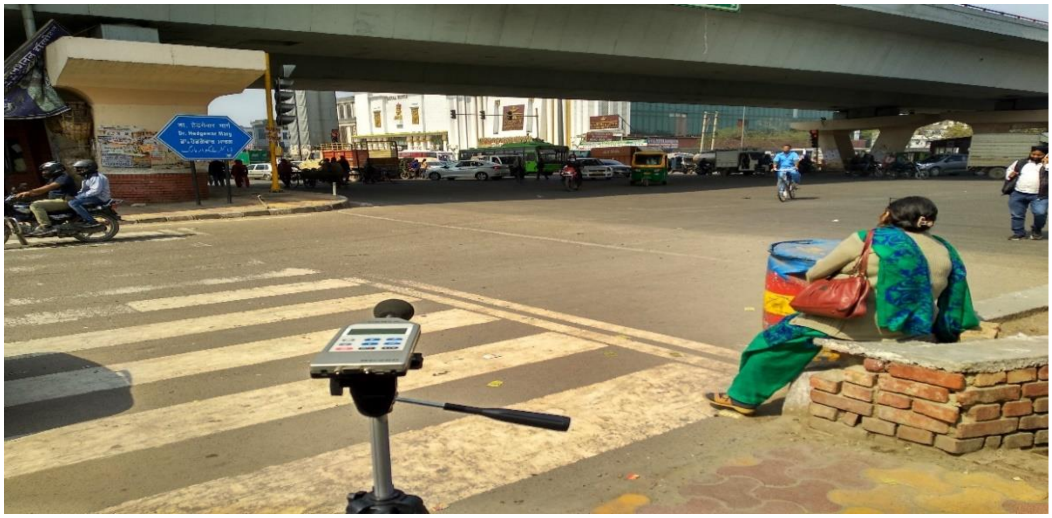

Figure 3.12: Noise monitoring at Peeragarhi chowk

3.3.10 Shastri Park

Shastri park is located in north east Delhi. It is the location of one of the very first metro station in the city of Delhi. The land use pattern of this area is residential type.

Figure 3.13: Noise monitoring at Shastri Park

3.4 Research Design

The research methodology includes selection or identification of study area, collection of noise level data and location details, development of noise maps and its plotting using GIS and its validation. The methodology is shown in Figure 3.14.

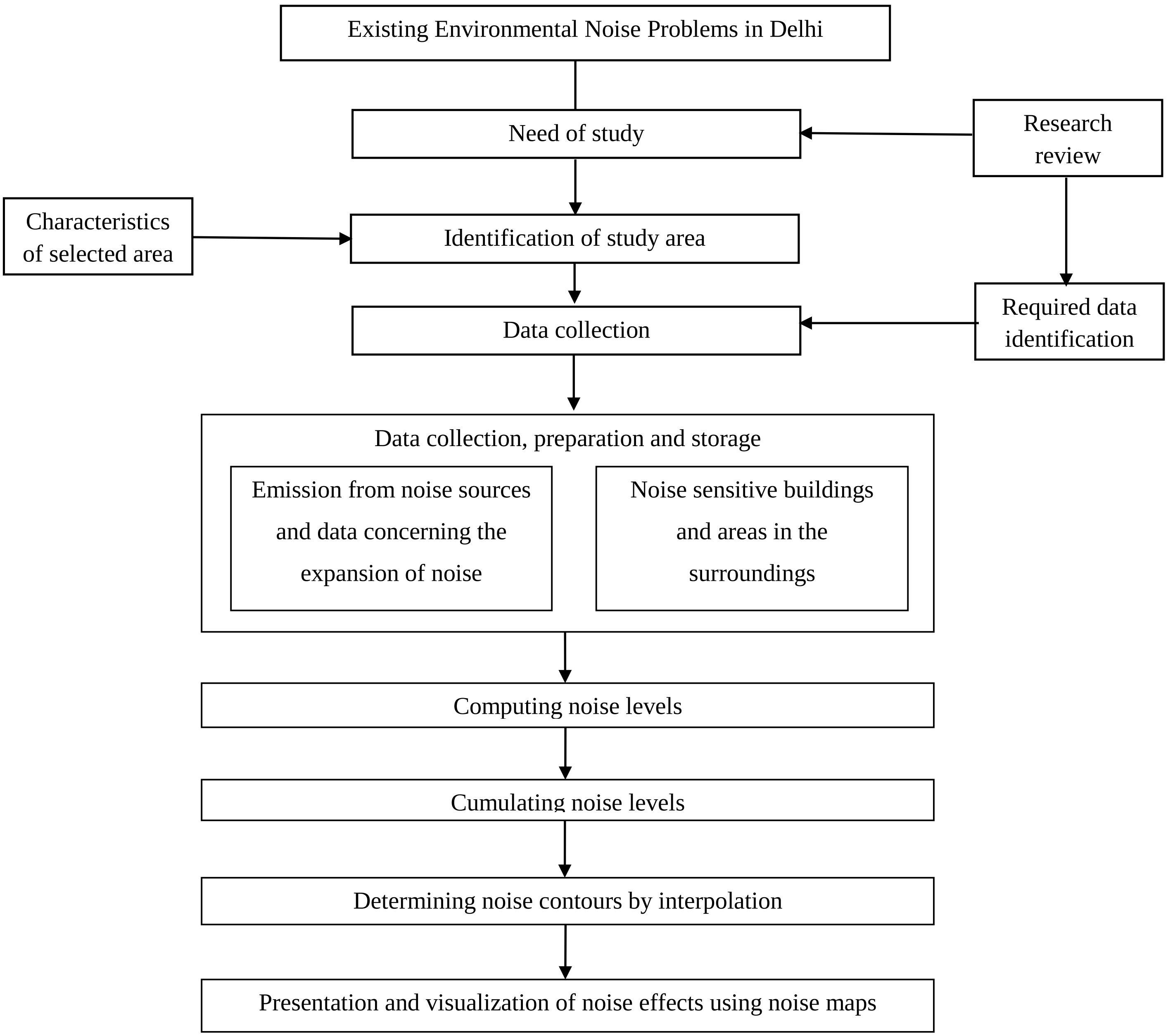

Figure 3.14: Framework methodology for noise mapping

3.4.1 Collection of Data

A noise effect study along with the essential data and the possibilities also needs a central spatial database to process the data in a GIS. The data can be classified into two types:

i. Data needed to assess noise levels i.e. the noise emission from the source and the factors that influence its transmission.
ii. Data about the location of people and their activities with respect to their sensitivity towards noise.

Combining the results from the two sets of data, the noise effects can be determined. The accuracy of the work depends upon the scale and level of detail of the data. In order to restrict the time duration required for collection, preparation and computation of data high amount of detailing should be avoided.

In this work data collection was done as follows:

- The study area was visited with the instrument and the data was collected for both peak hours during the morning and evening and also for off-peak hours
- Recording of the data value was done at an interval of 15 minutes. Using CESVA SC 260 sound level meter.
- Height of the instrument from the road surface is 1.5m. It is the average height of the ear of all women, men and children. The sound level meter should be kept at a proper distance from the edge of the road for safety purpose.

Figure 3.15: Sound Level Meter attached on tripod

3.4.2 Analysis of Data

Data analysis comprises of the following steps:

i. Computation of Noise Levels

In noise effects study computation of noise levels is preferred to that of measurement, the reason being that for measurement a large no. of measuring points is required for obtaining a clear picture of the noise situation which is practically infeasible to achieve. The computation methods are designed to give a precise result which is only obtained when these are adopted to the essential level of detail.

ii. Determining The Noise Contours

With the support of GIS, Noise contours are prepared by interpolating the noise levels of observation points. These interpolation techniques that are available in GIS are used to develop noise maps. It is important that these noise maps should be produced with high accuracy by taking high density observation points.

The noise levels are calculated using standard noise calculation models and then these models are integrated with GIS to develop noise maps

On the basis of the nature and characteristics of data set any method can be selected for interpolation. Noise contours for this study was developed using the following interpolation method.

Inversed Distance Weighted interpolation (IDW):

The inverse distance weighed interpolation (IDW) assumes that the value of an attribute z at some unidentified points is a distance mean of data points arising within a neighbourhood or space adjoining the unidentified point. This technique is suitable when the impact of variable being mapped reduces with distance from sample position.

Distance plays a significant role in IDW. The following choice has to be made before carrying out IDW interpolation:

- the amount of recognized data points to be used
- about maximum distance to identified data points
- scattering of recognized data points.

3.4.3 Presentation of noise levels

To give a more valuable significance to the results, understanding and presentation of the quality of the results is needed The dependability of the results depends upon the precision and quality of the data being used and the effectiveness and correctness of the computation process used. Practices for dealing with data scantiness and for revealing the quality of the results should be useful in noise effects studies.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Traffic noise monitoring at different locations

4.1.1 Variation of the average noise level during peak & off peak hours at Badli Crossing

At Badli Crossing, average road traffic noise level varied from 77.26 dB(A) to 80.44 dB(A) and 78.9 dB(A) to 82.6 dB(A), during morning and evening peak hours respectively, whereas during off- peak hours, the noise level varied from 69.42 dB(A) to 66.64 dB(A). The variation of road traffic noise level with respect to traffic volume is as shown in Figure 4.1. The noise level was found to be highest i.e. 80.44 dB(A) for the time period of 9am to 10am during which the traffic volume is found to be 14436. Also the noise levels were found to be exceeding the standards laid down by CPCB.

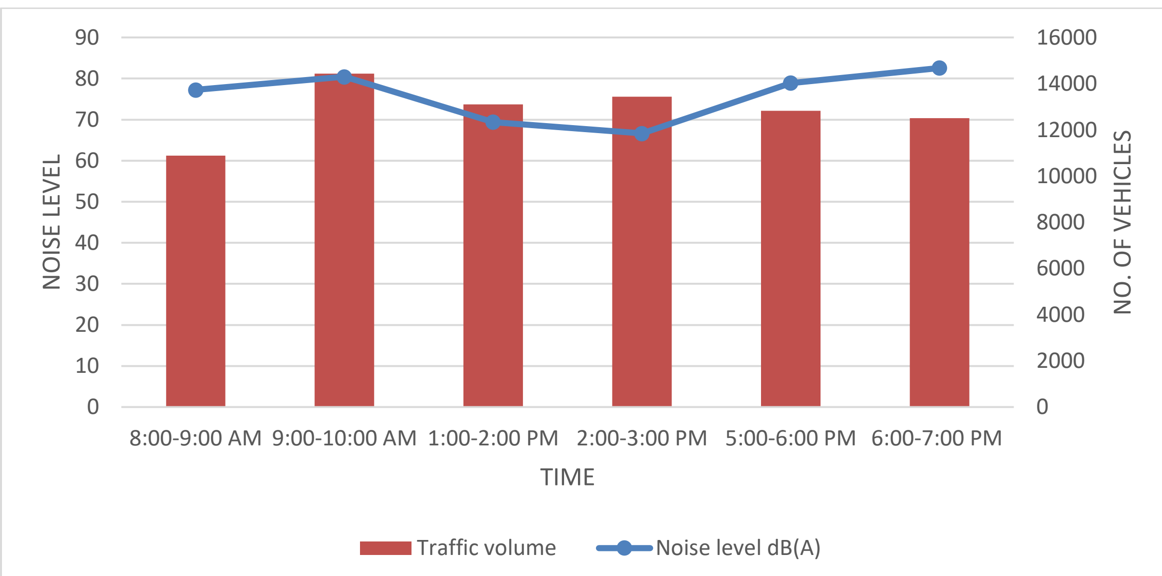

Figure 4.1: Traffic noise level vs Traffic volume at Badli Crossing

4.1.2 Variation of the average noise level during peak & off peak hours at Lodhi Road

The average road traffic noise level at Lodhi Road varied from 72.38 dB(A) to 77.84 dB(A), in the morning peak hour and in the evening peak hour it varied from 76.94 dB(A) to 83.72 dB(A). During the off-peak hours, the average road traffic noise level was found to be 65.49 dB(A). The highest noise level was found to be 83.72 dB(A) corresponding to the traffic volume of 6991 for 6pm-7pm time duration. In comparison to the permissible limit set by CPCB for silence zone i.e. 50 dB(A), the value measured was found to be high.

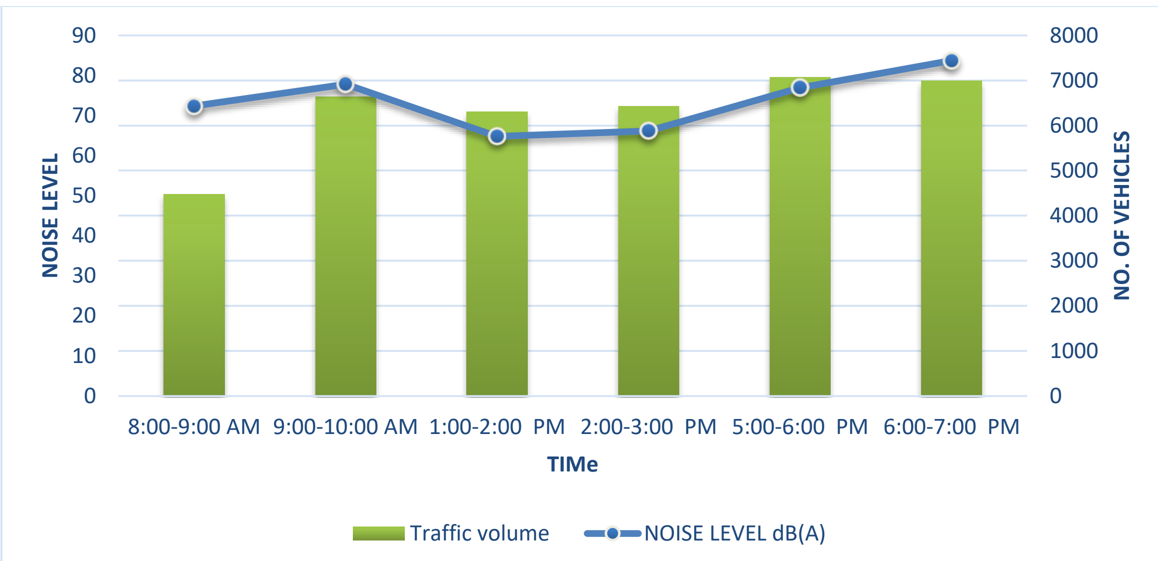

Figure 4.2: Traffic noise level vs Traffic volume at Lodhi Road

4.1.3 Variation of the average noise level during peak & off peak hours at Ashram Chowk

At Ashram Chowk, average road traffic noise level varied from 72.28 dB(A) to 79.48 dB(A) and from 79.94 dB(A) to 82.74 dB(A), during morning and evening peak hours respectively. Variation of road traffic noise level with respect to traffic volume is as shown in Figure 4.3. The noise level was found to be highest i.e. 82.74 dB(A) for the time period of 6pm to 7pm, during which the traffic volume is found to be 45380. The noise level During evening peak hours, the road traffic noise level is high due to heavy traffic flow and irregular movement of vehicles.

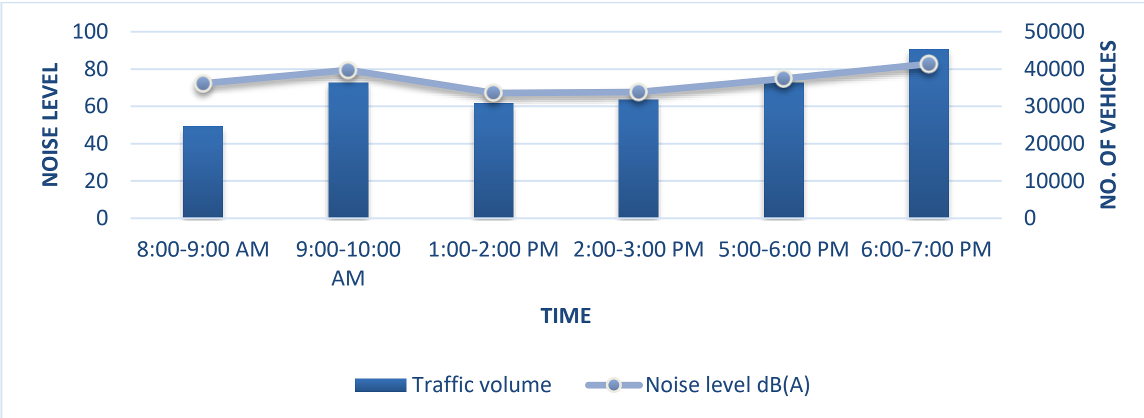

Figure 4.3: Traffic noise level vs Traffic volume at Ashram Chowk

4.1.4 Variation of the average noise level during peak & off peak hours at K. G & Tolstoy Marg

The average road traffic noise level at K.G & Tolstoy Marg varied from 72.7 dB(A) to 76.86 dB(A), in the morning peak hour and in the evening peak hour it varied from 71.98 dB(A) to 76.2 dB(A). During the off-peak hours, the average road traffic noise level was found to be 64.25 dB(A). The highest noise level was found to be 76.86 dB(A) In comparison to the permissible limit set by CPCB for silence zone i.e. 50 dB(A), the value measured was found to be high.

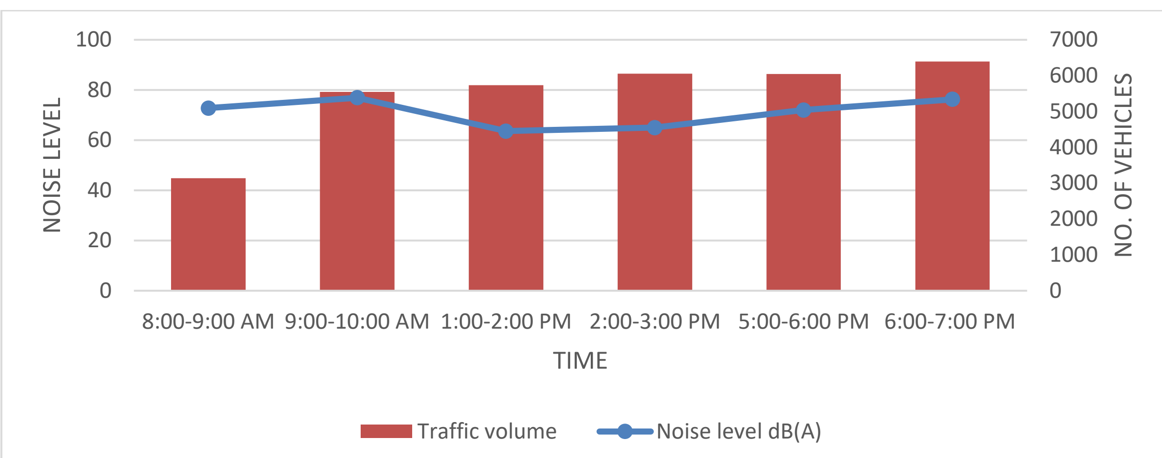

Figure 4.4: Traffic noise level vs Traffic volume at K.G & Tolstoy Marg

4.1.5 Variation of the average noise level during peak & off peak hours at Kingsway Camp

At Kingsway Camp, average road traffic noise level varied from 71.9 dB(A) to 78.12 dB(A) and 72 dB(A) to 79.34 dB(A), during morning and evening peak hours respectively, whereas during off-peak hours, the noise level varied from 67.78 dB(A) to 69.26 dB(A). The variation of road traffic noise level with respect to traffic volume is as shown in Figure 4.5. The highest noise level was found to be 79.34 dB(A) corresponding to the traffic volume of 6190, during 6pm-7pm time duration. In comparison to the permissible limit set by CPCB for residential zone i.e. 55 dB(A), the value measured was found to be high.

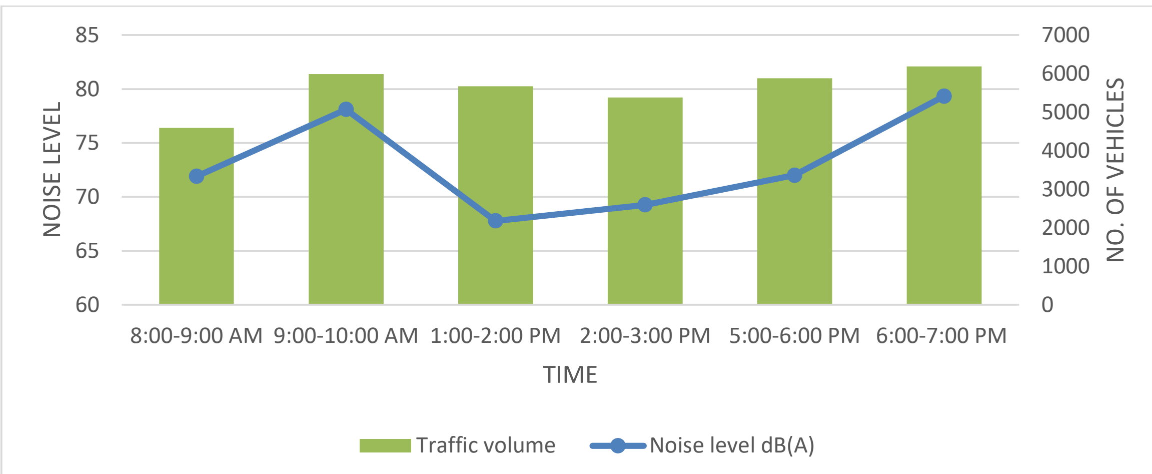

Figure 4.5: Traffic noise level vs Traffic volume at Kingsway Camp

4.1.6 Variation of the average noise level during peak & off peak hours at Nirman Vihar

The average road traffic noise level at Nirman Vihar varied from 69.46 dB(A) to 76.18 dB(A), in the morning peak hour and in the evening peak hour it varied from 74.76 dB(A) to 79.14 dB(A). During the off-peak hours, the average noise level was found to be 69.82 dB(A). The noise level was found to be highest i.e. 79.14 dB(A) for the time period of 6pm to 7pm during which the traffic volume is found to be 10157. In comparison to the permissible limit set by CPCB for commercial zone i.e. 65 dB(A), the value measured was found to be high.

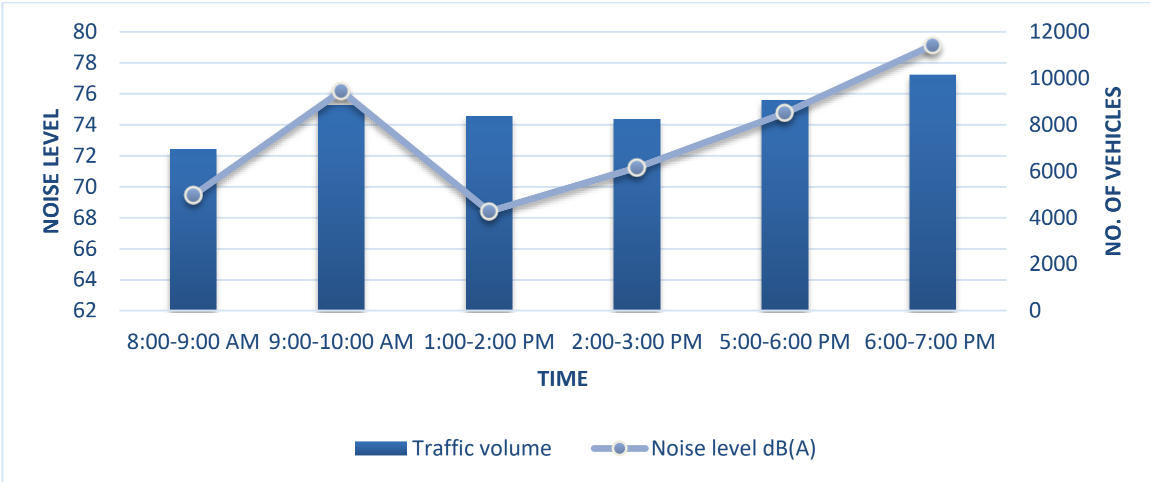

Figure 4.6: Traffic noise level vs Traffic volume at Nirman Vihar

4.1.7 Variation of the average noise level during peak & off peak hours at Paharganj Chowk

At Paharganj Chowk, average road traffic noise level varied from 73.28 dB(A) to 77.76 dB(A) and from 79.66 dB(A) to 83.46 dB(A), during morning and evening peak hours respectively. The highest noise level was found to be 83.46 dB(A) corresponding to the traffic volume of 7504, during 6pm-7pm time duration. Variation of road traffic noise level with respect to traffic volume is as shown in Figure 4.7. During evening peak hours, the traffic noise level is high due to heavy traffic flow and irregular movement of vehicles.

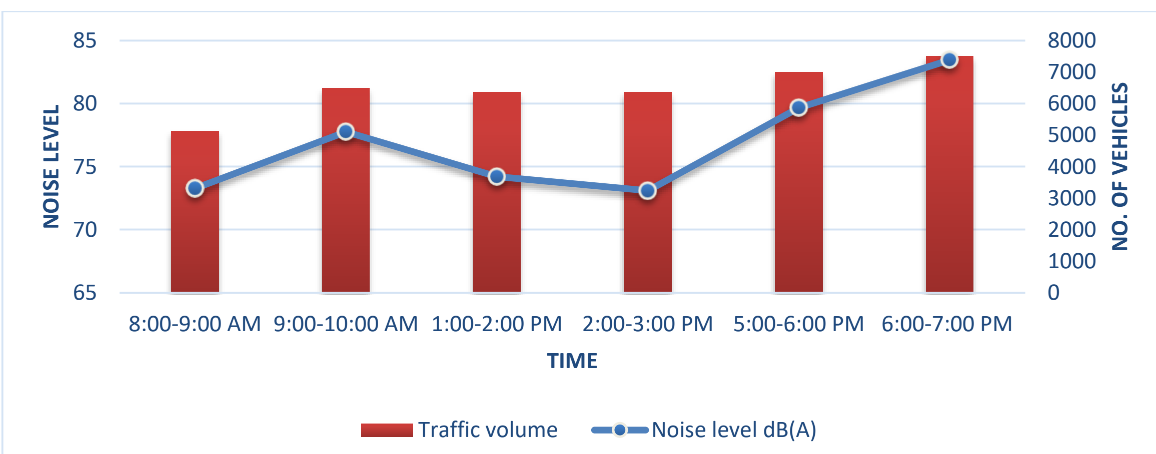

Figure 4.7: Traffic noise level vs Traffic volume at Paharganj Chowk

4.1.8 Variation of the average noise level during peak & off peak hours at Patel Nagar Chowk

The average road traffic noise level at Patel Nagar Chowk varied from 68.5 dB(A) to 73.44 dB(A), in the morning peak hour and in the evening peak hour it varied from 75.7 dB(A) to 80.1 dB(A). The noise level was found to be highest i.e. 80.1 dB(A) for the time period of 6pm to 7pm during which the traffic volume is found to be 31791. Also the noise levels were found to be exceeding the standards laid down by CPCB.

During the off-peak hours, the average noise level varied from 68.16 dB(A) to 73.34 dB(A).

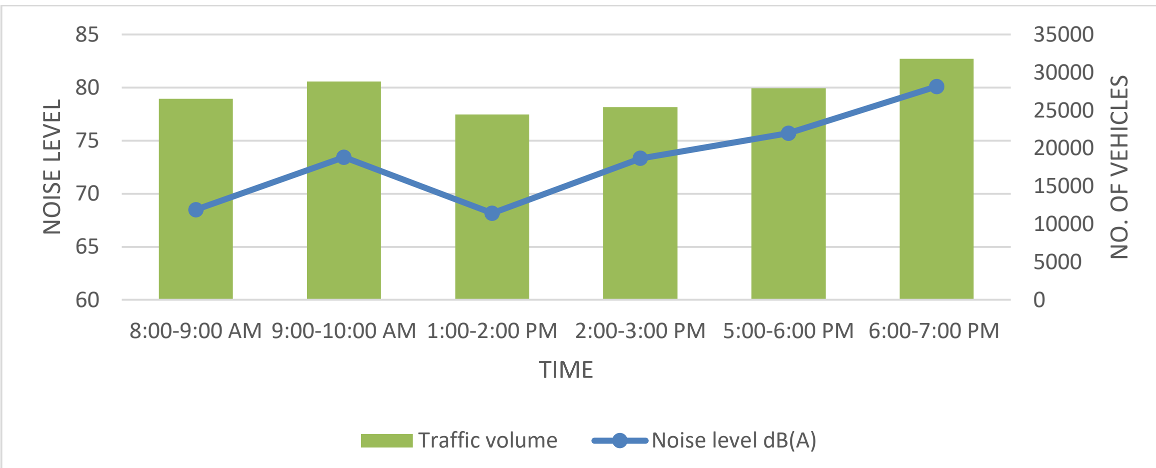

Figure 4.8: Traffic noise level vs Traffic volume at Patel Nagar Chowk

4.1.9 Variation of the average noise level during peak & off peak hours at Peeragahri Chowk

At Peeragarhi Chowk, average road traffic noise level varied from 74.2 dB(A) to 77.84 dB(A) and 79.86 dB(A) to 82.38 dB(A), during morning and evening peak hours respectively, whereas during off-peak hours, the noise level varied from 69.4 dB(A) to 70.9 dB(A). The variation of road traffic noise level with respect to traffic volume is as shown in Figure 4.9. The highest noise level was found to be 82.38 dB(A) corresponding to the traffic volume of 21636 for 6pm-7pm time duration. In comparison to the permissible limit set by CPCB for commercial zone i.e. 65 dB(A), the value measured was found to be high.

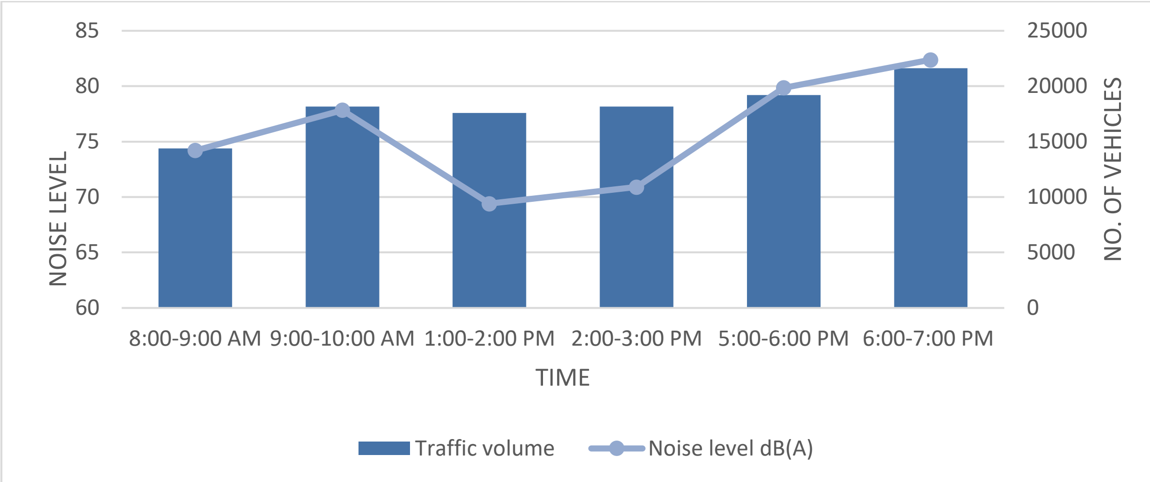

Figure 4.9: Traffic noise level vs Traffic volume at Peeragarhi Chowk

4.1.10 Variation of the average noise level during peak & off peak hours at Shashtri Park

The average road traffic noise level at Shastri Park varied from 74.24 dB(A) to 78.84 dB(A), in the morning peak hour and in the evening peak hour it varied from 74.96 dB(A) to 78.76 dB(A). During the off-peak hours, the average noise level was found to be 64.25 dB(A). The highest noise level was found to be 78.84 dB(A) corresponding to the traffic volume of 15306 for 6pm-7pm time duration. In comparison to the permissible limit set by CPCB for residential zone i.e. 50 dB(A), the value measured was found to be high.

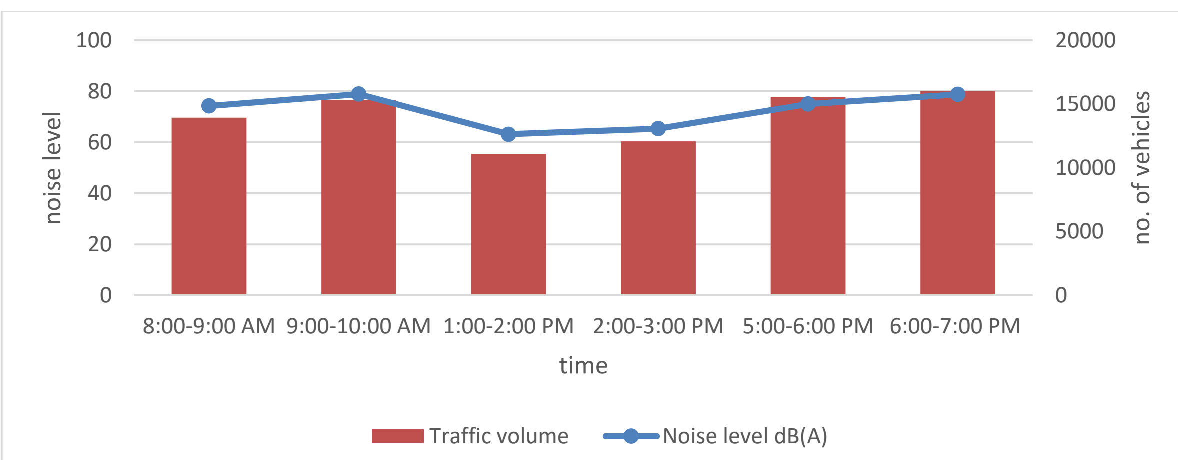

Figure 4.10: Traffic noise level vs Traffic volume at Shastri Park

4.2 Noise mapping at selected locations and validation of results

The noise maps for different noise levels within the city of Delhi has been created with the application of ArcGIS. These noise maps help in investigating the noise levels within the city. Noise map graphically represents sound levels of a region for a particular time interval. These are used for the assessment of sound levels and help in the pre-evaluation of action plans and noise control measures. This is done by comparing the noise levels with the permissible noise level standards. Thus noise mapping helps with the reduction in noise pollution by providing information about the noise levels at various locations throughout the city.

4.2.1 Duration of the day (8am-10am)

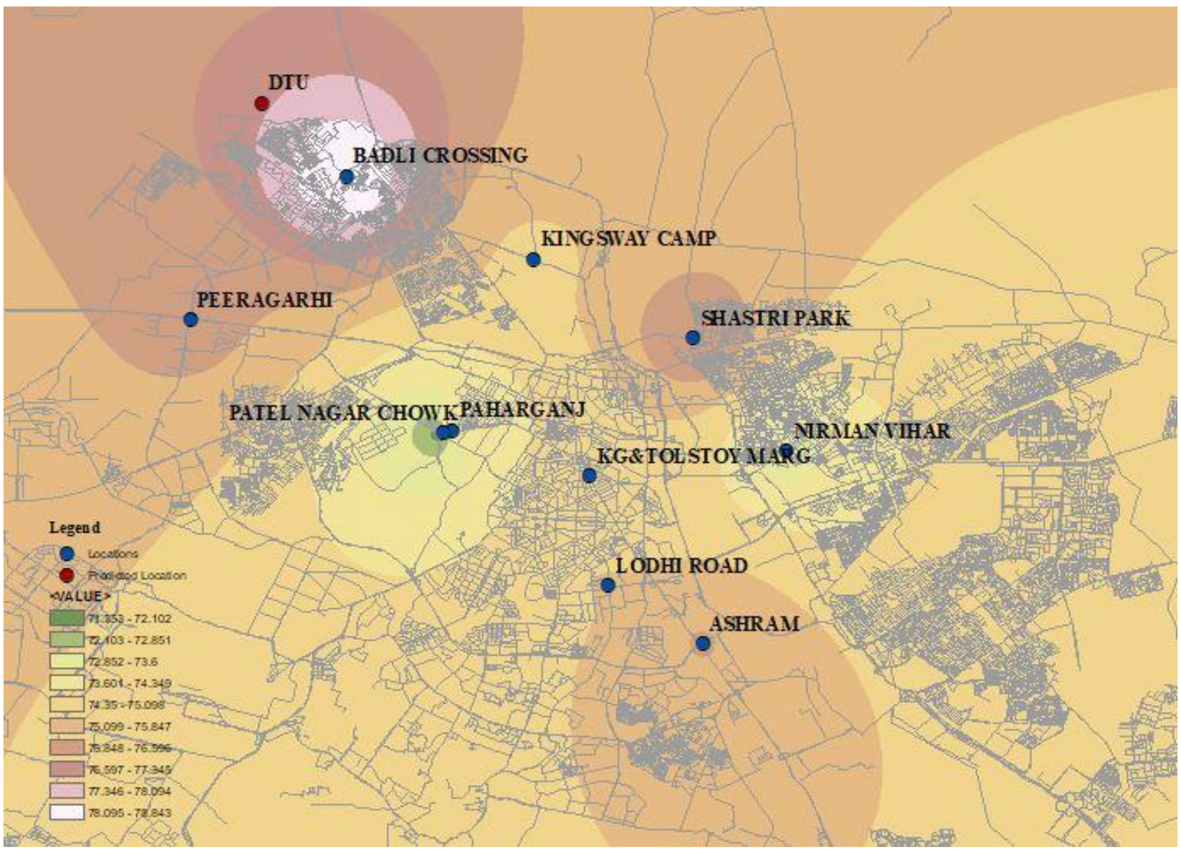

Figure 4.11: Noise map showing variation of noise level for the duration (8am -10am)

As shown in the noise map, the traffic noise level at Badli crossing is found to be highest. The value of noise level is found to be within the range of 78.095 dB(A)-78.843 dB(A). The area for these values of noise level has been depicted with white color. The minimum value of traffic noise level was found to be at Patel nagar chowk, the value obtained in this region lies within the range of 71.353 dB(A)-72.101 dB(A). The area for these values of noise level has been shown with dark green color. At Peeragarhi chowk and Shastri park, the value of the traffic noise level was found to be within the range of 75.848 dB(A)-76.996 dB(A).

At Lodhi road and Ashram chowk the value of the road traffic noise was with the range of 75.099 dB(A)-75.847 dB(A). At Kingsway camp the value was with 74.35 dB(A)-75.098 dB(A).

Also, the difference between monitored and predicted noise level in the morning peak hours at DTU was found to be 4.38 dB(A). The percentage difference between the monitored and predicted noise level as obtained from the developed noise was found to be 6.09%.

4.2.2 Duration of the day (12pm-2pm)

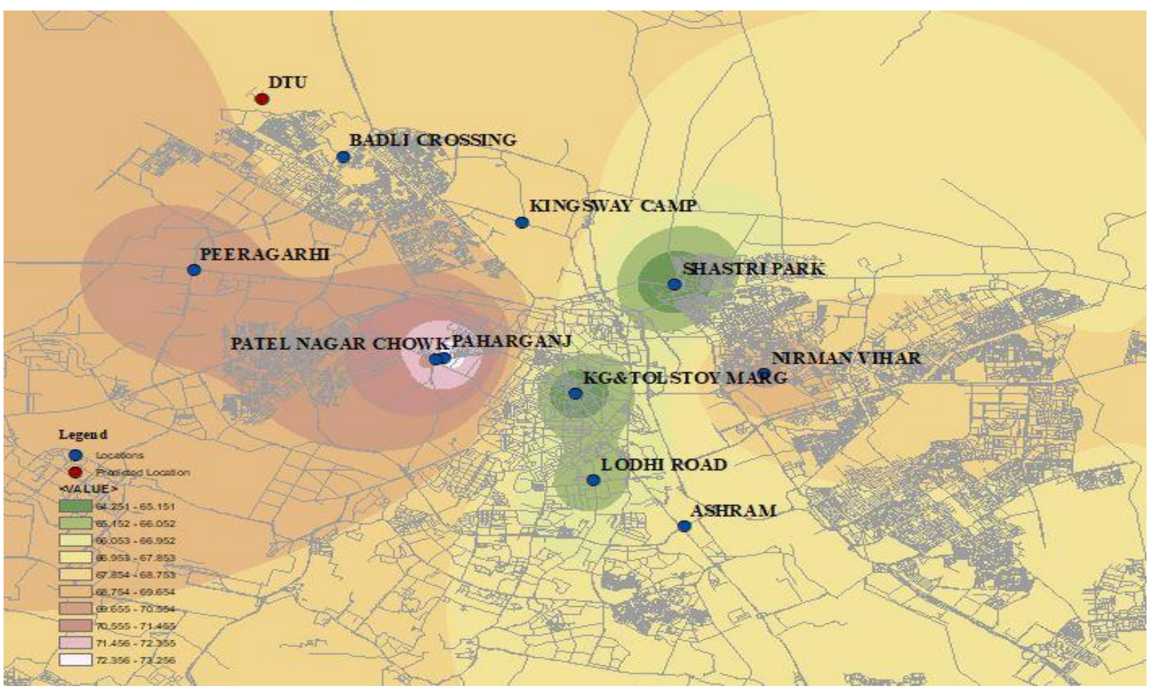

Figure 4.12: Noise map showing variation of noise level for the duration (12pm -2pm)

As shown in the noise map, the traffic noise level at Paharganj chowk is found to be highest. The value of noise level is found to be within the range of 72.356 dB(A)-73.256 dB(A). The area for these values of noise level has been depicted with white color. The minimum value of traffic noise level was found to be at Shastri park chowk and K.G. Tolstoy Marg, the value obtained in this region lies within the range of 64.251 dB(A)-65.151 dB(A). The area for these values of noise level has been shown with dark green color. At Peeragarhi chowk the value of road traffic noise was found to be within the range of 70.555 dB(A)-71.455 dB(A). At Patel nagar chowk the value was within 71.456 dB(A)-72.355 dB(A). At Nirman vihar chowk the value was within the range of 68.754 dB(A)-69.654 dB(A). At Ashram chowk the value obtained was between 67.854 dB(A)-68.753 dB(A). At Badli crossing, the noise level was found to vary between 68.754 dB(A)-69.654 dB(A) which was similar to that being measured at Kingsway Camp as well.

Also, the difference between monitored and predicted noise level in the off peak hours at DTU was found to be 3.12dB(A). The percentage difference between the monitored and predicted noise level as obtained from the developed noise was found to be 4.72%.

4.2.3 Duration of the day (5pm-7pm)

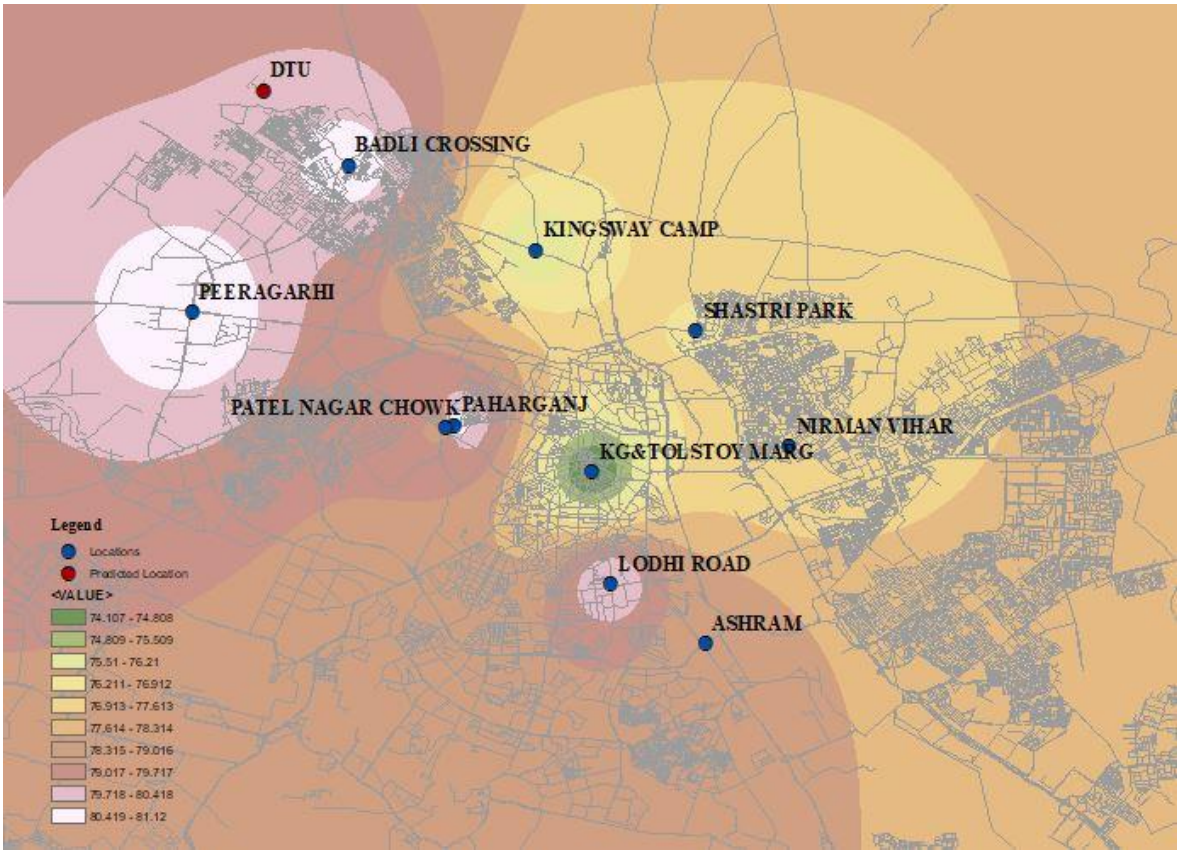

Figure 4.13: Noise map showing variation of noise level for the duration (5pm -7pm)

As shown in the noise map, the traffic noise level at Peeragarhi chowk and Badli crossing is found to be highest. The value of noise level is found to be within the range of 80.419 dB(A)-81.12 dB(A). The area for these values of noise level has been depicted with white color. The minimum value of traffic noise level was found to be at K.G. Tolstoy Marg, the value obtained in this region lies within the range of 74.107 dB(A)-74.808 dB(A). The area for these values of noise level has been shown with dark green color. At Kingsway Camp the value obtained was within 75.211 dB(A)-76.912 dB(A). At Lodhi road the value lied within the range of 79.718 dB(A)-80.418 dB(A).

At Shastri park the value of noise level varied between 75.211 dB(A)-76.912 dB(A). At Ashram chowk the noise level was found to be between 79.070 dB(A)-79.717 dB(A).
The difference between monitored and predicted noise level in the off peak hours at DTU was found to be 4.70 dB(A). The percentage difference between the monitored and predicted noise level as obtained from the developed noise was found to be 6.25%.

On the basis of the analysis between monitored and predicted noise levels, it has been found that the predicted noise levels at the location is found to be a bit higher in comparison to the measured value. For each time duration the percentage error has also been calculated and is found to lie within the range of 4% to 7%.

CHAPTER 5

CONCLUSION

After the analysis of the collected data, the noise levels due to road traffic was found more than the standard noise level as prescribed by CPCB at each location.

It is observed that the vehicular noise contributes significantly in noise generation at all the study locations. The noise levels are found to be in proportion to the vehicular population.

The traffic noise level was observed to be much more during the evening time as compared to morning time at all the locations. The reason behind this higher traffic noise may be due to high traffic density during the evening period and irregular movement of vehicles violating traffic signals during peak hours.

During the morning peak hours i.e. from 8 am to 10 am, the road traffic noise level was found to be maximum at Badli crossing. The noise level varied between the range of 78.095 dB(A)-78.843 dB(A). Whereas at Patel nagar chowk the noise level was found to be minimum with values between 71.353 dB(A)-72.101 dB(A).

During the evening peak hours i.e. from 5pm to 7pm, the road traffic noise level was minimum at Shastri park and K.G & Tolstoy Marg respectively. Also the noise levels in these areas was within the range of 74.101 dB(A)-74.808 dB(A). The maximum noise level value was obtained at Peeragarhi chowk and Badli crossing respectively for the evening peak hour duration and the corresponding value of noise level obtained was between 80.419 dB(A)-81.12 dB(A).

For the off-peak hours i.e. from 12pm to 2pm, the road traffic noise level was found to be maximum at Paharganj chowk, the noise level obtained in this region has a value between 72.356 dB(A)-73.256 dB(A). Whereas at Shastri park and K.G & Tolstoy Marg the value is between 64.251 dB(A)-65.151 dB(A).

At the silence zone locations i.e. Lodhi road and K.G. & Tolstoy Marg it has been observed that the traffic noise level is more than the prescribed standard noise level as given by CPCB and at times it was found equivalent to residential and commercial zone noise levels.

The ambient noise level standards have been violated at every locations during the peak and off peak hours. The noise level values obtained from the developed noise maps gives very close results to the measured values. Percentage difference obtained between the predicted noise level and the monitored noise level is found to be between 4% to 7%.

The noise levels at all the ten locations were found to be far exceeding than the permissible noise level, which indicates suitable mitigating measures like noise barriers would be required at all the locations to curb the noise pollution and its associated adverse health problems.

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