EVALUATION OF NOISE LEVEL AND POSSIBLE MITIGATION MEASURES FOR THE SELECTED AREAS OF RAWALPINDI AND ISLAMABAD PAKISTAN

By

BILAL KHAN

01-263172-002

Department of Earth and Environmental Sciences

BAHRIA UNIVERSITY, ISLAMABAD

2020

EVALUATION OF NOISE LEVEL AND POSSIBLE MITIGATION MEASURES FOR THE SELECTED AREAS OF RAWALPINDI AND ISLAMABAD PAKISTAN

A thesis submitted in fulfilment of the requirements for the award of the degree of MS Environmental Policy and Management

BILAL KHAN

Department of Earth and Environmental Sciences

BAHRIA UNIVERSITY, ISLAMABAD

2020

Bahria University

Department of Earth & Environmental Sciences
Islamabad Campus, Islamabad

Dated: 03/03/2020

Certificate

A thesis submitted by **Mr. Bilal Khan** to the Department of Earth & Environmental Sciences, Bahria University, Islamabad in partial fulfillment of the requirements for the degree of **Masters in Environmental Policy & Management** (Session **2017– 2019**).

Committee Member	Name	Signature
Supervisor	Dr. Asma Jamil	
Internal Examiner	Dr. Humera Farah	
External Examiner	Dr. Imran Shahid	
Post Graduate Coordinator	Prof. Dr. Muhammad Zafar	
Head of Department (E&ES)	Prof. Dr. Tahseenullah Khan	

Approval for Examination

Scholar's Name : Bilal khan

Registration No. : 01-263172-002

Program of Study : Environmental Policy and Management

Thesis Title : *EVALUATION OF NOISE LEVEL AND POSSIBLE MITIGATION MEASURES FOR THE SELECTED AREAS OF RAWALPINDI AND ISLAMABAD PAKISTAN*

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ABSTRACT

Environmental noise is one of the most unpredictable pollutant which adversely affects the physical and mental health of humans. Environmental noise consists of all the unwanted sounds except noise from the workplace. It is more severe, extensive and aggressive spread than ever before, and it continues to enhance because of population growth, urbanization, and the associated growth in the use of increasingly powerful, diverse, and highly mobile sources of noise. In this study, noise levels were recorded during daytime from six different locations of Rawalpindi and Islamabad, Pakistan. The purpose was to evaluate the noise levels and corresponding noise intensities with the variation of seasonal and meteorological factors. The noise levels were recorded with a calibrated digital sound level meter and corresponding sound intensity levels were calculated. Temperature and humidity values at all locations were also recorded. Data was recorded from morning 7am till night 10pm in four different time slots and 84 readings were recorded from each location. Over all data was recorded for a seven-month time period. The average noise level recorded from selected locations 6th road, Pirwadahi, Raja-bazar, Faizabad Rawalpindi, I-9/3 sector Islamabad and Karachi company Islamabad were 71.0, 85.5, 83.7, 79.9, 75.7 and 69.5 dB respectively. The result of the study revealed that the noise levels of all the locations exceeded the prescribed limits of National Environmental Quality Standards (NEQS). A trend of increasing noise levels during summer was observed with increasing humidity levels. Significant variation of noise levels was observed diurnally and season wise between winter and summer months. In order to control and reduce the noise pollution from the selected locations proper counter measures should be taken by the authorities.

Keywords: Environmental noise, Noise level, Sound intensity, Seasonal variation

ACKNOWLEDGEMENT

First and foremost, I would like to thank ALLAH Almighty for giving me the strength, knowledge, ability and opportunity to undertake this research and to persevere and complete it satisfactorily. I would like to thank Bahria University Islamabad for providing me a platform where i can boost up my skills and utilize them in a proper and symmetric way. I would like to express my sincere gratitude to my thesis supervisor Dr. Asma Jamil, Senior Assistant professor, Earth and Environmental Sciences, Bahria University, Islamabad who is more than a mentor for me. I would like to thanks her for her continuous support and guidance, her patience, motivation, enthusiasm, and immense knowledge for the completion of this research. I am also thankful to Prof. Dr. Tahseen Ullah Khan Head of department Earth and Environmental Sciences for providing all the support. I am thankful to the lab in charge of Bahria university Mr. Imtiaz who provided all the equipment on time.

I would especially like to thank all my family, my supporting mother Robina Obaid, and my brother Hayyan khan for their continuous and unparalleled love, help and support in every step of this journey. I am grateful to my sister Laila Tariq for always being there as a friend for me. I am so grateful to my brother in law Tariq Khalil who always be there as a role model for me, my niece Eshal Tariq who came as a lucky charm for me. I would like to thank my beloved wife, Shazia Noreen for her love and constant support and my father in law Sulman Zafar who always there as a father for me .

Lastly, I would like to thank all my class fellows and my best friends who helped me during all this journey.

ABBREVIATIONS

dB	Decibel (unit of sound level)
Leq	Equivalent Sound level
I_0	Reference intensity level
Hz	Hertz (unit of frequency)
W/m^2	Watt per meter square
NIHL	Noise-Induced Hearing Loss
NEQS	National Environmental Quality Standard
SIL	Sound Intensity Level
ISB	Capital Territory of Islamabad, Pakistan
RWP	Rawalpindi
WHO	World Health Organization
K-C	Karachi Company (Islamabad)

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Today's era is the world of technology which helps to make our living standard more comfortable and easier. Now a days it is difficult to find a calm, nonviolent and quite place. Even if we are living isolated from the noisy and busy places, our homes are probably filled with the buzz of computers and other modern utilizations. Due to the high encroachment in technology, nearly everyone is suffering from the noise pollution especially in urban areas. In order to compete with this modern world, we cannot stop to utilize and introduce new technologies to the world, which makes our life easier and comfortable. The dark side of all these luxurious technologies is that we are becoming a victim of noise pollution. It puts a terrible impact on human health and effectively damage both physically and mentally. Mostly, people are unaware of the effects of noise pollution on their health. Noise is called an unsolicited sound which makes someone vex and mislead from their focus. Sound become noise when it effects negatively on someone's daily routine. It is one of the most dangerous pollutant because of its unpredictable nature. Noise pollution is still ignored as a type of pollution in many developed cities of the world (Singh and Davar, 2004). Noise Pollution is also called a silent pollutant because the majority of the people are still unaware of the adverse effects of that pollution (Gai et al., 2017; Munzel et al., 2018).

1.2 History of noise pollution

In 6^{th} century, first known noise ordinance, the council of the province of Sybaris, a Greek colony in the Aegean, rules that potters, tinsmiths, and other tradesmen must live outside the walls of the city because they make a huge noise. They banned roosters too (Sacks et al., 2014).

London city of England declared first time a noisy city in 15 century. The world's first society for the suppression of noise was formed in London city. Its principal target was the newly-invented motor horn (Xie et al., 2009). The Rayleigh disc is known as the first ever noise measuring device. The pressure forces generate a torque that is counter balanced by the elasticity of the filament. The disc will position itself at an angle to the direction of flow that is greater than 45°. The intensity of sound can be determined from the angle of rotation of the Rayleigh disc. In a constant flow,

the angle of rotation is proportional to the square of the velocity. In the presence of sound oscillations, to the square of the amplitude of velocity, the angle of rotation does not depend on frequency. Flow around a Rayleigh disc (the disc is at an angle of 45° to the flow) the force of pressure as shown by the arrows. It was too delicate to be used outdoors as shown in figure 1.1 (Garbin et al., 2015).

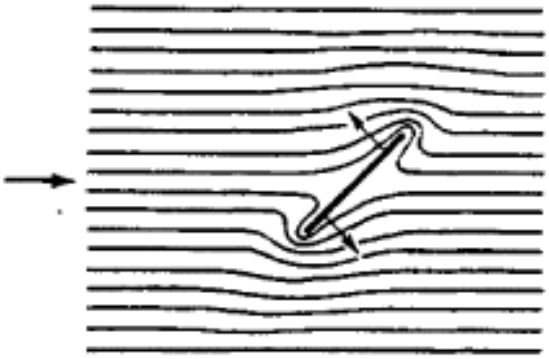

Figure 1.1 Rayleigh disc

1.3 Audible range

A normal human ear frequency range started from 20 hertz to 20,000 hertz. More or less than that range, normal human ear cannot respond (Duck et al., 2018).

The reaction of the human ear to sound depends on two parameters, frequency and pressure. Not all sounds are audible to human beings. The frequency limits of audibility for human range from 20Hz to 20,000 Hz. Below or above that frequency normal human cannot hear a sound. The frequencies less than 20 Hz are known as infrasonic sounds, while frequencies greater than 20,000 Hz is known as ultrasonic sounds. Exposure of high sound level has very harmful effects on human. The effects can range in severity from being annoying to being extremely painful and hazardous. The sound frequency which is not suitable with your hearing frequency that is called a noise. Graphically, noise doesn't make a proper sinusoidal wave (Sulphy and Safeer, 2015).

i. Sensitive Range

Our hearing is most sensitive in the 2000-5000 Hz frequency range. Threshold frequency of hearing is zero decibels scale. Ranges from 0 to 10 decibels are so quiet and almost impossible to hear while the top end scale level at 150 decibels can damage the eardrum of a normal person (Duck et al., 2018).

1.4 Classification of noise

Noise pollution is classified into two major groups

a. Community Noise / Environmental Noise
b. Occupational Noise

a) Community noise /Environmental noise

Community noise is well defined by the noise extracted from all source except noise at the industrial workplace.

b) Occupational Noise

Noise generated from industrial workplace.

1.5 Sources of noise pollution

Noise Pollution is one of the contaminants that disrupts, distracts and also detract from the regular functioning of life. This pollution is not new, it became stronger and more problematic with the passage of time and with the advancement of technology and new development (Karibasppa et al., 2015).

There are numerous sources of noise pollution around us, there is a list of different machines used in industries as well as in our homes to make our life easier. Due to the advancement in technologies and tremendous growth in automobile industries, number of vehicles increases day by day, especially in urban areas. The traffic noise become one of the major and dominating source of noise pollution (khan et al., 2011).

The noise pollution makes its origin from anthropogenic activities, significantly the urbanization and the unsustainable growth of transportation (Chauhan et al., 2010). Due to the advancement in technologies and tremendous growth in automobile industries traffic noise has become one of the major and dominating source of noise pollution. Unplanned infrastructure, improper shops and stalls, uncontrolled parking, unawareness, excessive use of loudspeakers and lack of check and balance are also the prominent reasons for the noise pollution in the cities (Khan and Ghauri, 2011).

1.6 Noise level standards in Pakistan

According to the World Health Organization (WHO) noise pollution is the third most hazardous environmental pollution in the world (Pathak et al., 2008). World Health Organization (WHO) recommends the day time noise limits of about 55dB as a general health goal for outdoor noise level in residential areas. While out door noise

level of about 45 dB is recommended at night (Gerard, 1998).The revised National Environmental Quality Standards (NEQS) for noise level effective from 1st July 2012 are shown in **Table 1.1**

Table 1.1 NEQS of noise level

Sr.#	**Location /Areas**	**(dB) Effective from 1st July -2010**	**(dB) Effective from 1st July -2012**
1	Residential	65	55
2	Commercial	70	65
3	Industrial	80	75
4	Outdoor Residential (WHO)	55	55

Source: The Gazette of Pakistan, extra, November 26, 2010 (Part-II), SRO 1064(1)/2010.

1.7 Adverse effects of Noise pollution

There are numerous medical studies which verified that noise become one of the major sources of physiological stress reactions like increasing blood pressure and also increases rate of heartbeat and generating both acute and chronic health effects, speech interference and disturbs sleep and rest are common effects of noise. Human ear is a very complex organ of human body which works under a specific range of frequency, under unfavorable condition like risky noisiest complex hearing mechanism could cause damage. The damage may be temporary or permanent depending upon the age of the person, medical health of the person, and intensity, type and time duration of exposure. Noise above 80 dB may increase aggressive behavior and the demand of various drugs, anti-depression pills and sleeping pills increases due to community noise and mental health problems. The incidence of psychiatric symptoms and the number of admissions to mental hospitals (Juang et al., 2010).

According to another study night-time noise may have more impact on cardiac health than day-time noise, and noise exposure at night is one of the main reasons of sleep disturbance. High noise exposure may lead to changes in living things body functionalities. Laboratory studies have clearly demonstrated that the body reacts to acute and high noise exposure by releasing stress hormones, such as adrenaline. Mostly field studies recorded that these severe effects occur not only at high noise levels in workplace settings, but also at relatively low environmental noise levels when

concentration, relaxation, or sleep is disturbed. This flight-or-fight reaction is involuntary and does not require a conscious awareness to occur. As a result, people do not get enough sleep and their sleep pattern is broken. Disrupted sleep can lead to cardiovascular health problems (Munzel et al., 2018).

Noise Pollution is also called a silent pollutant because majority of the people are still unaware of the bad or adverse effect of that pollution. It affects heart related diseases like respiratory, neurological and other physiological, high stress, high blood pressure, anger and frustration, asthma, headaches, gastrointestinal disorders, and many other physiological and psychological problems have been linked directly to the noise pollution (Cai et al., 2017).

Sound level become noise when it crosses the limit of 70 dB, and when it crosses the value above than 80dB it will produce damaging effects to the ears, if the level of noise reaches to 100 dB or more It can cause irreparable damage and lead to loss of hearing permanently and around 150 dB it will immediately damage our eardrum (Kalim et al., 2014).

According to the research carried out in ear, nose and throat (ENT) department of Sir Ganga Ram Hospital Lahore Pakistan, it concluded that about 65 % public transport drivers were exposed to noise induce hearing loss (NIHL) , about 25 % drivers had normal hearing threshold and while 10% had disabling hearing loss (Aslam et al., 2008).

Noise pollution is one of the reasons to make people nervous which lead them to unconfident position, it also become one of the main reasons of damaging the hearing sense permanently or temporarily depending upon the situation and also the physical condition of that individual. In Dhaka city of Bangladesh, it was reported that the hearing ability of habitants get reduced up to deafness level due to this deadly pollution (Alam, 2009).

According to one of the recent study the ratio of effected persons are distributed in percentage, out of 500 people got interviewed of different ages and material status in Varanasi city of India 65 % peoples get extremely effected by traffic noise, 51% got headache issue, 58 % get effected by the noise and suffered from high blood pressure problem, 53% felt fatigue, 49 % people found irritative behavior, `while 54% individual suffered dizziness (Prajapati and Tripathi, 2008).

A Comprehensive national survey has not been conducted yet to assess the level of noise level in big cities of Pakistan. This study was conducted to assess the noise

level of selected places of twin cities Rawalpindi and Islamabad as well as its main causes. This study will certainly help to authorized bodies to understand the severity of noise level and also find out the location where noise pollution reached in alarming situation.

According to the US-EPA, Noise level and human health are directly proportional to each other, there is a list of diseases whose source of generation is noise pollution. It is highly responsible for damaging physiological and psychological health moreover high blood pressure, stress related illness, and sleep disruption, hearing loss, and productivity loss are the problems associated with sound pollution. It can also cause memory loss, severe depression, and panic attacks (Keerthana et al., 2013).

One of the studies concluded that in United States, about five million children's at the age between six to nineteen years suffer from the noise induced hearing impairment due to the level of noise pollution (Casey et al., 2017).

According to another study the effect of noise pollution on pregnant women are more than a normal one, because those women are more sensitive to environmental stressors, and become a victim of disease name preeclampsia. Preeclampsia is defined as hypertension with blood pressure 140/90 mmHg (Auger et al., 2018).

According to another research in Dublin city of Ireland more than 27% of resident population are exposed to values above 70 dB noise (Murphy and King, 2010).

There are different sources within a hospital which become a reason to create a noisy atmosphere within premises of hospitals and put a negative impact on patients like alarms of the various monitors and maintenance appliances, new noisy machinery kept nearer to the patients which put a very bad impact on patients health and recovery time (Jonckheer et al., 2004).

Every wave having property of interference, when two sound waves have same frequency add up it will generate a resultant wave of larger wavelength. When two waves having different frequencies overlap and do not produce a systematic sinusoidal wave but an irregular wave with jerks then a normal sound becomes a noise on that time (Prolife et al., 2001).

Roughly 40 million Americans suffering from hearing loss, 10 million can be recognized to Noise-Induced Hearing Loss (NIHL). It can be caused by a one-time exposure to loud sound as well as by repeated exposure to sounds at various loudness levels over an extended period of time (Abu-Ghanem et al ., 2016).

Injury happens to the microscopic hair cells found inside the cochlea. These cells respond to mechanical sound vibrations by sending an electrical signal to the auditory nerve. Different groups of hair cells are responsible for different frequencies (rate of vibrations). Over time, the hair cell's hair-like stereo-cilia may get damaged or broken. If enough of them are damaged, hearing loss results. The high frequency area of the cochlea is often damaged by loud sound. Sound pressure is measured in decibels (dB). Like a temperature scale, the decibels scale goes below zero. The average person can hear sounds down to about 0 dB, the level of rustling leaves. Some people with very good hearing can hear sounds down to 15 db. If a sound reaches 85 dB or stronger, it can cause permanent damage to your hearing. The amount of time you listen to a sound affects how much damage it will cause. The quieter the sound, the longer you can listen to it safely. If the sound is very quiet, it will not cause injury even if you listen to it for a very long time, however exposure to some common sounds can cause permanent damage (Xu et al ., 2016).

A typical conversation occurs at 60dB. A bulldozer that is idling is loud enough at 85 dB that it can cause permanent damage after only 1 work day (8 hours).When listening to a personal music system with stock earphones at a maximum volume, the sound generated can reach a level of over 100 dB, loud enough to begin causing permanent damage after just 15 minutes per day (Daniel, 2007).

With extended exposure, noises that reach a decibels level of 85dB can cause permanent damage to the tinny hair cells in the Organ of Corti (spiral organ) of inner ear and leading to hearing loss. Since hair cells do not regenerate once they damage (Natarajan et al., 2017).

The level of a sound is normally defined in terms of the magnitude of the pressure changes it represents, which can be measured, and which does not depend on the frequency of the sound. In contrast, for sounds of constant pressure, the displacement of the medium is inversely proportional to frequency, with displacements increasing as frequency is reduced. This phenomenon can be observed as the difference in vibration amplitude between a subwoofer generating a low frequency tone and a tweeter generating a high frequency tone at the same pressure level. The speaker cone of the subwoofer is visibly displaced while the displacement of the tweeter cone is unrevealed. As a result of this phenomenon, vibration amplitudes to infrasound are larger than those to sounds in the auditory range at the same level, with displacements at 1 Hz being 1000 times those at 1 kHz when presented at the same pressure level. This

corresponds to a rise in displacement at a rate of 6 dB/octave as frequency is dropped. The concept that an infrasonic sound that cannot be heard can have no influence on inner ear physiology is incorrect (Salt and Hullar, 2010).

According to another study 54% of UK population was exposed to day-time noise pollution. The study results suggested that exposure to noise levels above recommended levels resulted in an additional 1169 cases of dementia, 788 cases of stroke and 542 cases of heart attack in the UK over the course of a single year (Harding et al., 2013).

The impact of noise pollution depends upon the age. Some of the noise pollution effect children more than adults while some noises affect the adults more than small children. Several studies found that school children (aged between 8 and 14) are less annoyed by aircraft and road traffic noise then adults. A paper, reviewing multiple studies, reported that both the youngest and people over 60 years are least likely to be highly annoyed by road traffic noise. Listening to music from headphones is the most common effects being short-term tinnitus and hearing loss (Kamp and Davies, 2013).

Another study conducted in city of Colombo, Sri Lanka Pure-tone audiometry test were performed on 287 traffic policemen and concluded that 118 policemen prevalence of Noise-induced hearing loss (NIHL) due to traffic flow noise level (Nagodawithana et al., 2015).

It is difficult to discriminate between NIHL and age-related hearing loss at an individual level. Sudden noise seems to be more harmful for hearings compared with continuous noise (Lie et al., 2016).

Traffic noise pollution has vigorous impact on hearing potentiality. When an individual has a loud noise for a long time, it can lead to hearing impairment, and hearing impairment is evident when he is interrupting normal activities (Shah et al., 2019).

Seasonal and climatic variations are found to affect noise parameters and also anthropogenic activities. Noise levels were recorded higher during mornings and evenings time in Karachi, Pakistan because of the school and offices timings. Maximum noise level was found over 101 dB, which is close to 110 dB which causes hearing impairment (Zafar et al., 2016). It is known that the noise propagation and noise emissions from some noise sources vary with meteorological conditions. As the meteorological conditions can affect the absorptivity of ground for surface transportation. Seasonal variations in emissions and propagation of noise are commonly

accounted for in noise surveys. However, in most situations, such effects are minor, short-lived, or localized. Few surveys report seasonal differences as annoyance reactions are found to be higher during warmer periods (Connor and Patterson, 1972; Borsky, 1978). While few other studies did not find seasonal effects on noise levels (Griffiths et al., 1980). It may be stated that noise annoyance varies over the year and is increased by temperature, more sunshine, less precipitation, and reduced wind speeds. However, a concrete relationship of noise levels with variation of meteorological conditions is not sufficiently established (Miedema et al., 2005).

One of the study provided the suitable mitigation measures for reducing the level of noise by installing noise insulated windows in Lithuania to reduce the noise level of location near railway lines (Tumavipo et al., 2016).

Building Facades is one of the reason to increase the level of noise up to 3 to 4dB (A). “Green wall” technology in building design would help to limit the increase in noise (Polifke et al 2001).

1.8 Objectives of the study

This study was designed with the following objectives:

a. Evaluation of noise level and calculated noise intensity level of selected areas.
b. Proposing possible preventive mitigation measures for the selection areas.

CHAPTER 2
MATERIALS AND METHODOLOGY

2.1 Study area

Six different locations were selected for the evaluation of noise level in Rawalpindi and Islamabad. Twin cities are ranked in top 6 populated cities of Pakistan as per the 2017 census official results. Four locations were selected from Rawalpindi and two locations were selected from Islamabad. Location and their coordinates are shown in table 2.1

Table 2.1 Study area Locations

Sr.	Selected Locations	Coordinates	
1	Faizabad Rawalpindi	33.6621° N	73.0834° E
2	Pirwadahi Rawalpindi	33.6298° N	73.04200° E
3	6th Road Rawalpindi	33.6431° N	73.0643° E
4	I-9/ 3 Islamabad	33.6617° N	73.0568° E
5	Karachi Company Islamabad	33.6888° N	73.0328° E
6	Raja Bazar Rawalpindi	33.6145° N	73.0555° E

Rawalpindi is the fourth largest city in Pakistan by population while Pakistan's third-largest metropolitan area. Rawalpindi city is recognized as a home of many outsider worker and students from all over the country. Rawalpindi is linked with the capital of Pakistan, Islamabad. Two are mutually known as the "twin cities" on account of strong social and economic links between the cities. Twin cities considered among the most populated cities due to the availability of numerous educational institutes and opportunities of working. Both cities are the major logistics and transportation centers for northern Pakistan.

2.2 Study map

To illustrate the selected study locations on a study map shown in Figure 2.0

A = Pirwadahi Rawalpindi

B = Karachi company Islamabad

C = Raja bazar Rawalpindi

D = 6th road Rawalpindi

E = Faizabad Rawalpindi

F = I9/3 Islamabad

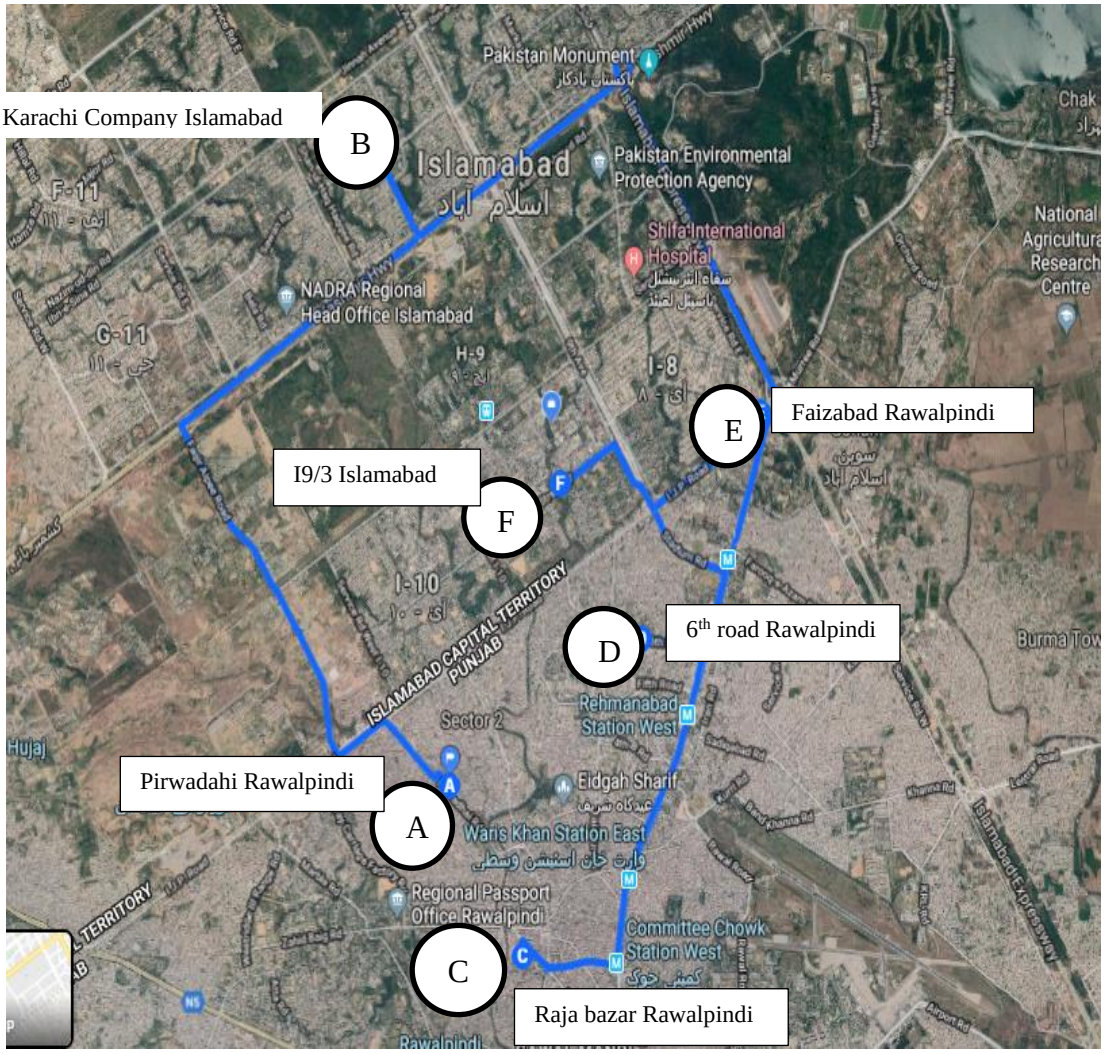

Figure 2.0 Study map

2.3 Factors effecting the choice of sample locations.

Islamabad and Rawalpindi were chosen as the target areas for data collection of noise pollution due to following factors.

Availability of

1- Commercial areas
2- High traffic flow area
3- Industrial area
4- Highly congested areas

2.4 Population

Twin cities are ranked in top 10 populated cities of Pakistan. According to the 2017 census official results, declared on August 25, 2017, the population of Pakistan was recorded 207,774,520 persons. Top 10 cities ranking shown in table 2.2 below (http://www.pbs.gov.pk/).

Table 2.2 Top 10 cities population

Rank	City	Population (1998 census)	Population (2017 census)	Change of Growth	Province
1	Karachi	9,339,023	14,910,352	37.37%	Sindh
2	Lahore	5,143,495	11,126,285	53.77%	Punjab
3	Faisalabad	2,008,861	3,203,846	37.30%	Punjab
4	Rawalpindi	1,409,768	2,098,231	32.81%	Punjab
5	Gujranwala	1,132,509	2,027,001	44.13%	Punjab
6	Peshawar	982,816	1,970,042	50.11%	KPK
7	Multan	1,197,384	1,871,843	36.03%	Punjab
8	Hyderabad	1,166,894	1,732,693	32.65%	Sindh
9	Islamabad	529,180	1,014,825	47.86%	ISB
10	Quetta	565,137	1,001,205	43.55%	Baluchistan

2.5 Data collection design

This study is based on measurements of outdoor noise level recorded from December 2018 to June 2019 of six different prominent locations of Rawalpindi and Islamabad Pakistan. In this study an effort is made to evaluate the noise levels and its corresponding intensity levels were calculated by using following derived relationship $I = \text{Antilog}\,[(L/10) + \log I_0]$. Noise level measurement were recorded with calibrated digital noise level meter. Since noise level varies with atmospheric conditions, like atmospheric temperature and humidity ratio. Respective temperature and its humidity also recorded at the time of data collection with digital temperature and humidity meter.

Noise level data was recorded from morning 7AM till night 10PM in four different time slots. From each location, in total, 84 readings were recorded and their mean values were found to obtain a single value. Each measurement was recorded after a regular interval of 10 minutes. Three times data were recorded during each time slot. Standard deviation was calculated from 84 measurement obtained from each location.

Data collection strategy were designed in such a way to cover the maximum area of specific locations. Data was collected to observe the seasonal and diurnal variations. Hence the measurements were recorded in two phases. First phase for data collection starting from December 2018 to February 2019. Temperature range recorded from 6° C to 22° C during the first phase. Second phase of data collection was from March 2019 to June 2019. Temperature range recorded from 25° C to 42° C during the second phase. In order to investigate the diurnal variation data were recorded in four different time slots of a day from each location. S1 from 7:00 to 8:00 am, S2 from 1:00 to 2:00 pm, S3 from 5:00 to 6:00 pm, and S4 from 9:00 to 10:00 pm respectively. The analysis of data was done by Analysis of Variance in Excel 2013.

Data collection strategy as shown in Figure 2.1.

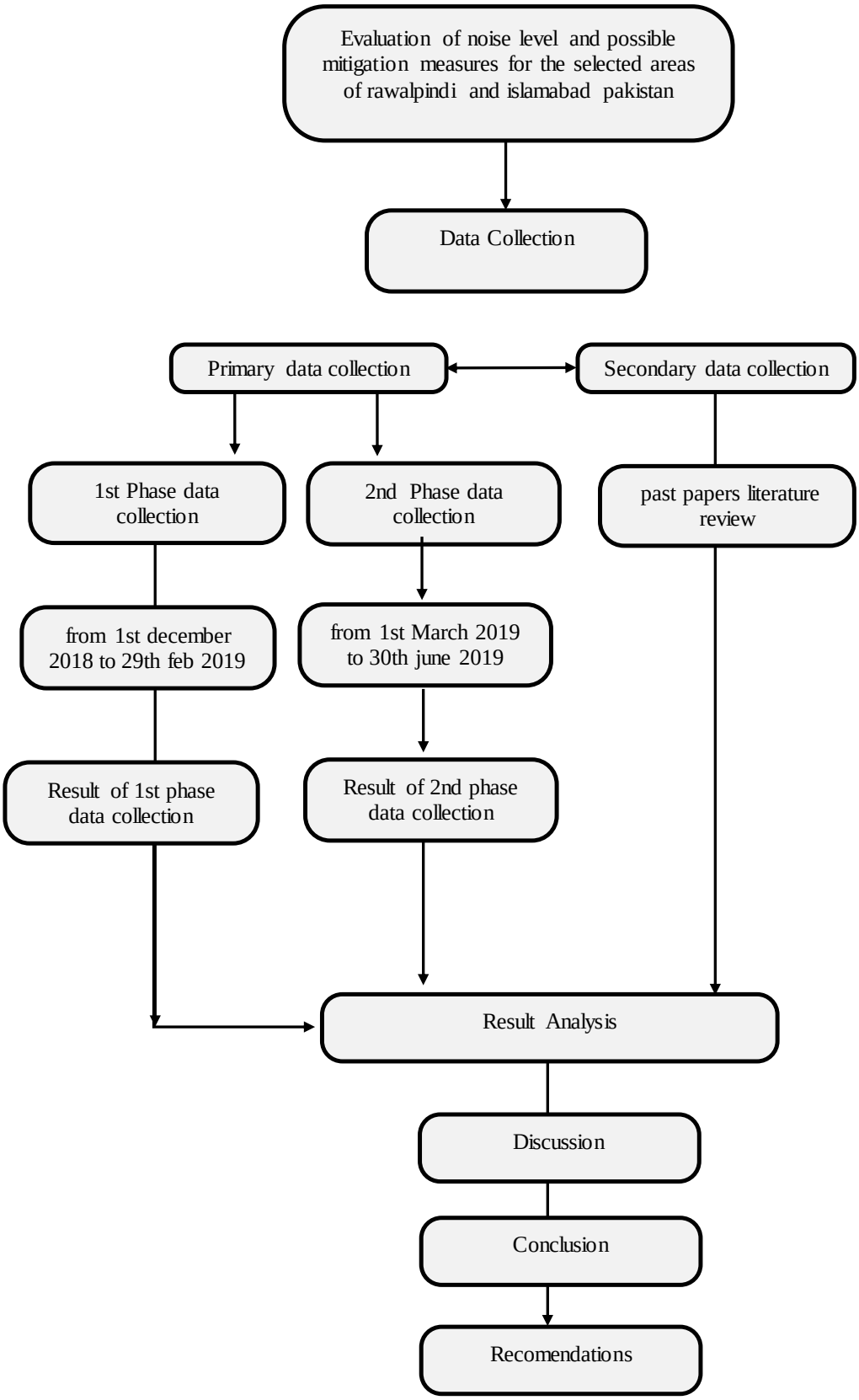

Figure 2.1 Schematic flow chart for data collection

2.6 Recorded parameters

Following are the parameter recorded at the time of data recording.

a. Atmospheric temperature in degree Celsius
b. Relative humidity in percentage.
c. Noise level in that area in dB
d. Intensity level in watt/m^2 were calculated by using the intensity level formula I =Antilog [(L /10) + log I_0].

2.7 Instrument used

Sound level meter type Model # JK-NM-814 with the capacity of measuring noise from 30 dB to 130 dB, having accuracy of + 1.5dB , operation conditions are relative Humidity < 99 % , temperature = 0^0C to +40^0C and response time of noise meter was fast= 0.5 s while slow time =0.1s. Typical digital noise level meter was used to record the required measurement for this study as shown in Figure 2.2

Figure 2.2 Digital noise meter.

In order to record other parameters involved, digital temperature and humidity meter were used for recording temperature in °C and humidity ratio in percentage (%) as shown in Figure 2.3.

Figure 2.3 Digital temperature and humidity meter

Noise level were recorded as per National Environmental Quality Standards guidelines for Noise level. Data were recorded by using digital noise level meter shown in Figure 2.4.

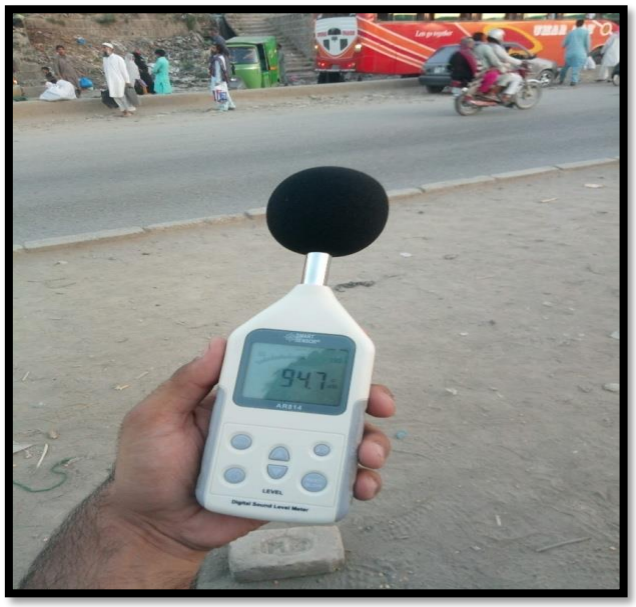

Figure 2.4 Data recording during day time

Noise level data also recorded during night time of day as shown in Figure 2.5.

Figure 2.5 Data recording during night time

Data of noise level recorded of high traffic flow shown in Figure 2.6

Figure 2.6 Data recording from high traffic flow area

Unplanned and unauthorized parking in selected location as shown in Figure 2.7 become a reason of overcrowding.

Figure 2.7 Unauthorized parking

Improper parking become one of the main reason of overcrowdings. In figure 2.8 represent the high congested area due to unplanned and improper parking of local vehicles.

Figure 2.8 Improper parking in day time

2.8 Derivation of sound intensity level.

Noise level recorded in decibels unit and its calculated intensity level derived in [watt per meter square] Watt/m^2 unit. Following derivation used to calculate the corresponding intensity level. Sound intensity level also known as acoustic intensity level, it is defined as the power carried by sound waves per unit area in a direction perpendicular to that area (A). Mathematically it can be expressed as follow

$I=P / A$

Where P is the power crossing area A. Many sound intensity measurements are made relative to a standard threshold of hearing intensity.

$I_0 = 1 \times 10^{-12}$ (W/m^2)

The loudness (L) of a sound is directly proportional to the logarithm of intensity i.e.

$L \propto \log I$

$L = K \log I$ …… (1)

Where k is a constant of proportionality, K =10

Let L_0 be the loudness of the faintest audible

$L_0 = K \log I_0$……..... (2)

Where k is a constant of proportionality, where K =10

Now, subtracting equation (2) from (1), we get:

L.H.S – L.H.S = R.H.S –R.H.S

$L - L_0 = K \log I - K \log I_0$

Taking K as a common, we get

"$L - L_0 = K (\log I - \log I_0)$"

Single log Property is used to write the multiple log into single log, and mention in product and division form, above equation become as follow,

Sound Equivalent level in (dB) = $k \log I/I_0$

Sound Equivalent level in (dB) = $10 \log I/I_0$

Where $L-L_0$ = Sound Equivalent level in (dB) =L

Where K = Constant = 10

$L = 10 \log (I / I_0)$

Apply Log Property of product and division into sum and differences

$L = 10(\log I - \log I_0)$

$L/10 = \log I - \log I_0$

$\{(L /10) + \log I_0) = \log I$

Rearrange the above equation

Log I = {(L /10) + log I_0}

I = Anti log [(L /10) + log I_0]…….. (3)

By using equation # 3 sound level intensity in watt/ meter square can be calculated.

CHAPTER 3

RESULTS AND DISCUSSIONS

Data was recorded during the day time from 7:00am to 10:00pm. From each location 84 reading of noise level were recorded and their mean values were found to get a single value. Each measurement were recorded after the interval of 10 minutes. Standard Deviation was calculated from 84 measurement obtained from each location.

Data was collected to observe the seasonal and diurnal variations. Hence the measurement were recorded in two phases. In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM.

3.0 First phase data collection

First phase for data collection starting from December 2018 to February 2019. Eighty four measurements of noise level were recorded from each location and their mean values were found to get a single value of noise level in dB. Noise intensity level of average noise level were calculated by the derived formula. In order to analyze the recorded measurements, standard deviation of all the recorded readings were calculated. Table 3.0 represent the recorded data collection of first phase. Temperature range recorded from 6° C to 22° C and humidity percentage recorded less than 90% during the first phase of data collection.

Table 3.0 Data collection of first phase.

Sr.#	Location #	Average Mean(dB)	Max	Min	Standard Deviation	Intensity level
1	1	78.9	91.3	68.6	4.7	7.8×10^{-5}
2	2	85.1	95.63	70	6.2	3.2×10^{-4}
3	3	70.7	89.6	62	6.5	1.2×10^{-5}
4	4	75.4	85	64.2	4.6	3.4×10^{-5}
5	5	68.7	75.3	61.25	3.5	7.3×10^{-6}
6	6	82.6	94.3	70	5.2	1.8×10^{-4}

3.1 Location Faizabad Rawalpindi

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.1 represent the first phase data collection of location Faizabad Rawalpindi at selected hours of a day.

Table 3.1 Noise level of Faizabad Rawalpindi at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	80.00	75.5	83.2	74.5
2	81.2	77	82	78
3	80	70	85	82.2
4	85	78	88	78
5	80	80	85	83
6	78	80	90	80
7	75.6	81.2	91.3	77
8	70	78	80	75
9	77.5	80	82	70
10	75	78	75.7	75.7
11	73	82	84.6	70
12	80	80	85.6	75
13	81	78.6	85	78
14	80	82	82.4	70
15	82	77.6	82	79
16	78	75	84	80
17	83	74	85	78
18	78	75	78.5	72.1
19	77	78	85	70
20	78	80	82	75
21	80	70	83	68.6
Max noise level	85	82	91.3	83
Min noise level	70	70	75.7	68.6
Mean	78.68	77.61	83.78	75.67
Intensity level	7.38×10^{-5}	5.77×10^{-5}	2.39×10^{-4}	3.69×10^{-5}
Temperature [°C]	8	7.7	15	10.7
Humidity [%]	83.7	76.3	55.3	74.0

3.2 Location Pirwadahi Rawalpindi

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.2 represent the first phase data collection of location Pirwadahi Rawalpindi at selected hours of a day.

Table 3.2 Noise level of Pirwadahi Rawalpindi at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	85	78	80	75.6
2	80	85	85.5	78
3	80	82	85	78
4	75	90	90	79
5	80	93	90	78
6	78	95	90	80
7	82.5	95.2	89	70
8	88.6	95	88	76
9	92	88	78.7	78
10	90	90.2	90	80
11	92	90	85	80.2
12	80	94	95.4	82
13	93	82	88	82
14	90	80	85.7	82.3
15	88.6	88.2	82.6	80
16	85	95	86.2	80
17	87	92.2	90.5	74
18	80	85	82.3	75
19	90	87.6	95.2	75.4
20	92	90.1	95.6	79
21	85	90	92.3	80
Max noise level	93.00	95.20	95.60	82.30
Min noise level	75.00	78.00	78.70	70.00
Mean	85.4	88.8	87.9	78.2
Intensity level	3.48×10^{-4}	7.64×10^{-4}	6.11×10^{-4}	6.63×10^{-5}
Temperature [°C]	7	7.3	16	10.3
Humidity [%]	86.3	71	45.7	66.3

3.3 Location 6th road Rawalpindi

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.3 represent the first phase data collection of location 6th road Rawalpindi at selected hours of a day.

Table 3.3 Noise level of 6th road Rawalpindi at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	65.0	65	78	75.2
2	70.0	65.2	70	65.2
3	70.0	68	87	70
4	65.4	65.2	85.5	68
5	73.0	65.5	88	65.9
6	76.6	65	87	66
7	70.0	62	89.6	65.1
8	65.3	67.7	76	68
9	70.0	68	75	68.2
10	71.6	70.2	88.5	65.1
11	62.3	68	70.8	65
12	65.0	64	68	65
13	65.1	68.5	77	70
14	68.0	70	87	66
15	62.6	74.5	76.3	71
16	68.0	70	75	67.4
17	69.7	75	77	65
18	70.0	68.5	78	66
19	71.2	70	75.6	68
20	66.0	64	78	66
21	71.3	70.2	77	65.3
Max noise level	76.60	75.00	89.60	75.20
Min noise level	62.30	62.00	68.00	65.00
MEAN	68.4	67.8	79.3	67.2
Intensity Level	6.90×10^{-6}	6.07×10^{-6}	8.42×10^{-5}	5.26×10^{-6}
Temperature [°C]	6.7	8.7	17	9.7
Humidity [%]	85.7	72.3	48.7	76

3.4 Location I9/3 Islamabad

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.4 represent the first phase data collection of location I9/3 Islamabad at selected hours of a day.

Table 3.4 Noise level of I9/3 Islamabad at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	71.3	68.2	77.0	72.0
2	70.0	72.0	81.0	75.5
3	73.0	74.0	75.0	82.0
4	68.0	74.0	78.0	78.0
5	64.2	75.0	81.0	70.0
6	68.5	76.0	74.0	74.0
7	69.0	78.2	80.0	75.3
8	70.0	75.0	75.0	70.0
9	65.9	78.0	79.0	72.0
10	68.0	75.0	78.0	75.2
11	70.2	74.0	80.0	79.0
12	76.0	74.0	75.0	72.6
13	73.2	78.0	80.0	70.0
14	67.0	79.0	82.0	71.0
15	73.1	80.0	78.0	75.2
16	75.0	80.0	82.0	70.0
17	78.0	74.0	85.0	70.0
18	75.5	75.0	84.0	85.0
19	75.0	74.0	76.0	76.0
20	78.0	78.0	82.0	82.0
21	72.3	80.0	82.0	80.0
Max noise level	78.00	80.00	85.00	85.00
Min noise level	64.20	68.20	74.00	70.00
Mean	71.5	75.8	79.2	75.0
Intensity level	1.41×10^{-5}	3.79×10^{-5}	8.39×10^{-5}	3.1×10^{-5}
Temperature [°C]	10.3	9.3	15.7	10.7
Humidity [%]	79.3	73.7	60.7	78

3.5 Location Karachi Company Islamabad

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.5 represent the first phase data collection of location Karachi Company Islamabad at selected hours of a day.

Table 3.5 Noise level of Karachi Company Islamabad at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	65.5	62.3	64.8	65.5
2	70.0	68.0	70.0	70.0
3	71.2	65.0	65.0	64.6
4	70.0	70.0	62.2	70.0
5	75.3	68.0	70.0	69.0
6	75.2	65.0	71.3	68.0
7	72.3	72.3	75.0	72.3
8	68.0	68.0	68.0	65.0
9	65.0	65.0	69.0	65.0
10	72.0	72.0	72.0	70.0
11	65.0	72.5	70.0	65.0
12	70.0	71.6	65.2	70.0
13	63.2	72.2	70.0	63.2
14	68.0	69.0	70.2	75.0
15	65.2	74.0	74.0	61.3
16	67.0	66.5	68.0	70.0
17	66.0	75.0	67.0	67.0
18	70.0	63.2	71.5	65.0
19	72.6	74.5	68.0	62.3
20	73.5	73.5	65.9	70.0
21	68.0	68.0	65.5	67.6
Max noise level	75.30	75.00	75.00	75.00
Min noise level	63.20	62.30	62.20	61.30
Mean	69.2	69.3	68.7	67.4
Intensity level	8.30×10^{-6}	8.54×10^{-6}	7.40×10^{-6}	5.52×10^{-6}
Temperature [°C]	6.3	9	15.7	9.3
Humidity [%]	86	65.7	40.7	68.3

3.6 Location Raja bazar Rawalpindi

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.6 represent the first phase data collection of location Raja bazar Rawalpindi at selected hours of a day.

Table 3.6 Noise level of Raja bazar Rawalpindi at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	75.0	80.0	78.6	76.2
2	81.6	81.9	90.0	88.0
3	80.0	82.3	91.2	75.0
4	82.0	75.0	88.0	88.0
5	82.1	90.2	90.0	79.6
6	75.6	82.2	86.3	88.6
7	78.2	78.8	90.0	85.5
8	75.0	74.6	85.0	88.4
9	82.9	78.0	92.2	87.0
10	77.4	82.3	84.6	70.0
11	74.6	90.1	85.0	76.0
12	84.6	88.4	80.0	74.7
13	85.0	82.2	85.0	78.3
14	80.0	81.0	88.0	80.0
15	76.0	77.0	80.0	78.6
16	81.9	81.9	78.2	80.0
17	82.3	81.6	87.0	78.0
18	90.1	78.6	90.0	84.6
19	88.0	94.3	78.2	82.6
20	85.2	82.2	90.2	85.6
21	78.8	85.0	91.7	81.2
Max noise level	90.10	94.30	92.20	88.60
Min noise level	74.60	74.60	78.20	70.00
MEAN	80.8	82.3	86.2	81.2
Intensity Level	1.20 x 10-4	1.69 x 10-4	4.12 x 10-4	1.33 x 10-4
Temperature [°C]	7.3	7	15.7	8.7
Humidity [%]	86.3	73	48.3	76.7

3.7 Second phase data collection

Second phase of data collection starting from March 2019 to June 2019. Eighty four measurements of noise level were recorded from each location and their mean values were found to get a single value of noise level in dB. Noise intensity level of average noise level were calculated by the derived formula. In order to analyze the recorded measurements, standard deviation of all the recorded readings were calculated. Table 3.7 represent the recorded data collection of second phase. Temperature range recorded from 25° C to 42° C and humidity percentage recorded less than 90% during the second phase of data collection.

Table 3.7 Data collection of second phase.

sr.#	Location	Average Mean	Max	Min	Standard Deviation	Intensity
1	1	81.0	94.3	74.0	4.6	1.20×10^{-4}
2	2	85.9	97.6	74.0	6.3	3.90×10^{-4}
3	3	71.3	89.6	64.0	7.1	1.40×10^{-5}
4	4	76.0	86.0	65.9	4.7	4.00×10^{-5}
5	5	70.4	77.0	63.2	3.3	1.10×10^{-5}
6	6	84.9	95.3	74.6	5.0	3.10×10^{-4}

3.8 Location Faizabad Rawalpindi

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.8 represent the second phase data collection of location Faizabad Rawalpindi at selected hours of a day. Temperature range recorded from 25° C to 42° C and humidity percentage recorded < 90% during the second phase of data collection.

Table 3.8 Noise level of Faizabad Rawalpindi at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	85.2	76	85.2	74.5
2	82.6	78	90.3	80
3	85	78	90.9	85
4	88	80	94.3	75
5	85	80.2	87	85
6	84	82.1	94	78
7	82.5	80	92.1	78
8	81.4	78	81.4	76
9	78	80.1	83.3	75
10	75.7	80	75.7	75.7
11	74.4	84	84	74.4
12	83.2	83.2	83.2	75
13	80	84.7	84.7	80
14	82	85	82	75
15	82.2	80	82.2	79
16	80	74.4	84	80
17	85.4	74	85.4	78
18	78	78	78.1	78
19	75	80	80.2	75
20	80	80.3	80.3	80
21	82	75	85.2	80
Max noise level	88.00	85.00	94.30	85.00
Min noise level	74.40	74.00	75.70	74.40
Mean	81.4	79.6	84.9	77.9
Intensity Level	1.3×10^{-4}	9.06×10^{-5}	3.11×10^{-4}	6.21×10^{-5}
Temperature [°C]	22.5	27.5	33.25	25.25
Humidity [%]	48.5	36.5	25.75	38

3.9 Location Pirwadahi Rawalpindi

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.9 represent the second phase data collection of location Pirwadahi Rawalpindi at selected hours of a day. Temperature range recorded from 25° C to 42° C and humidity percentage recorded < 90% during the second phase of data collection.

Table 3.9 Noise level of Pirwadahi Rawalpindi at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	85.4	83	83	76
2	85	88	88	74
3	85	87.7	87.7	78
4	82	92.1	92.1	79
5	77	95	96.7	78
6	80	94.5	92	80
7	78.9	97.6	90	74
8	85	96.2	90	76
9	90	85	85	78
10	92.3	91.5	91.5	80
11	93	89.9	89.9	85
12	81.4	94	94	82
13	92.2	82	82	82
14	90.9	81	81	85
15	90	90	85	80
16	80	92.3	90	75
17	91	93	92.3	74
18	85	81.4	93	75
19	91.5	92.2	81.4	78
20	89.9	90.9	92.2	79
21	88	89	90.9	80
Max noise level	93.00	97.60	96.70	85.00
Min noise level	77.00	81.00	81.00	74.00
MEAN	86.4	89.8	88.9	78.5
Intensity Level	4.32×10^{-4}	9.60×10^{-4}	9.83×10^{-4}	7.04×10^{-5}
Temperature [°C]	22.75	25.5	33.75	29
Humidity [%]	54.74	41.75	31	39.25

3.10 Location 6th road Rawalpindi

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.10 represent the second phase data collection of location 6th road Rawalpindi at selected hours of a day. Temperature range recorded from 25° C to 42° C and humidity percentage recorded < 90% during the second phase of data collection.

Table 3.10 Noise level of 6th road Rawalpindi at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	70.0	65.0	78.0	66.0
2	72.5	65.2	84.0	65.2
3	71.0	68.0	87.0	68.4
4	70.5	70.0	85.5	68.0
5	72.6	65.5	88.0	65.9
6	70.0	65.0	87.0	66.0
7	68.0	67.0	89.6	65.1
8	68.0	67.7	76.0	68.0
9	65.5	68.0	86.9	68.2
10	70.0	70.2	88.5	65.1
11	66.2	68.0	70.8	66.0
12	67.0	64.0	68.0	65.0
13	68.0	68.5	77.0	69.2
14	64.0	76.7	87.0	66.0
15	68.0	74.5	85.2	71.0
16	65.8	70.0	78.0	67.4
17	70.0	75.0	77.0	65.0
18	68.6	68.5	88.2	66.0
19	67.0	70.0	75.6	68.0
20	65.0	64.0	78.0	66.0
21	70.0	70.2	77.0	65.3
Max noise level	72.60	76.70	89.60	71.00
Min noise level	64.00	64.00	68.00	65.00
Mean	68.5	68.6	81.5	66.7
Intensity level	7.02×10^{-6}	7.28×10^{-6}	1.42×10^{-4}	4.68×10^{-6}
Temperature [°C]	22.5	26	32.25	26
Humidity [%]	56.5	40.75	30.5	34.75

3.11 Location I9/3 Islamabad

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.11 represent the second phase data collection of location I9/3 Islamabad at selected hours of a day. Temperature range recorded from 25° C to 42° C and humidity percentage recorded < 90% during the second phase of data collection.

Table 3.11 Noise level of I9/3 Islamabad at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	71.3	70.0	77.0	72.0
2	70.0	72.0	81.0	75.5
3	73.0	74.0	75.0	82.0
4	68.0	74.0	78.0	78.0
5	66.0	75.0	81.0	70.0
6	68.5	76.0	74.0	74.0
7	69.0	78.2	80.0	75.3
8	70.0	75.0	75.0	70.0
9	65.9	78.0	79.0	72.0
10	68.0	75.0	78.0	75.2
11	70.2	74.0	86.0	79.0
12	76.0	74.0	75.0	72.6
13	78.0	78.0	80.0	70.0
14	67.0	79.0	82.0	71.0
15	75.0	80.0	78.0	75.2
16	80.0	80.0	82.0	70.0
17	78.0	74.0	85.0	82.3
18	80.0	75.0	84.0	82.0
19	75.0	74.0	76.0	76.0
20	80.0	80.1	82.0	82.0
21	82.0	80.0	85.5	80.0
Max noise level	82.00	80.10	86.00	82.30
Min noise level	65.90	70.00	74.00	70.00
Mean	72.9	76.0	79.7	75.4
Intensity level	1.95×10^{-5}	3.95×10^{-5}	9.31×10^{-5}	3.49×10^{-5}
Temperature [°C]	22.5	24.5	32.25	26.25
Humidity [%]	54.5	46	28.5	42.75

3.12 Location Karachi company Islamabad

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.12 represent the second phase data collection of location Karachi Company Islamabad at selected hours of a day. Temperature range recorded from 25° C to 42° C and humidity percentage recorded < 90% during the second phase of data collection.

Table 3.12 Noise level of Karachi Company Islamabad at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	65.5	73.5	72.0	65.5
2	70.0	68.0	75.0	70.0
3	71.2	71.2	74.0	64.6
4	70.0	72.5	75.0	70.0
5	75.3	75.0	72.0	69.0
6	77.0	71.1	71.3	68.0
7	72.3	72.3	75.0	72.3
8	68.0	70.0	68.0	68.0
9	65.0	75.0	69.0	70.2
10	72.0	72.0	75.0	70.0
11	65.0	72.5	75.0	65.0
12	70.0	71.6	75.2	70.0
13	63.2	72.2	70.0	63.2
14	68.0	69.0	76.0	68.0
15	65.2	74.0	74.0	65.2
16	71.0	66.5	71.5	71.0
17	67.0	75.0	67.0	67.0
18	72.0	72.0	71.5	70.0
19	74.5	74.5	70.0	66.9
20	73.5	73.5	65.9	70.0
21	68.0	68.0	68.0	67.6
Max noise level	77.0	75.0	76.0	72.3
Min noise level	63.2	66.5	65.9	63.2
Mean	69.7	71.9	71.9	68.2
Intensity level	9.33×10^{-6}	1.54×10^{-5}	1.56×10^{-5}	6.56×10^{-6}
Temperature [°C]	21.25	27	33.5	24.5
Humidity [%]	62.25	48.25	28.5	52.5

3.13 Location Raja bazar Rawalpindi

In order to investigate the diurnal variation data were recorded during different hours of a day from each location. Starting from 7:00AM to 8:00AM, 1:00PM to 2:00PM, 5:00PM to 6:00PM, and 9:00PM to 10:00PM. Table 3.13 represent the second phase data collection of location Raja bazar Rawalpindi at selected hours of a day. Temperature range recorded from 25° C to 42° C and humidity percentage recorded < 90% during the second phase of data collection.

Table 3.13 Noise level of Raja bazar Rawalpindi at selected hours

Sr.#	7:00AM to 8:00AM	1:00PM to 2:00PM	5:00PM to 6:00PM	9:00PM to 10:00PM
	Noise level(dB)	Noise level(dB)	Noise level(dB)	Noise level(dB)
1	78.0	80.0	91.2	90.0
2	81.6	81.9	92.5	88.0
3	80.0	82.3	91.2	85.3
4	82.0	90.1	90.0	88.0
5	82.1	90.2	90.0	79.6
6	80.0	82.2	91.2	88.6
7	78.2	78.8	90.0	85.5
8	75.0	74.6	91.2	92.0
9	82.9	78.0	92.2	87.0
10	77.4	82.3	84.6	85.0
11	74.6	90.1	85.0	87.0
12	84.6	88.4	80.0	85.6
13	85.0	82.2	85.0	90.0
14	80.0	81.0	91.0	80.0
15	76.0	77.0	95.3	88.0
16	81.9	81.9	82.0	85.6
17	82.3	81.6	87.0	82.4
18	90.1	90.1	90.0	84.6
19	88.0	94.3	90.0	82.6
20	85.2	82.2	90.2	85.6
21	78.8	85.0	91.7	81.2
Max noise level	90.1	94.3	95.3	92.0
Min noise level	74.6	74.6	80.0	79.6
Mean	81.1	83.5	89.1	85.8
Intensity level	1.30×10^{-4}	2.26×10^{-4}	8.15×10^{-4}	3.79×10^{-4}
Temperature [°C]	22.75	26.5	33	27
Humidity [%]	55.5	50.75	30.25	39.5

4.0 Comparison of noise level of 1st and 2nd phase

By comparing Noise level recorded during 1st and 2nd phase, it was observed that Noise level is higher in 2nd phase. Figure 3.1 represent the noise level recorded during 7:00am to 8:00am for both 1st and 2nd phase.

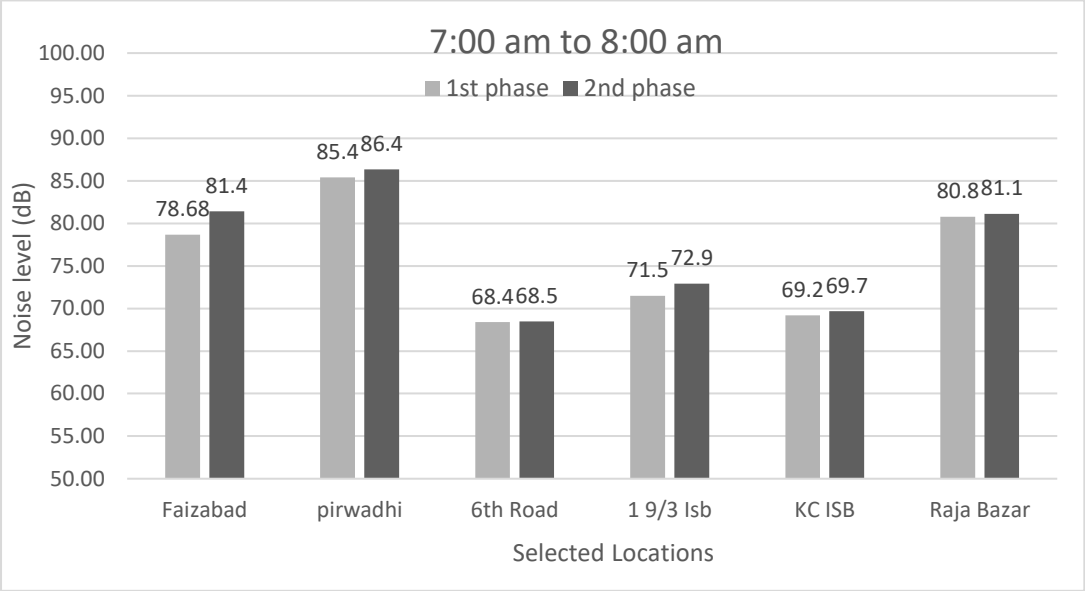

Figure 3.1 Noise level from 7:00am to 8:00am

Figure 3.2 represent the noise level recorded during 1:00pm to 2:00pm for both 1st and 2nd phase.

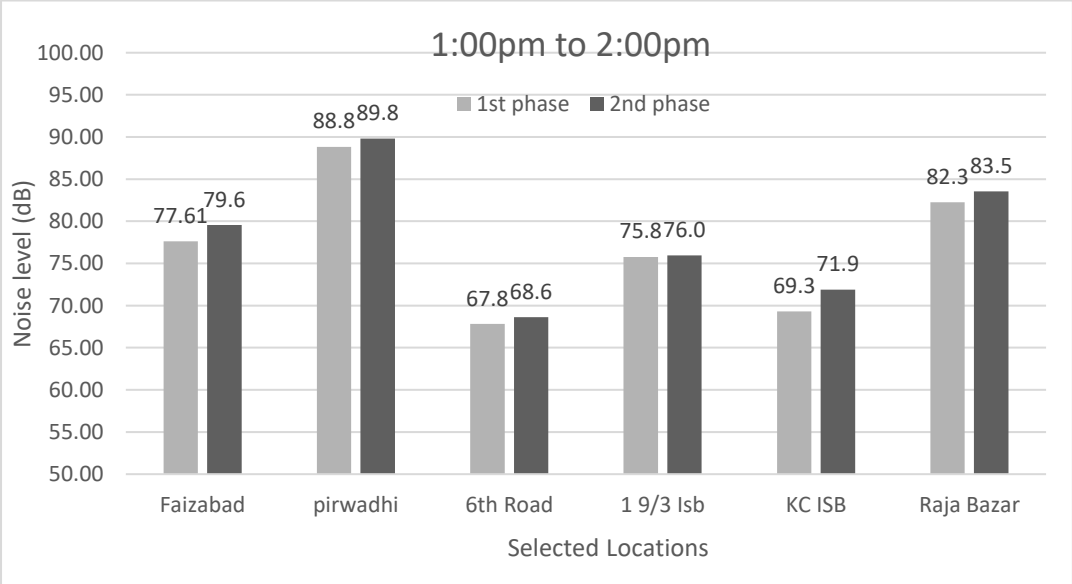

Figure 3.2 Noise level from 1:00pm to 2:00pm

Figure 3.3 represent the noise level recorded during 5:00pm to 6:00pm for both 1st and 2nd phase.

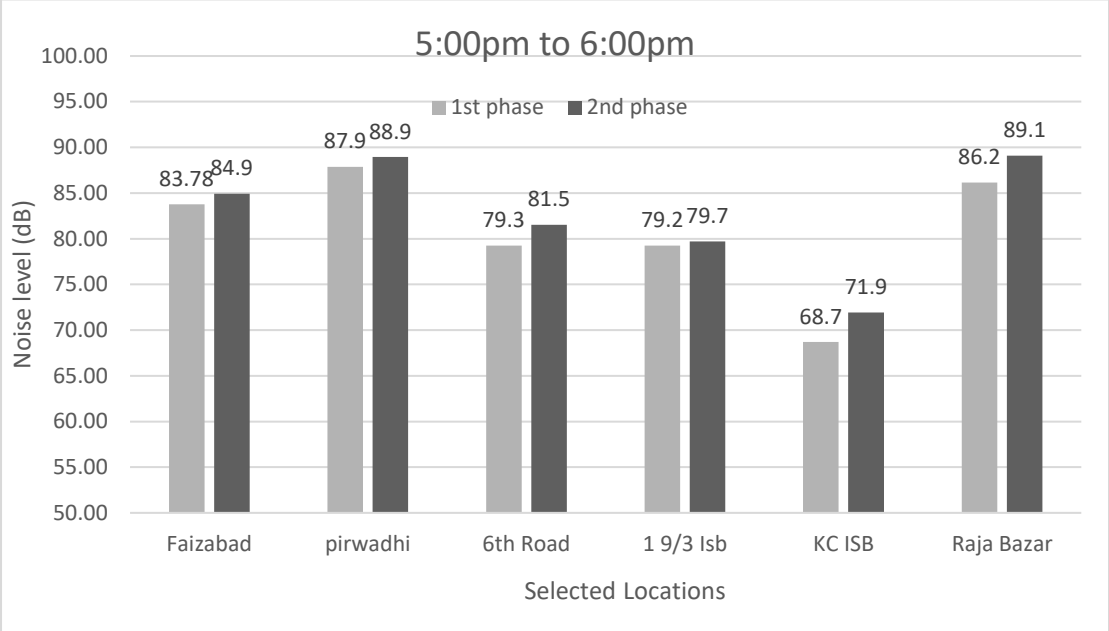

Figure 3.3 Noise level from 5:00pm to 6:00pm

Figure 3.4 represent the noise level recorded during 9:00pm to 10:00pm for both 1st and 2nd phase.

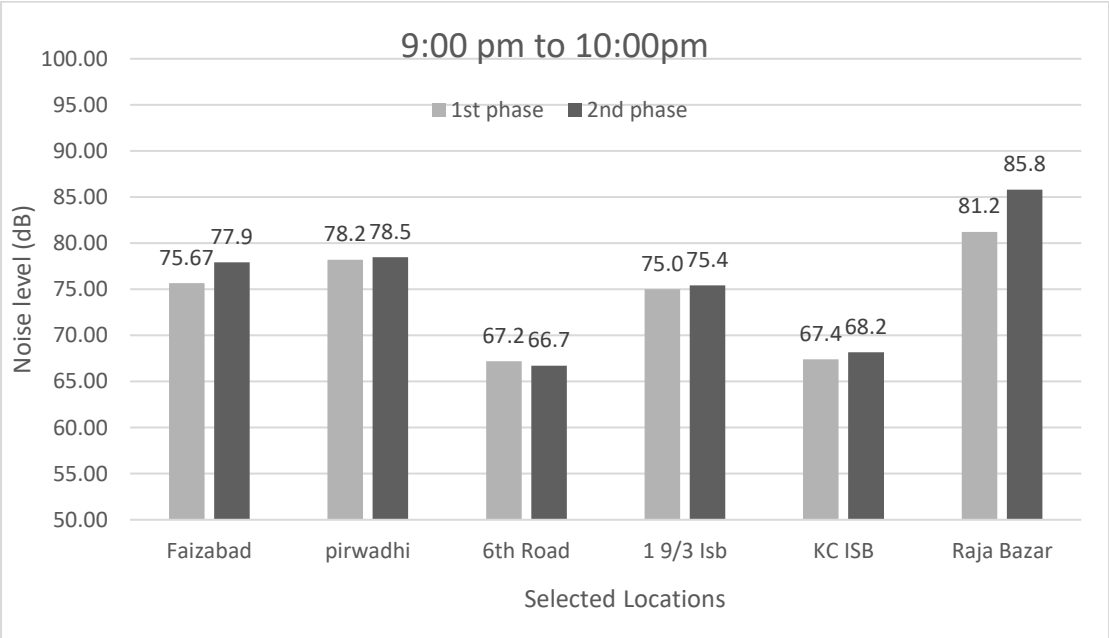

Figure 3.4 Noise level from 9:00pm to 10:00pm

5.0 Average value of seven month data collection

Noise level data was recorded on average basis in two phases. Over all data were recorded in seven month time period. In order to summarize all the recorded data, average measurements were calculated to represent the seven month noise level and its corresponding sound intensity level. Table 3.15 represent the average value of noise level for comprehensive analyze among selected locations. Noise level were recorded in unit decibel and intensity of sound level were calculated in watt per meter square.

Table 3.14 Average measurement of seven month data.

Average measurement from Dec-2018 to June -2019						
Location #	Noise level (dB)	Max (dB)	Min (dB)	S.D	Sound intensity level (w/m2)	NEQS limit
Faizabad Rwp	79.9	92	72.2	4.4	9.90×10^{-5}	70 dB
Pirwadahi Rwp	85.5	96.4	72	6	3.50×10^{-4}	65 dB
6th road Rwp	71	89.6	64	6.6	1.30×10^{-5}	50 dB
I9/3 Isb	75.7	85	65.1	4.5	3.70×10^{-5}	75 dB
K.C Isb	69.5	76.1	63.2	3	8.91×10^{-6}	65 dB
Raja bazar Rwp	83.7	94.3	74.6	4.6	2.34×10^{-4}	65 dB

Average value of noise level recorded during 1st phase and 2nd phase variation exhibits in Figure 3.5

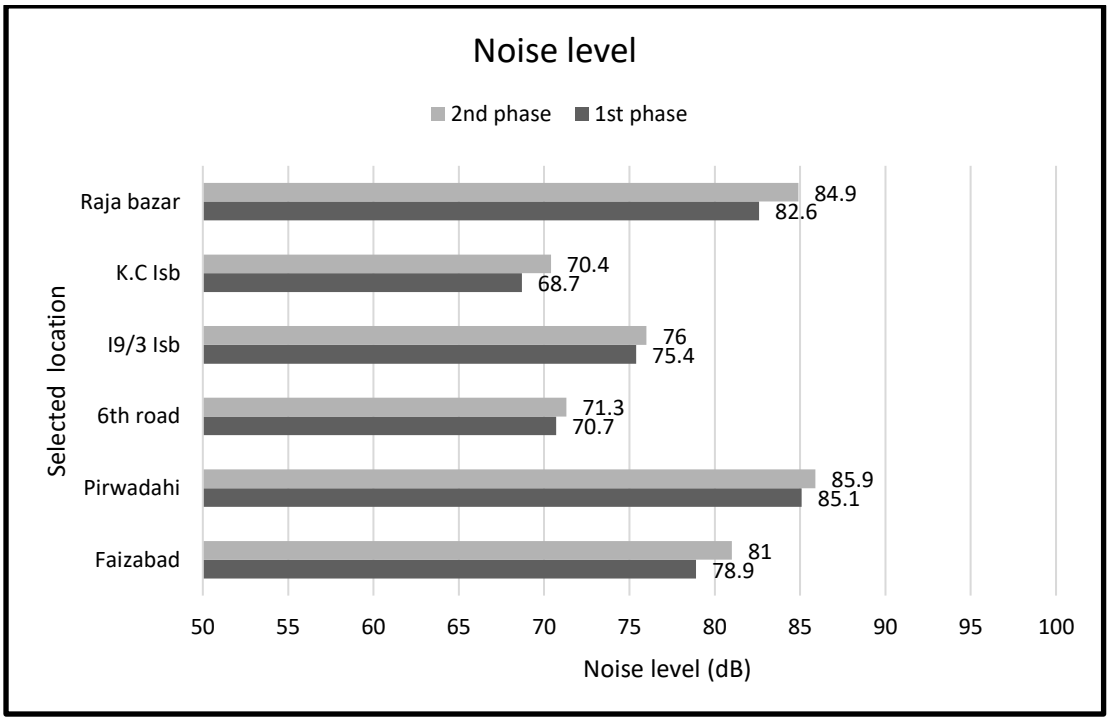

Figure 3.5 Noise levels of 1st and 2nd phase.

Average value of noise intensity level calculated during 1st phase and 2nd phase variation exhibits in Figure 3.6

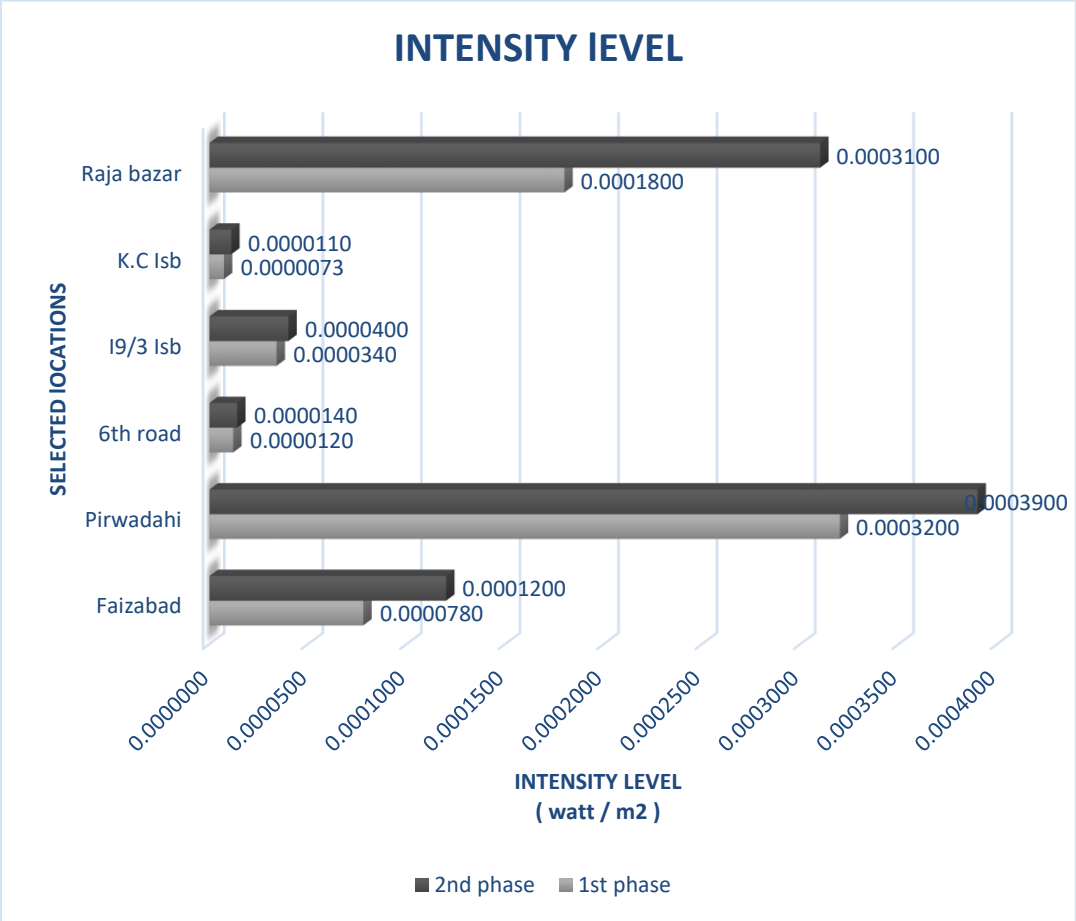

Figure 3.6 Noise intensity levels of 1st and 2nd phase.

6.0 Statistical analysis

The statistical analysis of data recorded during winter and summer months showed a significant variation in noise levels ($p<0.001$) at all locations.

6.1 Statistical analysis phase 1

Faizabad [1st phase]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance		
7:00AM to 8:00AM	21	1652	78.7	11.4		
1:00PM to 2:00PM	21	1630	77.6	11.4		
5:00PM to 6:00PM	21	1759	83.8	12.4		
9:00PM to 10:00PM	21	1589	75.7	18.1		
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	754	3	251	18.8	0.00	2.72
Within Groups	1067	80	13.3			
Total	**1821**	**83**				

Pirwadahi [1st phase]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance		
7:00AM to 8:00AM	21	1794	85.4	29.6		
1:00PM to 2:00PM	21	1866	88.8	26.9		
5:00PM to 6:00PM	21	1845	87.9	22.5		
9:00PM to 10:00PM	21	1643	78.2	9.09		
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1450	3	483	21.9	0.00	2.72
Within Groups	1763	80	22			
Total	**3213**	**83**				

6th road [1st phase]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance		
7:00AM to 8:00AM	21	1436	68.4	12.9		
1:00PM to 2:00PM	21	1425	67.8	11		
5:00PM to 6:00PM	21	1664	79.3	43		
9:00PM to 10:00PM	21	1411	67.2	6.77		
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2077	3	692	37.5	0.00	2.72
Within Groups	1476	80	18.4			
Total	**3553**	**83**				

I9/3 [1st phase]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance		
7:00AM to 8:00AM	21	1501	71.5	15.2		
1:00PM to 2:00PM	21	1591	75.8	8.88		
5:00PM to 6:00PM	21	1664	79.2	9.79		
9:00PM to 10:00PM	21	1575	75	20.8		
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	638	3	213	15.6	0.00	2.72
Within Groups	1093	80	13.7			
Total	**1731**	**83**				

K-C [1st phase]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance		
7:00AM to 8:00AM	21	1453	69.2	12		
1:00PM to 2:00PM	21	1456	69.3	15		
5:00PM to 6:00PM	21	1443	68.7	10		
9:00PM to 10:00PM	21	1416	67.4	12		
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	47.3	3	15.8	1.3	0.29	2.72
Within Groups	993	80	12.4			
Total	**1040**	**83**				

Raja bazar [1st phase]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance		
7:00AM to 8:00AM	21	1696	80.8	19		
1:00PM to 2:00PM	21	1728	82.3	25.2		
5:00PM to 6:00PM	21	1809	86.2	22.1		
9:00PM to 10:00PM	21	1706	81.2	28.7		
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	376	3	125	5.28	0	2.72
Within Groups	1900	80	23.8			
Total	**2277**	**83**				

6.2 Statistical analysis phase 2

[2nd phase] Data Analysis

Faizabad [2nd phase]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1710	81.4	13.3
1:00PM to 2:00PM	21	1671	79.6	9.92
5:00PM to 6:00PM	21	1784	84.9	25.1
9:00PM to 10:00PM	21	1637	77.9	9.92

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	568	3	189	13	0	2.72
Within Groups	1164	80	14.6			
Total	1732	83				

Pirwadahi [2nd Phase]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1814	86.4	25
1:00PM to 2:00PM	21	1886	89.8	24.3
5:00PM to 6:00PM	21	1868	88.9	19.8
9:00PM to 10:00PM	21	1648	78.5	10.9

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1679	3	560	28	0	2.72
Within Groups	1599	80	20			
Total	3278	83				

6th road [2nd Phases]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1438	68.5	5.69
1:00PM to 2:00PM	21	1441	68.6	12.3
5:00PM to 6:00PM	21	1712	81.5	40.8
9:00PM to 10:00PM	21	1401	66.7	2.71

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2965	3	988	64.2	0	2.72
Within Groups	1231	80	15.4			
Total	4196	83				

I9/3 [2nd Phases]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1530.9	72.9	27.3
1:00PM to 2:00PM	21	1595.3	76.0	8.3
5:00PM to 6:00PM	21	1673.5	79.7	13.4
9:00PM to 10:00PM	21	1584.1	75.4	19.4

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	494.6	3.0	164.9	9.6	0.0	2.7
Within Groups	1368.6	80.0	17.1			
Total	1863.2	83.0				

K-C [2nd Phases]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1464	69.7	14.198
1:00PM to 2:00PM	21	1509	71.876	5.9459
5:00PM to 6:00PM	21	1510	71.924	9.5659
9:00PM to 10:00PM	21	1432	68.167	5.84033

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	209.5	3	69.845	7.85871	0.0001	2.72
Within Groups	711	80	8.8875			
Total	**920.5**	**83**				

Raja Bazar [2nd Phases]

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1703.7	81.129	16.317
1:00PM to 2:00PM	21	1754.2	83.533	26.371
5:00PM to 6:00PM	21	1871.3	89.110	14.219
9:00PM to 10:00PM	21	1801.6	85.790	10.827

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	726.69	3	242.23	14.30	0.00	2.72
Within Groups	1354.69	80	16.93			
Total	**2081.37**	**83**				

6.3 Comparison of Phase 1 & 2

i. Faizabad Rawalpindi

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM [1]	21	1652.3	78.68	11.43
1:00PM to 2:00PM [1]	21	1629.9	77.61	11.44
5:00PM to 6:00PM[1]	21	1759.3	83.78	12.37
9:00PM to 10:00PM [1]	21	1589.1	75.67	18.12
7:00AM to 8:00AM[2]	21	1709.6	81.41	13.27
1:00PM to 2:00PM[2]	21	1671	79.57	9.92
5:00PM to 6:00PM[2]	21	1783.5	84.93	25.11
9:00PM to 10:00PM [2]	21	1636.6	77.93	9.92

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1493.91	7.00	213.42	15.30	0.00	2.07
Within Groups	2231.73	160.00	13.95			
Total	**3725.64**	**167.00**				

ii. Pirwadahi Rawalpindi

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1793.70	85.41	29.63
1:00PM to 2:00PM	21	1865.50	88.83	26.92
5:00PM to 6:00PM	21	1845.00	87.86	22.53
9:00PM to 10:00PM	21	1642.50	78.21	9.09
7:00AM to 8:00AM	21	1813.50	86.36	24.99
1:00PM to 2:00PM	21	1886.30	89.82	24.33
5:00PM to 6:00PM	21	1867.70	88.94	19.75
9:00PM to 10:00PM	21	1648.00	78.48	10.86

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3157.13	7.00	451.02	21.46	0.00	2.07
Within Groups	3362.21	160.00	21.01			
Total	**6519.34**	**167.00**				

iii. 6th road Rawalpindi

Anova: Single Factor
SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1436.10	68.39	12.95
1:00PM to 2:00PM	21	1424.50	67.83	11.04
5:00PM to 6:00PM	21	1664.30	79.25	43.03
9:00PM to 10:00PM	21	1411.40	67.21	6.77
7:00AM to 8:00AM	21	1437.70	68.46	5.69
1:00PM to 2:00PM	21	1441.00	68.62	12.31
5:00PM to 6:00PM	21	1712.30	81.54	40.84
9:00PM to 10:00PM	21	1400.80	66.70	2.71

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5059.81	7.00	722.83	42.72	0.00	2.07
Within Groups	2707.00	160.00	16.92			
Total	**7766.81**	**167.00**				

iv. I9\3 islamabad

Anova: Single Factor
SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1501.20	71.49	15.22
1:00PM to 2:00PM	21	1591.40	75.78	8.88
5:00PM to 6:00PM	21	1664.00	79.24	9.79
9:00PM to 10:00PM	21	1574.80	74.99	20.76
7:00AM to 8:00AM	21	1530.90	72.90	27.26
1:00PM to 2:00PM	21	1595.30	75.97	8.33
5:00PM to 6:00PM	21	1673.50	79.69	13.41
9:00PM to 10:00PM	21	1584.10	75.43	19.43

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1148.5	7.00	164.08	10.66	0.00	2.07
Within Groups	2461.7	160.00	15.39			
Total	**3610.2**	**167.00**				

v. Karachi Company islamabad

Anova: Single Factor
SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1453.00	69.19	12.38
1:00PM to 2:00PM	21	1455.60	69.31	14.82
5:00PM to 6:00PM	21	1442.60	68.70	10.41
9:00PM to 10:00PM	21	1415.80	67.42	12.04
7:00AM to 8:00AM	21	1463.70	69.70	14.20
1:00PM to 2:00PM	21	1509.40	71.88	5.95
5:00PM to 6:00PM	21	1510.40	71.92	9.57
9:00PM to 10:00PM	21	1431.50	68.17	5.84

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	387.18	7.00	55.31	5.19	0.00	2.07
Within Groups	1703.99	160.00	10.65			
Total	2091.17	167.00				

vi. Rajabazar Rawalpindi

Anova: Single Factor
SUMMARY

Groups	Count	Sum	Average	Variance
7:00AM to 8:00AM	21	1696.30	80.78	19.04
1:00PM to 2:00PM	21	1727.60	82.27	25.23
5:00PM to 6:00PM	21	1809.20	86.15	22.08
9:00PM to 10:00PM	21	1705.90	81.23	28.65
7:00AM to 8:00AM	21	1703.70	81.13	16.32
1:00PM to 2:00PM	21	1754.20	83.53	26.37
5:00PM to 6:00PM	21	1871.30	89.11	14.22
9:00PM to 10:00PM	21	1801.60	85.79	10.83

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1322.07	7.00	188.87	9.28	0.00	2.07
Within Groups	3254.83	160.00	20.34			
Total	**4576.90**	**167.00**				

6.4 Noise level with average temperature and humidity %

Anova: Single Factor Phase 1

SUMMARY

Groups	Count	Sum	Average	Variance
dB [1]	24	1845.29	76.89	48.06
" °C" [1]	24	248.67	10.36	12.07
% [1]	24	1678	69.92	184.89

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	64169.04	2.00	32084.52	392.84	0.00	3.13
Within Groups	5635.40	69.00	81.67			
Total	**69804.44**	**71.00**				

Anova: Single Factor Phase 2

SUMMARY

Groups	Count	Sum	Average	Variance
dB [2]	24	1877.98	78.25	52.75
" °C" [2]	24	647	26.96	16.26
% [2]	24	1017.25	42.39	110.29

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	33239.7	2	16619.8	278.07	0	3.13
Within Groups	4124.02	69	59.77			
Total	**37363.7**	**71**				

Measurement of noise level data during different time periods of day shows a trend of variation. The variation is found to be statistically significant during different time slots of the same location as well as various locations. The only exception was the location of Karachi Company; where noise level data during summer months did not showed significant variation. It might be due to similar business activities all the time at this location. However; the same location showed significant diurnal variation in data during winter months. In order to summarize all the recorded data, average measurements were calculated to represent the noise levels and its corresponding sound intensity level during seven months of study period It was observed that the allowable noise limit of Pirwadahi Rawalpindi was 20 dB above the prescribed limit of 65 dB, with a calculated intensity level of 3.54×10^{-4} w/m^2. While the highest noise recorded was up to 96.4 dB, which exceeded 31.4 dB from the standard limit. Location Raja bazar is a commercial zone of Rawalpindi so its permissible noise limit assigned by NEQS was also 65 dB. The noise level recorded at this location was exceeding 19 dB from its standard limit. While the highest noise level recorded was up to 94.3 dB which exceeded 29.3 dB as compared to the standard. Location of Faizabad Rawalpindi was located in front of heavy traffic flow. The permissible noise level according to NEQS was 70 dB, the actual noise level at this location was found to be 79.9 dB with calculated intensity level of 9.88 x 10-5 w/m^2, which prominently exceeds about 10 dB from its standard value. While the highest noise recorded up to 92 dB which exceeded 22 dB from the standard limit. Location I-9/3 is an industrial zone in Islamabad. The allowable limit of noise assigned by NEQS was 75 dB. Highest noise level at this location was 85.0 dB, exceeding 10 dB from the standard limit. Location of 6th road is heavily populated with a number of educational institutes in Rawalpindi and traffic load. According to NEQS, the allowable limit assigned to this location is 50 dB. Average noise level recorded was 71.0 dB which exceed about 21 dB from the standard limit with corresponding sound intensity level were calculated as $1.26\ X10^{-5}$ watt/m^2. Maximum level recorded of concern location was 89.6 dB which exceed prominently 39.6 dB from the allowable standard. Location Karachi company Islamabad was not found that much noisy, but still the recorded values exceeded from NEQS. This location is also a commercial zone of Islamabad and the allowable limit of noise level was 65 dB. Highest noise level recorded at this location was up to 76.1 dB.

Recorded noise level of all the selected location exceeded from its allowable limit and corresponding intensity levels also increased as noise level increased assigned

from NEQS and WHO. Figure 3.6 clearly illustrated the exceedances of noise level of selected locations.

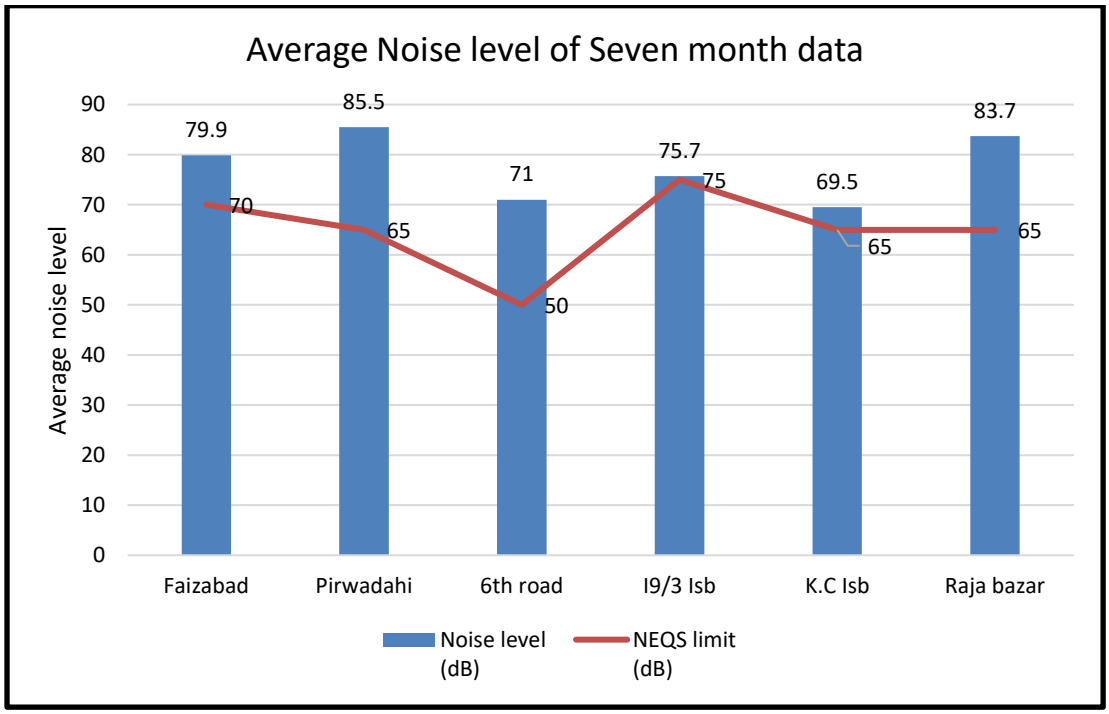

Figure 3.7 Recorded and Allowable noise levels.

In recent years, in many countries including Pakistan studies have been carried out to determine noise levels. According to one of the study Kalim et al.(2014) concluded that noise level recorded at some of the important locations in Rawalpindi and Islamabad exceed the limit of given standards, Gordon college Rawalpindi which is located near Liaquat Bagh , it consider one of the biggest and oldest Collage in Rawalpindi , the noise level recorded upto 85db, maximum noise level were recorded 90.2db which exceed prominently from it's given standard limit. Similar at the case of Govt. College for women s/town Rawalpindi, noise level were recorded 69 dB, with the maximum reading 77.8 dB. Chandni Chock flyover Rawalpindi is one of the most important and busy pass way for the local people, workers, students and office workers, the noise level were recorded on average basis 73.5db with the maximum level 101.9 db which violently crosses the standard limit of NEQS.

The similar e interdependence of temperature, humidity and noise level is reported in a recent study in which the effects of temperature and pressure on sound speed in sediments and their trends were analyzed. (Kan et al., 2019). Noise level comparison

during winter (1st phase) and summer months (2nd phase). The statistical analysis of data recorded during winter and summer months showed a significant variation in noise levels ($p<0.001$) at all locations. In another study evaluating the interdependence of air temperature, radiant heat, wind velocity and noise intensity it was revealed that less noise in forests affects positively to reduce the intensity of other factors. Consequently, a forest setting is more comfortable for people than an urban setting during the summers (Park et al., 2011). The psychological responses to physical environments are also significantly related to air temperature, relative humidity, radiant heat and wind velocity. The temperature effect is highest in low and high frequency ranges of noise. It has been found that the sound frequencies have a strong correlation with temperature and humidity (Xia et al., 2006). Our results show a significant variation of noise levels data with temperature and humidity variation during winter and summer phases of data collection.

According to a study by Kalim et al. (2014), it was reported that noise levels recorded at some of the important locations in Rawalpindi exceed the limit of given standards. The study recorded few areas of Rawalpindi indicating maximum noise levels of 90,77.8and 101dB at Gordon college, Women college and Chandni Chowk respectively. Our study focused on more diverse locations of twin cities including temporal and seasonal variations with noise data. There is a lack of awareness regarding the noise pollution. People are unaware regarding physical and social harms of noise. There are not many complaints regarding noise from any part of the community. That might be the reason for no steps ever taken by the authorities to reduce the noise pollution in selected areas. There is a disproportionate use of loudspeakers in Pirwadahi and Faizabad bus stops for the purpose of attracting the passengers which is the reason for increased level of noise. There are a number of Auto repair and denting painting workshops at bus/HiAce stops which prominently contribute to increase the level of noise at Pirwadahi. Abundance of unapproved and unplanned stalls and shops in Raja bazar, and Pirwadahi location is responsible for the massive overcrowding and increased level of noise. There are no proper and enough parking areas for the local vehicles in raja bazar and 6th road Rawalpindi due to which massive congestion is observed for most of the time. Overcrowding has become a foundation to increase the level of noise to a prominent range. Unplanned urbanization has severely damaged the natural green areas of Rawalpindi and is strongly contributing towards noise pollution.

Based upon the situation of noise pollution in the study area; various strategies as mitigation measures can be adopted. As the recorded noise levels of all the selected locations exceeded from NEQS and WHO standards. So, the use of loudspeakers should be minimized, and proper board systems should be implemented for public addressing purposes. Green patching walls should be used abundantly which would reduce the noise levels significantly. Auto repairs workshops which produce prominent sound should be removed from the bus/ HiAce stops and should be in designated areas only. Unapproved and unplanned stalls should be removed from the locations to clear the traffic and maximum utilization of the parking areas. The traffic management system should be improved. Strict actions should be taken against overcrowding and violation of motor vehicle rule should be taken into serious consideration. Media should be used to spread awareness regarding the harms of increased noise pollution. Moreover, a specific and detailed legislation is needed to control the noise pollution.

CONCLUSIONS

Based on the results of the study following conclusion can be drawn:

The results show that recorded noise levels at all locations exceeded NEQS and WHO guidelines. Noise levels and intensity levels were found higher during summer months as compared to winter and affected by metrological conditions. Significant variation in noise levels was observed with seasonal and diurnal variations. However, more investigations are required to establish the effect of metrological parameters on noise levels. National level survey must be conducted to assess the noise level for major cities of Pakistan. The study will help to provide a guideline and symmetric path to follow for the concerned authorities of Pakistan to understand the severity of deadly pollution and take proper counter measures to protect the public health. There is a disproportionate use of loudspeakers in Pirwadahi and Faizabad bus stop for the purpose of attracting the passengers which is the reason of increased level of noise. There is a number of Auto repair and denting painting workshop at bus/Hiace stops which prominently contribute to increase the level of noise in Pirwadahi Rawalpindi location. Abundance of unapproved and unplanned stalls and shops in raja bazar, and Pirwadahi location is responsible for the massive overcrowdings and increased level of noise. There is no proper and enough parking areas for the local vehicles in raja bazar and 6th road Rawalpindi due to which massive congestion is observed for most of the time. Overcrowding has become a foundation to increase the level of noise to a prominent range. There is lack of awareness regarding the noise pollution. People are unaware regarding physical and social harms of noise. There is not much complaints regarding noise from any part of the community. That might be the reason of no steps ever taken by the authorities to reduce the noise pollution in selected areas. Unplanned urbanization has severely damaged the natural green areas of Rawalpindi and is strongly contributing towards noise pollution.

RECOMMENDATIONS

1. The use of loudspeakers should be minimized and proper board system should be implemented for public addressing purposes.
2. Auto repairs workshop which produce prominent sound should be remove from the bus/hiace stops and should be in designated areas only.
3. Unapproved and unplanned stalls should be remove from the locations to clear the traffic, and maximum parking area can be utilized.
4. Traffic management system should be improved. Strict actions should be taken against overcrowding, unauthorized installation of stalls.
5. Violation of motor vehicle rule 1969 section 154, 155 and 158 should be taken into consideration.
6. Media should be used to spread awareness regarding the harm of increased noise level.
7. Green patching walls should be used abundantly which will reduce the noise up significantly.
8. National level survey must been conducted to assess the noise level for major cities of Pakistan.
9. Specific and detailed legislation is needed to control noise pollution.
10. The study will help provide a guideline and symmetric path to follow for the concerned authorities of Pakistan to understand the severity of deadly pollution and take proper, solid counter measures.

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