ASSESSING THE IMPACT OF TRAFFIC FLOW ON NOISE POLLUTION

A Capstone project submitted in partial fulfillment of the

Requirements for the award of a degree of

Bachelor of Science in Civil Engineering

by

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This certifies that the student shown below completed the Capstone Project titled " **Assessing the Impact of Traffic Flow on Noise Pollution** " under my supervision. as part of the requirements for the Bachelor of Science in Civil Engineering degree. The presentation of the work was successfully held on 20 September 2025.

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DECLARATION

The dissertation, titled " Traffic Volume and Noise" was completed under the supervision of Kazi Obaidur Rahman (Assistant Professor), Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh, and was approved in partial fulfillment of the requirement for the capstone project part of the Bachelor of Science in Civil Engineering

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ABSTRACT

Noise pollution is a serious problem in Bangladesh, which we face in our daily life. It harms environment and is unfavorable for mental health which leads to an increase in corresponding disorders. Therefore, the government has to be proactive in controlling this situation. This project aims at studying methods of measuring noise pollution in decibels and formulating mitigation measures. The restricted data collection period is a challenge that we encounter. The primary aim of our work is to control the raw data gathered and suggest solutions such as tree plantation on highways. All studies, including ours, on noise pollution emphasize the need for a single and unified approach, prompting Bangladesh to promulgate the Sound Pollution Control Rules of 2006. These regulations form an adequate frame for our assessment and the proposal of local solutions. A major area of interest for this research is Dhaka - Archica National Highway (N-5), which is important for the economy of the nation, since it interconnects the capital Dhaka with the western part of our country. We inspect about 850-metre length of this highway from the C&B foot-over bridge to the Bangladesh Public Administration Training Centre. Though focusing on a particular part of the national road may limit the general vision of our research, it will prepare the ground for further investigations. Our findings point to an increased noise level with the acute necessity of government intervention to quell the issue. Further, the study highlights deforestation – as one of the major concerns and calls for a new tree-planting initiative, particularly, along the either side of the National Highway.

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INTRODUCTION

1.1 Noise Pollution in Bangladesh

Noise pollution in Bangladesh is not only a major environmental problem; it has reached crisis proportions. Housing a population of over 170 million and the pace of urbanisation and industrial growth is extremely fast, the level of noise in the cities of the country often surpasses noise levels established by both WHO (the World Health Organisation) and the DOE (the Department of Environment, Bangladesh). These benchmarks are 55db (day) and 45db (night) for residential areas, and 70db (day) and 60 db (night) for commercial districts. Nonetheless, this research indicates that noise levels at Dhaka, Chattogram, and Khulna range between 70 and 90 db with peak levels of 100 db in chaotic environments (Alam et al., 2018; Hossain et al., 2020). Road traffic makes up 60–70% of urban noise, i.e., road traffic is the main reason for the noise, is followed by construction activities, industrial operations, and public announcements (Department of Environment 2020). As over 30% of Bangladesh's population live in urban settlements and the regulation of noise levels by law go unchecked, Bangladesh is among South Asia's most noise-polluted countries (Bangladesh Bureau of Statistics, 2022). This noise pollution is pervasive and affects millions and most especially in densely urbanized cities. Immediate steps are needed to fight this crisis and ensure the population's health and well-being.

1.2 Dhaka's Contribution and Specific Locations

Dhaka, the 21 million people's home, is the epicentre of Bangladesh's problem of noise pollution. The heavy traffic, poor road infrastructure and ill traffic management in the city contribute to committing high levels of noise all the time. Neighbourhoods including Motijheel, Gulshan, Dhanmondi, Mirpur, and Farmgate record noise levels between 78 to 85 db while peak levels are at 90 db during peak hours (Chowdhury et al., 2019). Research carried out in Motijheel in 2021 showed an average noise at daytime to be 82 db brought mainly by heavy vehicles and constant honking (Rahman et al., 2021). Of Dhaka's registered 1.2 million vehicles, 40%, are motorcycles, 25% are private cars, 15% are auto-rickshaws, and buses and trucks occupy 10% each (BRTA, 2023). Two-stroke engines, or exhaust systems on motorcycles emit high frequency noise in contrast with the low frequency engine sounds from the older buses and trucks. CNG driven auto-rickshaws make sharp piercing noises and honking represents 20-25% of the traffic noise (Islam et al., 2022). In Chattogram, areas such as Agrabad, New market and the port record noise levels of between 75 and 88 db from truck traffic, ship breaking yards and port activities (Monir, 2020). The industrial areas of Gazipur and Narayanganj is 80 db on an average as opposed to the commercial areas of Sylhet and Rajshahi which 70-75 db which is a marker of increase in the vehicle ownership and the urban growth (Hassan et al., 2023).

1.3 Health and Environmental Impacts

The impact of noise pollution is multifaceted, affecting human health as well as the environment. One hearing outcome is noise-induced hearing loss (NIHL), which the World Health Organization (WHO) estimates affects about 1.3 billion people globally (Gilani, 2021).In Bangladesh, people at high risk include traffic police, rickshaw pullers, and street vendors, who are repeatedly subjected to more than 85 db of noise according to WHO (2015). In 2020, a survey of Dhaka found that 15% of the traffic police reported problems with their hearing (Ahmed et al., 2020). Non-auditory consequences include 20–25 % increased risk of hypertension and cardiovascular diseases associated with continuous noise levels beyond 65 db (Münzel et al. 2018). Sleep disturbances weaken approximately 30% of residents living along the Dhaka roads hence the low productivity. In addition, children that go to schools close to busy roads have a decline in cognitive performance by 10-15% (Stansfeld & Matheson, 2003; Doe, 2022). Schools in the Tejgaon and Mohammadpur areas report an impact of noise level on the concentration of students from 70 to 80 db (Rahman, 2021). Environmentally, noise disrupts urban ecosystems. In the Ramna Park of Dhaka and Foy's Lake in Chattogram, noise between 65-75 db has been demonstrated to result in 20% loss in bird mating success (Slabbekoorn & Ripmeester 2008; Alam, 2022). Furthermore, noise pollution increases the urban heat islands effect resulting into 5–10% of increase vehicle emissions. Underwater noise around Chattogram's port also negatively influences fishery yields, resulting in 10 – 15% decrease per annum (Hossain et al., 2021; Islam, 2023).

1.3.1 Importance of Experimental Studies

Experimental studies are fundamental in addressing noise pollution in Bangladesh because they offer location-specific data needed for strategy formulation to reduce noise pollution. Generic noise models are typically inattentive to local arrangements including traffic composition and road quality. Noise mapping of such places as ‘Dhaka’s Farmgate’ or ‘Chattogram’s Agrabad’, allows to detect contributions of vehicles, to shape policies like honking ban or promotion of electric cars (which are able to reduce noise level by 10 – 15db) (Doe, 2023). Studies reveal the existence of practical solutions for pedestrians (preventing noise: noise barriers and green belts; especially tree-lined roads) of reducing noise by 5–8 db (Fang & Ling, 2003). Zoning policies based on experimental data serve residents because they could mean an exposure reduction of 10-20 db (Hassan et al., 2022). In addition, research has measured the effects of noise on biodiversity, which further reinforcements the need to limit heavy vehicle movement as bird migrate which has been proven to increase reproductive success by 15% (Alam, 2022). The innovative techniques such as machine learning and Iot-based monitoring greatly increase precision and accuracy. For instance, a pilot in Dhaka using Iot sensors reduced noise by 5 db by dynamic traffic schematic (Rahman et al., 2023). Partnership of academia as well as Government and WHO with each other facilitate policies to be in line with international guidelines with the goal of ensuring that community noise remains at or below 55 db (WHO, 2018). In general, the experimental studies promote evidence-based answers that improve public health, quality of life, and environmental sustainability.

1.4 Objectives of the Study

This research aims to evaluate the current noise pollution in the arcades of road in Savar and examine its relationship with the flow of traffic . The particular objectives are:

1. Evaluation of noise levels and existing traffic circumstances on the roadways connecting at the studied area.
2. Investigate the relationship between existing traffic conditions and noise level at studied area, as well as develop recommendations and suggestions for future traffic and roadway enhancements.

The aim of this study is to establish a comprehensive traffic noise database of the area between C&B up to Bangladesh Public Administration Training Centre. Notable noise sources will be identified during this investigation. This knowledge on the correlation between noise levels and traffic conditions will hence enable the development of improved estimates of pollution on the basis of existing road conditions, the traffic density and the manner in which the people utilize the roads. The analyzed parameters comprise of Time, average decibel (db), maximum decibel (db), minimum decibel (db), Vehicle Count and Passenger Count per unit (PCU). This study seeks to determine relationships between these parameters based on a correlation study results and make recommendation and forecasts using the multilinear regression analysis.

1.5 Outline of Methodology

Completing this research project necessitated undertaking the following activities to achieve the objectives mentioned earlier.

- **Location of Study:** Sites used in measuring road noise are identified on major streets in the city. The selection of these locations is such that it addresses different land-use aspects including the C&B footover bridge to themetropolitan area of the Bangladesh Public Administration Training Centre thus giving an all-encompassing account of the prevailing noise pollution situation within the city. Measurements relating to noise level are taken together.
- **Noise level recording:** A data-logging digital sound level meter records the noise level. Measurements are taken over 15-second intervals, resulting in a cumulative duration of 10 minutes. These readings are crucial for the study's effectiveness; however, the analysis is segmented into 10-minute intervals, each consisting of 15 seconds, generating 40 data points. Additionally, the physical and environmental conditions present during data collection, like weather and traffic, are documented to maintain measurement accuracy.
- **Traffic data recording:** Traffic density is assessed by recording videos of traffic flow while measuring noise levels. The video records the number of vehicles over a designated period, facilitating precise estimation of traffic flow and a comprehensive understanding

of conditions at each site. Additionally, tools such as MS Excel assist in data entry, analysing the experiment, and formulating predictions and recommendations for future experiments.

1.6 Organisation of the Thesis

- This thesis consists of five main chapters.
- Chapter One is the introductory part, which provides the background information and purpose of the current study and a description of the methodology used.
- Chapter Two is the Review of Literature which encompasses noise terminology, the possible noise sources, the effects of the same, and the standards set by other organisations to reduce noise pollution. It sums up past research done on this topic too.
- Chapter Three outlines the research methodology, detailing the location and procedures used to collect noise and traffic data, as well as the noise parameters and evaluation methods employed.
- Chapter Four outlines the findings and discussions, illustrating the study's overall findings regarding noise levels. It compares noise levels across different timeframes using various graph interpretation methods and within road corridors, utilising a suitable noise map. Furthermore, it includes a detailed, step-by-step development of the noise parameters and their assessment, accompanied by comprehensive discussions.
- Chapter Five gives the limitations, conclusion, and future research carrying out of this study.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Loud noises severely spoil living in a city. In this chapter, a short description of operational definitions and terminology of noise pollution, including its measurement and parameters of noise levels are given. It also has various short evaluations of the present presence of information and a few past studies that will provide practical points that can be used in your research and professional pursuits, arming you with those tools for combating noise pollution.

2.2 Operational Definitions of Sound

Sounds are the transfer of motion without mass, with energy. Sound is production of waves of pressure in an elastic medium, caused by a wave of pressure moving through that medium at some characteristic speed. A sound wave is a vibration i.e. a displacement in the air. Sound pressures generated by different generators are extremely wide in scale. Audio Pressure and power measures are done logarithmically to simplify the understanding of the same. Decibel (db) is the most usually used measurement of sound. Sound quantity measured in terms of decibels is relative measure and is ratio of sound pressure at a normal sound pressure (Davis and Cornwell, 2008; Crocker, 2007).

2.2.1 Sound pressure level

The volume of the sound is a proportionality in relation to the sound pressure level square. To illustrate, when the strength of the source is doubled, the level of intensity increases by 3 db, sound pressure by 6 db (Tripathi, 2008). Figure 2.1 is the representation of a relative level of various sound pressures of some familiar sounds we produce in our everyday life.

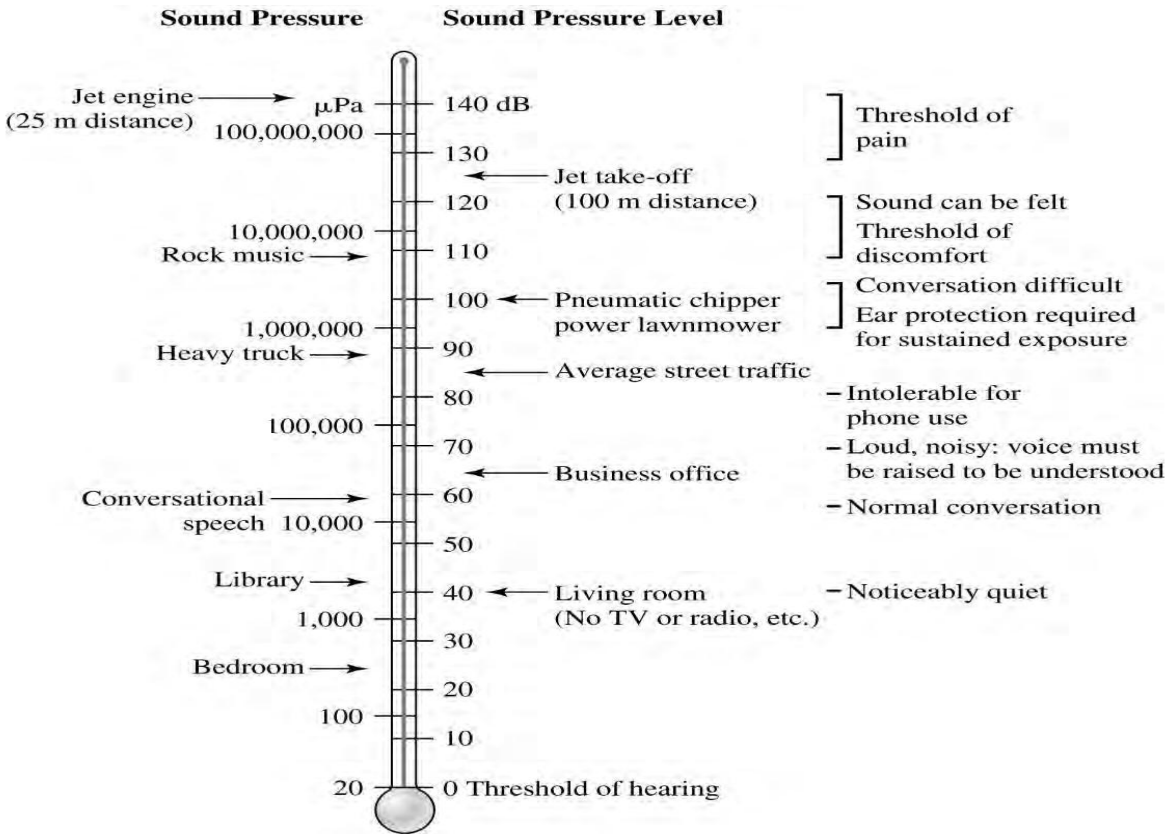

Figure 2.1: The relative scale of sound pressure level (Davis and Cornwell, 2008)

2.3 Noise and Environmental Noise

Noise is an obnoxious sound and a phenomenon of the environment as well as a pollutant due to several mechanical activities that cause vibrations. We encounter it all over the lives. How we perceive sound is necessary for identifying noise from pleasant sounds. This consciousness identifies the harmful nature of noise,and increases our knowledge of our environment. Unlike sound – which is typically pleasant, as well as disturbing - noise has unfavorable connotations and may be harmful in a variety of ways. It is most often linked to annoyance and negative impacts. While the sound may be soothing to the ear in its most naturalist form, the volume shall move to unappealing levels depending on the environment. In addition, levels of noise exceed normal volumes. Subject to each individual, identifying sound as noise is a common occurrence and differs from person to person. Other variables that influence noise annoyance are these: frequency, duration, punctuality /intermittent, The time of day /nighttime, nature of place and activity.

Noise in the environment could be described as the undesirable, damaging and damaging sound produced from actions of humans (Murphy et al., 2009). Noise from the environment is created by outdoor pursuits including transportation, industry, leisure pursuits, and It affects people's physical and mental well-being. Therefore, environmental noise is a commonly known sort of pollution.

2.4 Types of Noise

Qualitative descriptions of noise patterns can consist of the following terms: intermittent, impact, impulse, and steady-state or continuous (Davis and Cornwell, 2008). The noise doesn't stop. consistently and its fluctuations do not exceed 5 db within the period of observation. One is sound of raindrop. Intermittent noise is any sustained noise of over A single second interspersed with many seconds. Using a hammer by the construction workers would form an example of intermittent sound. The impulse noise is formed when there is a change of sound pressure of at least 40 db in Duration: 0.5 seconds that is less than a second (Davis and Cornwell, 2008). An example of impulsive noise is shooting using a rifle.

2.5 Noise Sources

There are works found that signify that the level of noise in a city is usually higher in comparison with the countryside and the denser population stays in metropolitan conditions the better the benefit of a study gets to be (1972 US DOT; CPU, 1985). US EPA, 1971; Simpson and Bishop, 1971. Urban noise comes as a result of transport, factories, industries, people, machines. The three categories of the noise sources include the following: the industrial, residential and transport related noise sources (Wang et al., 2004).

Manufacturing machinery and construction activities are important contributors to noise. Machinery itself is one example; high speed fans or blower systems are as well. The operators of the equipment and the industrial workers are the principal sufferers of this noise pollution, plus the inhabitants around. Payments for various types of residential machinery and equipment, including air conditioners, lawnmowing units, and equipment in the kitchen and laundry areas and stereo sets are existed in being significant sources of residential noise. In addition, The number of device and tools in contemporary societies has made the situation much more complicated. Transportation noise, especially noise from road traffic, is the main subject of this study. Comprehension of and dealing with the consequences of road traffic noise is an important aspect of the research and is taken up in the latter part of this chapter.

2.6 Transportation-Related Noise

Environmental noise like that of traffic and transportation is the one that is experienced most all round the world. Authorities in Europe have estimated that 89.8 million individuals are subjected to more than 55 Lden dB noise that is caused by road traffic and the numbers of exposed individuals by railways and aircraft respectively are 11.7 million and 4.3 million people (European Commission, 2011). According to different modes of transportation, the sounds associated with transportation May can be classified into three groups: T road traffic noise, railway noise, and a plane (Murphy and King, 2014). The aircraft noise however is not so relevant to the greater community noise picture given it is operating under enormous distances separating most airports with the urban centre. The sound of the railway is something that has only locations with tracks and within a fixed time duration. The main component of transportation noise is Road traffic noise.

Road traffic noise is a type of field noise composed of percussions caused by each individual vehicle (i. e. by A car's propulsion system e. g. friction and engine noise) (i. e. Road noise, tyre noise, or rolling noise) between the tyres of the car and the roadway. The intensity of noise emitted by a vehicle to a large extent is dependent on speed and this affects the contribution of every mechanism of source. The noise form an engine is predominating at low speed ranges; and at high speed ranges it is predominating with tyre/road noise.

2.7 Factors Influencing Road Traffic Noise

The noise caused by traffic is in all respects more capricious and irregular than any other sort a noise. As a vehicle moves to an observation site, noise intensity increases and reaches out the top (peak) value and then it decreases as the car travels further. Constant flow of traffic creates a sound pattern of unvaried road noise, leaving the one solely sent out by some vehicles to define. in variable conditions (Bugliarello et al., 1976). Traffic pollution is a parameter that is dependent on a number of other parameters and these are identified Figure 2.4.

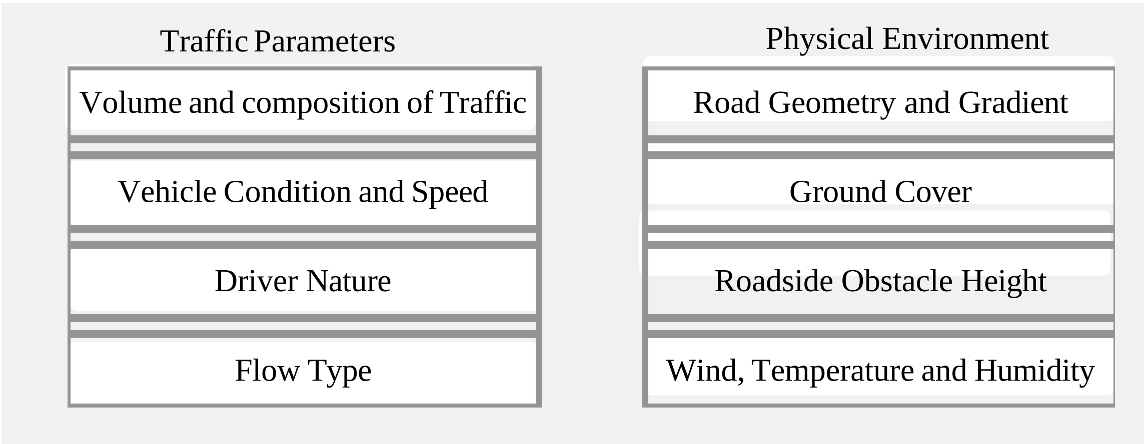

Figure 2.1: Overview of parameters for road traffic noise calculation

2.7.1 Traffic Parameters

There is also an increment in the average of the sound level with increase in the vehicles. Various researchers have noted that increase in the volume of traffic is one of the major contributing factors to increase in level of noise. The overall consequences of rate and density of traffic are revealed in Figure 2.5, which demonstrates the output of such a computer simulation in order to approximate passenger car traffic noise in a lane.

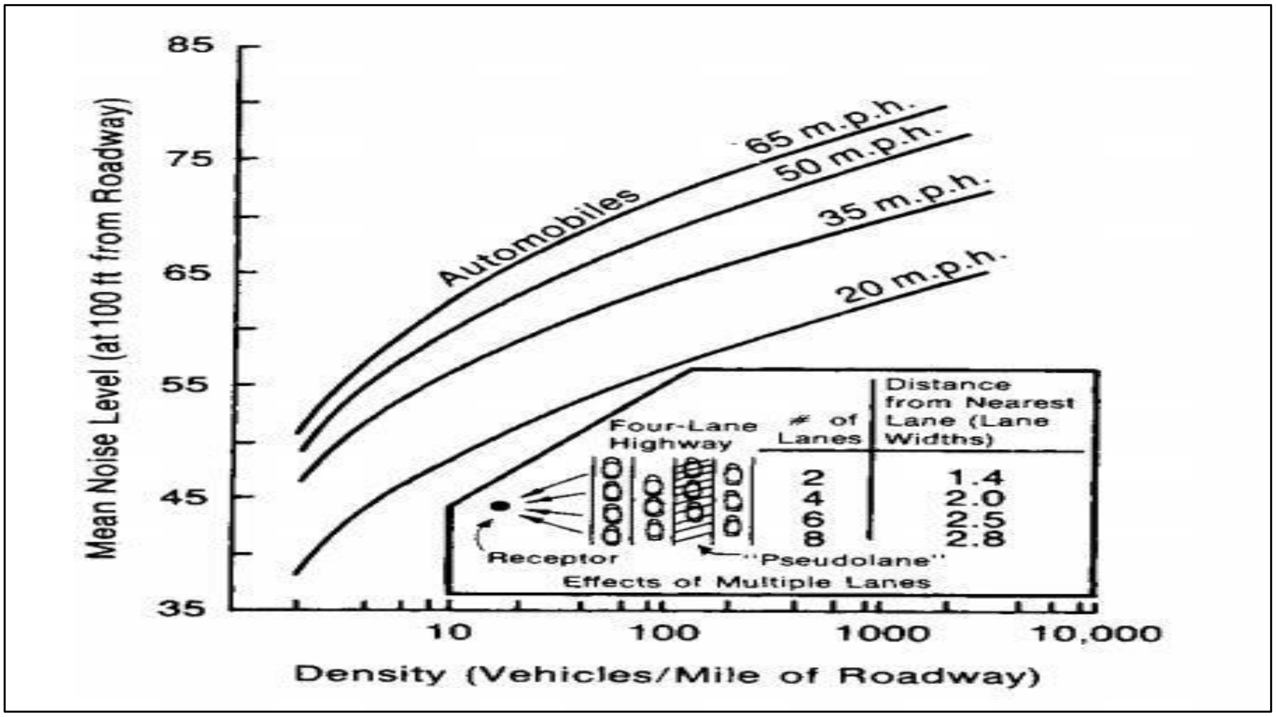

Figure 2.2: Estimated mean noise level at different speeds and densities

As seen in Figure 2.4, the fraction of heavy trucks has a significant impact on the noise level.

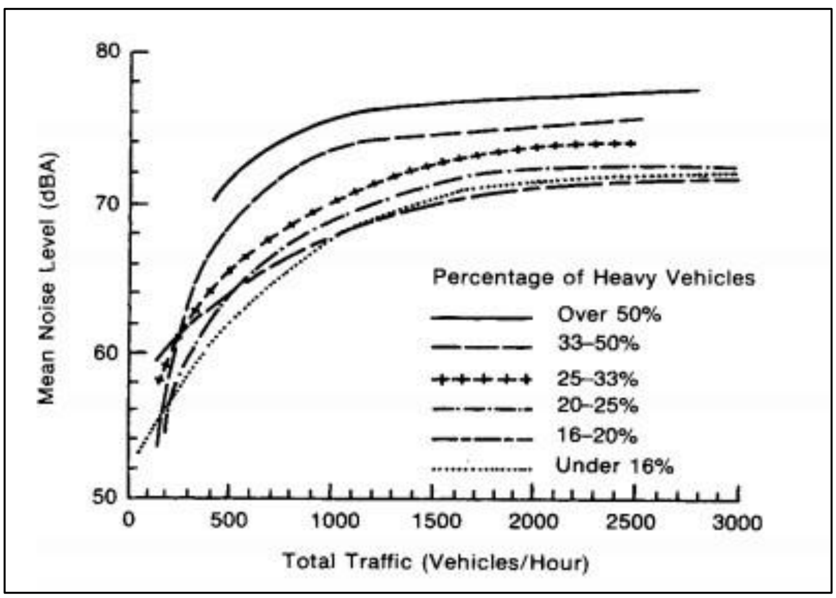

Figure 2.3: Relationship between mean noise level and traffic composition

The engine for the cars, its horn, exhaust, and brakes and transmission, and suspension generate road noise, which is optimal when the car accelerates up hill slopes and during stop-and-go traffic. One of the major causes of such is defective vehicle maintenance. Consequently, it tends to increase with speed of the engine, and so, speed of The car and the gear the vehicle is in (Bhosale, 2023).

The most significant contributor to the total traffic noise is noise produced when tyres and pavements come into contact. There are two major ways in which noise is generated. First, the irregularities the surface of the road force the vibrations in the Vehicle, especially the tyres, which lead to sound radiations. Second, the regular congestion and deflation of air in the tyre contact patch results in aerodynamic sound (Patil, 2019).

High engine speeds on vehicles, blasting of the horns coupled with high volume music are also large contributors to noise pollution on the road. Also, drivers scream at each other and brake or accelerate at unexpected moments in order to overtake, which increases noise significantly (Shinde, 2022).

Motors and exhaust systems of the huge, fat cars and trucks contribute in a large way to noise pollution on highways and drivers pay most for it. The major traffic noises generated in the city are from autos, light vehicles, buses, and motorcycles.

Discontinuous traffic induces greater peaks and a lower noise level on average (Bugliarello et al., 1976). Uniform traffic with a low velocity provides low average level and relatively tiny peaks. The traffic that has steady high speeds produces the very best average levels.

2.7.2 Physical environment

The second group of parameters defining the level of traffic noise can be linked to road environment. The spreading of noise varies at different topographical conditions of the roads. Enough noise reduction is experienced in roads situated in cuts which had steep slopes. The noise production is significantly contributed by some surfaces of roads. The gradient also has effect along with the effective road width on noise level. A street with high buildings around it might create a hotspot of noise with the noise level being up to 6 dB louder than the one in the open space in all other conditions. Such an increase in noise (it could be as high as six dBs) could be found in a street with a steep slope (Bugliarello et al., 1976). The level of the noise too is determined by nature of cover on the earth.

The noise barrier and the distance between the road and the viewpoint, the ability of the ground to absorb or reflect the noise determines the level of noise. The perceived peaks in the noise that is received by the observer are dependent upon distance basis along the road. The mean level (L50) decreased by 5 dBs, and the sound peaks were attenuated by 7-8 dBs (A). (A) with each doubling of distance to the road (Lamure, 1972). The other prevailing requirement as far as the road environment is concerned, natural or artificial screens do have a significant role in reducing the magnitude of noise to a large extent depending on how deep and dense the shielders used are. Rain is also a significant parameter that influences noise production as well as speed generation of vehicles and thus, significant in noise research. Other profiles such as that of the wind, humidity, and temperature, among others, play a major role in the generation of noise field as is reflected in various research works, which varies across different countries (Subramani et al., 2012; Bugliarello et al., 1976).

2.8 Auditory and Non-auditory Effects of Noise on Health

Noise is omnipresent in daily life because it has auditory as well as non-auditory impacts to human health. The loss of hearing induced by noise is very popular nowadays, and nowadays it is more and more often a result of prolonged exposure to high noises levels. Impacts environmental noise that affects public health but is not audible are also conspicuous. Based on experimental studies, it is noted that habitual exposure to high noise levels causes annoyance, sleep interruption, daytime sleep, delay in patients' recovery in hospitals and raises a rate of cardiovascular disease and hypertension (Basner et al, 2013). Research studies conducted before have reported that noise from traffic is second to no other environmental stressor facing public health ramifications (WHO, 2011), which points to noise pollution being increasingly worrisome topic and with heightened consciousness amongst the population.

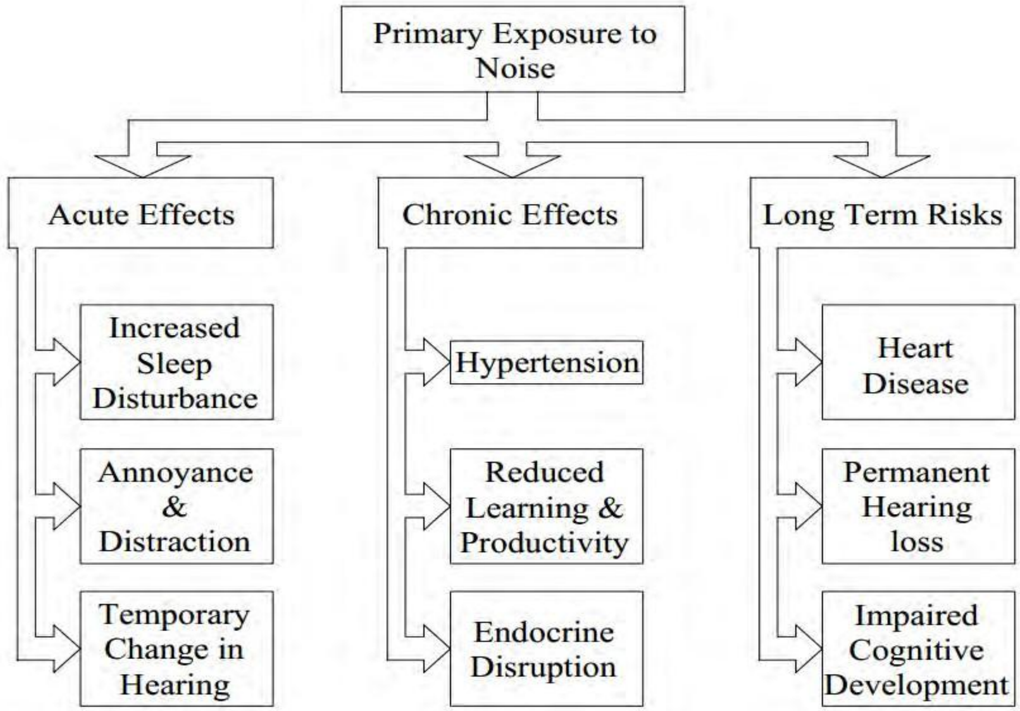

Figure 2.4: Noise effects reaction scheme (Basner, 2013)

2.8.1 Auditory effects

Auditory consequences from noise apply when there is high noise associated with long-term noise exposure. The aural effects differ from age to occupation to exposure time, etc., conditions. Proliferation of noise consistently ranks high in being a major contributor to causing loss of hearing, and preventable. Noiseinduced hearing loss is possible even with sounding an intense noise, such as shots from a gun, or constant, long threatening of the air with high pressure of sound, higher than 75 db, which, for example, can be observed in the industrial setting (Basner, 2013). Overexposure to noise is generally associated with the onset of tinnitus. Partial hearing loss is intimately linked to tinnitus, which is the sense of sound in the absence of an external source (Murphy and King, 2014). In many ways it can damage the quality of life such as feeling depressed, insomnia, sleep disorders and inability to sustain attention. The greatest public concern is noise-induced hearing loss. According to Approximately 1.3 billion individuals worldwide suffer from hearing loss, according to the Global Burden of Disease (2011). Researchers noted that hearing loss as the 13th leading cause of a major proportion (2.6%) of the world years lived with disability

(YLD) (19.9 million years) Basner (2013).

2.8.2 Non-auditory effects

There are non-auditory effects of noise, such as: Noise annoyance can affect sleep., develop cardiovascular diseases, and have adverse influences on cognitive growth, among others (Kumari, 2020).

2.8.3 Noise annoyance

Annoyance is one of the most prevalent reactions to the noise that can be accompanied by some fearfulness and slight anger. The annoyance level associated with a particular quality of sound may be a factor that must be taken into consideration in determining the health effects of noise as some stressful impacts of the noise are sound quality dependent, but not sound level dependent. Annoyance becomes evident due to the aversive characteristics of the sounds in combination with activities that are interrupted by the sound and physiological responses to sound. The extent to which the annoyance and complain about noise is determined by numerous aspects that are evaluated by researchers (Davis & Cornwell, 2008; Sharma, 2018).

2.8.4 Cardio-vascular disease

According to other surveys and research works, one of the factors that lead to negative cardiovascular impacts is the noise created by transportation. Specifically, evidence of a relation connection between ischemic heart disease (IHD) and transport noise has grown by leaps and bounds (Babiesh 2011). The compliance with the high degree of noise raises the threat of arteriosclerosis and hypertension. Recent study revealed that Residential Road traffic noise and hypertension had positive correlation implying that exposed individuals to a lot of environmental noise have comparatively stronger chances of having hypertension than individuals not exposed (males have a 3.8 stronger chance) (Davies and Camp, 2012; Bollinger et al 1998; Gilfillan 2007). According to Barregard et al., 2009). The narrowing of the peripheral blood vessels, which include the brain and retina's growing blood vessels, fingers, toes, and abdominal organs and this can cause headaches occurs even at low levels of noise.

2.8.5 Impaired cognitive development

However, the last 20 years showed a marked rise in the number of projects that focus on the influence of ambient noise on youngsters (Murphy & King, 2014). Excessive noise may result in the development of speech difficulties or inability to read by children who are exposed regularly to noise that interfere with their speech understanding. This is as a result of noise pressure on any auditory processing functions. The skills of speech perception develop until the adolescence period. Children attend noisier classrooms where they find it hard to comprehend speech as compared to quieter rooms. Children may be taken as one of the groups of people in which the health effects of the environmental noise are more profound than of the general population (Murphy & King, 2014; Gupta, 2021).

2.8.6 Noise exposure and sleep interference

One of the most developed late forms, the state of a noisy state called sleep interference is presented by the fact that the problem appeared at the stage just recently and started to be discussed and watched. According to World Health Organization, health can be defined as the state wherein there is complete physical, mental, and social well being and sleep loss is harmful to health (Bugliarello et al., 1976). The quality and intensity of the noise are two of the many criteria that determine how noise affects sleep, duration, repetition and the timing, at which the noise interferes with sleep, age and the health status. Form of transport (road, rail, or air mode) or combined mode also is a determinant of noise-induced sleep disturbance (Murphy & King, 2014). In case the discrepancy between the highest and the median level of noise exceeded 15 dBA, the process of sleeping was heavily impaired (Bugliarello et al., 1976; Patel, 2019).

2.9 Noise Standards and Acceptance Level

Standardization and noise level limiting are differentially adopted across the world in respect of the various noise levels criteria. In this paper, the limit of acceptable noise level according to the Department of Environment (DOE), Bangladesh is addressed. Since the main target of the study is the road corridors, the established standards as outlined by the FHWA on noise abatement are used and the WHO noise guidelines are considered to recognize the health effects of varying levels of noise under differing conditions (Hossain, 2023).

2.9.1 The permissible noise levels in Bangladesh

Bangladesh has established noise level standards intended for compliance by the road and highway authority; however, adherence is diminishing among both the public and the government. Thus, the government must take essential actions to enforce these standards to tackle growing noise pollution issues in the future.

2.9.2 Bangladesh Noise Pollution (Control) Rules, 2006

The permissible noise levels in Bangladesh, as defined by the Bangladesh Noise Pollution (Control) Rules, 2006, are as follows:

Table 2.1: Permissible Noise Levels in Bangladesh

Area Type	Daytime (dB)	Nighttime (dB)
Sensitive Area	40-50	40-50
Residential Area	55	45
Mixed Area	60	50
Commercial Area	70	60
Industrial Area	75	70

2.9.3 Noise abatement criteria by FHWA

The Federal Highway Administration (FHWA) of the United States creates a noise abatement standard that must be adhered to while implementing highway projects in the surrounding region. (Table 2.2).

Table 2.2: Noise abatement criteria by FHWA (FHWA, n.d.)

Activity Description	Leq(dB)	L10(dB)
calm and serene places	57 (Exterior)	60 (Exterior)
Recreation places, houses, hotels, schools, hospitals, and other facilities.	67 (Exterior) 52 (Interior)	70 (Exterior) 55 (Interior)
Developed lands, properties, or activities not covered above..	72 (Exterior)	75 (Exterior)

For these conditions, a project may employ Leq or L10 (but not both).

2.9.4 Noise standards by WHO

The World Health Organisation (WHO) created precautionary guidelines for noise levels related to various health effects across different types of areas, as outlined in Table 2.3.

Table 2.3: WHO noise regulations for various regions (Berglund, 2000)

Environment	Critical Health Effects	Leq (dB)	Measurement Duration (Hours)
Residential Area (Outdoor), School (Outdoor)	Annoyance	55 (Day) 50 (Evening)	16 8
Industrial, Commercial, Traffic (Indoor and Outdoor)	Hearing Impairment	70	24

2.10 Noise Pollution Research in Bangladesh

In their study case of noise pollution in the city of Dhaka, Arif and Ali (2014) conducted a road survey to establish the major noise sources at the road intersections in the said city and the proportion of those sources to the actual noise space. A trigger was set in the present study to monitor the noise level every hour in five busy intersections on working and holiday days and capture the traffic flow as the traffic was filmed. Based on the observation, it is evident that the values of noise in the road intersections are in most traffic conditions exceed the permitted levels. The unnecessary use of horns was found in both the moving and the stationary vehicle cases to be a primary reason of raising the sharp and high levels of noise. The level of noise during such circumstances was not a set pattern to differentiate the noise (Arif & Ali, 2014; Rahman, 2022).

Hussain and Asha (2007) were able to measure the noise impact to Dhaka city through different land uses. The data obtained in this study was raw data collected on the basis of a 10-second interval within various regions and various land usages within the specific City of Dhaka in the morning and evenings at times. According to the findings, noise pollution in Dhaka city is at high levels almost everywhere.

According to the study conducted by Munsi (2015), it has been observed that the interior noise level of buses greatly depends on the velocity of buses, the age of the bus engine, number of intersections along all bus routes, and the engine type at its disposal. The pre-discharges demonstrate that noise risk level of the bus transport within the urban Dhaka city is so high that it may give the exposure of harmful health and productivity effects on the bus drivers and conductor along with the passengers.

At Ramna Thana in Dhaka city, the noise pollution research was done by Monir and Islam (2016) that road traffic in combination with road characteristics is having the greatest effect on traffic noise in the study area. Also, construction activities on this site also contribute to noise exposure levels. The findings of this research show that almost all the regions under Ramna Thana are inauspicious for meeting the respective standards of noise levels, prescribed by the Department of Environment (DOE), Bangladesh on the basis on land use.

Hoque et al. (2014) in a study established that motor vehicles were the major cause of high noise levels. The most frequent problems that accompany high noise levels included increased heart rate, drowsiness, headaches and hearing impairments.

2.11 Noise Pollution Research Review in “C&B to BPATC”

The locations selected for this study include the C&b foot over bridge and the Bangladesh Public Administration Training Centre. The C&B foot over bridge connects to the Bangladesh Public

Administration Training Centre and is situated on the Dhaka-Aricha National Highway, known as N-5, which is one of the most heavily trafficked highways in the country. This bridge plays a vital role in the economy. However, from an engineering standpoint, we assess not just economic impacts but also environmental consequences. It's essential to evaluate environmental effects from a transportation engineering perspective, where we consider roadway conditions, pedestrian factors, and environmental issues, including noise pollution. Today, noise pollution significantly contributes to mental health problems and diseases, much like water and air pollution.

2.12 Noise pollution on the National Highway in Bangladesh

It is indicated that highways have a considerable share to add to noise pollution. Often, national highways will run through quiet districts such as suburbs and rural communities. The effects are however much more detectable in the urban centres. These cities are usually full of such facilities as medical centres, schools, creative spaces and offices where noise may interfere with concentration. In cities, most people tend to unite in order to collaborate, brainstorm, or plan. Non-stop honking of vehicles can distract learning centers as well as workplaces. One of the major problems is that loud noise not only increases the decibel meter, but it also creates mental health problems such as anxiety making it hard for anyone to concentrate with their work. Patients and students alike encounter disruptions that are comparable in registered institutional settings.

The highways are quite apt to resemble crowded bazaars or congested markets and play an important role in promoting noise pollution. It should be acknowledged that there are several factors that lead to noise. the highway jam-packed with cars and revving horns, alongside the surrounding market / bazaar, economic hub where the mass adds further noise. This overall sound exceeds the normal limit, which comes to noise pollution. The situation is further complicated if these increased noise levels persist for extended timeframe.

Chapter 3
METHODOLOGY

3.1 Introduction

This study examines the extent of noise pollution at the C&B foot over bridge, a key pedestrian crossing point, and BPATC Gate No. 1, a major entry point to the Public Administration Training Center of Bangladesh. (BPATC), located along the Dhaka-Aricha National Highway (N-5). This significant roadway links the capital city of Dhaka to the western regions of the country. In this chapter, we outline the study's methodological framework, which describes the procedures, supplies, instruments, and scientific methods we employed.

3.2 Methodology Overviews

This chapter is intended to sketch the process of the research in a step-by-step manner. Firstly, according to the study objectives, the research area is chosen. Subsequently, important road corridors and measurement sites are selected. Collection of data is pegged on two critical components: monitoring sound levels and characteristics of traffic. The sound level data obtained are analyzed in developing noise level descriptors and indices for ease of examination of noise pollution situations. Traffic characteristic data mainly results from the analysis of traffic video as well as other visual observations of road conditions. Interpretations from the analytical figures are offered to make the relationship between noise levels and the traffic context clearer. The models are reviewed for considerations of validity. In conclusion the main points of the analysis are summarised and recommendations are given how the current situation can be improved.

3.3 Attributes of Study Area

C&B footover bridge (23.8727° N, 90.2731° E) to BPATC GATE NO: 1 (23°51'57.3"N 90°16'13.5" E)

In our study, we are considering a footbridge that accommodates pedestrians who contribute noise, albeit to a limited extent. Additionally, when evaluating the study, both sides of the road and the surrounding area were filled with marketplaces, which also contribute sound minimally; however, this is generally factored into the noise measurement. These attributes are not just incidental, but significant as they provide a comprehensive understanding of the noise pollution scenario, considering both vehicular and pedestrian contributions.

The segment of the Dhaka-Aricha Highway (National Road-5, N5) between the C&B footover bridge (23.8727° N, 90.2731° E) and BPATC Gate No. 1 (23°51'57.3"N, 90°16'13.5"E) spans approximately 3.5 km within the Savar Upazila, a bustling peri-urban area near Dhaka. This segment is a four-lane asphalt road, part of the 526.59-km N5, designed to accommodate heavy vehicular traffic, including buses, trucks, and private cars. Key attributes include:

- **Traffic Composition**: The road experiences mixed traffic, with 40% of vehicles being heavy (trucks and buses), 30% being light (cars and rickshaws), and 20% being motorcycles, contributing to congestion during peak hours (7–10 AM and 5–8 PM).
- **Road Infrastructure**: The segment features a median strip, occasional pedestrian crossings, and the C&B footover bridge, all of which enhance pedestrian safety. However, narrow shoulders and encroaching roadside markets limit effective road width, exacerbating traffic bottlenecks.
- **Surrounding Land Use**: The area includes commercial zones (shops, small industries), educational institutions (e.g., BPATC), and residential settlements, increasing human exposure to traffic-related disturbances.
- **Maintenance and Condition**: The road is relatively well-maintained; however, potholes and uneven surfaces near intersections cause vehicles to decelerate, resulting in increased engine noise.

These attributes make the segment a critical link for economic activities, connecting Dhaka to industrial and agricultural regions, while also serving as a hotspot for environmental challenges, such as noise pollution.

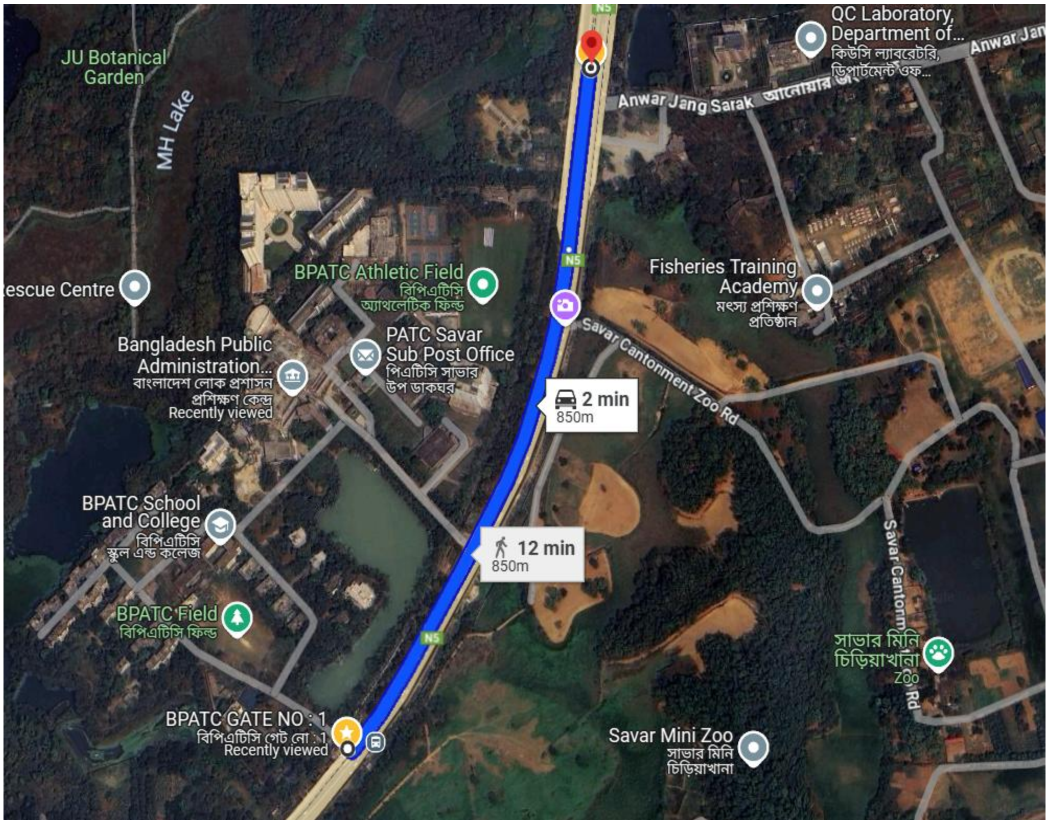

Figure 3.1: Location of the study area.

3.4 Data Collection Points on the Dhaka-Aricha National Highway

This study focuses on two critical locations: the C&B foot over bridge, which serves as the starting point, and BPATC Gate No. 1, the endpoint. These sites are situated along the Dhaka-Aricha National Highway (N-5), one of the busiest roads in the area that connects the capital, Dhaka, to the western regions of the country. This location is economically important, as it is not only near a Hat-Bazar but also contributes to significant noise pollution, which is a key finding of the study.

At C&B, the foot over the bridge has an 8-lane, 2-way highway layout.

At BPATC Gate No. 1, the highway layout is a 4-lane, 2-way road.

The distance to the selected point is roughly 850 m. The area is similar to the one at BPATC, characterised by a wide, busy highway and surrounded by various markets and shops.

Figure 3.1: Collecting Data at C&B foot over the bridge

Figure 3.2: Collecting Data at BPATC

3.4.1 Data Collection Procedure

In certain places, the sites of data collection are well placed at intersections of the roads. There is a two-way movement in vehicles where full points are maximum and at a few points, there is no traffic movement because one way traffic movement is minimal. This strategic selection is not random but ensures a comprehensive understanding of the noise pollution scenario, demonstrating the thoroughness of our research. Reading is taken for two different times at one point or another. The total experimental time is 10 minutes, consisting of 5 minutes during the daytime from 12:31 PM to 12:35 PM and another 5 minutes from 4:31 PM to 4:35 PM. These reading times are shown in Table 3.2.

Table 3.1: Reading Times

Reading	Times
Data-set-1. Thursday, 13 February, 2025	Weekday 12:31 PM – 12:35 PM
Data-set-2. Thursday, 13 February, 2025	Weekday 4: 31 PM – 4:35 PM

Sound pressure levels and traffic videos are recorded manually for one minute, divided into four 15-second segments for detailed data collection. Measurements occur under typical daytime and afternoon weather conditions, while the current road situation is documented through visual observation.

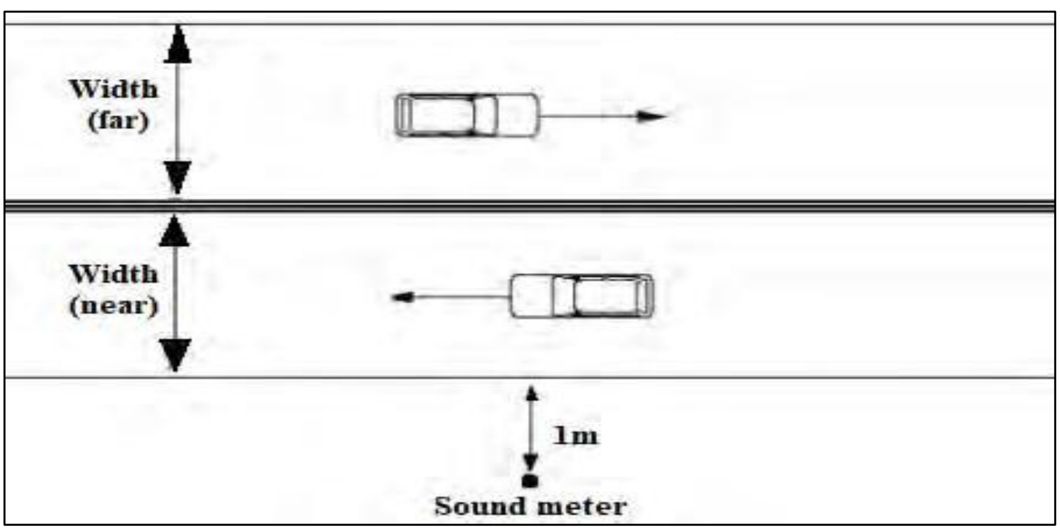

Figure 3.3: Data collection arrangement

3.4.2 Sound pressure level recording precise process

To achieve the goal, it would be interesting to calculate the level of noise when a pedestrian will be walking in the footpath while measuring those moving in their entirety, who create the typical user of the infra-structure on the roadside. To read the sound level, use an AS824 Digital Sound Level Meter (Smart sensor AS824 mini digital sound noise level meter has 30~130 dBi range, 1 / 2 inch microphone, 30~130 dBa measuring level, 35~130 dB accuracy, 31.5 Hz ~ 8.5 KHz frequency, 9V battery). The sound level meter is a standard calibration at 94 db 1 kHz in the Laboratory through regular calibration by a Sound Level Calibrator. The readings are placed on the roadside and tap them and mainly on the footpaths (where available) at the road tread at a distance of nearly 1m along the margin. The sound meter probe is grasped by hand, and is also at the same height as that of the upper ear of the standard receptor (ca. 1.5 meters above the prevailing permanent standing position). Figure 3.4 represents the design of the data collection arrangement given above.

Noise level measurements were taken for approximately 15 seconds, fluctuating with traffic conditions at intervals of a few seconds. Thus, one minute is divided into four parts, and every part records 20 data points that brings up a total experiment time of 5 minutes. The data set is kept as memory data after being sent to a computer from the sound level meter. The data is generated in Microsoft Excel spreadsheets by the output. Figures 3.5 present photographs from real-time data collection.


SMART
SENSOR
SMART
SENSOR
LEVEL
F/S
A/C
LEVEL
MIN/MAX
LIGHT
Digital Sound Level Meter
AS824
SMART
SENSOR
Digital Sound Level Meter
AS824
CE

Figure 3.4: The real-time data collection shots in different places

3.4.3 Effective road width measurement

The effective width or right-of-way is the main factor to support the traffic of road vehicles. Consequently, the relationship with ease of road could be high between the effective road width and noise intensity. A manual odometer is used to measure the real road width that is used by the movement of cars in the two directions on the road.

3.4.4 Road environment observation recording

The road environment significantly influences noise levels. Factors such as atmospheric temperature, humidity, activities by pedestrians and hawkers, the type of traffic, and vehicle behaviors are known to correlate with noise levels. During data collection, relevant observations of the road environment are documented and organized for future modeling efforts.

The level of traffic noise is affected by weather phenomena, such as surface humidity and temperature (Subramani et al., 2012). The website www.worldweather.com provides information on the study area's air temperature and relative humidity. If timely and reliable weather forecasts are not available data, the values will be calculated with the help of interpolation that will determine the precise values.

3.5 Data Processing

Data processing entails standardizing the raw data gathered from primary sources to make it suitable for thorough analysis and interpretation. The sound level data recorded and the traffic flow video footage are then analyzed to derive insights on noise levels and the volume of traffic during the measurement periods. Since different source types create variations in the sound intensity at a given place, the dataset is standardized, including traffic signals, honking, and crowds.

3.5.1 Traffic Density Calculation

The video also estimates the traffic flow by the counting of the number of vehicles within the identified period. Automobiles are categorized into a number of classes to achieve this. Through multiplication of the number of motorised vehicles by a passenger car equivalent unit (PCEU) or Passenger Car Unit (PCU), the various kinds of vehicles are recorded as falling into three categories. This categorisation is subsequently used in modelling. Table 3.3 illustrates the original categories of vehicles, the PCU to convert and the end resulting converted categories.

Table 3.2: Vehicle PCU conversion, including early and final (RHD Geometric Design Standard, 2000; Saha et al., 2009)

The initial category of vehicle	Passenger Car Equivalent Unit (PCEU)	Final Category
Non-motorized vehicles (Bicycle, rickshaw, van)	-	NMV
Motorcycle	0.75	Light vehicles (LV)
CNG auto-rickshaw and Tempu	0.75	
Microbus	1.5	Medium vehicles (MV)
Car	1	
Utility (Minivan, pickup)	1.5	
Bus	3	Heavy vehicles (HV)
Truck, covered van, trailer	3	

Chapter 4

RESULTS AND DISCUSSIONS

4.1 Data introduction

This is study covers two distinct periods. The first data were collected on Thursday the 13th of February, 2025 between 12:31 – 12:35 PM on the National Highway-5 (Dhaka-Aricha, N-5) where the average noise (dB) level exhibited a slight variation. The second set of observations was conducted on the same day, between 4:31 PM and 4:35 PM, during which time average noise level in dBs did not change much because there were no stationary vehicles on the highway. Other analyses were conducted to explore specific relationships and correlations of parameters, in an attempt to understand the background of environmental factors causing noise pollution and to inform the future of Bangladesh Road and Highway Authority. Therefore, this chapter is dedicated to analysing and interpreting the results of the study while providing some useful insights to both transportation engineering and environmental improvement.

In this study, we carefully gathered data manually – trying to obtain as many samples as possible. The one-minute observation was divided into 15-second intervals where we recorded the total traffic that passed a highway segment. These raw counts, despite not being conductive to direct analysis of data, were converted into PCU (Passenger Car Unit) for analytical purposes.

The main purpose of our work entailed altering the data in the database specially with the help of tools, like Microsoft Excel. Having taken data from each vehicle after 15 seconds, we began with the Excel process. The process involved averaging, maximizing and minimization of the data. The study data were serialized after these calculations worked out.

Table 4.1: Time frame of experiment

Data set	Point	Date	Time	
1st	C&B foot over bridge	Thursday, 13 February, 2025	12:31 PM	12:35 PM
2nd	BPATC gate no. 1	Thursday, 13 February, 2025	4:31 PM	4:35 PM

Table 4.2: 1st data set Thursday, 13 February, 2025 at 12:31 PM to 12:35 PM

Time slot	time slot	Avg	Avg DB (avg)	Max	Max DB (avg)	Min	Min DB (avg)	Count	count (avg)	PCU	pcu (avg)
0-15	12:31	83.53	83.12	90.6	89.78	77.6	78.83	15	16.75	18.25	20.69
15-30		84.12		94.2		80.5		23		27.75	
30-45		82.6		87.6		78.1		15		18	
45-60		82.23		86.7		79.1		14		18.75	
0-15	12:32	82.35	82.48	88.6	86.48	77.1	79.7	10	13	11.75	16.88
15-30		84.46		91.2		81.3		16		19	
30-45		81.22		83		80.1		8		11.5	
45-60		81.88		83.1		80.3		18		25.25	
0-15	12:33	83	85.09	89	88.78	79.4	82.88	13	13	17	18.81

15-30		82.96		86.8		80.3		16		21	
30-45		84.48		89.4		81.9		16		27.25	
45-60		89.9		89.9		89.9		7		10	
0-15	12:34	84.68	83.59	88.4	87.3	79.4	80.28	13	13	22.5	21.13
15-30		82.47		84.7		80.8		11		17.25	
30-45		83.14		87.7		80.9		18		29.25	
45-60		84.08		88.4		80		10		15.5	
0-15	12:35	83.77	83.95	93.3	89.83	77.6	78.33	12	15	17.25	19.94
15-30		85.53		89		79		14		21	
30-45		84.63		90.9		78.9		15		21	
45-60		81.88		86.1		77.8		19		20.5	

Table 4.3: 2nd data set Thursday, 13 February, 2025 at 4:31 PM to 4:35 PM

Time slot	time slot	Avg	Avg DB (avg)	Max	Max DB (avg)	Min	Min DB (avg)	Count	count (avg)	PCU	pcu (avg)
0-15	4:31	80.5	82.27	85.2	89.05	77.2	78.15	22	19.25	32.5	29.63
15-30		82.88		93.8		79.1		21		28	
30-45		77.81		80		76.6		16		30.75	

45-60		87.89		97.2		79.7		18		27.25	
0-15	4:32	83.87	80.76	89.1	84.48	77.7	76.9	15	15	20	24.19
15-30		80.39		84.1		75.8		20		35.75	
30-45		79.71		83.7		75.9		14		18.5	
45-60		79.05		81		78.2		11		22.5	
0-15	4:33	81.75	80.57	92.1	87.83	77.8	75.45	12	16.75	17.5	26.25
15-30		80.73		91.1		71.1		25		41	
30-45		79.62		83.9		76.2		17		22.25	
45-60		80.29		84.2		76.7		13		24.25	
0-15	4:34	88.1	83.23	92.2	87.65	83.4	79.63	20	17	23.75	23.88
15-30		82.56		85.7		80.5		16		19.5	
30-45		81		88.9		76.2		16		24.75	
45-60		81.26		83.8		78.4		16		27.5	
0-15	4:35	81.25	83.03	83.6	88.45	77.3	79.33	18	22.5	28.75	33.56
15-30		80.93		85.4		77.5		26		39.5	
30-45		85.36		92		82.5		23		29	
45-60		84.58		92.8		80		23		37	

4.2 Data set correlation

To analyse the two distinct data sets and develop conclusions and recommendations for future research, we must first correlate the dataset parameters. This analysis reveals the relationships, enabling us to derive insights and identify key points. As a result, the correlation matrix displays the relationships between various parameters and their corresponding correlations. Notably, the Pearson correlation applies to two data sets, while correlation matrices are employed for more than two.

Table 4.4: 1st data set and correlation matrix between parameters

	avg db	Max db	Min db	count	pcu
avg db	1				
max db	0.438255	1			
min db	0.660747	-0.24899	1		
count	-0.20514	0.772855	-0.6453	1	
pcu	0.224874	0.516048	-0.23721	0.468462	1

Analysis of Correlations

1. **Average db (avg db):**

   - ❖ The correlation with itself is 1 (by definition).
   - ❖ It exhibits a moderate positive correlation with min db (0.660747), suggesting that as average decibel levels increase, minimum decibel levels tend to rise as well.
   - ❖ A weak positive correlation is observed with max db (0.438255), indicating a less pronounced linear relationship with maximum decibel levels.

- ❖ A weak negative correlation with count (-0.20514) implies that higher average decibel levels may be associated with slightly lower counts.
- ❖ A weak positive correlation with PCU (0.224874) suggests a minor tendency for average decibel levels to increase with higher PCU values.

2. **Maximum db (max db):**
    - ❖ The correlation with itself is 1.
    - ❖ It shows a moderate positive correlation with count (0.772855), indicating that higher maximum decibel levels are strongly associated with increased counts.
    - ❖ A weak positive correlation with PCU (0.516048) suggests that maximum decibel levels tend to rise with increasing PCU.
    - ❖ A weak negative correlation with min db (-0.24899) indicates a slight inverse relationship with minimum decibel levels.
3. **Minimum db (min db):**
    - ❖ The correlation with itself is 1.
    - ❖ It displays a moderate positive correlation with avg db (0.660747), reinforcing the strong linear relationship with average decibel levels.
    - ❖ A moderate negative correlation with count (-0.6453) suggests that higher minimum decibel levels are associated with lower counts.
    - ❖ A weak negative correlation with PCU (-0.23721) indicates a slight decrease in minimum decibel levels as PCU increases.
4. **Count:**
    - ❖ The correlation with itself is 1.
    - ❖ It exhibits a strong positive correlation with max db (0.772855), suggesting that count is a significant predictor of maximum decibel levels.
    - ❖ A moderate negative correlation with min db (-0.6453) indicates an inverse relationship with minimum decibel levels.

- A moderate positive correlation with PCU (0.468462) implies that higher counts are associated with increased PCU values.

5. **PCU:**

- The correlation with itself is 1.
- It shows a moderate positive correlation with max db (0.516048) and count (0.468462), indicating that PCU is positively associated with both maximum decibel levels and counts.
- A weak positive correlation with avg db (0.224874) and a weak negative correlation with min db (-0.23721) suggest minor influences on average and minimum decibel levels, respectively.

Interpretation

The matrix reveals a complex interplay among the variables. The strongest correlations are observed between count and max db (0.772855) and between avg db and min db (0.660747), indicating robust linear relationships. The moderate correlations involving PCU with max db and count suggest that utilization may drive acoustic peaks and frequency of events. The weak R^2 values and mixed positive/negative correlations (e.g., min db with count and max db) highlight that non-linear or additional confounding factors may influence these relationships. This analysis underscores the need for further multivariate modeling or time-series analysis to elucidate causality and improve predictive accuracy.

Table 4.5: 2nd data set and its correlation matrix between parameters

	avg db	Max db	Min db	count	pcu
avg db	1				
max db	0.554856	1			
min db	0.966976	0.343081	1		
count	0.644594	0.719624	0.55182	1	
pcu	0.405159	0.62443	0.326882	0.954048	1

Analysis of Correlations

1. **Average db (avg db):**
    - ❖ The correlation with itself is 1 (by definition).
    - ❖ It shows a strong positive correlation with min db (0.966976), indicating that average decibel levels are highly aligned with minimum decibel levels.
    - ❖ A moderate positive correlation with max db (0.554856) suggests a reasonable but less pronounced relationship with maximum decibel levels.
    - ❖ A moderate positive correlation with count (0.644594) implies that higher average decibel levels are associated with increased counts.
    - ❖ A moderate positive correlation with PCU (0.405159) indicates a tendency for average decibel levels to rise with higher PCU values.
2. **Maximum db (max db)**:
    - ❖ The correlation with itself is 1.
    - ❖ It exhibits a weak positive correlation with min db (0.343081), suggesting a limited linear relationship with minimum decibel levels.

- ❖ A strong positive correlation with count (0.719624) indicates that higher maximum decibel levels are closely tied to increased counts.
- ❖ A moderate positive correlation with PCU (0.62443) suggests that maximum decibel levels tend to increase with higher PCU values.

3. **Minimum db (min db)**:
   - ❖ The correlation with itself is 1.
   - ❖ It displays a strong positive correlation with avg db (0.966976), reinforcing a near-linear relationship with average decibel levels.
   - ❖ A moderate positive correlation with count (0.55182) indicates that higher minimum decibel levels are associated with increased counts.
   - ❖ A weak positive correlation with PCU (0.326882) suggests a slight increase in minimum decibel levels with higher PCU.
4. **Count**:
   - ❖ The correlation with itself is 1.
   - ❖ It shows a strong positive correlation with max db (0.719624) and a moderate positive correlation with avg db (0.644594) and min db (0.55182), indicating that count is a significant factor influencing decibel levels across all metrics.
   - ❖ A very strong positive correlation with PCU (0.954048) suggests that count and PCU are nearly linearly related, implying a dominant role of utilization in driving count.
5. **PCU**:
   - ❖ The correlation with itself is 1.
   - ❖ It exhibits a moderate positive correlation with avg db (0.405159) and min db (0.326882), and a stronger positive correlation with max db (0.62443), indicating that PCU influences decibel levels, particularly at their peak.
   - ❖ The exceptionally strong correlation with count (0.954048) highlights a near-linear

dependence of PCU on count, suggesting that utilization is a primary determinant of event frequency.

Interpretation:

The matrix reveals robust linear relationships, particularly between avg db and min db (0.966976) and between count and PCU (0.954048), indicating high consistency in these pairings. The strong correlations involving count with all decibel metrics and PCU suggest that event frequency is a key driver of both acoustic output and system utilization. The moderate to strong positive correlations of PCU with decibel levels imply that utilization significantly impacts acoustic performance. The overall pattern suggests a system where increased activity (count and PCU) correlates with elevated decibel levels, though the weaker correlation of max db with min db (0.343081) indicates some independence in peak and baseline noise levels. Further analysis, potentially including regression or time-series models, could refine these insights and explore non-linear effects.

4.3 Time vs Noise comparisons

The initial analysis consists of comparing noise levels, focusing on average, maximum, and minimum noise parameters. This study is closely related to noise pollution and seeks to monitor it over a defined period.

4.3.1 1st Data set

Table 4.6: 1st Data set (average of every 1 minute)

time	avg db (avg)	max db (avg)	min db (avg)
12:31	83.11964	89.775	78.825
12:32	82.47679	86.475	79.7
12:33	85.085	88.775	82.875

12:34	83.58917	87.3	80.275
12:35	83.95	89.825	78.325

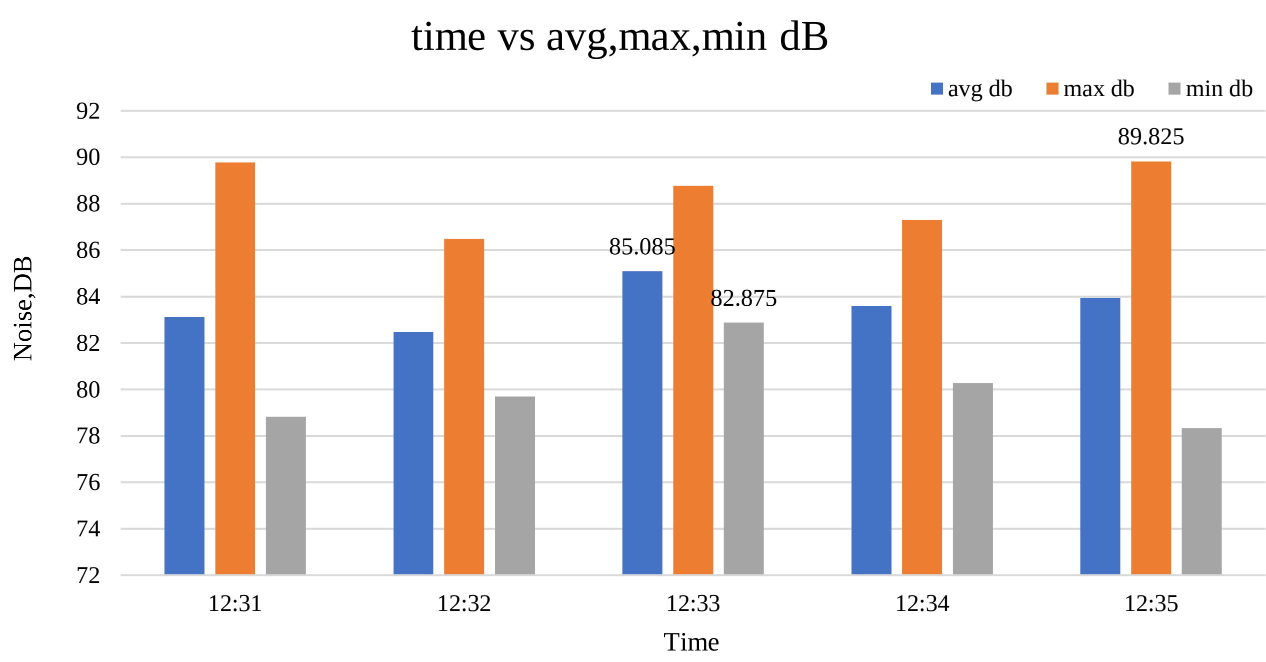

Figure 4.1: Time vs avg, max, min dB for 1st Data set

At 12:33 PM, the highest average is 85.085 dB and the highest minimum is 82.875 db. However, the highest maximum value recorded at 12:35 PM is 89.825 dB.

4.3.2 2nd Data set

Table 4.7: 2nd Data set (average of every 1 minute)

time	avg db	max db	min db
4:31	82.26989	89.05	78.15
4:32	80.75643	84.475	76.9

4:33	80.59573	87.825	75.45
4:34	83.22929	87.65	79.625
4:35	83.02819	88.45	79.325

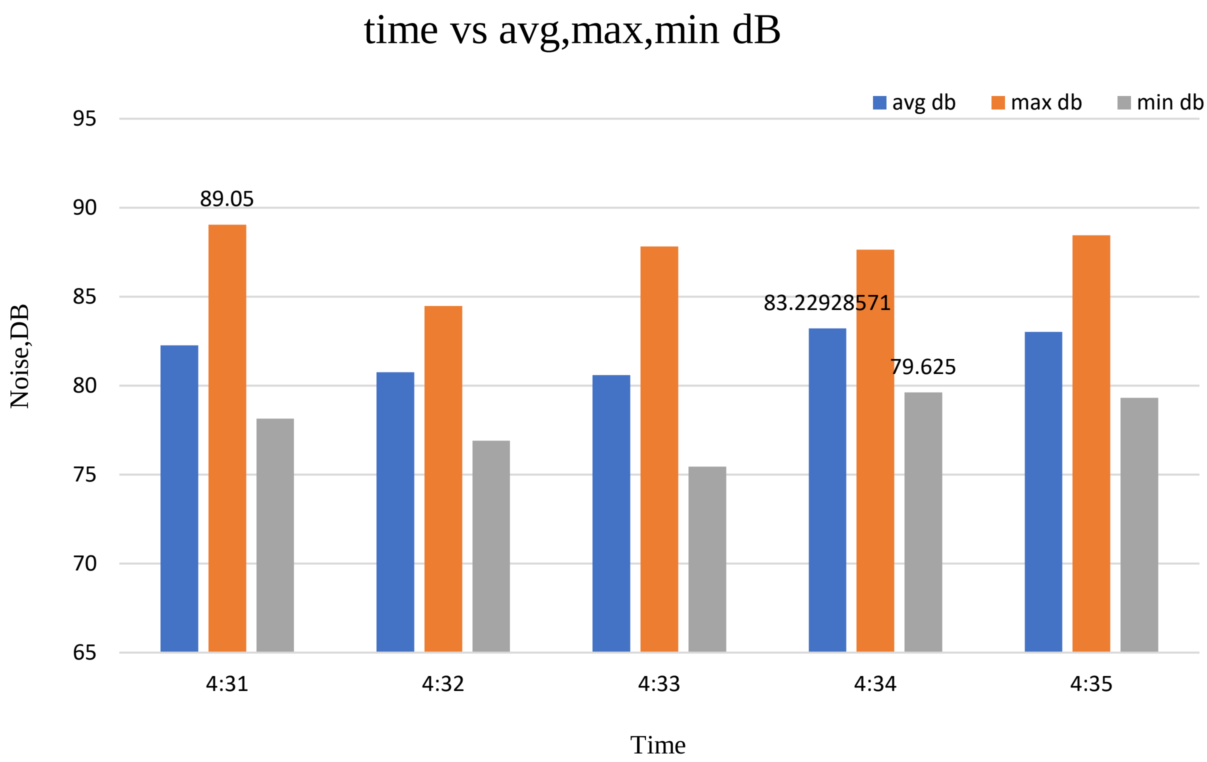

Figure 4.2: Time vs avg, max, min dB for 2nd Data set

At 12:33 PM, the highest average is 83.2293 dB and the highest minimum is 79.625 db. However, the highest maximum value recorded at 12:35 PM is 89.05 dB.

4.3.3 Comparison between two data sets

Table 4.8: Time vs Noise (avg, max, min) comparison between the two data sets

time	avg	max	min
12:31 - 12:35	83.64412	88.43	80

4:31 - 4:35	81.97591	87.49	77.89

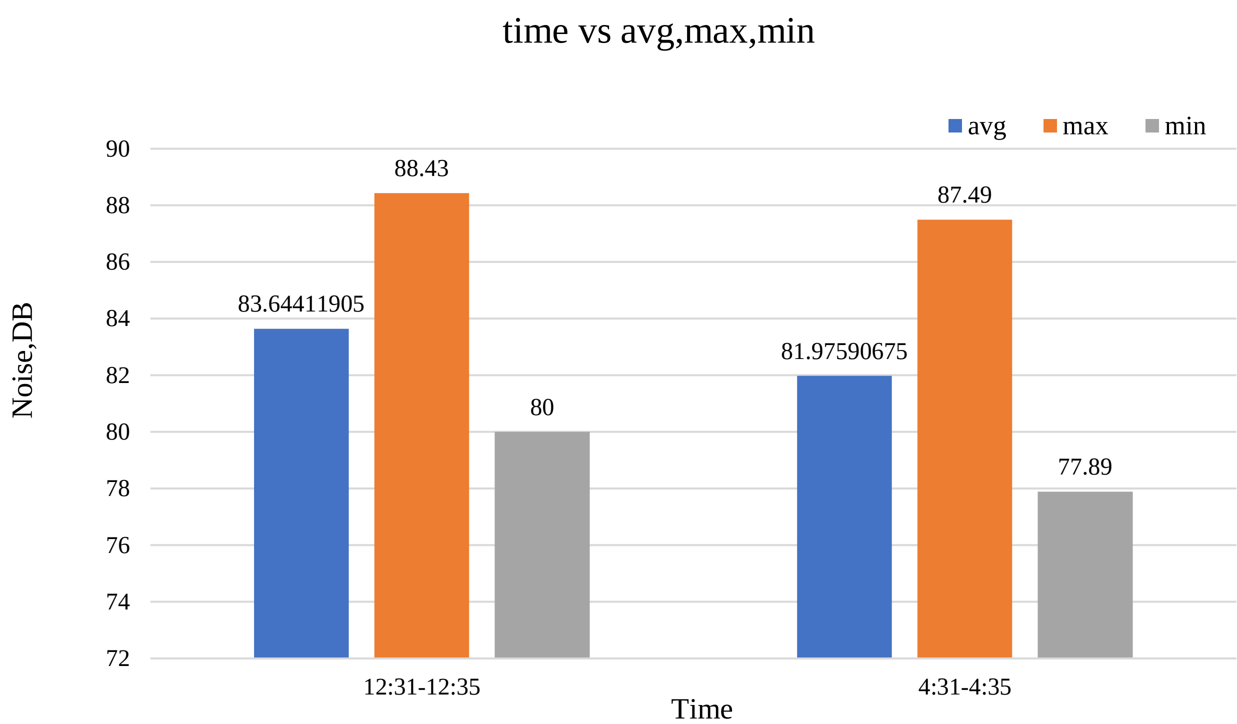

Figure 4.3: Comparison between the two studied datasets

This analysis needs deep explanation as the comparison is based on the analysis of two datasets on particular moments. The C&B road layout is made of 8 lanes on both sides while that of BPATC has four lanes on every side. The first dataset was recorded in C&B from 12:31 PM to 12:35 PM, and the second dataset was recorded in BPATC from 4:31 PM to 4:35 PM Furthermore, as indicated in Figure 4.3, the "average, maximum and minimum" values for the former are higher than for the latter maximum values in terms of the first dataset. The average for C&B is 83.64 dB, BPATC's average is 81.98 dB; the highest one for the first dataset is 88.43 db, which is 87.49 dB for the second; and the lowest one for the first dataset is 80 dB, while the lowest for the second one is 77.89 dB.

As such, because the C&B road has a longer roadway compared to the BPATC, the noise levels for C&B are higher than for BPATC.

4.4 Noise comparisons vs Vehicles (count, PCU)

4.4.1 Noise comparisons vs PCU for 1st data set over time

Table 4.9: 1st Data to compare avg, mix, and min vs PCU over time

time	avg db	max db	min db	count	pcu
12:31	83.11964	89.775	78.825	16.75	20.6875
12:32	82.47679	86.475	79.7	13	16.875
12:33	85.085	88.775	82.875	13	18.8125
12:34	83.58917	87.3	80.275	13	21.125
12:35	83.95	89.825	78.325	15	19.9375

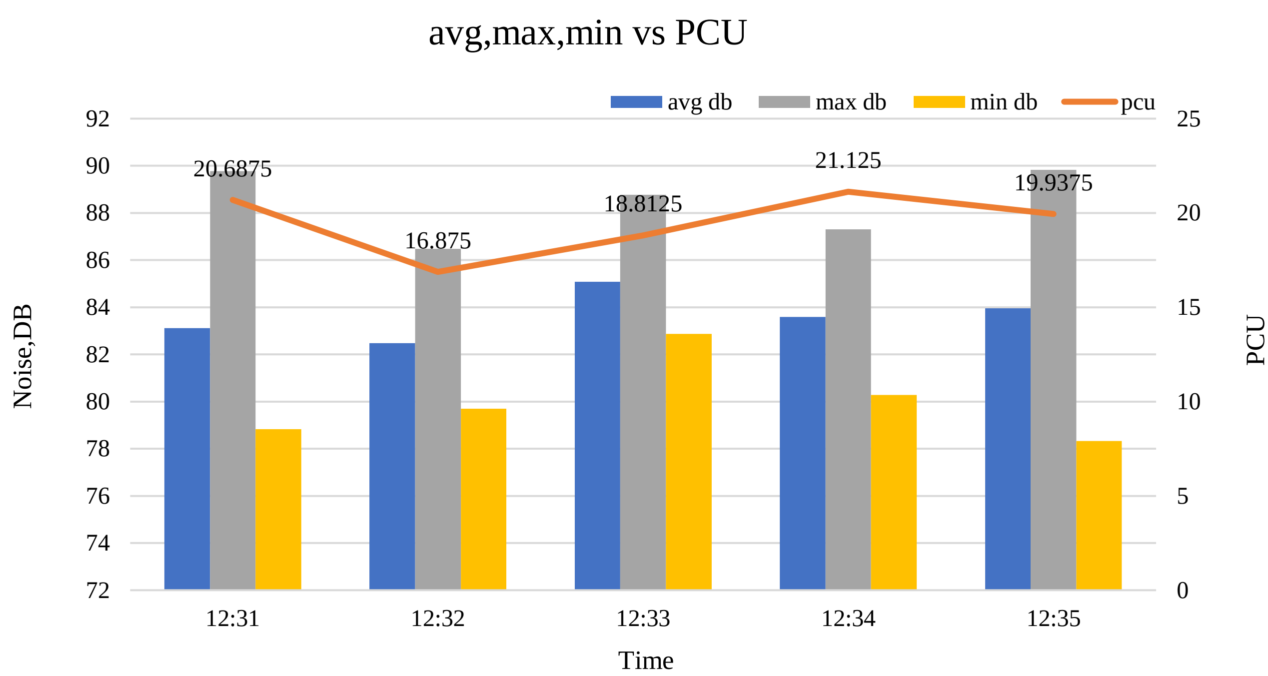

Figure 4.4: avg, max, min vs PCU over time for 1st data set.

4.4.2 Noise comparisons vs PCU for 2nd data set over time

Table 4.10: 2nd Data to compare avg, mix, and min vs PCU over time

time slot	avg db	max db	min db	count	pcu
4:31	82.26989	89.05	78.15	19.25	29.625
4:32	80.75643	84.475	76.9	15	24.1875
4:33	80.59573	87.825	75.45	16.75	26.25
4:34	83.22929	87.65	79.625	17	23.875
4:35	83.02819	88.45	79.325	22.5	33.5625

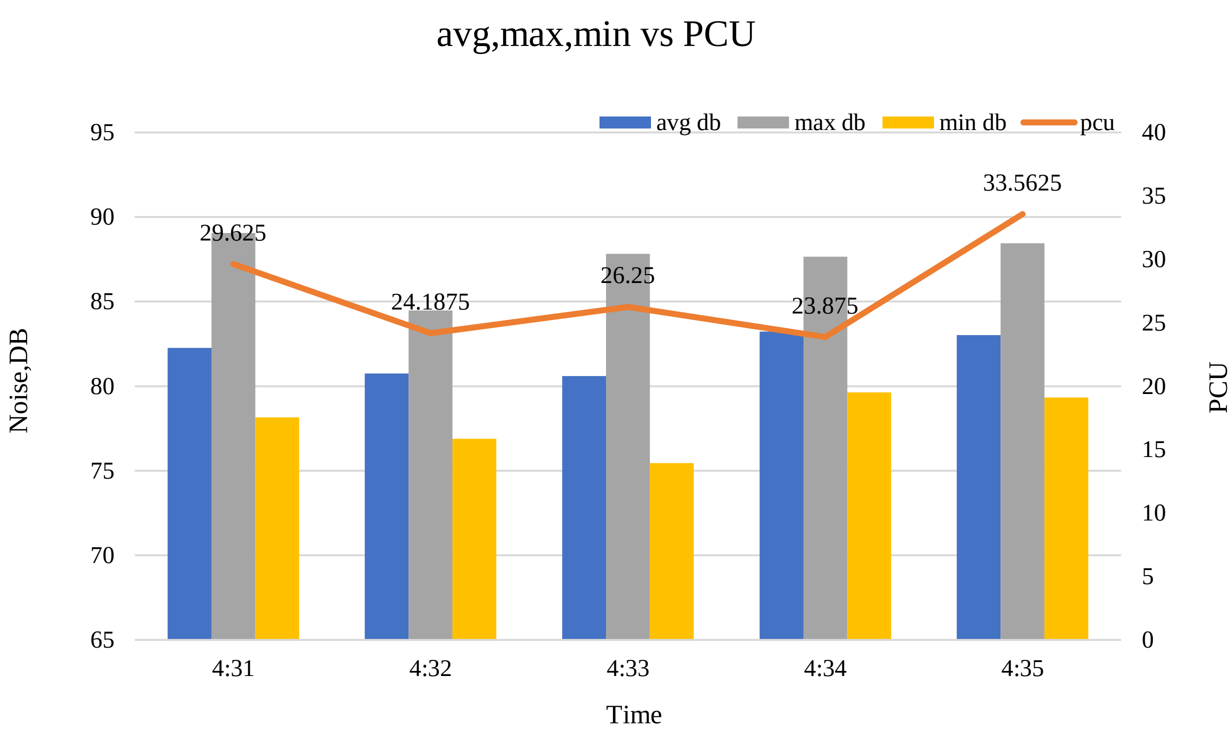

Figure 4.5: avg, max, min vs PCU over time for 2nd data set.

4.4.3 Noise comparisons vs PCU for both datasets over time

time slot	avg	max	min	count	pcu
12:31-12:35	83.64412	88.43	80	14.15	19.4875
4:31-4:35	81.97591	87.49	77.89	18.1	27.5

Table 4.11: Noise comparisons PCU

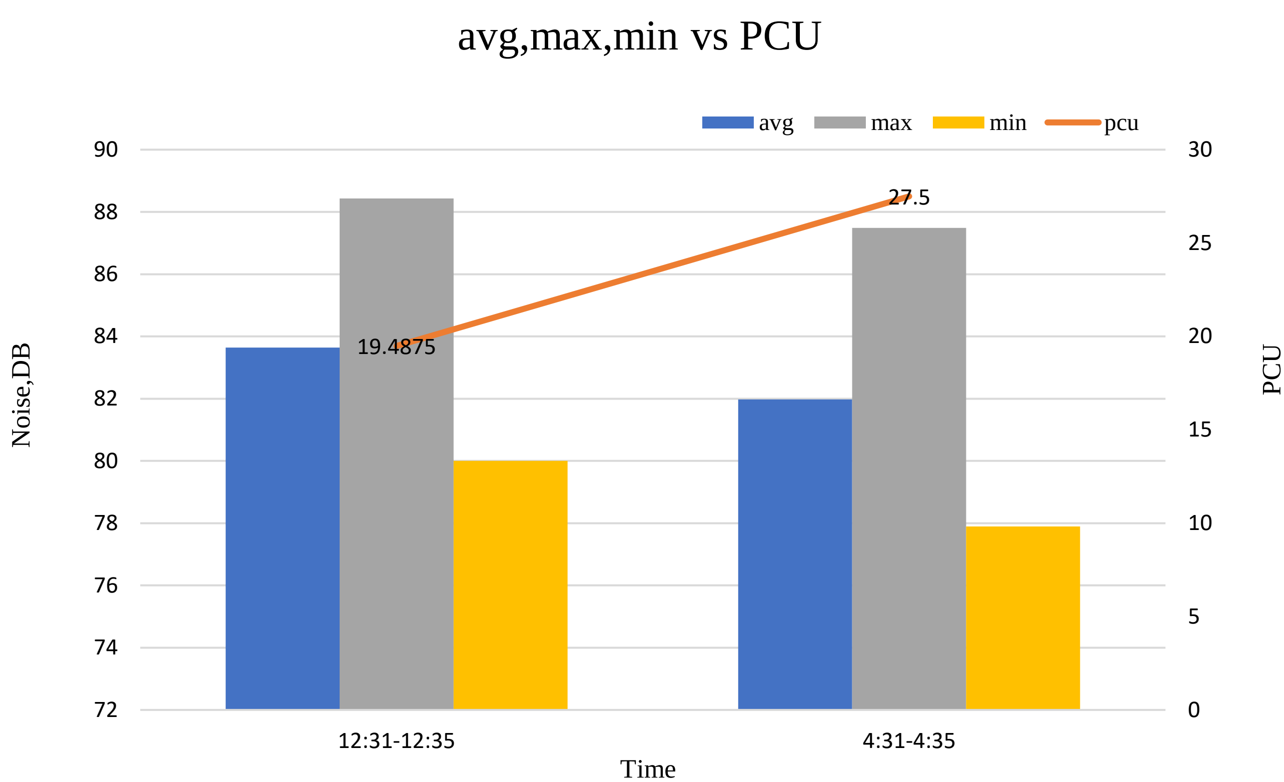

Figure 4.6: avg, max, min vs PCU over time for both datasets.

The research showed that the PCU values at BPATC exceed those seen in C&B comparisons. Conversely, the NOISE parameters, i.e., average, maximum, and minimum on the other hand are higher to C&B than to the BPATC. This inconsistency is to be expected, because BPATC processes more vehicles, while its roadways are narrower than at C&B. The presence of different small to mini-type vehicles/car was among the important findings of the BPATC study; sometimes they can lead to traffic jams. On the other hand C&B' s wider streets permit the unimpeded passage of all forms of heavy vehicle especially a container lorry and its content in consideration of the distance to the customs point as compared to Hobanya. Naturally, at BPATC, the situation is different because of the car diversity more significant in number than the overall "count of vehicles" or the PCU.

Chapter 5
CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Noise pollution along two sections of National Highway-5 (Dhaka-Aricha, N-5) in Bangladesh was studied in this research, on Thursday February 13, 2025 namely C&B and BPATC. In evaluating levels of noise and the number of vehicles, converted to Passenger Car Units, i.e. a standardized measure of output from different vehicles in terms of noise, for two periods (12:31 PM to 12:35 PM at C&B and 4:31 PM to 4:35 PM at BPATC), the research identified the relationship between traffic patterns and environmental noise. The outcome showed that traffic flow changed based on road design, vehicle category and volumes. This chapter brings together the findings, provides recommendations for Bangladesh Road and Highway Authority, analysis of the theoretical and practical implications, and outlines possible future research. The conclusions are built on having justified the data correlations, the comparisons of the noise level, and the PCU analyses as in the chapter 4 for the purpose of improving the transportation engineering and to contribute to the environmental sustainability.

5.2 Significance of The Findings

The differences in noise and traffic patterns between C & B and BPATC were noticeable through the analysis. The C &B segment, which has an 8-lane design recorded higher averages, maxima and minima noise levels (83.64, 88.43 and 80 dB respectively) compared to BPATCs 81.98, 87.49 and 77.89dB 4 lane design. This difference is largely because C&B is capable of handling more heavy vehicles that make more noise via engine power and friction between the tires. On the other hand, BPATC had increased PCU values implying there were more smaller vehicles: cars and mini-vehicles. Despite congestion caused by this, noise is not intense due to narrow road. The correlation matrices (Tables 4.4 and 4.5) showed closer links between PCU at C&B and noise parameters as a result of persistent heavy traffic. Time based analysis (Figures 4.1, 4.2, and 4.3) showed highest saturation level around 12:33pm in case of C&B (average 85.085 dB) and 4:33 pm in case of BPATC (average 83.2293 dB) coinciding with high intensity of traffic. Comparisons of C&B versus PCU and BPATC versus PCU versus time (Figures 4.7 and 4.8) showed peak hours of 12:34 pm for the C&B activity and 4:35 pm for the BPATC activity, which agreed with increased vehicle count. One of the main findings of this research is that there exists an inverse relationship between PCU and noise levels. Despite having higher PCU figures, the noise levels gauged from the BPATC were lower compared to C&B, suggesting that type of vehicles and capacity of roads greatly affect noise pollution. The fact that BPATC is characterized by prevalence of small vehicles and has fewer lanes led to higher traffic density with reduced noise in comparison to heavy vehicle traffic at C&B. Such insights emphasize the need for custom-designed noise mitigation solutions, including imposition of vehicle-type restrictions during rush-h and installation of noise-absorbing baffle in busy areas.

5.3 Theoretical and Practical Contributions

This study improves our theoretical consideration of noise pollution by merging environmental acoustics and analysis of traffic flow. By using PCU as a measurement standard, engineering and ecological effects can be linked together to generate a reproducible evaluation structure of the effects of different traffic compositions on the environment. The correlation matrices are congruent with quantitative approaches in environmental science, providing a strong way to analyze noise-traffic relations (Banerjee et al., 2019).

The studies look at sound pressure level models, and it is revealed that noise strength is controlled by both source and environmental context. The increased noise levels at C & B support this model in that with wider lanes there is accommodation for the movement of heavier vehicles thus heightening sound waves. The reduced lanes and vehicles of the BPATC correlate with lower level of sound pressure, which proves the applicability of the model. This theoretical consistency makes this study more valuable for literature on urban noise pollution in the developing areas.

Practically speaking, the findings of the research serve policymakers as practical tools. Differentiating peak noise and traffic times (e.g. 12:34 PM at C & B) identifies points of intervention. The manual data collection approach in 15-second intervals provides a convenient technique to monitor noise in resource challenged environments and is appropriate for developing nations (Ali et al., 2020). The emphasis to National Highway 5 acts as a case study for managing noise in busy corridors but has important lessons to offer urbanizing regions everywhere.

The results highlight the consequences for public health as well, the measurements of noise surpassing the 70 db threshold set by the WHO (2018), the World Health Organization thus, increasing the risk of hearing loss and stress. This support reinforces the need for noise reduction strategies to be incorporated into transportation planning, following Sustainable Development Goal 11 (United Nations, 2015).

5.4 Recommendations

To address noise pollution challenges, the following recommendations are proposed:

1. **Acoustic Barriers**: Install sound-absorbing barriers along C&B’s high-traffic segments, especially near the 12:34 PM peak zone. Materials such as concrete can lessen noise exposure for nearby communities (Ahmed & Rahman, 2020).
2. **Traffic Optimization**: Implement vehicle type restrictions at BPATC during peak hours (e.g., 4:35 PM) to reduce congestion caused by smaller vehicles. Intelligent traffic systems can minimize idling and honking, which are key contributors to noise.
3. **Infrastructure Upgrades**: Expand BPATC’s four-lane segments to alleviate congestion and reduce PCU-driven noise. At C&B, incorporate green belts as natural sound buffers, which will enhance air quality and minimize noise.
4. **Community Engagement**: Launch campaigns to raise driver awareness about the health effects of noise pollution, with a focus on excessive honking. Collaborate with local groups to promote noise-conscious driving at BPATC.
5. **Continuous Monitoring**: Establish automated noise monitoring stations along National Highway 5 to collect real-time data, complemented by manual surveys, to assess the effectiveness of mitigation measures.

These recommendations strike a balance between engineering and behavioral interventions, aligning with Bangladesh's environmental and transportation goals.

5.5 Limitations of the Study

The study's scope presents limitations:

- **Temporal Scope**: Data collection spanned two 4-minute periods on a single day, potentially missing diurnal or seasonal variability.
- **Manual Collection**: Manual counting is prone to errors during high-traffic periods. Automated sensors could improve accuracy.
- **Parameter Focus**: The study prioritized noise and PCU while excluding vehicle speed and atmospheric factors that affect noise propagation.
- **Geographic Specificity**: Focusing on two segments limits the generalizability to other highways.

These limitations highlight opportunities for improving methods.

5.6 Future Work

To extend the study's impact, the following research directions are proposed:

1. **Longitudinal Studies**: Collect data over several days and seasons to capture temporal variations, thereby enhancing the robustness of the findings.
2. **Expanded Variables**: Utilize sensors to measure vehicle speed and road conditions, thereby revealing their roles in noise generation.
3. **Predictive Modelling:** Develop machine learning models to predict noise levels, allowing for proactive mitigation strategies.
4. **Broader Scope**: Analyze additional highways to compare noise pollution levels and inform national policy.

5. **Health Studies**: Assess the health impacts of noise pollution on surrounding communities, quantifying risks such as hearing loss (WHO, 2018).

These directions aim to deepen understanding of noise pollution and support the development of evidence-based policies.

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List of Deliverables

No.	Deliverable	Timeline	Format	Date of Submission
Level-4/Term-1				
1	Project Proposal	Week 1-3	Writeup	Not applicable.
2	Detail planning, methodology, data/survey requirement, and identification of external expert requirement.	Week 4-5	Writeup, Presentation	18/08/2024
3	Data/survey Summary (Traffic & Noise)	Week 6-9	Writeup	17/07/2024
4	Preliminary Analysis of Traffic & Noise	Week 10-12	Writeup	29/07/2024
5	Analysis of Traffic Volume & Noise	Week 13	Writeup and Presentation	12/08/2024
6	Feasibility Study (Technical, Social, Environmental)	Week 14-15	Writeup and Presentation	15/08/2024
Level-4/Term-2				
7	Analysis scheme for detail design (Noise & Traffic Flow Model)	Week 1-2	Writeup	01/09/2024
8	Analysis output (Noise–Traffic Relation)	Week 3-4	Writeup	20/09/2024

9	Detailed Report (Traffic Noise Modeling)	Week 5-9	Writeup, Drawings, and Presentation	2/10/2024
10	Final Report, and Cost Estimation (Noise Barrier, Traffic Management)	Week 10-11	Writeup, and Presentation	25/11/2024
11	Implementation Schedule	Week 12-13	Writeup, Gantt Chart	Only Gantt Chart were submitted at

No.	**Deliverable**	**Timeline**	**Format**	**Date of Submission**
12	Final Report (Including Ethical aspects, lifelong learning)	Week 14	Writeup and Drawings	08/12/2024
13	Final Presentation	Week 15	Presentation	Presented to supervisor twice a week and the final One presented to examiner board at 20/09/2025

Self-assessment of COs with Knowledge Profile, Traffic Engineering Problem Solving and Traffic Engineering Activities

COs	Description	Criteria	Justification
CO1 (K6, P1, A1)	Application of traffic volume and noise	Applied for practical survey	Used Excel for data analysis, prepared time vs. noise & PCU graphs.
CO2 (K7)	Work on a Team	Attendance	Collaborated effectively through regular meetings and task integration. Name: Md. Leon Hossain ID: 213-47-491 Name: Ashifa Rahman ID: 213-47-488
CO3 (K7, P2, A2)	Alternative analysis presented	Environmental, social, ethical aspects considered	Conducted alternative analysis for traffic noise reduction methods (e.g., barriers, traffic control).
CO4 (K7)	Societal and environmental benefit evaluation	Environmental, social, ethical obligation	Proposed eco-friendly solutions to minimize traffic noise impact.

CO5 (K7)	Professional and ethical responsibility	Punctuality based on submissions	Maintained punctuality in data survey and presentations.

COs	**Description**	**Criteria**	**Justification**
			upheld professionalism.
CO6 (P5, A3)	Lifelong learning	Demonstrate the ability to learn new skills (based on the statement in accordance with the lifelong learning in Final report)	Learned advanced Excel analysis & Microsoft Project for traffic noise scheduling.
CO7 (A1)	Effective project management – time, financial	Prepared project Document	Created graphs, PCU vs noise charts, and Gantt chart for project management.
		Prepared graph	ensuring accurate traffic and noise planning for the project.
		Show compare Assessment	Due to time limitations, incomplete

		Show time management skill	Used a Gantt chart to manage project timelines and ensure timely completion.

COs	**Description**	**Criteria**	**Justification**
CO8 (K7)	Communication	Analysis, Presentation, Report	Created precise technical noise reduce graph chart in project book for clear detailing.
		Presentation	Presented the visibility of the project by showcasing its innovative noise reduce in traffic volume.
		Report	i. Time vs avg, max, min dB for 1st Data set. ii. Time vs avg, max, min dB for 2nd Data set. iii. Comparison between the two studied datasets. iv. avg, max, min vs PCU over time for 1st data set.. v. avg, max, min vs PCU over time for 2nd data set., vi. avg, max, min vs PCU over time for both datasets.