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Research Article

Traffic Induced Noise Pollution in Rajshahi City Corporation: A Study on Sources, Impacts and Solutions

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Abstract

Urban areas are affected by traffic-induced noise pollution, which has detrimental effects on the health and well-being of individuals. The objective of this research is to assess the magnitude of traffic-related noise pollution in Rajshahi City Corporation, Bangladesh, and suggest potential solutions to alleviate its adverse effects. Information was gathered from 28 distinct locations in week and weekend days throughout the city utilizing a UT353 UNI-T decibel meter sound level reader. The statistical analysis unveiled notable fluctuations in noise levels ranging from 57 dB to 108.3 dB based on which we have divided the areas in different zones to visually observe the spatial distribution of noise pollution. The results underscore the extensive incidence of noise pollution within Rajshahi City Corporation, which presents significant health hazards to inhabitants, such as disruptions in sleep patterns and cardiovascular ailments. A multifaceted approach is suggested in order to tackle this matter; it includes technological solutions, public awareness campaigns, and traffic management strategies. In addition, it is suggested that public education initiatives be implemented to promote responsible driving practices among motorists and residents and to increase awareness regarding the adverse health effects of noise pollution. By incorporating these proposed measures, Rajshahi City Corporation can strive towards establishing an urban setting that is more tranquil and promotes the health and welfare of its residents.

Keywords

Traffic Induced Noise Pollution, Decibel Meter, Sound Level, Pollution, Rajshahi City Corporation, Spatial Distribution, Technological Solution

1. Introduction

Urbanization and population growth have led to the transformation of cities into vibrant centers of activity and progress. However, amidst this dynamism, cities face numerous challenges, among which noise pollution stands out as a pervasive and insidious issue. Among the various sources of environmental noise, traffic noise emerges as a particularly potent disruptor of urban soundscapes, significantly impacting the quality of life for city residents.

Noise pollution, derived from the Latin "nausea" meaning undesired sound [1], has far-reaching effects on health and behavior. The exponential increase in urban traffic, driven by the automotive revolution, exacerbates this issue. Rajshahi, a prominent divisional city in Bangladesh, exemplifies the challenges posed by rapid urbanization and industrial growth, leading to a surge in noise pollution, particularly from vehicular traffic [2].

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As a key educational, administrative, and commercial hub, Rajshahi has experienced substantial urban growth alongside a corresponding rise in traffic, endangering the well-being of its residents. This paper explores the intricate web of issues surrounding noise pollution induced by transportation within the framework of Rajshahi City Corporation. By identifying areas with elevated noise levels, the study aims to provide valuable insights for urban planners and decision-makers to implement necessary measures.

Urbanization and population growth have led to the transformation of cities into vibrant centers of activity and progress. However, amidst this dynamism, cities face numerous challenges, among which noise pollution stands out as a pervasive and insidious issue. Among the various sources of environmental noise, traffic noise emerges as a particularly potent disruptor of urban soundscapes, significantly impacting the quality of life for city residents.

The origins of traffic-induced noise pollution lie in the development of transportation systems and the consequent transformations of urban landscapes. The proliferation of vehicles in densely populated areas, compounded by inadequate urban planning, exacerbates noise pollution levels. This paper delves into the impacts of traffic-induced noise pollution on health, cognition, social dynamics, and ecosystems, highlighting the urgent need for effective mitigation strategies [3].

The primary objectives of this study include:

1. Identifying sources and levels of traffic-induced noise pollution.
2. Assessing temporal and spatial variations in noise levels.
3. Evaluating the effects of noise pollution on human health and socio-economic factors.
4. Examining mitigation strategies and technological solutions to reduce noise levels caused by traffic.

By addressing these objectives, this paper aims to provide a comprehensive understanding of traffic-induced noise pollution and propose actionable measures to create more livable and sustainable urban environments.

2. Methodology

To measure sound levels, we use the unit of decibels (dB). Sound intensity (I) is typically measured in watts per square meter (W/m^2). The equations for these measurements are as follows:

Sound Level (L):

The sound level (L) in decibels (dB) is calculated using the formula:

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

$$\text{Or, } I = 10^{-12} * I_0(L/10) \quad (1)$$

Where:

L = Sound level in decibels (dB)

I = Sound intensity in watts per square meter (W/m^2)

I0 = Reference sound intensity, typically set at $10\text{-}12 W/m^2$ for the threshold of human hearing.

Note: The sound level is a logarithmic representation of the ratio between the measured sound intensity and the reference intensity.

Sound Intensity (I)

The following formula can be used to compute the sound intensity (I) in watts per square meter (W/m^2):

$$I = P/A \quad (2)$$

Where:

I = Sound pressure expressed in W/m^2, or watts per square meter.

Watts (W) of acoustic power equal P.

A = Square meters (m^2) of the area the sound is traveling through

Note: The quantity of energy transferred across a unit area perpendicular to the direction of propagation in a unit of time is represented by sound intensity.

2.1. Site Selection

Selecting appropriate sites for studying traffic-induced noise pollution in Rajshahi City Corporation requires careful consideration of various factors. We have divided the city corporation area into different zones which are:

1. Recreational area
2. Train/Bus Stand area
3. University area
4. Residential area
5. Factory area
6. Area Near Highway
7. Market area
8. VIP area
9. Hospital area.

Here we have provided the map of Rajshahi City Corporation showing the different zones and data collection points.

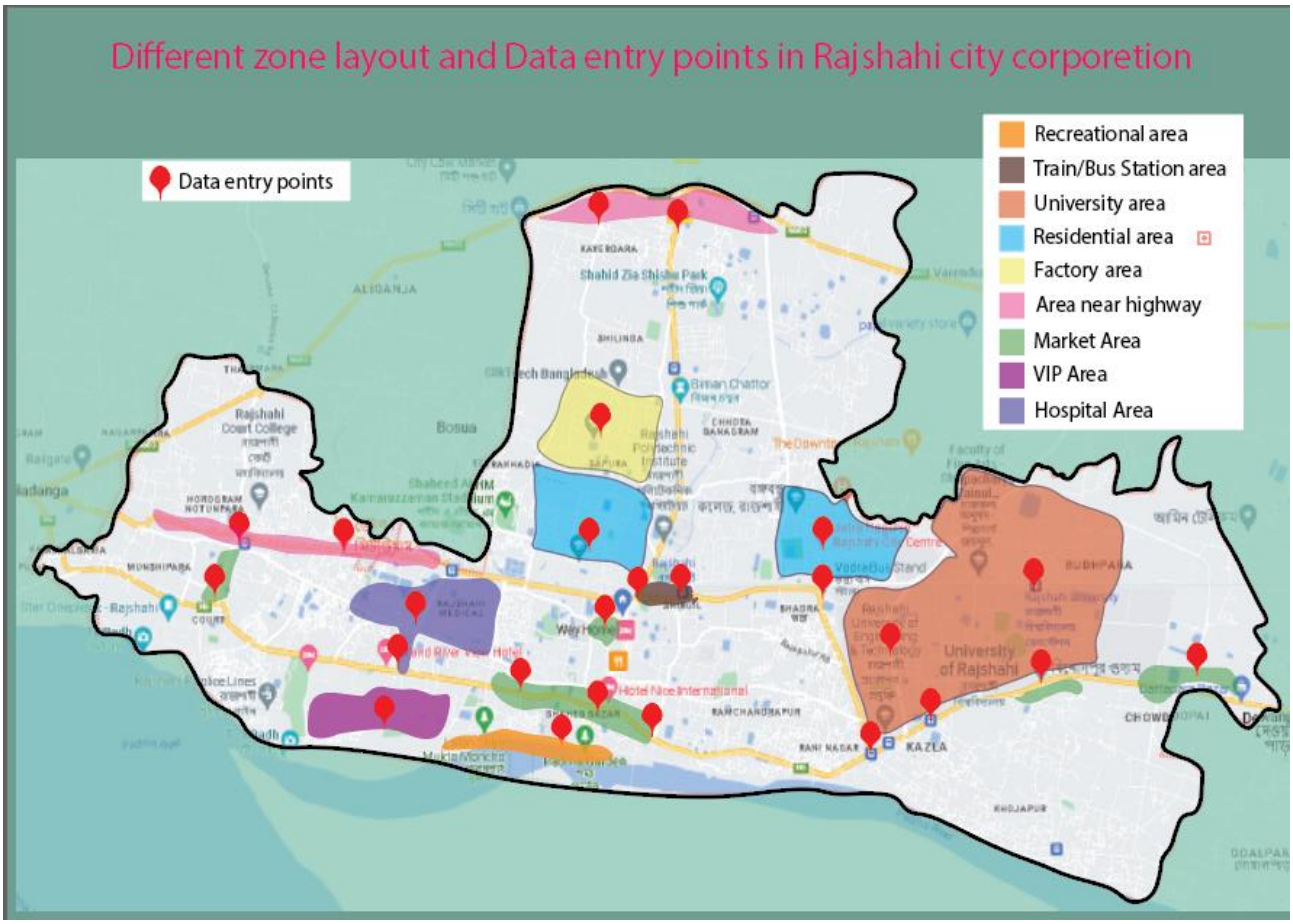

Figure 1. *Different Zone Layout and Data Entry Points in Rajshahi City Corporation.*

Figure 2. *Sound Measuring Decibel Meter.*

2.2. Noise Measurement Device

Noise measurement devices, also known as sound level meters or noise dosimeters, are instruments designed to quantify and analyze the level of sound in a given environment. These devices play a crucial role in assessing noise levels, ensuring compliance with regulations, and implementing effective noise control measures.

2.3. Data Collection Method

To collect data more accurately and reliably, we have set the device to slow mode and taken data after every 30 sec for 10 minutes at each data collection point (i.e 20 data/ collection point). Then the arithmetic mean of the 20 data is recorded as a noise level of that collection point. The sound levels are recorded based on different traffic volume i.e Morning-Peak (8:00-9:00AM), Afternoon-Peak (2:00-3:00PM), Evening Peak (8:00-9:00 PM) on weekdays as well as weekends.

3. Result Analysis

Graphical representation of sound level with respect to different locations for week days (8am to 9.00am, 2pm to 3.00pm and 8pm to 9.00pm).

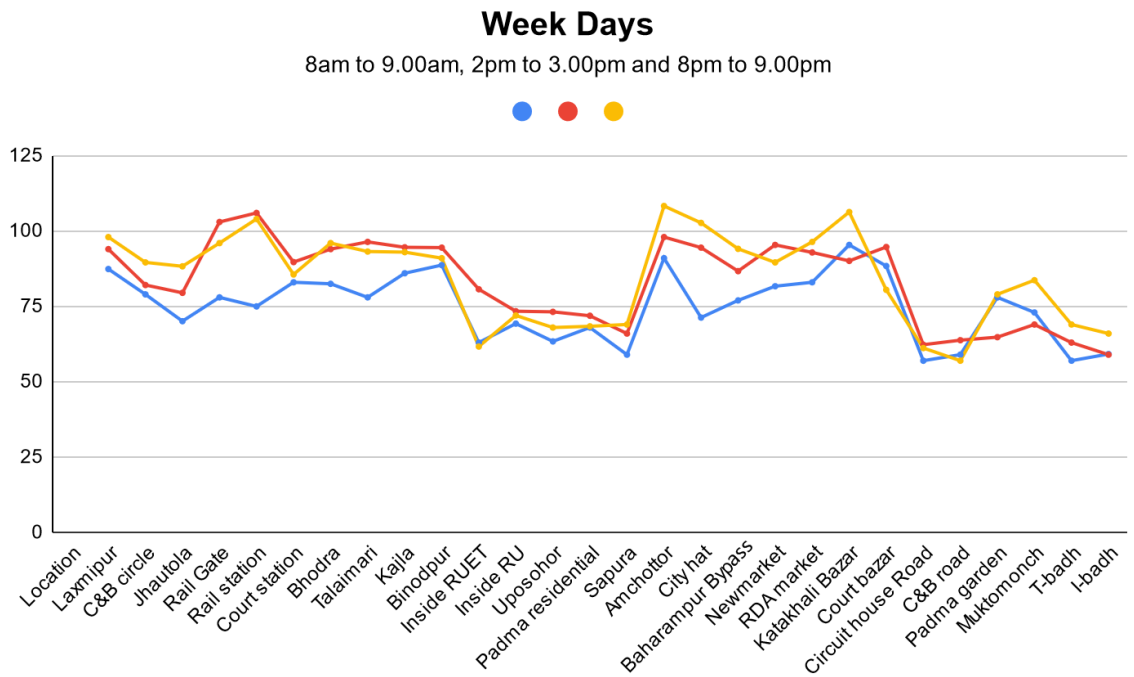

Figure 3. *Graph showing the Sound level vs Different Locations for week days (8am to 9.00am, 2pm to 3.00pm and 8pm to 9.00pm).*

Graphical representation of sound level with respect to different area for weekends (8am to 9.00am, 2pm to 3.00pm and 8pm to 9.00pm).

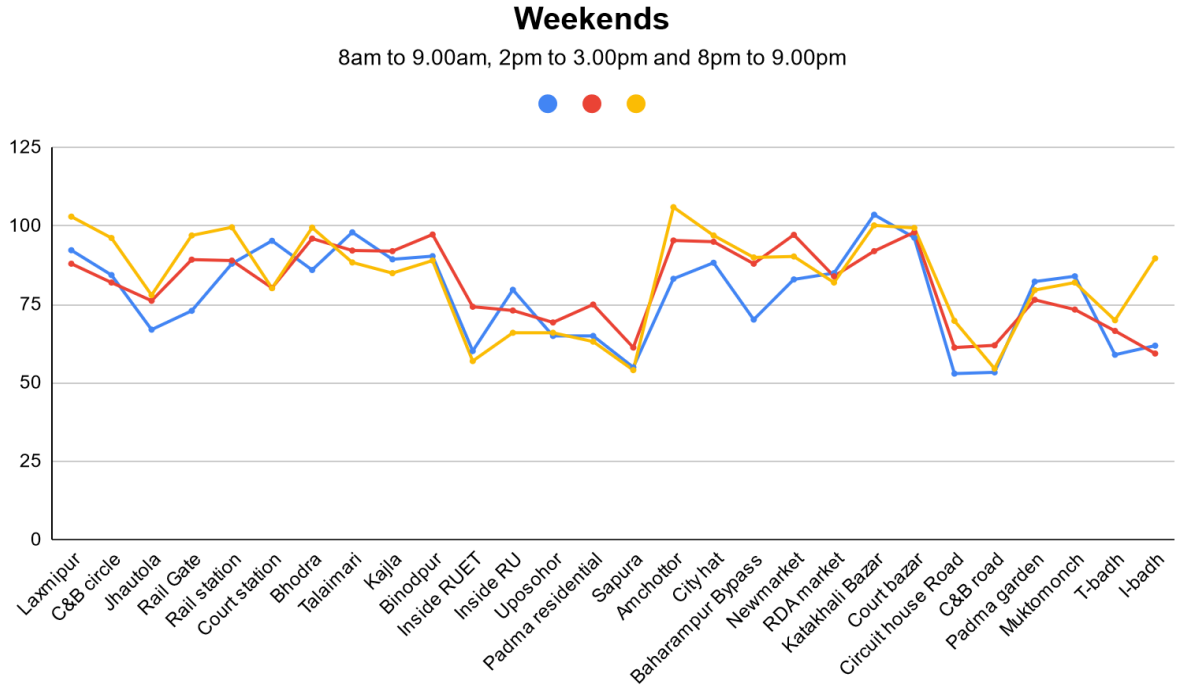

Figure 4. *Graph showing the Sound Level vs Different Locations for weekends (8am to 9.00am, 2pm to 3.00pm and 8pm to 9.00pm).*

The World Health Organization (WHO) provides guidelines for acceptable noise levels in various environments to safeguard public health and well-being. Here are the recommended noise level thresholds for different areas according to WHO:

Table 1. Sound level value according to WHO for different areas [4].

Areas	Sound level	
	Daytime (6:00 AM - 10:00 PM)	Nighttime (10:00 PM - 6:00 AM)
Residential Areas	55 decibels (dB) or less	45 dB or less
Educational and Recreational Areas	55 dB or less	45 dB or less
Hospitals and Healthcare Facilities	35 dB or less	30 dB or less
Workplaces	55 dB or less	70 dB or less
Transportation and Traffic Noise	Inside Homes (with windows closed) 30 dB or less	Inside Bedrooms (for sleep quality) 30 dB or less

Table 2. Sound level and sound intensity of different vehicle's horn.

Types of vehicle	Sound level Max (db)	Sound level min (db)	Sound level avg (db)	Avg sound intensity (W/m^{-2})
Auto rickshaw	116.8	115.5	116.1	0.40
Motorcycle	120.3	117.3	118.1	0.70
Private car/ Microbus	126.8	125	125.9	3.9
Mini bus/ Bus	130	127	128.5	7.1
Truck/Heavy vehicle	133	131.5	132.25	16.7

4. Discussion

1. Morning (8:00 AM to 9:00 AM):

Weekends generally tend to have slightly higher sound levels compared to weekdays in most locations. This suggests potentially more traffic or activity during weekend mornings. But areas such as Railgate, Jhautola, Sapura, Amchottor etc have higher traffic noise on weekdays compared to weekends because traffic volume is less on weekends in these areas.

2. Afternoon (2:00 to 3:00 PM):

Sound levels during afternoons are relatively similar between weekdays and weekends across most locations. But there are some differences such as for recreational areas the sound level is higher on weekends compared to weekdays as more people visit these areas for recreation. On the other hand, market areas which are closed on weekends have less sound level compared to weekdays.

3. Evening (8:00 to 9:00 PM):

Weekends exhibit varied trends during evening hours. While some locations show slightly higher sound levels on weekends compared to weekdays, others show significantly higher levels on weekends. Educational areas have lower sound level on weekends as they are closed and recreational areas have higher sound level as traffic volume is higher in these areas. This could indicate increased activity or events happening around those locations during weekend evenings, leading to higher traffic noise levels.

Specific Observations:

Some locations consistently show higher sound levels throughout the day, regardless of weekdays or weekends. Examples include Jhautola, Binodpur, RUET, and I-Badh during evening hours. Also Station areas on weekdays and weekends have similar sound level throughout all day as traffic volume remains similar at all days throughout the week.

There are locations like Court Bazar and Padma Garden where weekdays tend to have higher sound levels during evening hours compared to weekends, indicating potentially more activity or events happening during weekday evenings.

During the evening time frame, Railgate, Talaimari, Kajla, Binodpur, Aamchattor, and I-Badh exhibit sound levels exceeding 90 dB on both weekdays and weekends. This suggests potentially high levels of traffic noise or other activities in these areas during evening hours.

During all time frames, C&B Road, Circuit house road, T-Badh, and I-Badh consistently exhibit sound levels less than 70 dB on both weekdays and weekends. This suggests relatively quieter environments in these areas compared to others during the specified time frames.

Overall, the comparison highlights variations in traffic noise levels among different locations and time frames, with

certain patterns observed across weekdays and weekends.

5. Remedial Measures

Active Noise Cancelation

Active noise cancellation (ANC) is a technology used to reduce unwanted ambient sounds by generating sound waves that are precisely phase-inverted to cancel out the noise. It operates through a simple principle: sound waves have both peaks (compressions) and troughs (rarefactions), and when two sound waves of the same frequency meet, they interfere with each other. If the trough of one wave meets the peak of another, they cancel each other out, resulting in silence.

Here's a brief overview of how ANC works:

1. Microphones: ANC devices have built-in microphones that capture the ambient noise around them.
2. Noise Analysis: The microphones analyze the incoming noise and determine its frequency and amplitude characteristics.
3. Inverse Sound Waves: The ANC system then generates sound waves that are the exact opposite (180 degrees out of phase) of the incoming noise.
4. Cancellation: The generated sound waves are played through the device's speakers simultaneously with the incoming noise. When these waves meet, they interfere with each other, effectively canceling out the ambient noise.

Road Preservation and Design

Quieter Road Surfaces:

By employing noise-reducing materials like rubberized asphalt, stone mastic asphalt, or porous asphalt, road pollution can be absorbed and diminished. [5]

Noise Barriers: Along highways and busy roads, erecting barriers constructed of transparent or concrete-based materials can effectively insulate adjacent residential zones from the detrimental effects of excessive noise. [6]

Consistent Maintenance: By performing routine road maintenance tasks such as patching damaged surfaces, filling potholes, and maintaining smooth roads, one can effectively mitigate the detrimental effects of vehicle vibrations and uneven surfaces, which can contribute to excessive pollution. [7].

Urban Planning and Zoning

Buffer Zones:

Designating urban regions with parks, green spaces, or business zones as buffers between residential neighborhoods and raucous transit corridors might assist lessen the negative effects of traffic noise on nearby inhabitants.

Zoning laws: Reducing noise pollution for locals can be achieved by enacting laws that divide loud establishments, like businesses or industries, from residential zones. [8]

Building Design: Soundproof windows, insulation, and building orientation are examples of noise-reducing elements that can be included to lower indoor noise levels in both residential and commercial structures. [9]

Infrastructure for Sound Absorption: Along vehicle corridors, installing barriers, smoothing out surfaces, and placing materials that absorb sound can assist reduce noise and lessen its effect on the neighborhood. [10]

Electric and Hybrid Vehicles

Promoting the adoption of electric and hybrid vehicles, which produce less noise compared to conventional internal combustion engine vehicles, can help reduce overall traffic noise levels. [11, 12]

Public Education and Awareness:

Obtaining support for noise reduction initiatives and educating the public about the detrimental health consequences of noise pollution, such as sleep disruptions, tension, and cardiovascular issues, can increase public consciousness. [13]

Behavioral Modifications: Promoting modifications in conduct such as abstaining from aggressive driving behaviors, minimizing superfluous horns, and adhering to responsible vehicle maintenance protocols can effectively alleviate the issue of noise pollution. [14]

Community Engagement: The active participation of local communities in noise monitoring, reporting, and mitigation initiatives provides residents with the authority to identify problematic regions and devise focused resolutions through collaborative efforts with authorities. [15]

6. Conclusion

In conclusion, the paper examined traffic noise pollution in Rajshahi City Corporation, including its frequency, effects, and solutions. We have gathered a lot of data on motor traffic noise pollution from 28 locations throughout the city using decibel meters. Highway areas always exceed 90 dB, weekdays or weekends. However, residential and VIP zones are below 70 dB.

We have discovered numerous forms of traffic that contribute to noise pollution through extensive investigation. Understanding the relative contributions of each form of traffic has illuminated urban noise levels.

1. Assessing Temporal and Spatial Variations: Our temporal and spatial noise analysis showed large variability among metropolitan contexts. Factors such as traffic volume and time of day have been investigated to understand the dynamic nature of noise pollution.
2. Assessment of Effects on Human Health: Empirical studies and data analysis have assessed the health implications of traffic-induced noise pollution, including sleep disruptions, heightened stress levels, cardiovascular dangers, and overall well being. Pedestrians, drivers, homeowners, shopkeepers, and anyone who live in places with sound levels above 85 dB may face health risks. Public health and well-being require noise pollution reduction, as these data show.
3. Examination of Mitigation Strategies: Research and evaluation of a range of mitigation policies and techniques have been conducted, encompassing technolog-

ical solutions such as Active Noise Cancellation, promoting of electric and hybrid cars etc, urban planning measures and traffic management strategies. These findings give useful recommendations for politicians and urban planners in establishing appropriate noise abatement methods.

In summary, this paper contributes to the body of knowledge on traffic-induced noise pollution in Rajshahi City Corporation by giving thorough insights into its sources, affects, and mitigation options. By meeting the objectives mentioned herein, this research aims to inform evidence-based policies and solutions targeted at building healthier and more sustainable urban environments.

Abbreviations

dB	Decibel
ANC	Active Noise Cancellation
WHO	World Health Organization

Conflicts of Interest

The authors declare no conflicts of interest.

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