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Research Article

Noise Pollution Assessment, Spatial Noise Mapping and Associated Health Impacts in Dinajpur City, Bangladesh

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Abstract

Noise pollution is one of the more prevalent types of pollution caused mainly by urbanization. It is characterized as noise propagating throughout a living being in a way that is to its physical and mental health. Along with the growth of the city, trade, business, shopping, education, and other activities have been accelerating. The main purpose of the study was to address the dangerous point of noise pollution in Dinajpur municipality and identify the causes of noise pollution. For this study, data sets on the amount of noise pollution at 35 different places throughout Dinajpur city have been analyzed. Three shifts of data collection were conducted: morning (8 am to 10 am), afternoon (12 pm to 2 pm) and evening (4.00 pm-6.00 pm). Using the ArcGIS 10.8 program, descriptive statistics tools and analysis of variance were carried out. The highest average noise level (105.7 dB) was found at Central Bus Terminal at the time of evening which is a mixed zone. The lowest average noise level (64 dB) was found at Chotogurgola and Balubari at the time of morning and evening respectively which is residential zone. The noise levels throughout the city vastly exceed both the WHO and DoE recommendations. The main causes of noise pollution are the expanding urban area, unregulated auto rice mills establishment, the heavy use of construction equipment, automobile engines, uncontrolled horns, and outrageous auto rickshaws etc. It is vital to take action to lower noise levels because prolonged exposure to noise has numerous negative effects. The development of comprehensive land use plans for this city would benefit from taking noise pollution into consideration.

Keywords

Noise Pollution, Public Transportation, Noise Mapping, Health Impact

1. Introduction

Lives are becoming more and more reliant on noise, which seems to be an unfavorable but ultimately preventable consequence of contemporary technology. In emerging nations, noise pollution is becoming a major problem in urban areas due to factors like population pressure, the use of outdated construction equipment and careless land use [23]. Accordingly, another environmental contaminant that has been officially acknowledged as presenting a major risk to human health and quality of life is noise pollution [22]. In urban settings, the culprits could be public transportation systems,

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private vehicles and car horns. The growth of industry, urbanization, and communication and transportation networks, coupled with the speed at which infrastructure is developed, all contribute to increased noise levels in urban areas and annoyance among surrounding residents [2, 5, 19].

For a certain geographic area, noise maps are simply visual representations of the noise pollution caused by traffic or industry [12]. These maps can be utilized to support action-planning techniques focused on reducing noise at problem hotspots as well as locating and protecting quiet area areas [13]. High noise levels can have negative effects on human cardiovascular health and raise the risk of coronary heart disease. Noise can raise the risk of death in animals by affecting how they detect and avoid predators and prey, interfering with reproduction and navigation, and causing irreversible hearing loss [8, 24]. Children who are in school are more likely to experience respiratory conditions, wooziness, and fatigue due to noise and air pollution [1, 20]. Adults exposed to noise pollution have been linked to both cognitive problems and high blood pressure [6, 17]. Murphy, E. and King, E. discovered that population exposure was over the WHO's recommended nighttime limits and was a substantial source of annoyance for locals [12].

The purpose of this research is to assess noise pollution at Dinajpur city levels across various zones and to pinpoint the main sources of noise pollution. Furthermore, a GIS-based noise mapping tool is created to predict the degree of noise pollution. The findings of this study will be useful in developing appropriate legislation and public action initiatives, which will enhance the lives of those who reside in the Dinajpur municipality.

2. Materials and Methods

2.1. Study Area

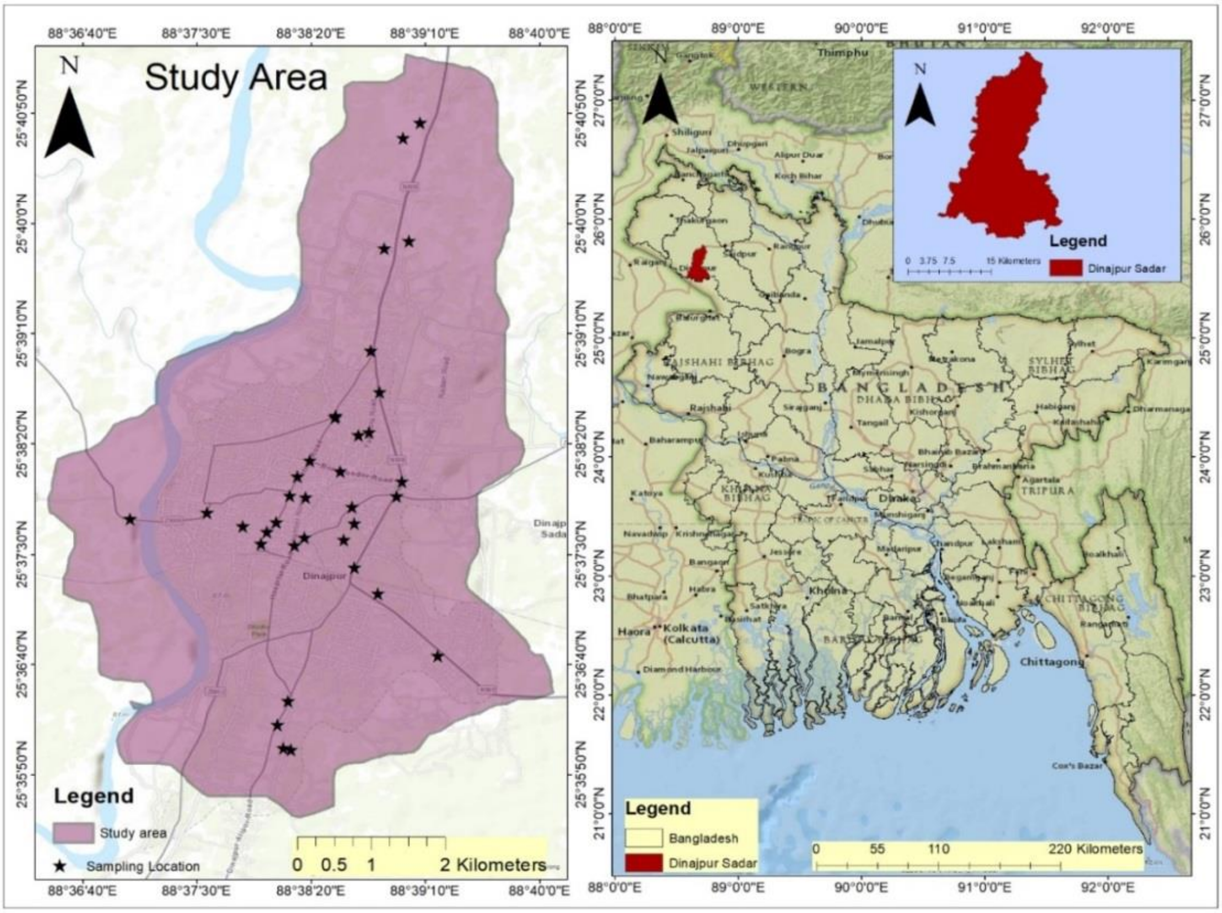


Figure 1. *Study area of noise measurement location in Dinajpur municipality.*

The city of Dinajpur is located on a geographically balanced terrain, far from the sea in the south and near the Himalayan foothills in the north. The location of Dinajpur is 25°35′ N latitude and 88°40′ E longitude, on the eastern bank of the Punarbhaba River. As per the census, the population of Dinajpur municipality is approximately 1,86,727 individuals.

7,247 people per square kilometer in an area of 24.50 sq km is the population density [7]. It includes four marketplaces, a kheya ghat, a truck terminal, and bus terminals. Since the turn of the 20th century, the size of this city has increased following the growth of trade, commerce, shopping, education, and culture, among other activities. In the present scenario, waste management, water pollution, noise pollution, air pollution, and other serious environmental issues are being faced by the municipalities of Dinajpur.

2.2. Data Analysis

Noise levels have been measured from 35 different locations in Dinajpur municipality among different zones which are sensitive, residential, commercial, industrial, and mixed areas. Data have been collected in three shifts, morning (8.00 am-10.00 am), afternoon (12.00 pm-2.00 pm), and evening (4.00 pm-6.00 pm). Noise measurements were determined by digital noise meters. Inverse Distance Weighting (IDW) method of spatial analysis tool used for noise mapping through Geographical Information System software ArcGIS 10.8 version. IDW can analyze the noise levels in the surrounding region by evaluating the noise level at the selected point.

3. Result and Discussion

The context of the report is that different land uses in different categories result in varying noise levels. Table 1 displays the distribution of noise mapping locations categorized by land use, along with the corresponding sampling period. Various land use categories, including residential, commercial, educational, and traffic areas, are covered to measure noise. The WHO and DOE recommendations on the impact of the environment on humans and noise levels were compared. Throughout the sampling period, various noise levels were measured at various times of the day. The Central Bus Terminal has the maximum noise level of 105.7 dB (L*max*), while 64 Chotogurgula and Balubari have the lowest noise level (L*min*). The noise level in Dinajpur city has been measured at 35 important places.

Table 1. *The sampling point of the different zones in Dinajpur municipality and value (dB).*

Land Use Category	ID	Location	Morning	Noon	Evening
	1	Balubari (BB)	72.6	71	64
	2	Aloha Zone (AZ)	68.9	81	69
Residential	3	Chotogurgula (CG)	64	76	71
	4	Baluadanga (BD)	71.8	69	76
	5	Fakirpara (FP)	75	78.1	74
	6	Modern Moor (MM)	97	99	95.6
	7	Jail Moor (JM)	96.5	95	95
	8	Lily Moor (LM)	97	100	105
Commercial	9	Chaurongi Moor (CM)	84	101.2	100.5
	10	Nimtola Moor (NM)	99	96.5	105
	11	Moharaja Moor (MH)	86.2	86	103.1
	12	Shuihari (S)	81	86	84
	13	Infornt of Diabetic Hospital (IDH)	89.2	82.2	83
	14	North Balubari Govt. School (NBS)	78.7	98	91.2
	15	Labaid Diagnostic Center (LDB)	95	90.1	101.5
Sensitive	16	Sadar Hospital (SH)	98.8	100.2	102
	17	Poly Technical College (ITC)	86.5	100.2	99.3
	18	M Abdur Rahim Medical College Hospital (ARMCH)	97.4	91	91
	19	Ikbal School Moor (ES)	89	86.5	99
	20	Infront Dinajpur Govt. College (IDGC)	100.7	100.5	94.3
	21	Infront of Patoary Autorice Mill (PA)	83	88.5	100

Land Use Category	ID	Location	Morning	Noon	Evening
	22	Awliapur (AP)	86.2	86	81
	23	Infront of Zia Auto Rice Mill (ZA)	82.4	99.4	103
Industrial	24	Infornt of Raj Auto Rice Mill (RA)	76	75.6	76.1
	25	Infront of PR Auto Rice Mill (PR)	76.9	77.2	78
	26	Infront of Meherunnesa Auto Rice Mill (MA)	82	76	77
	27	Infront of Rupali Auto Rice Mill (IRA)	80	79.6	78.9
	28	Horishovar Moor (HM)	85	102	87.9
	29	kalitola Thanar Moor (KTM)	96.7	97	98.1
	30	Charubabur Moor (CM)	98.5	101	97
Mixed	31	Staion Road (SR)	87.2	97	97
	32	Pulhat Moor (PM)	98.1	100	101
	33	Chirirbondor Bus Stand (CBS)	103	101.8	102.6
	34	Central Bus Terminal (CBT)	105.3	103	105.7
	35	Kanchon Bridge Moor (KBM)	96.3	89.5	92.5

[According to DoE, 2006 [14] Noise Level Standard (dB): Mixed (60), Commercial (70), Residential (50), and Industrial (75), Sensitive (45); According to WHO, 2009 [14]: Sensitive (45), residential (55), Commercial (55), Industrial (65)]

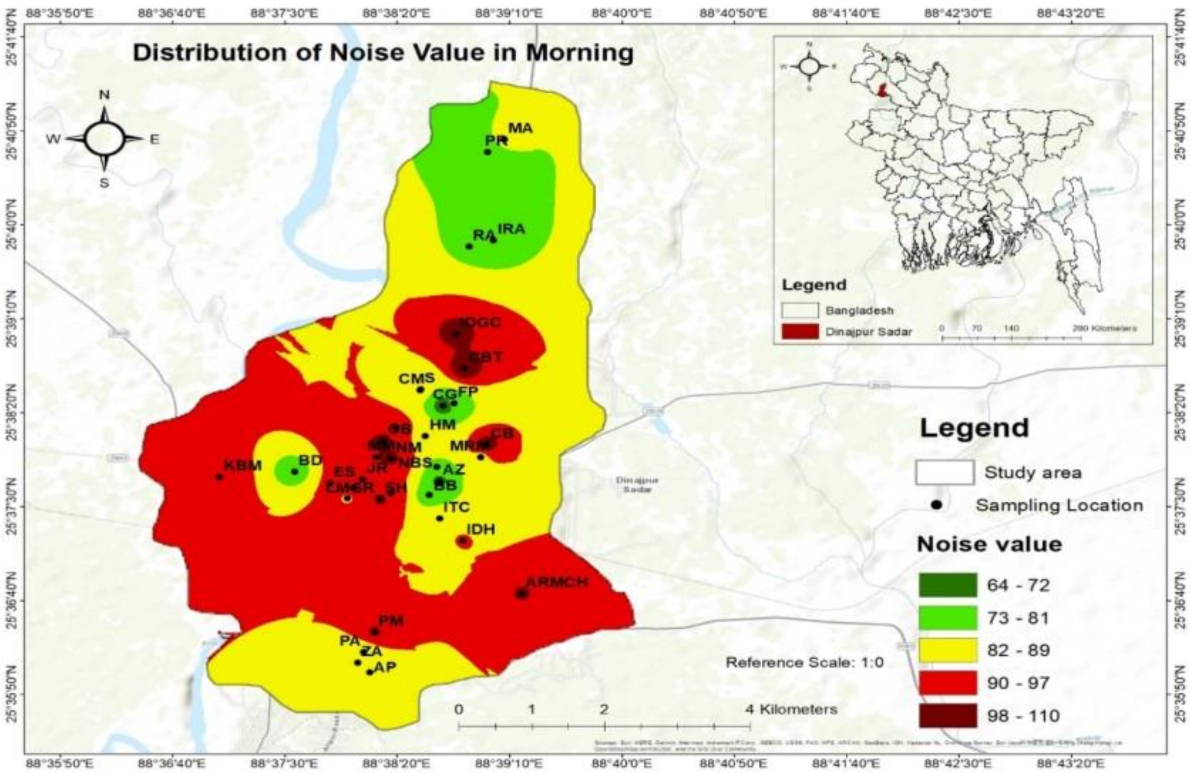


Figure 2. *Spatial analysis of noise value in the morning of Dinajpur Municipality.*

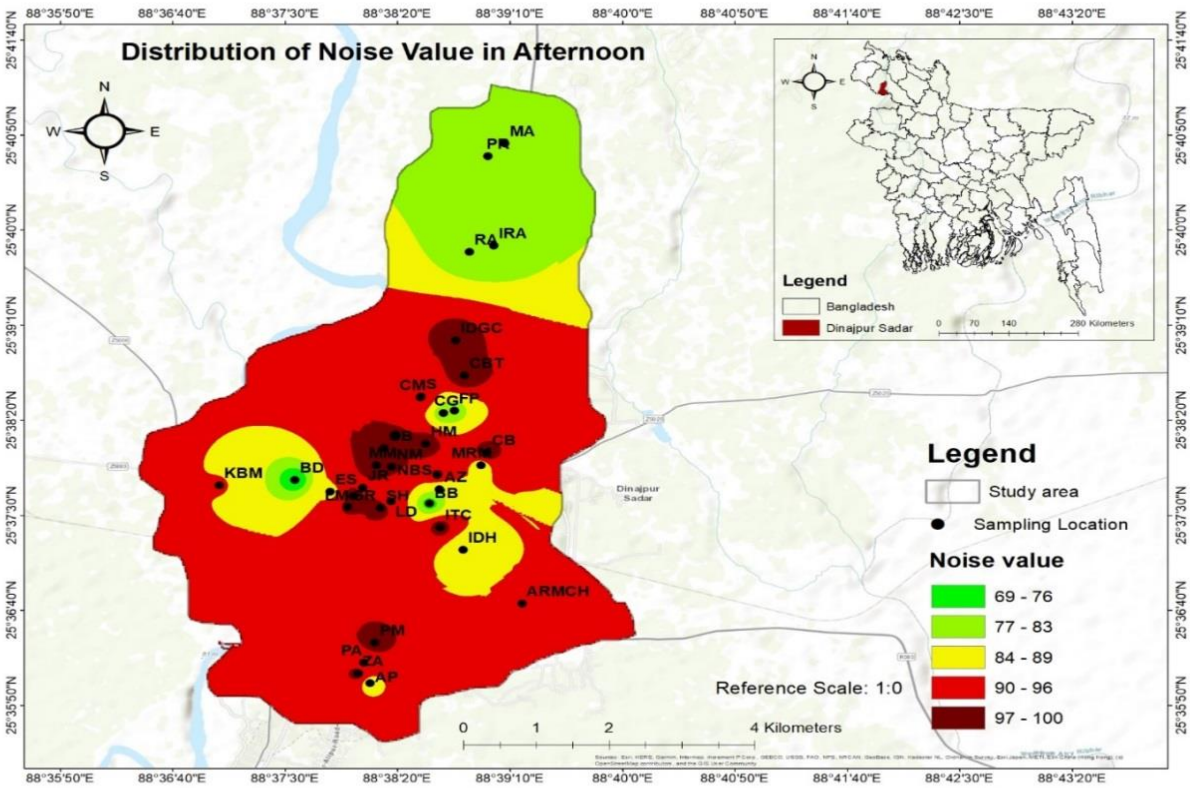


Figure 3. Spatial analysis of noise value in the afternoon of Dinajpur Municipality.

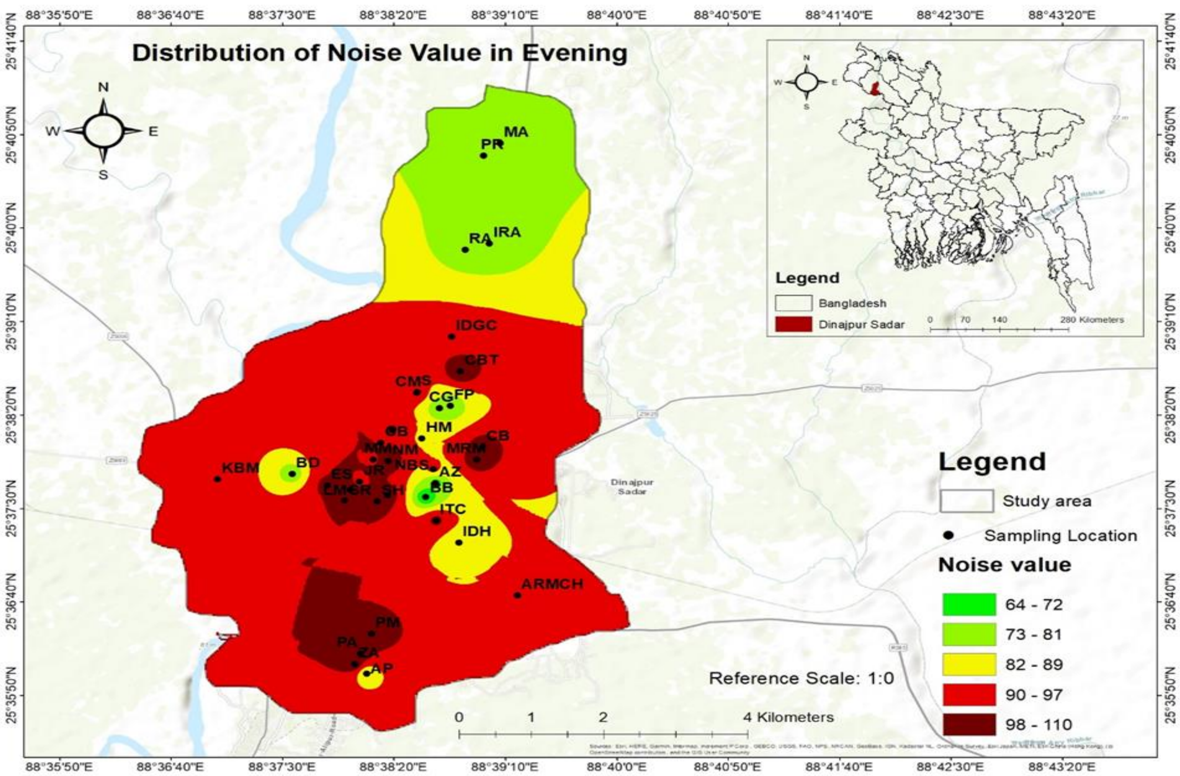


Figure 4. Spatial analysis of noise value in the evening of Dinajpur Municipality.

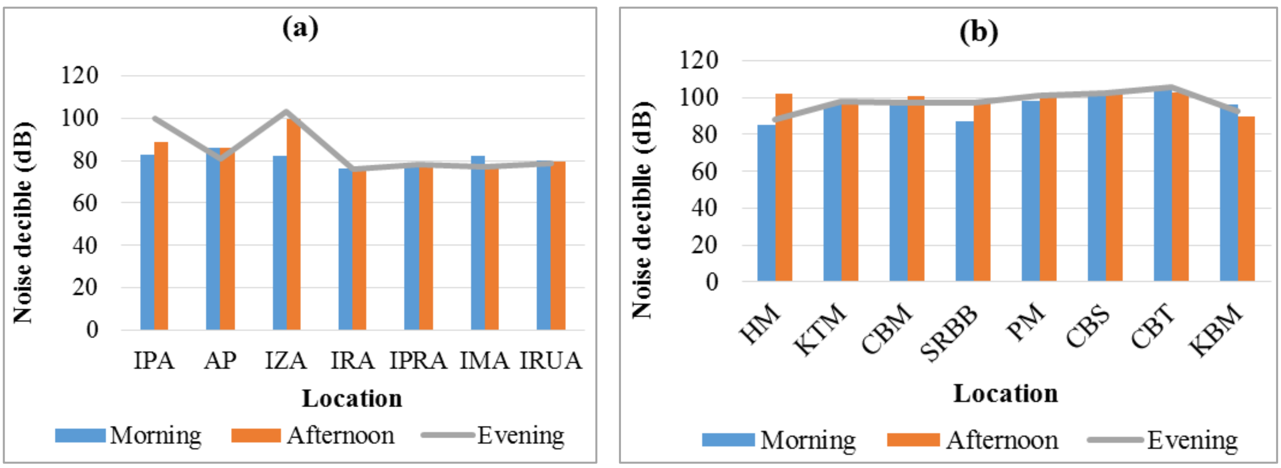
Residential area noise evaluation measurements reveal that every location exceeds DoE and WHO guidelines. The highest noise value recorded during the morning is 105.3 dB in the point of Central Bus Terminal and lowest value is 64 dB in Chotogurgola (Figure 2). The Aloha zone L*max*, which is the highest value in this area, is 81 dB at noon (Figure 3), the hour that this zone is selected. A slightly lower value is assigned to another measured residential location, which is approximately 70 dB (+-5). The Chotogurgola 64 dB noise level is the lowest recorded in residential areas. Major findings indicate that auto-rickshaws, motorcycles, people getting around, kids and office workers, small vegetable markets, and gatherings of people at tea stalls are noise-causing factors in residential zones. Fakirpara is a crowded area at all times, whereas other locations vary in timing from one moment to the next.

More commercial space is required in an exceedingly densely populated city to accommodate the daily needs of the residents. Ultimately, one of the main causes of noise pollution that is detrimental to humans is commercial space. The highest noise value recorded in commercial areas during the evening is 103.1 dB (Figure 4), according to noise measurement data. Furthermore, areas of Chaurongi Moors with extreme noise levels, measured between 101.2 and 100.5 dB, predominate. Each of those business locations is worth far more than the standard value of 50 dB. An individual's ears may be harmed by sounds that are louder than 85 dB [16]. Commercial noise exposure causes tension, headaches, and disturbed sleep. Dinajpur city has experienced constant road traffic and commercial activity as a result of its economic development and expansion, which has increased the amount of traffic noise. Especially when people spent long duration on commercial crowded zone, they felt serious stress level and other disturbance effects.

People become agitated and find it difficult to communicate, sleep, or go about their daily lives in environments with noticeably higher noise levels [11]. Chronic stress can also cause these risk factors on its own, in addition to increasing blood pressure, glucose levels, blood viscosity, blood lipids, and blood coagulation [3, 11]. Traffic noise is one of the most significant forms of vehicle emissions that affects people's physical and mental health. It is a result of urbanization and an increase in the number of vehicles on the road [9]. Increased noise levels in the surroundings have been connected to psychological problems such as anxiety and depression, which are recognized to have an adverse effect on cardiovascular well-being [21].

According to WHO guidelines, a city requires sensitive zones for research, healthcare, and educational institutions. The recommended noise level in those areas is 45 dB, however, the WHO and DoE limits are exceeded in all of these sensitive locations. The North Balubari Govt. School has the lowest noise level, 78.7 dB, which is higher than the average. Large volumes of noise discourage students, especially those in educational institutions, from studying. However, educators are unable to conduct their lectures in the classroom effectively. Some measured locations reveal excessively damaging noise pollution for humans. At noon and evening, MARMCH, a prominent healthcare facility in the Dinajpur district, records 91dB, which is perilous for patients, nurses, and physicians. The Labaid Diagnostic Centers, located by the side of the road, has the highest noise level, which was measured at 101.5 dB (Figure 5e).

Industries noise pollution is significantly hampering regular work, especially for workers, and laborers. Dinajpur municipality is famous for its rice-producing and processing industries. That kind of rice boiler produces high noise and the highest noise value is recorded 103 dB at Zia Auto Rice Mill (Figure 5a). Measuring all of these auto rice mills produces excessive noise and is much higher than standard. When workers use the boiler and other processing units for steaming, rice boiling, drying, polishing, and packaging, they do not use earplugs or any kind of noise reduction instrument. Inside of auto rice mills, generated high noise and crossed 75 dB. Loud noise can hinder the ability to hear warning signals, which can lead to workplace accidents and injuries. Loud noise can also cause physical and mental stress, diminish productivity, disrupt communication, and interfere with focus.



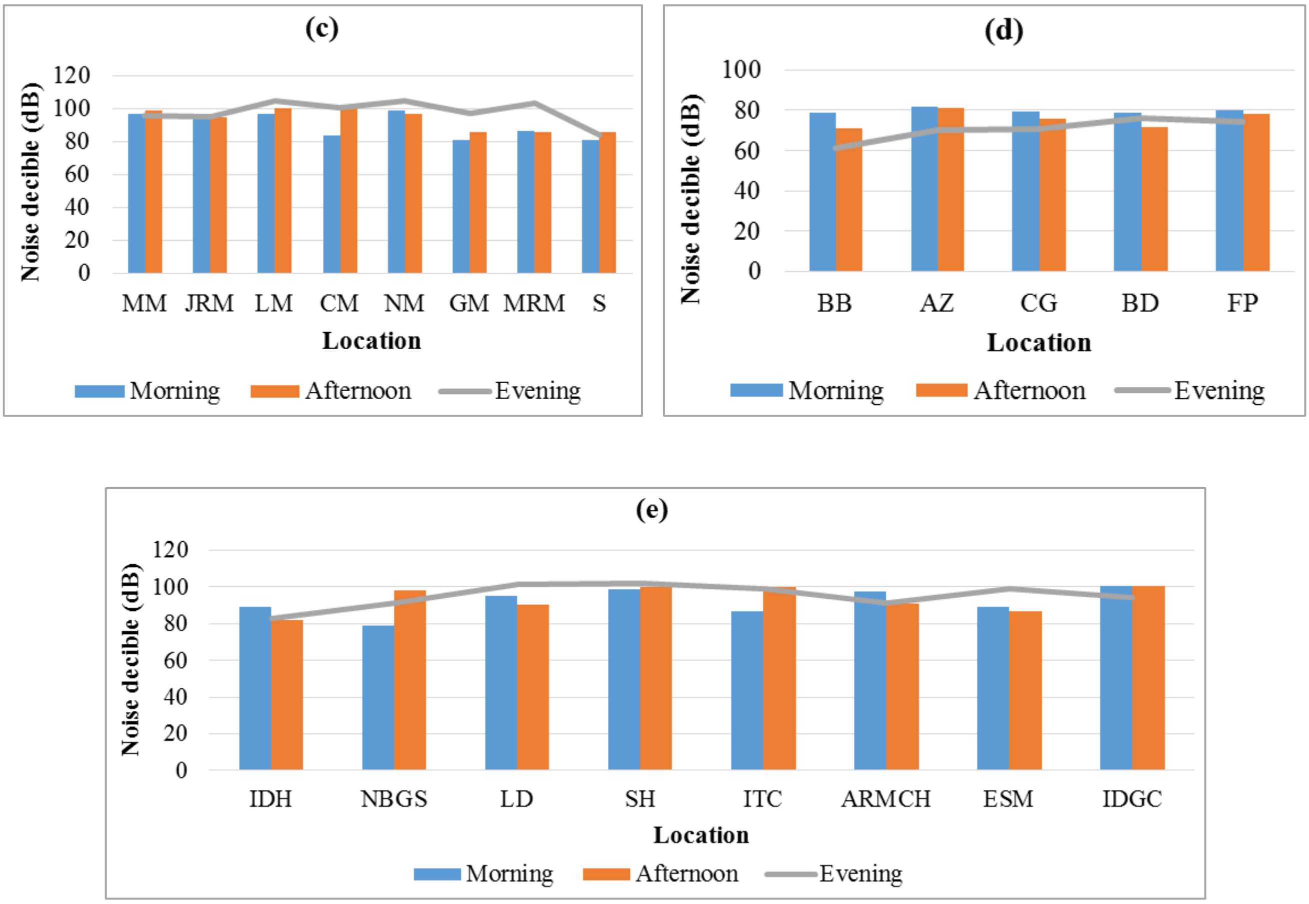


Figure 5. *Variation of noise value among different zones within three different time scale; (a) Industrial zones, (b) Mixed zones, (c) commercial zones, (d) Residential zones (e) Sensitive zones.*

The consequences of noise-induced hearing loss can be severe, reducing your capacity to hear high-frequency sounds, comprehend speech, and communicate effectively [18]. A little over 53% of adults aged 20 to 69 who have hearing loss due to noise report having never been exposed at work [4].

In the study area, it was hypothesized that traffic-related noise has increased and is now above the WHO's allowed level. All of the roadside surveyed areas crossed the limit of WHO. Mixed areas are more polluted than any other location. Those mixed areas are referred traffic, few commercial spaces and limited educational instructions are located. Measured 8 mixed points and the highest noise value is recorded 105.7dB at the Central Bus Terminal where morning, noon, and evening noise values cross 100 dB (Figure 5b). But the lowest noise value is recorded at 85dB in Horishovar Moor in the morning. All of the recorded data shows exceed the standard limit that is harmful to people especially newborn babies, school-going children and those are working people. Uncontrolled vehicle movement, rapid passing, unwanted horns, crowds, auto-rickshaws, construction, welding works, political movement, etc. are major causes of noise pollution in study areas.

4. Recommendations

The methods that reduce noise closest to its source are the most successful and economical. A comprehensive EU noise plan will include legislation, noise abatement measures, and other elements that would be helpful for developing countries. It would be advantageous on a broad scale to incorporate worries about noise pollution into plans to upgrade transportation networks.

Table 2. *Noise abatement approaches.*

Abatement procedures	Reduction in noise, dB	Cost-effectiveness score (1-5)*
Noise barriers	3-20	2
Brake Blocks for trains	8-10	4

Abatement procedures	Reduction in noise, dB	Cost-effectiveness score (1-5)*
Building insulation	5-10	1
Building design	2-15	3
Changing driving styles	5-7	3
Quiet road surfaces	3-7	5
Low-noise tires	34	3
Land use planning and design	Unknown	4
Electric cars	1	1
Traffic management	3	3

*Evaluated by the European Commission in "10 ways to combat noise pollution", Lowest score=1; highest score =5. [11, 15].

Cost-benefit analysis is a crucial decision-support tool that can assist in ranking various noise reduction strategies and ensuring that limited resources are used most effectively [9]. Road traffic is considered to be responsible for 80% of all noise pollution in urban areas [22]. High noise levels, such as those near busy roads, can be greatly reduced by the use of noise barriers. By avoiding direct propagation between the source and the receiver, they reduce noise. Adoption of electric vehicles is a more radical method of lowering traffic noise. By switching to quieter tires, noise emissions could be reduced by about 3 dB. A porous tread could lower noise emissions by 5 dB and represent more significant modifications to tire design [10].

To ensure that upcoming constructions are planned and built to minimize noise problems, local authorities are involved in the planning process. Additionally, decisions may be made to build parking spaces, bike pathways, pedestrian zones, and low-speed zones, as well as to enhance public transportation [22]. For those urban planning added to environmental protection agencies, environmental engineers, urban planning authorities, local transport companies, highways departments, and local community. Check on regular all noisy vehicles including good, reconditioned vehicles including banning all unqualified transportation.

5. Conclusions

Noise evaluation of all of these locations in this overpopulated city is cross DoE and WHO noise level standards. The concerning thing is that the measured noise levels at the present moment are significantly higher than the upper limit and are dangerous for people, birds, and other urban animals. The study locations observed traffic noise levels in Leq, which ranged from 64 dB to 105.7 dB, considered high. Traffic noise pollution poses a threat to the research area and might be a serious long-term health risk to city dwellers. Considering prolonged exposure to noise can have negative effects, at least a step toward lowering noise levels must be implemented. Public education campaigns are in place to raise awareness of noise issues and how they impact nearby residents. Eventually, noise pollution is a serious issue that degrades the overall standard of life. This research contributes in identifying shared difficulties and workable alternatives which are successful in various zones. Through comprehending the origins and consequences of noise pollution, researchers can offer fact-based suggestions for urban development and policy formulation.

Abbreviations

dB: Decibel
WHO: World Health Organization
DoE: Department of Environment
IDW: Inverse Distance Weighting

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Author Contributions

Shree Bipulendu Basak: Conceptualization, Investigation, Methodology, Supervision, Writing – original draft

Nazmunnaher Nipa: Software, Validation, Writing – original draft

Touhidur Rahman Tuhin: Investigation, Software, Writing – review & editing

Mohammad Jawad Uddin: Investigation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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