

Research Article

Assessment of Noise Pollution in Khulna City, Bangladesh

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Abstract

This study has been conducted to assess the current state of noise pollution across various regions of Khulna City. 6 distinct zones and 39 locations were identified in Khulna City according to land use criteria. A sound level meter (REED SD-4023) was utilized to monitor noise levels in Khulna City from January 1, 2021, to April 30, 2021. At each sampling site, multiple samples were collected. The noise level at all locations had been measured three times per day. The mean noise level and Leq in Khulna City were found to be 72.82 dBA and 94.99 dBA, respectively. The measured mean and Leq values were 68.16 dBA and 80.22 dBA for silent areas, 67.82 dBA and 80.45 dBA for residential areas, 78 dBA and 100.95 dBA for mixed areas, 72.77 dBA and 83.24 dBA for commercial areas, 79.89 dBA and 85.36 dBA for industrial areas, and 78.76 dBA and 101.60 dBA for road intersections. The hierarchy in various land uses based on mean noise level was Industrial Area > Road Intersection > Mixed Area > Commercial Area > Silent Area > Residential Area. The three highest noise-polluted areas were Shib Bari Mor Bus Stand (106.94 dBA), Khulna Stadium Area (105.81 dBA), and Sonadanga Bus Station (104.50 dBA), whereas the three lowest noise-polluted areas were Khulna Govt. Girls High School (65.87 dBA), Khulna New Market (70.85 dBA), and Karim Nagar (74.92 dBA) based on Leq. However, we found that the noise level in all study locations exceeded the national standard.

Keywords

Noise Pollution, Land Use, Noise Standard, Khulna City, and Bangladesh

1. Introduction

Noise is conceived of as any undesirable sound that exceeds the tolerance limit of an individual. Khulna City is surrounded by noise pollution, which refers to detrimental or disruptive noises in the environment that adversely impact human health, wildlife, and overall quality of life. The escalation of noise pollution in Khulna City is attributed to rapid urbanization, increasing vehicle traffic, and industrial activities. Noise pollution can lead to several significant health physical and mental problems, including hearing impairment, sleep disturbances, heightened stress, hypertension, and car-

diovascular disease [1-3]. Moreover, noise can interfere with animals' communication, navigation, and reproductive systems. Motor cars are one of the biggest sources of noise pollution in cities [4].

Traffic-congested regions are the noisiest, after commercial and industrial zones in Khulna City [5]. The traffic police, who are engaged in traffic management, particularly at congested intersections, constitute a demographic highly susceptible to the adverse health impacts of noise and air pollution [6-12]. Individuals afflicted by this ailment frequently en-

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counter auditory impairment and psychological health challenges [13-16]. The World Health Organization (WHO) evaluated the worldwide health impact of industrial noise, methodically identifying 25 risk variables [17].

Hearing loss may arise from occupational exposure and might be unilateral, bilateral, whole, or partial [18]. It encompasses both noise-induced hearing loss (NIHL) and traumatic acoustic damage. Globally, elevated noise levels in the workplace remain an issue. Approximately 30 million American employees are subjected to hazardous noise levels in the workplace [19]. Approximately 12% to 15% of Germany's workforce—around four to five million individuals—are exposed to noise levels classified as detrimental by the World Health Organization [20]. While noise is a fundamental characteristic of all occupations, certain jobs are linked to significantly elevated levels of it. These encompass impact operations, handling certain materials, and piloting commercial aircraft. Noise-Induced Hearing Loss (NIHL) predominantly occurs in the following professions: agriculture, construction, transportation, mining, and military service. In industrialized nations, the situation is improving as increased awareness of the risks has resulted in the implementation of preventative measures. There is not a vast amount of information about less-developed countries, but it is clear that noise levels there are much higher than the safety levels set for workplaces in many industrialized countries [21-24].

Noisy environments have audible and non-audible impacts on people's health. Several researchers have examined these effects in groups of individuals who work in environments with high-volume, high-frequency noise. These studies are available in international journals [25-29]. However, no one has ever looked at how traffic police hearing is affected by vehicle exhaust, especially in India [12]. Traffic police should feel compelled to intervene now that they are aware of the dangers to their health. As most people do not consider noise an environmental issue, few have expressed concern about its effects. Noise levels more than 80 dBA can cause harm to people's hearing, both immediately and over time, according to physicians.

At first glance, the noise issue in our country might not seem serious. Having that thought cross our mind is still a beneficial choice. If the government does not intervene, the situation in noisy neighborhoods will escalate. Consequently, this study aimed at assessing the extent of the problem, the correlation between noise and different land uses, and the spatial distribution of noise levels across Khulna City by examining the levels of noise pollution in different areas.

2. Methodology

2.1. Study Area

Khulna City (Map) is the area that this research is focused on. Khulna has lately seen a giant growth in the number of

vehicles and industries, in addition to strong demand from tourists and rapid urbanization, which is why it was chosen as the site. The ambient noise quality in Khulna city usually exceeds international guidelines by 2/3 folds. Potentially harmful effects on human and environmental health are associated with this phenomenon. This research focused on the city areas in Khulna that had larger traffic volumes compared to others. Based on land use, 6 unique zones and 39 sites were identified in Khulna City.

2.2. Data Collection

A sound level meter (REED SD-4023) was used for ambient sound pressure level monitoring in the concerned areas of Khulna city from January 1, 2021, to April 30, 2021. This SD series sound level meter has triple-range measurement and features user-selectable sampling rates from 1 to 3600 seconds. Using an SD card (up to 16 GB), a user can select the desired sampling rate and quickly generate an Excel file with raw data, all without the use of software. Optional accessories include a tripod and AC adapter for continuous long-term monitoring and PC software that allows a user to track live measurements. The survey was conducted on working days. The measurement was carried out for the major traffic intersection of the city. The sound pressure level of the traffic zone was measured by A-weighting.

2.3. Measuring Procedure and Analysis

The data record function records the maximum and minimum readings. Press the REC button once to start the Data Record function, and a "REC" symbol will appear on the display. The display will display the "REC" symbol. 1. Press the REC button once, and a "REC. MAX." symbol along with the maximum value will appear on the display. To delete the maximum value, press the Hold Button once and the display will show a "REC." symbol only and execute the memory function continuously. 2. Press the REC button again, and a "REC. MIN." symbol along with the minimum value will appear on the display. To delete the minimum value, press the Hold Button once, and the display will show a "REC." symbol only and execute the memory function continuously. 3. To exit the memory record function, press the REC button for 2 seconds. The display will revert to the current reading. The data was collected above 1.5 meters from the ground, and it was taken while standing on the roadside. Any kind of noise barrier was avoided when measuring the actual sound level. Every second, data was taken for sampling, and the total sampling time for each station was 5 minutes. Recorded data was stored on a microSD card (memory card). Collected data were analyzed in Microsoft Excel v.2010 and IBM SPSS v.20. All data are visualized in different graphs and tables according to different ArcGIS v.10. 2.1 was used to create a study area map and a noise buffering map.

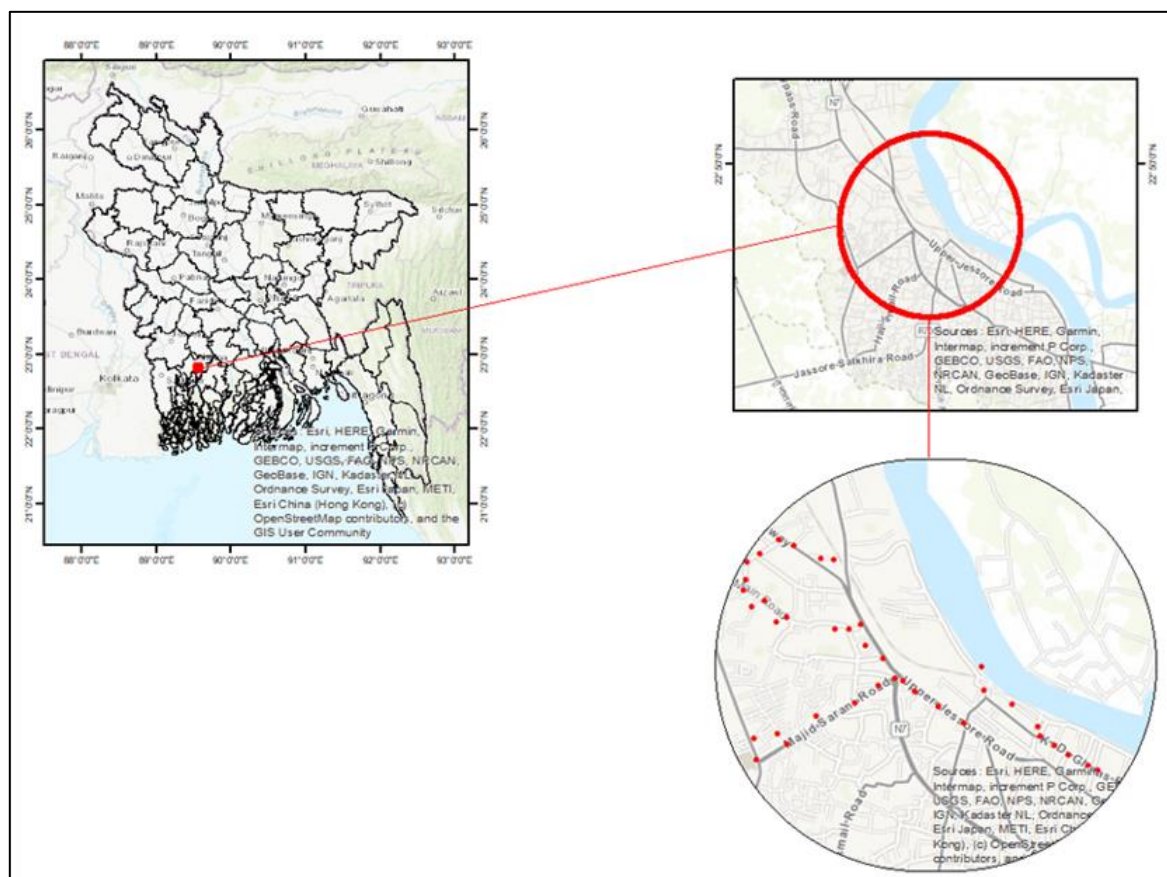


Figure 1. Sampling Locations of Khulna City.

3. Results and Discussion

The mean noise level and Leq in Khulna City were 72.82 dBA and 94.99 dBA, respectively.

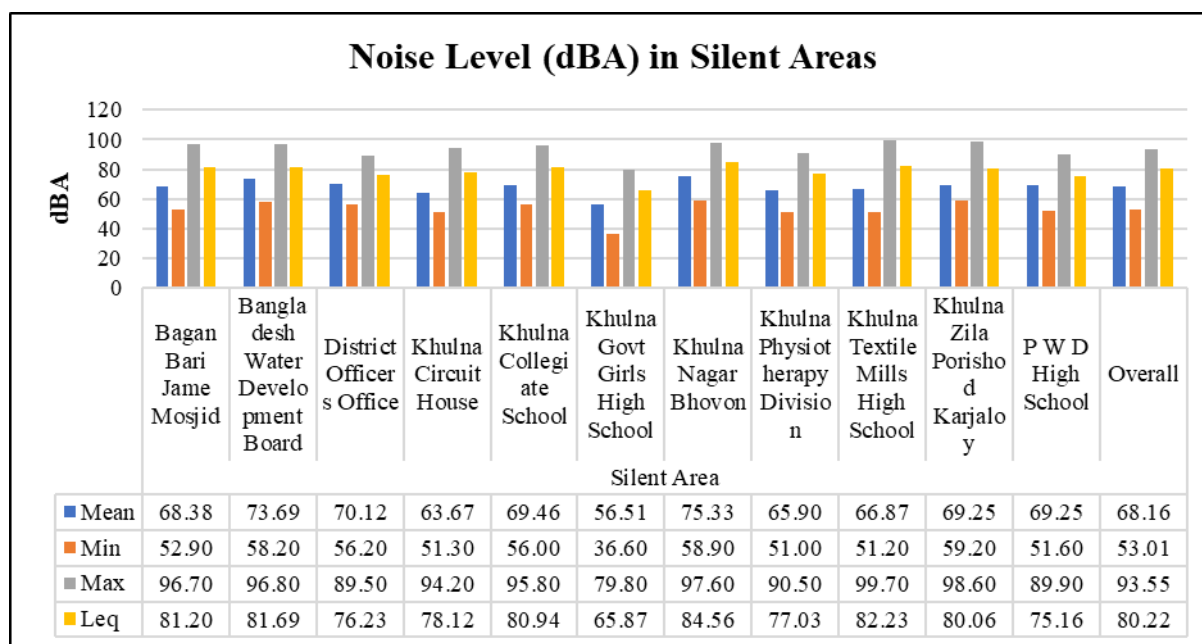


Figure 2. Noise Level (dBA) in Silent Areas.

Data analysis from 11 locations inside the silent area of Khulna city indicates that, as seen in Figure 2, the Leq of the silent area was 80.22 dBA and the mean noise level was 68.16 dBA. The highest Leq was found in Khulna Nagar Bhovon (84.56 dBA), whereas the lowest Leq was found in Khulna Government Girls High School (65.87 dBA). The maximum noise level measured at Khulna Textile Mills High School

was 99.70 dBA, exceeding the silent area's statutory daytime noise level by over double and approximately doubling the nighttime level. The minimum recorded level was at Khulna Government Girls High School (36.60 dBA). The investigation revealed that the highest mean sound level is recorded at Khulna Nagar Bhovon (75.33 dBA), while the lowest is at Khulna Govt Girls High School (56.51 dBA).

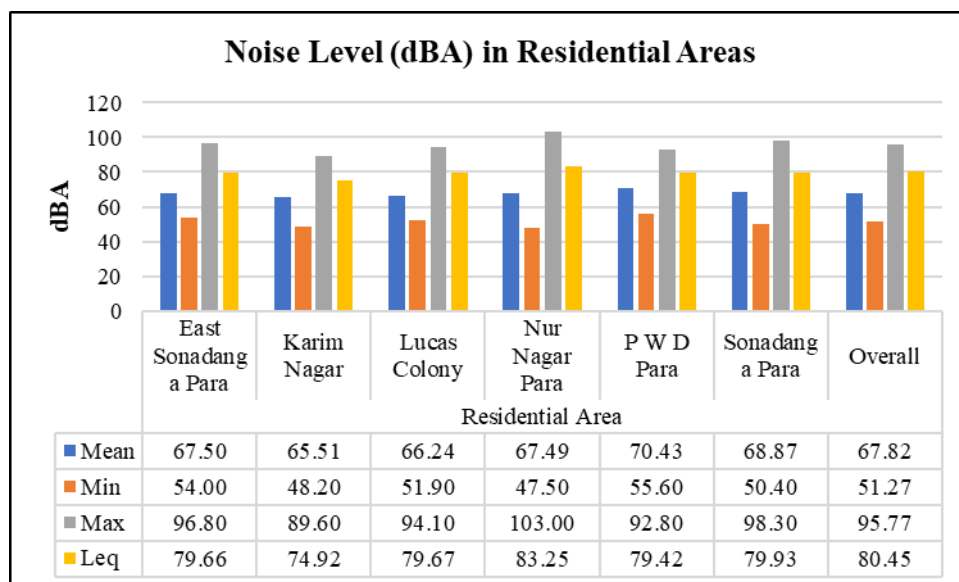


Figure 3. Noise Level (dBA) in Residential Areas.

In Figure 3, out of 6 areas, the mean noise level in residential areas is shown as 67.82 dBA, while the highest noise level was recorded at Nur Nagar Para at 103 dBA and the lowest noise level was recorded at the same location at 47.50 dBA. The residential area's highest mean noise level was

recorded at PWD Para (70.43 dBA), while the lowest mean was seen at Karim Nagar (65.51 dBA). The Leq of the residential area was 80.45 dBA. The maximum Leq was found in Nur Nagar Para (83.25 dBA), while the minimum Leq was 74.92 dBA at Karim Nagar.

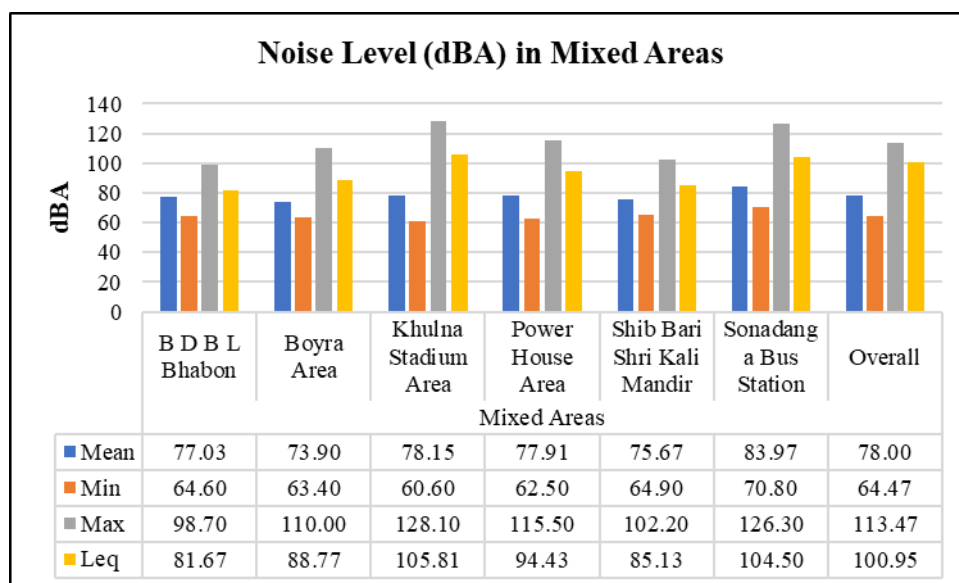


Figure 4. Noise Level (dBA) in Mixed Areas.

Figure 4 demonstrates that noise data from 6 mixed areas of Khulna City indicates a maximum level of 128.10 dBA in the Khulna Stadium Area and a minimum level of 60.60 dBA in the Khulna Stadium Area. The maximum noise level substantially exceeds the standard noise level for the mixed area. The Department of Environment (DoE) sets standard noise levels for mixed areas at 60 dBA during the day and 40 dBA at night. The Leq of the mixed area was 100.95 dBA and the

mean noise level was 78 dBA. The maximum Leq was found in the Khulna Stadium Area (105.81 dBA) and the minimum Leq was at B D B L Bhabon (81.67 dBA). The highest mean noise level was recorded at Sonadanga Bus Station (83.97 dBA), while the lowest mean noise level was noted in Boyra Area (73.90 dBA). Both values exceed the noise standards recommended by the DoE.

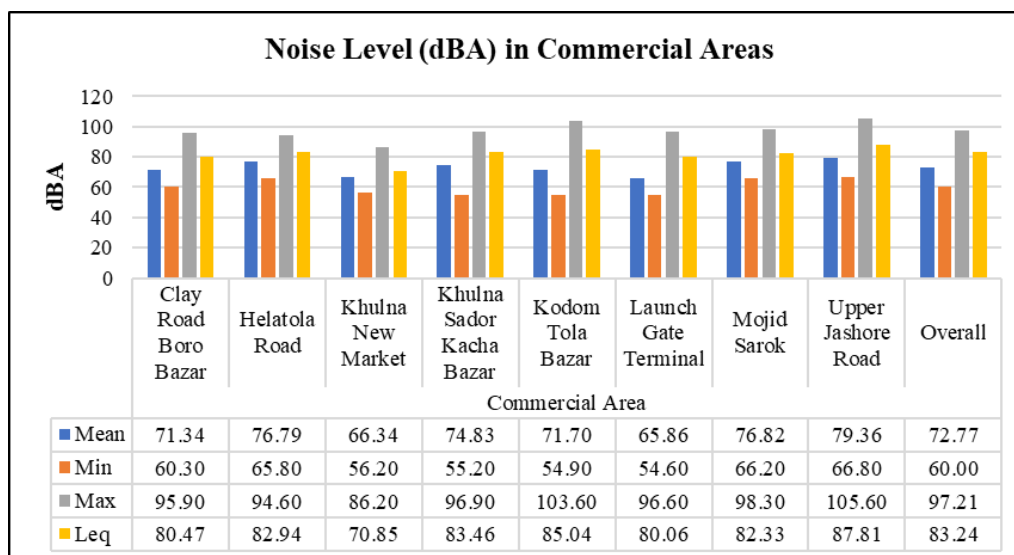


Figure 5. Noise Level (dBA) in Commercial Areas.

The standard sound value for a commercial area is 70 dBA. Figure 5 indicates the noise level of 8 commercial areas. The Leq of the commercial area was 83.24 dBA and the mean noise level was 72.77 dBA. The highest Leq was found in Upper Jashore Road (87.81 dBA), and the lowest Leq was found in Khulna New Market (70.85 dBA). Furthermore, the

commercial area exhibits Upper Jashore Road with the highest noise level at 105.60 dBA and the lowest at the Launch Gate Terminal at 54.60 dBA. Consequently, the highest mean recorded noise level is 79.36 dBA at Upper Jashore Road, while the lowest mean was 65.86 dBA at Launch Gate Terminal.

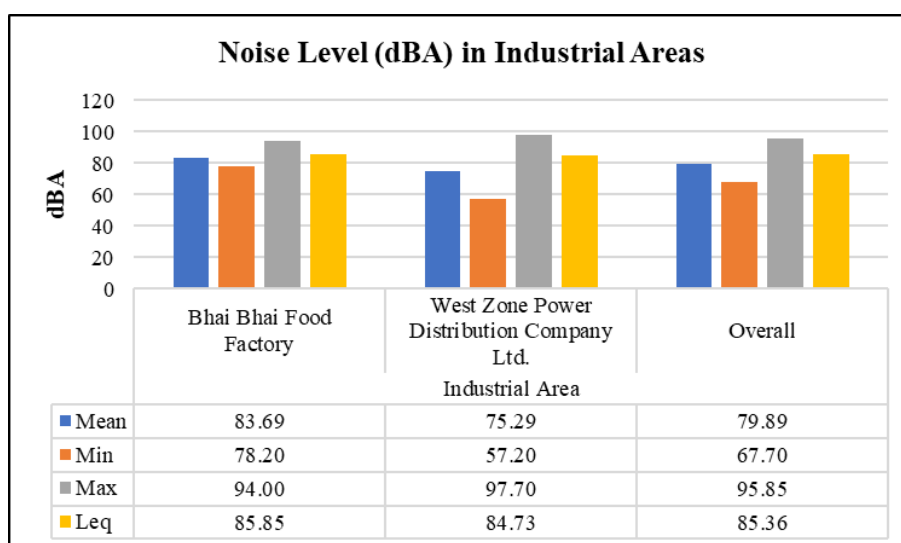


Figure 6. Noise Level (dBA) in Industrial Areas.

In Figure 6, the noise levels were measured in 2 industrial areas. The Leq of the industrial area was found to be 85.36 dBA and the mean noise level was 79.89 dBA. The maximum Leq was observed in Bhai Bhai Food Factory (85.85 dBA) and the minimum Leq was found in West Zone Power Distribution Company Ltd. (84.73 dBA). The maximum noise was recorded in the industrial area named West Zone Power

Distribution Company Ltd. (97.70 dBA). Additionally, a minimum noise level of 57.20 dBA was reported in the area of West Zone Power Distribution Company Ltd. Moreover, the highest recorded mean noise level was 83.69 dBA at Bhai Bhai Food Factory, while the lowest mean was 75.29 dBA at West Zone Power Distribution Company Ltd.

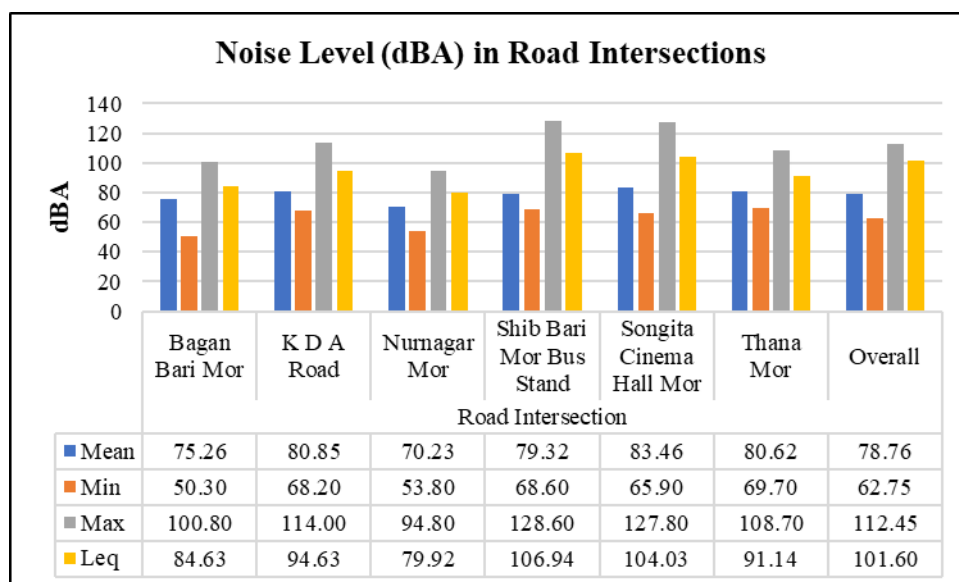


Figure 7. Noise Level (dBA) in Road Intersections.

Figure 7 depicts the noise levels of 6 areas in road intersections. The Leq of the road intersection was 101.60 dBA and the mean noise level was 78.76 dBA. The highest Leq was found in Shib Bari Mor Bus Stand (106.94 dBA) and the lowest Leq was observed in Nurnagar Mor (79.92 dBA). The maximum noise

level was found at Shib Bari Mor Bus Stand (128.60 dBA) and the minimum noise level was identified at Bagan Bari Mor (50.30 dBA). The maximum mean noise level was reported at Songita Cinema Hall Mor (83.46 dBA), while the minimum mean noise level was found at Nurnagar Mor (70.23 dBA).

Table 1. Dispersion of Noise Level in Different Land Use in Khulna City.

Land Use (N)	Mean	Minimum	Maximum	Standard Deviation	Range	Median	Rank
Silent Area (11)	68.16	36.60	99.70	9.81	63.10	67.80	5
Residential Area (6)	67.82	47.50	103.00	9.10	55.50	66.50	6
Mixed Area (6)	78.00	60.60	128.10	8.78	67.50	76.40	3
Commercial Area (8)	72.77	54.60	105.60	8.78	51.00	72.40	4
Industrial Area (2)	79.89	57.20	97.70	8.17	40.50	80.40	1
Road Intersection (6)	78.76	50.30	128.60	9.76	78.30	78.10	2
Overall (39)	72.82	36.60	128.60	10.40	92.00	72.60	-

The subsequent table 1 presents the descriptive statistics for the noise quality of the study. The study encompasses six dis-

tinct land uses. As we can see, the noise range were highest at the road intersections (78.30 dBA) and lowest in the industrial

areas (40.50 dBA). When we look at the mean, standard deviation, and coefficient of variation, we can see that the noise

levels vary the most in the industrial area. This variability is because of all the different activities that happen there.

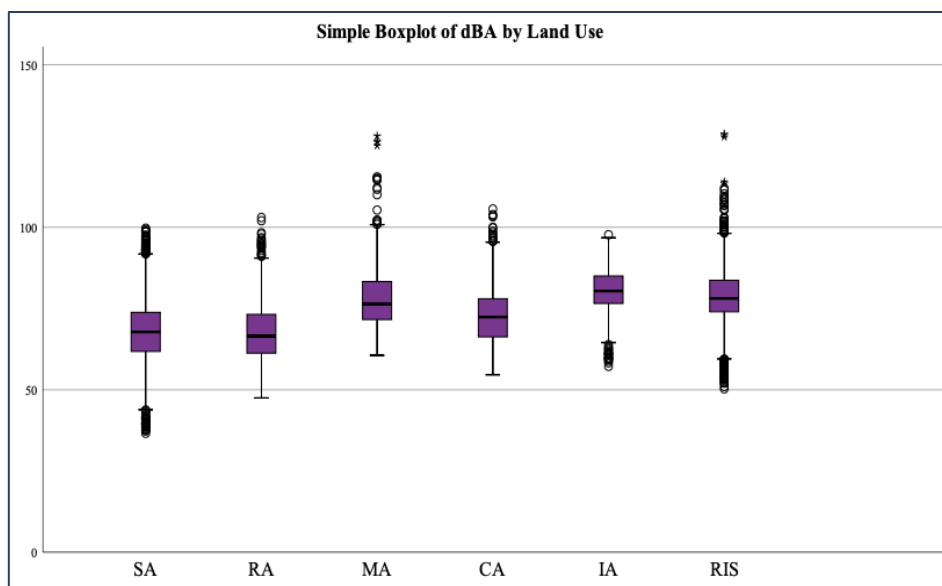


Figure 8. Mean Noise Pollution (dBA) in Khulna City.

The whisker box plot (Figure 8) shows mean noise pollution in Khulna City. A horizontal black line marks the median. The lower boundary of the box indicates the 25th percentile. The 75th percentile is shown by the upper edge of the box.

The whisker represents the maximum (upper whisker) and minimum value (lower whisker). Points above the whiskers indicate outliers.

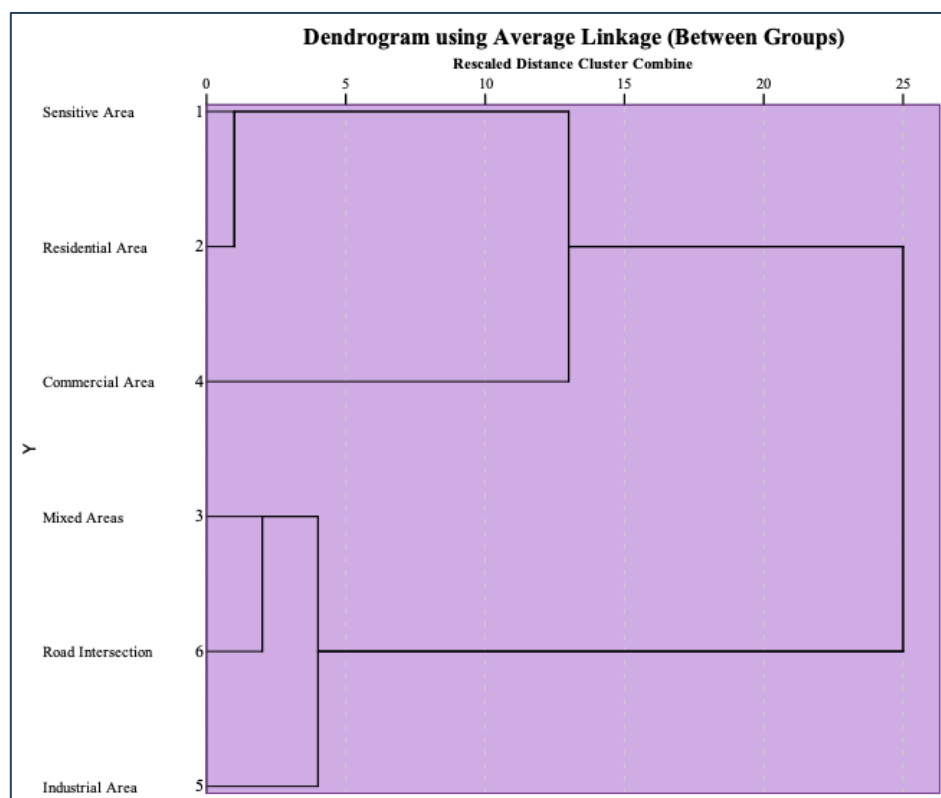


Figure 9. Land Use Based Cluster, in Terms of dBA.

Figure 9 demonstrates the land-use-based cluster; in terms of dBA, there are three clusters. Silent, residential, and commercial areas are in the first cluster, whereas the mixed

areas and road intersections are in the second cluster. Moreover, the industrial area represents the final cluster.

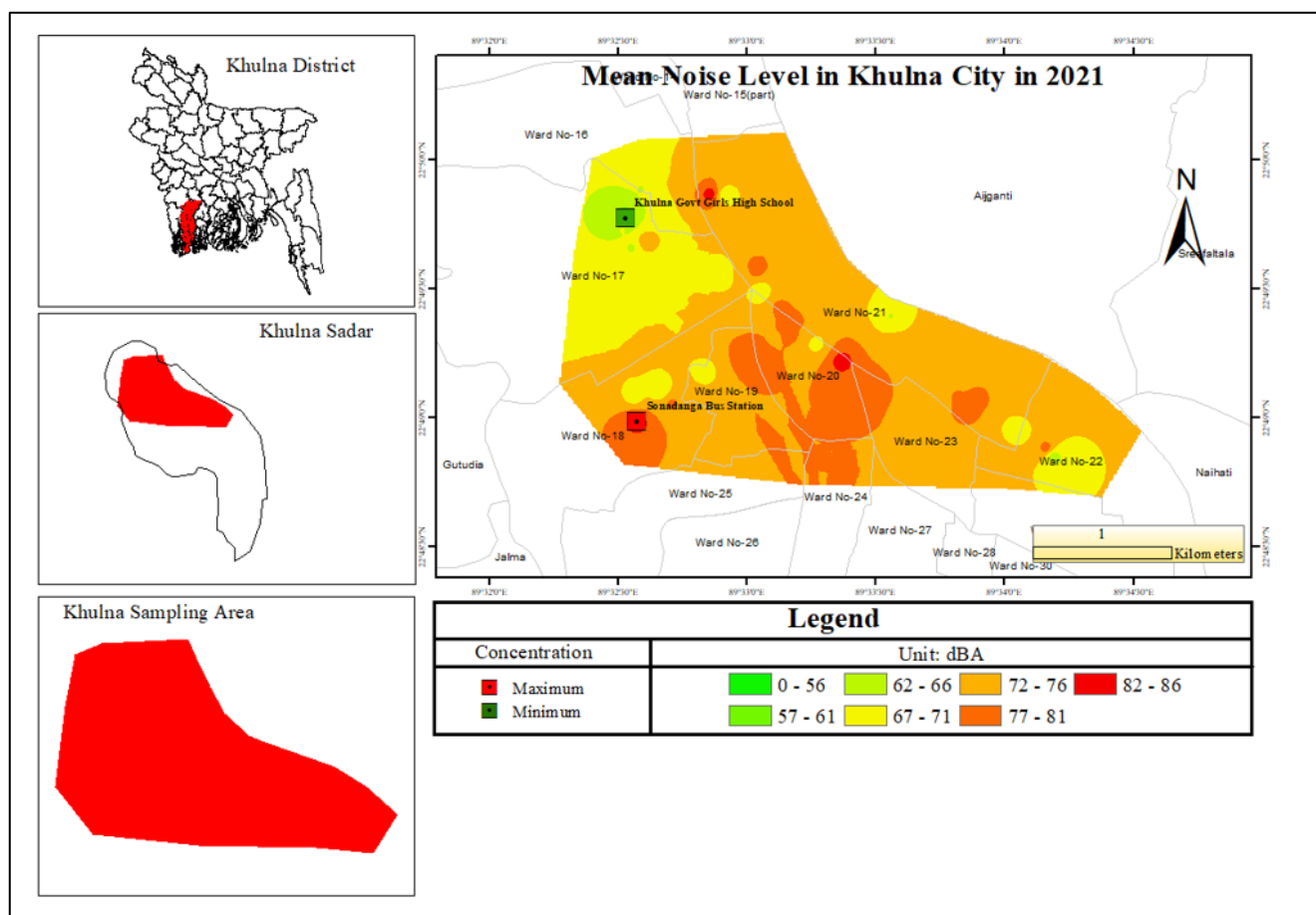


Figure 10. Spatial Map of Mean Noise Pollution.

Figure 10 shows the noise level at different places in Khulna City. The yellow areas indicate lower noise levels, while the orange and red areas indicate higher levels. The noise was found to be higher (78-81 dBA). Sonadanga Bus Station (83.97 dBA), Bhai Bhai Food Factory (83.69 dBA),

and Songita Cinema Hall Mor (83.46 dBA) were under the Red Zone; however, Khulna Govt Girls High School (56.51 dBA), Khulna Circuit House (63.67 dBA), and Karim Nagar (65.51 dBA) belong to the Green Zone.

Table 2. Post-hoc Analysis.

(I) Land Use	(J) Land Use	Mean Difference (I-J)	Standard Error	Sig.
Silent Area	Mixed Areas	0.3363	0.30122	0.264
	Residential Area	-9.8416*	0.28578	0
	Commercial Area	-4.6135*	0.27353	0
	Industrial Area	-11.7248*	0.51743	0
	Road Intersection	-10.5984*	0.29067	0
Mixed Areas	Silent Area	-0.3363	0.30122	0.264

(I) Land Use	(J) Land Use	Mean Difference (I-J)	Standard Error	Sig.
Residential Area	Residential Area	-10.1779*	0.33544	0
	Commercial Area	-4.9498*	0.32507	0
	Industrial Area	-12.0611*	0.54642	0
	Road Intersection	-10.9347*	0.33962	0
	Silent Area	9.8416*	0.28578	0
	Mixed Areas	10.1779*	0.33544	0
	Commercial Area	5.2281*	0.31082	0
	Industrial Area	-1.8832*	0.53807	0
	Road Intersection	-.7568*	0.32601	0.02
	Silent Area	4.6135*	0.27353	0
Commercial Area	Mixed Areas	4.9498*	0.32507	0
	Residential Area	-5.2281*	0.31082	0
	Industrial Area	-7.1113*	0.53167	0
	Road Intersection	-5.9849*	0.31533	0
	Silent Area	11.7248*	0.51743	0
Industrial Area	Mixed Areas	12.0611*	0.54642	0
	Residential Area	1.8832*	0.53807	0
	Commercial Area	7.1113*	0.53167	0
	Road Intersection	1.1263*	0.54068	0.037
	Silent Area	10.5984*	0.29067	0
Road Intersection	Mixed Areas	10.9347*	0.33962	0
	Residential Area	.7568*	0.32601	0.02
	Commercial Area	5.9849*	0.31533	0
	Industrial Area	-1.1263*	0.54068	0.037
	Silent Area	10.5984*	0.29067	0

* The mean difference is significant at the 0.05 level.

Table 2 represents the post-hoc analysis that identified disparities between land uses. It demonstrates substantial disparities between the six distributed land uses. The mean differences decrease significantly (the mean difference is significant at the 0.05 level) for certain land uses.

Table 3. Comply with Noise Standard [30].

Land Use (N)	Location	Standard Value	Within Standard (%)
Silent Area (11)	Bagan Bari Jame Masjid	50	0.00%
	Bangladesh Water Development Board		0.00%
	District Officers Office		0.00%
	Khulna Circuit House		0.00%
	Khulna Collegiate School		0.00%
	Khulna Govt Girls High School		25.68%

Land Use (N)	Location	Standard Value	Within Standard (%)
Mean	Khulna Nagar Bhovon	55	0.00%
	Khulna Physiotherapy Division		0.00%
	Khulna Textile Mills High School		0.00%
	Khulna Zila Porishod Karjaloy		0.00%
	P W D High School		0.00%
Residential Area (6)	East Sonadanga Para	55	2.33%
	Karim Nagar		2.70%
	Lucas Colony		8.97%
	Nur Nagar Para		8.67%
	P W D Para		12.16%
	Sonadanga Para		0.00%
Mean			2.70%
Mixed Areas (6)	B D B L Bhabon	60	5.87%
	Boyra Area		0.00%
	Khulna Stadium Area		0.00%
	Power House Area		0.00%
	Shib Bari Shri Kali Mandir		0.00%
	Sonadanga Bus Station		0.00%
Mean			0.00%
Commercial Area (8)	Clay Road Boro Bazar	70	0.00%
	Helatola Road		57.09%
	Khulna New Market		15.53%
	Khulna Sador Kacha Bazar		71.58%
	Kodom Tola Bazar		24.38%
	Launch Gate Terminal		52.58%
	Mojid Sarok		71.48%
	Upper Jashore Road		7.42%
Mean			5.29%
Industrial Area (2)	Bhai Bhai Food Factory	75	38.17%
	West Zone Power Distribution Company Ltd		0.00%
Mean			48.17%
All Mean			24.09%
			14.09%

Table 3 demonstrates that 14.09% of areas in Khulna District Town belonged to the noise standard among 5 land uses. 2.33% of the areas in the silent zone met the noise standard across 11 locations, 5.87% of the areas in the residential zone met the noise standard across 6 locations, no areas in the

mixed zone met the noise standard across 6 locations, 38.17% of the areas in the commercial zone met the noise standard across 8 locations, and 24.09% of the areas in the industrial zone met the noise standard across 2 locations.

25.68% conforms to the criterion established at Khulna

Government Girls High School, a sensitive area. The residential area values constitute 12.16% of the standard value in Nur Nagar Para. The mixed areas exhibited no adherence to the criteria. The commercial area data is highest in the Khulna New Market, at 71.58%. The data provided in the shown industrial area indicate a peak value of 48.17% within the standards given by West Zone Power Distribution Company Ltd.

The present study was carried out on 6 land uses, but only 5 were included in the Sound Pollution (Control) Rules—2006. Therefore, while comparing all land uses with noise standards, village areas and road intersections were not taken into account.

4. Conclusions

Noise levels crossed the boundary at all the surveyed locations in Khulna City. The current study revealed the mean noise level in Khulna City was 72.82 dBA. The Leq of silent areas, residential areas, mixed areas, commercial areas, industrial areas, and road intersections were 80.22 dBA, 80.45 dBA, 100.95 dBA, 83.24 dBA, 85.36 dBA, and 101.60 dBA. The maximum noise pollution level was noticed in the road intersection (101.60 dBA), mixed areas (100.95 dBA), and industrial areas (85.36 dBA), whereas the minimum noise pollution was found in the silent areas (80.22 dBA), residential areas (80.45 dBA), and commercial areas (83.24 dBA) based on Leq measurement. The mean noise levels in different locations of Khulna included silent areas (68.16 dBA), residential areas (67.82 dBA), mixed areas (78 dBA), commercial areas (72.77 dBA), industrial areas (79.89 dBA), and road intersections (78.76 dBA). The hierarchy of land uses according to mean noise levels is Industrial Area > Road Intersection > Mixed Area > Commercial Area > Silent Area > Residential Area. The areas with the highest noise pollution levels based on Leq were Shib Bari Mor Bus Stand (106.94 dBA), Khulna Stadium Area (105.81 dBA), and Sonadanga Bus Station (104.50 dBA). Conversely, the areas with the lowest noise pollution levels were Khulna Govt. Girls High School (65.87 dBA), Khulna New Market (70.85 dBA), and Karim Nagar (74.92 dBA), as measured by Leq. Our analysis indicated that the noise levels exceeded the acceptable national guideline at every site. Khulna city, among other major metropolitan centers and rapidly developing semi-urban areas in Bangladesh, accommodates about ten million inhabitants, rendering noise pollution a significant environmental issue in the nation. The World Bank research revealed that the financial burden of diseases and premature fatalities attributable to noise pollution totals several hundred million dollars per year. Besides the overarching implications for future research, the present study offers some specific insights. Moreover, this study has underscored the need for enhanced noise quality monitoring.

Abbreviations

AC	Alternating Current
BDBL	Bangladesh Development Bank PLC
CAPS	Center for Atmospheric Pollution Studies
dBA	A-weighted Decibel
DoE	Department of Environment
GB	Gigabyte
GIS	Geographic Information System
Govt	Government
KDA	Khulna Development Authority
Leq	Equivalent Continuous Sound Pressure Level
Ltd	Limited
MAX	Maximum
MIN	Minimum
N	Number (in terms of quantity)
NIHL	Noise-Induced Hearing Loss
PC	Personal Computer
PWD	Public Works Department
REC	Record
SD	Secure Digital
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization

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Author Contributions

Ahmad Kamruzzaman Majumder: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Aniruddha Paul: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Validation, Writing – original draft, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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