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NOISE POLLUTION MONITORING AND NOISE MAPPING AT RAJSHAHI UNIVERSITY, BANGLADESH

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ABSTRACT

Noise pollution is harmful to human health. Loud noise generation is a growing issue across the world as well as in Bangladesh. A relatively quiet environment is required in educational areas. So, an acoustic study was conducted for the assessment of noise levels on the campus of Rajshahi University. The noise monitoring was carried out at twenty-one locations, and the traffic count was carried out at six road intersections simultaneously at three specific times (morning, afternoon, and evening) during the peak period from January to February 2023. A calibrated digital sound level meter was used to monitor the noise level, and traffic volume was counted manually. Noise mapping was generated by Kriging interpolation analysis using GIS software. Results show that a maximum noise value L_{max} of 110.1 dBA was found around the central library in the evening periods, followed by 105.3 dBA at an entrance gate adjacent to the busy road; however, the L_{max} value randomly exceeded 100 dBA at the three entrance points. The equivalent continuous noise level, L_{eq}, was measured between 53 and 77.3 dBA. The highest L_{eq} of 77.3 dBA was found at an entrance point, and a minimum noise level of 46.4 dBA was observed in a residential zone. A significant correlation between traffic volume and noise level shows that the flow of traffic influences the noise level in the campus area. The mapping visualizes the unknown point values based on the weighted average of known point values to form a noise map. These findings are much higher than the acceptable limit for noise levels in sensitive areas like educational institutions in Bangladesh. Whereas limit 35 dBA is advised by WHO for educational institutions. The noise level was found to increase with an increase in motorized traffic volume, where three-wheeled autorickshaws were dominant, followed by two-wheeled motorcycles. Proximity of the national highway and railway on two different sides of the study area. Loudspeakers for various events enhanced the noise level. The collected data were used in GIS software to produce the noise map, and the outcome obtained from it revealed the spatial extent of noise variations throughout the university campus in the form of noise maps.

Keywords: *Equivalent Continuous Noise Level (Leq), Noise Mapping, GIS, Traffic Volume.*

1. INTRODUCTION

Noise can be defined as an unwanted or harmful outdoor sound produced by human activities, including noise emitted by means of transport, road traffic, air traffic, and sites of industrial activity. Noise affects people in certain built-up areas, public parks, or other quiet areas in an agglomeration, in quiet areas in open country, near schools, hospitals, and other noise-sensitive premises (Directive EU, 2002). Human health and wellbeing are harmed by prolonged exposure to loud noise, which is a growing issue for the public and policymakers (WHO, 2018). The negative physiological and psychological effects of noise discomfort can be severe.

Uncontrollable noise has a significant negative influence on cognitive function (Stansfeld & Matheson, 2003; Wright *et al*., 2016). Experimental and epidemiological studies show that long-term exposure to noise alters how the brain organizes speech processing and attention management, lowering academic performance (Shield & Dockrel, 2008). Several studies found that road traffic noise is a major source of annoyance in urban areas (Ouis, 2001).

Nowadays, noise pollution is a vital environmental problem, treated as a top environmental health hazard for all ages and social groups (UNEP, 2022). Community noise, both traffic and non-traffic in origin, has mentionable effects on the physical and mental well-being of adults (Omlin *et al*., 2011).

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While a quiet environment is crucial for effective learning, especially for university students, many university campuses in Bangladesh are located in noisy and busy urban settings. Despite this, relatively little research has been conducted on how noise annoyance impacts academic performance among university students in the context of Bangladesh. In Rajshahi city, sound levels exceeding permissible limits have been reported (Bari *et al*., 2016). However, specific studies focusing on noise pollution within the campus environment of Rajshahi University, which is situated between the busy Natore Road and a railway line, are lacking. Given the prevalence of noise from motorized vehicles, train horns, and loudspeakers during various events on campus, it is crucial to assess the noise levels and their effects on the academic environment.

This study aims to address this gap by conducting a comprehensive acoustic assessment of the Rajshahi University campus, which can serve as a foundation for raising awareness and informing policy and planning efforts. The objectives of the study are to determine the noise level at different locations on the Rajshahi University campus, analyze the relationship between noise and traffic volume at selected intersections and prepare a noise map using GIS.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted on the main campus of Rajshahi University (Figure 1), which is located on 753 acres of land in Mothihar Thana, Rajshahi city, seven kilometres east of the city center. This educational premise is very near the mighty Padma River. Founded in 1953, the university's 59 departments and six institutes currently hold approximately thirty thousand students and twelve hundred faculty members. 17 residential halls and other buildings serve as accommodations on campus.

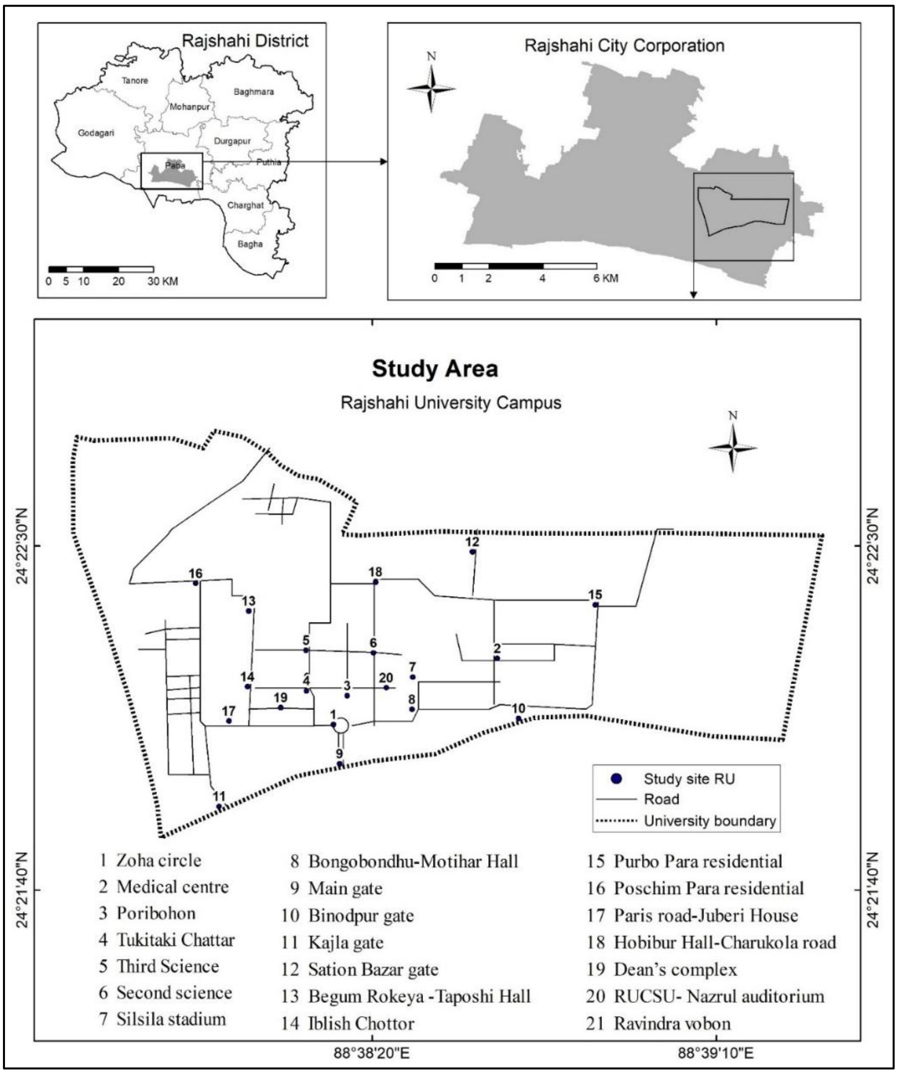

Figure 1: Map showing the noise pollution measurement sites of Rajshahi University campus

2.2 Acoustic Study

The noise monitoring was carried out at 21 different locations, including six road intersections, from January to February 2023. These locations were chosen based on their exposure to noise-generating activities across different zones so that such locations are likely to represent hotspots of noise pollution on the campus. A calibrated digital sound level meter with a data logging function designed according to IEC 61672, type 2, was used. Precautions were adopted to avoid the reflection of sound by setting a suitable distance from the source, and the readings were performed under ideal meteorological conditions. The schedule selected during the daytime was as follows: morning, 8- 11am; afternoon, 12- 4 pm; evening, 5- 8 pm. The noise descriptor L_{eq} was determined in dBA, which denotes the time-weighted average of the level of sound in decibels on scale A, which is relatable to human hearing. The noise descriptor L_{eq} represents the equivalent continuous noise level, sometimes known as the average sound level. Leq was calculated by using the following Equation (1) (Robinson, 1971; Swain & Goswami, 2014):

$$L_{eq} = L_{50} + (L_{10} - L_{90})^2/56 \quad (1)$$

Where L_{10} is the sound level surpassing 10% of the total time of measurement; L_{50} is the sound level surpassing 50% of the total time of measurement; and L_{90} is the sound level surpassing 90% of the total time of measurement. The maximum (L_{max}) and minimum (L_{min}) noise values of specified time spells were also considered for the study.

2.3 Traffic Volume Count

The number of vehicles like 3-wheelers, easy bikes, 2-wheel motorcycles, cars, and buses passing through a fixed point of the road was manually counted at six important road intersections inside the campus during the study period to demonstrate the relationship with noise level. An increase in traffic volume will usually increase the noise level.

2.4 Noise Map Preparation

A noise map is a cartographic depiction of noise levels in each location at a given period. Noise mapping for the current study is generated by adopting ArcGIS software. At first, the shape file of the Rajshahi University campus is produced from the base map, which also covers the road networks of the campus area. The geospatial data of longitude, latitude, and non-geospatial data of noise level from each sampling site's excel file are then imported to ArcGIS, where sampling points are plotted on the Rajshahi University shapefile. In the present study, L_{eq} noise level data for the morning, afternoon and evening hours were considered for map preparation. The interpolation method of Kriging is employed in the study; now the noise levels at other places are also visible along with the study points.

The collected data were described using tabular and graphic forms using Microsoft Excel. To determine the relationship between variables, Pearson correlation was assessed using the SPSS software version 26. One-way ANOVA tests were also performed to analyzed the variation in noise level at different shifts.

3. RESULTS AND DISCUSSION

3.1 Noise Levels

Noise level was evaluated and analyzed in 21 different locations on Rajshahi University campus, which are stated in the table. Table 1 shows results for noise descriptor like maximum noise level (L_{max}), minimum noise level (L_{min}) and continuous equivalent noise (L_{eq}) in different locations.

The noise value obtained from the surveyed locations revealed noise variations in different parameters that were evaluated at three separate defined periods: morning: 08- 11 am; afternoon: 12- 4 pm; and vening: 05- 08 pm. The highest noise level was found at Tukitaki in the evening hours, with a maximum noise value of 110.1 dBA during a cultural event of an alumni reunion program. The second and third highest noise descriptors of L_{max} were recorded at Kajla gate (105.3 dBA) and Binodpur gate (104.1 dBA). Although Tukitaki recorded the highest noise value of L_{max} in the entrance points of Kajla gate, Binodpur gate, and Main gate, it randomly exceeded 100 dBA. This is because these entrance gates are located on the heavily used Natore Road and are adjacent to a crowded local kitchen market.

Two schools within the campus premises, namely Sheikh Rasel Model School and Rajshahi University School and College are located close to Kajla Gate. Therefore, the students of these two schools were randomly affected by the high level of traffic noise. This might create difficulty concentrating and learning in such a noisy environment on the school campus. On the other hand, the vegetative cover and distance from the highway kept the main academic buildings away from this high level of sound emitted from heavy and light vehicles on the busy road. The lowest noise level was measured at Poschim Para residential area with a L_{min} of 46.4 dBA during the morning hours as vehicles and mass movements were restricted there.

Table 1: Noise levels in dBA at selected locations in Rajshahi University campus at different time

ID	Location	Morning			Afternoon			Evening		
		L_{eq}	L_{max}	L_{min}	L_{eq}	L_{max}	L_{min}	L_{eq}	L_{max}	L_{min}
1.	Zoha circle	64.3	93.2	55.0	65.1	90.4	52.1	63.1	90.4	52.2
2.	Medical centre	55.0	90.6	50.1	57.6	80.2	49.4	56.2	89.4	49.1
3.	Poribohon	65.0	100.3	55.0	67.2	94.1	54.3	70.2	96.3	55.1
4.	Tukitaki Chattar	68.4	89.4	56.1	70.9	89.4	53.2	66.4	110.1	54.3
5.	Third Science	60.2	82.9	53.3	64.3	85.3	53.2	56.3	80.9	50.4
6.	Second science	63.2	85.2	55.0	65.2	88.4	53.1	63.3	84.3	51.4
7.	Silsila stadium	61.1	79.3	53.3	60.6	82.9	52.3	63.7	84.1	53.1
8.	Bongobondhu-Motihar Hall	63.0	85.1	51.1	61.4	93.3	52.3	61.6	85 2	51.2
9.	Main gate	74.0	101.7	57.8	74.9	102.4	59.6	74.6	103.5	60.7
10.	Binodpur gate	75.0	101.3	57.8	75.1	103.1	64.1	75.6	104.1	64.1
11.	Kajla gate	76.0	103.0	59.1	76.1	103.1	64.1	77.3	105.3	65.3
12.	Sation Bazar gate	66.1	93.4	56.9	64.2	89.1	56.3	66.2	88.4	55.2
13.	Begum Rokeya -Taposhi Hall	58.1	83.3	52.4	58.1	84.2	51.3	56.3	80.9	49.1
14.	Iblish Chottor	64.2	91.4	57.1	65.2	90.5	57.1	63.3	94.3	53.2
15.	Purbo Para residential	54.0	81.6	50.3	55.1	80.8	56.3	53.1	80.6	49.1
16.	Poschim Para residential	52.6	82.9	46.4	55.1	80.8	49.1	53.0	75.4	47.1
17.	Paris road-Juberi House	64.3	89.1	57.6	65.1	88.1	54.3	66.1	90.4	52.1
18.	Hobibur Hall-Charukola road	63.2	81.9	56.2	62.1	81.7	56.1	63.2	91.3	56.3
19.	Dean's complex	67.3	80.9	60.3	70.1	83.4	62.1	63.4	81.2	54.4
20.	RUCSU- Nazrul auditorium	62.4	93.5	55.2	63.5	100.1	55.2	62.1	108.1	55.3
21.	Ravindra Bhaban	66.3	91.1	54.1	66.2	89.7	54.0	65.1	89.8	53.7

The noise descriptor L_{eq}, usually known as average sound level, is displayed in Figure 2. The highest L_{eq} (77.3 dBA) was during the evening hours at Kajla Gate. Besides the entrance points, the noise environment of academic areas of Rajshahi University campus had the highest L_{eq} (70.9 dBA) at Tukitaki during the afternoon hours, when students used to gather very often for refreshments and relaxation. The excess noise might affect the quietness of Central Library due to its proximity to this site. The survey indicated that meetings, cultural programs with loudspeakers, excess noise from the movement of vehicles, the arrangement of different programs, and the random use of vehicle horns are the main sources of excess sound on the university campus. Moreover, a railway line runs along the northeast boundary of the university; on average, twenty-eight commuter and express trains passe every day, making annoying noise in the residential hall area. Additionally, ongoing mega construction works for two residential halls and an academic building also added extra sound to the campus during the study period.

The highest and lowest noise values at Dhaka University were 82.9 dB and 60.15 dB, respectively (Hossain *et al.*, 2019). In comparison to Dhaka University, the noise level at Rajshahi University was slightly lower. Whereas noise levels of 94.8 dB in the afternoon at George Court around Zila School and Police Lines School and 84.3 dBA at Edward College Gate in Pabna municipality were measured (Arifuzzaman & Razu, 2015). The measured mean L_{eq} on campus at Silkaporn University, Thailand, was recoded at 64.7 dBA, which did not exceed Thailand's permissible nose limit of 70 dBA (Onchang *et al.*, 2018). A noise level of 56.3 dBA was observed at Malviya Institute of Technology in the quiet zone of Jaipur City (Raman *et al.*, 2014). Another study at a university in Turkey revealed a proportional increase in regions exposed to 60 dBA noise values (Çolakkadıoğlu *et al.*, 2018). Alarmingly, these findings are much higher than the prescribed level, the acceptable limit of noise level for sensitive areas like educational institutions by the Bangladesh Department of Environment (DOE) during the daytime is 45 dBA (Sultana *et al.*, 2020). Wherever there are WHO recommendations for road traffic noise of 53 dBA to prevent noise-related irritation in daytime residential areas (WHO, 2018), and limit 35 dBA is advised for educational institutions (Berglund *et al.*,1999).

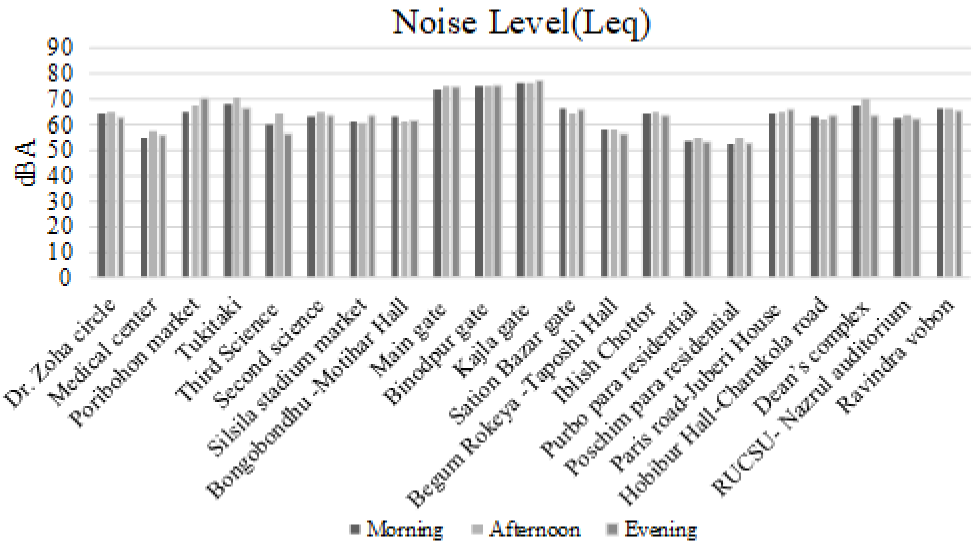

Figure 2: Measurement of equivalent continuous noise (L_{eq}) at different sampling sites

3.2 Traffic Volume and Noise

Table 2 provides comparative information on the variety of vehicles that pass through the six busy Road intersections on the Rajshahi University campus. Every working day, a good number of 3-wheeler auto rickshaws (locally known as Easy bikes), 2-wheeler motorcycles, cars, student buses, and even trucks run along different roads of the university campus. The maximum number of vehicles was observed at Tukitaki chattar (6152) and Paris Road-Juberi House corner (5997), while the minimum number of vehicles was observed at Bangabandhu-Motihar Hall Road intersection (4609). The noise level increases with an increase in motorized traffic volume. Among the vehicles, three-wheeled autorickshaws were dominant, followed by two-wheeled motorcycles and bicycles. Motorcycles were found to produce more noise than other vehicles.

Table 2: Number of vehicles at 6 road intersections on the Rajshahi University campus

Location	Vehicle types	3-Wheeler	2-Wheeler	Cars	Bus or truck	Subtotal of shifts	Total traffic volume
1.Dr. Zoha circle	Morning	1504	376	114	64	2118	5381
	Afternoon	1292	343	110	62	2272	
	Evening	1121	297	35	62	1762	
2.Tukitaki chattar	Morning	1530	390	198	0	2118	6152
	Afternoon	1582	470	220	0	2272	
	Evening	1340	322	100	0	1762	
3.Second science	Morning	1365	335	72	0	1772	4985
	Afternoon	1320	330	52	0	1702	
	Evening	1180	300	31	0	1562	
4.Bangabandhu-Motihar hall	Morning	1240	326	64	0	1630	4609
	Afternoon	1247	310	48	0	1605	
	Evening	1070	260	24	0	1354	
5.Station Bazar gate	Morning	1435	345	18	6	1804	4985
	Afternoon	1178	300	21	6	1505	
	Evening	1210	314	19	12	1555	
6.Paris Road – Juberi House corner	Morning	1493	397	182	3	2075	5997
	Afternoon	1505	400	188	3	2096	
	Evening	1430	350	46	0	1826	

Table 3 shows the relationship between noise level (L_{eq}) and the number of traffic vehicles during the morning hours. Pearson correlation was measured to be positive and statistically significant ($r = 0.604$, $p < 0.001$), which means the flow of traffic influenced the noise level in the study area. A rise in traffic flow would result in more noise. Another study in Zaria, Nigeria, found that the amount of traffic around schools had an impact on the noise level (Owojori *et al*. 2017).

Table 3: Correlation analysis of traffic volume and noise level (L_{eq})

	Traffic volume	Noise level
Traffic volume	1	
Noise level	0.604**	1

** Correlation is significant at the 0.01 level (2-tailed)

An analysis of variance is determined from all the twenty-one investigated locations in different shifts (Table 4). It shows that the obtained value of F (0.122) is less than the P value (0.885), which is not significant at the 5% level of significance. It demonstrates that noise levels in different shifts (morning, afternoon, and evening) do not differ significantly.

Table 4: Analysis of variance (ANOVA) test of noise level in different shifts of the day

Categories	Summation of squares	Degree of freedom (df)	Mean square value	F	*P*
Between groups	10.671	2	5.335	0.122	.885
Within Groups	2626.780	60	43.780		
	2637.451	62			

3.3 Noise Map

The noise map of Rajshahi University produced after interpolation in ArcGIS software is presented in Figure 2. So far, noise maps have been generated for residential, educational, roadway, airport, and hospital regions in urban areas (Manojkumar *et al*., 2019). In this study, the noise level (L_{eq}) of the morning, afternoon, and evening hours in dBA is used to visualize the noise level during vital academic hours and form a noise map. The unknown point values are measured based on the weighted average of known point values. The findings align with Tahlyan and Ohri's (2015) observations, where noise levels were significantly higher in areas near major traffic routes and lower in residential zones. In our study, sampling sites near the highway road exhibited noise levels ranging from 70–76 dBA, similar to the high-noise zones identified in Chandigarh. Such tools are invaluable for urban planners aiming to mitigate noise pollution through targeted interventions.

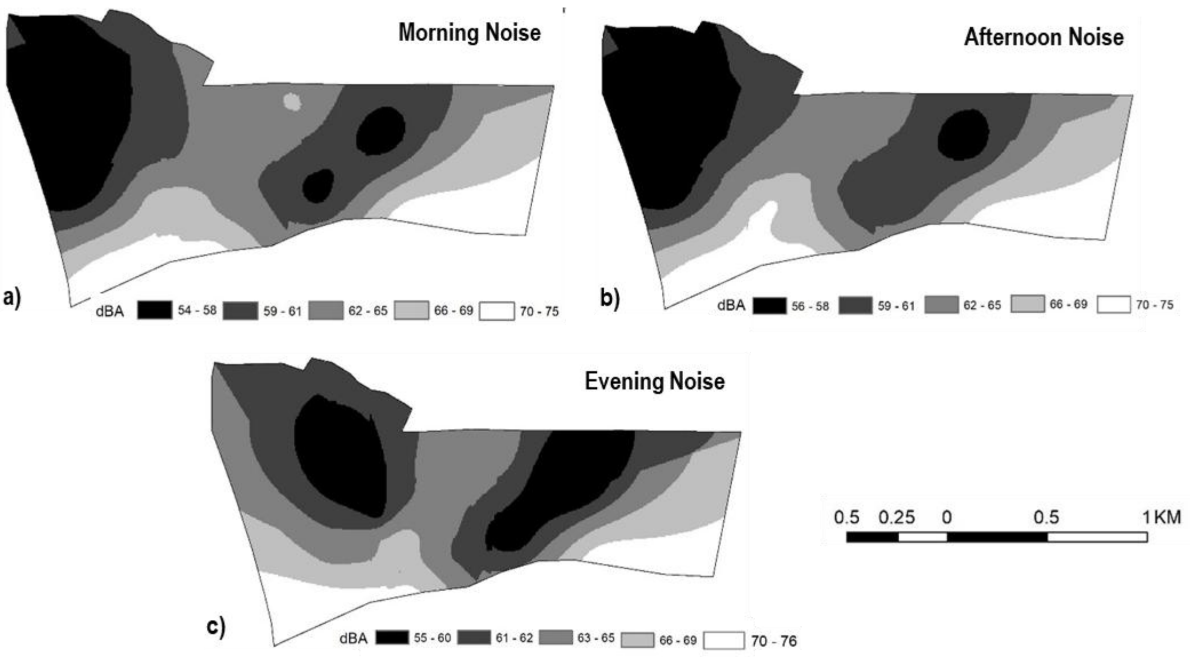

Figure 2: Noise map of Rajshahi University at (a) morning, b) afternoon and c) evening time

4. CONCLUSIONS

From the present study, the equivalent continuous noise level L_{eq} at 21 locations of Rajshahi University ranged from 52.6 -77.1 dBA, which is higher than the permissible limit recommended by WHO and DOE. The GIS based noise map is convenient and useful to visualise the noise pollution level. The increased number of motorised vehicles, the passing of railways; volume of loudspeakers used in meetings, cultural events, and construction projects contribute to the noise level at the Rajshahi University campus. The students, along with faculty members and staff are exposed to noise pollution every day. Therefore, awareness among the students, academicians, and staff is necessary to reduce the health risks.

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