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Assessment of Sound Pollution and Control Initiatives in Growing Suburb of Jhapa, Koshi Province of Nepal

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Abstract

This study presents an assessment of noise pollution in Gauradaha Municipality, Nepal, focusing on sound level measurements and evaluation of noise control initiatives across five categorical areas: commercial, industrial, quiet, rural, and urban residential zones. Using a systematic sampling approach, three sites per category were selected across nine wards, with sound level measurements conducted using a Sound Level Meter at 10-second intervals for 10 minutes, five times between 6 am and 9 pm. Questionnaire surveys were also administered to assess community perceptions and existing noise control measures. Results indicate widespread noise pollution exceeding both national and WHO standards, with an overall equivalent sound level of 65.19 dBA. Industrial areas exhibited the highest levels (90.78 dBA), while rural areas showed the lowest (47.34 dBA). Control measures predominantly included no horn zone declarations and physical barriers such as cemented structures and bamboo barriers. However, effectiveness varied across areas, suggesting a need for enhanced enforcement and community awareness. This study underscores the urgent need for targeted interventions to mitigate noise pollution, recommending strengthened enforcement of regulations, increased community awareness, and innovative solutions tailored to specific sources of noise pollution in each area.

Keywords: *Gauradaha, guideline and standard, noise pollution, noise status*

Introduction

Noise is defined as a harmful, disturbing, undesirable loud sound that causes discomfort and hearing loss and at the same time disturbs physiology and psychology (Kam et al., 1994; Miller, 1998). Urban noise is increasing daily at a high rate and significantly affecting human health and the environment. The main sources of urban noise are population growth, urbanization, and technological development (WHO, 1999). People in urban environments experience a high level of sound in different sectors such as shopping malls, schools, the workplace, recreational centers, and at home in many cases (Chauhan et al., 2021). The effects of these noises may be direct and indirect, mainly on health, and can cause disturbances in social, working places, and environment as a whole (Goines & Hagler, 2007). Continuous exposure to noise over a long period within a range of 85 to 95 dBA leads to hearing loss and psychological disorders. Noise has also been seen as a minor factor in cardiovascular diseases and blood pressure (Stansfeld & Matheson, 2003). The reduction of noise pollution requires a coherent strategy of long-term and medium to short term, which tend to be focused on mitigation of more specific and localized noise conflicts (Loucks, 2012). There are several methods by which noise problems can be controlled. Commonly adopted methods include design and specification change, command and control, and economic instruments (Peters et al., 2018). In a country like Nepal, which is technically behind in developing new technologies, command and control methods have been used widely. For instance, after enforcing the no-horn regulation in Kathmandu Valley, the noise level was reduced significantly by 2.1 dB(A) in high-traffic, low-traffic, and residential zones (Chauhan et al., 2021). The use of barriers is another option for noise reduction through path interventions. According to Önder & Akay (2015), if suitable areas and proper maintenance facilities exist, vegetation could be preferred to mitigate traffic noise. The diversity of plant species and green space establishment techniques should be according to scientific methods and appropriate to local ecology. These must be increased in terms of both quality and quantity due to their positive effects on the environment, which in turn will be very effective in reducing noise pollution. In the context of Nepal, many of the studies regarding noise pollution are focused on Kathmandu Valley and urban areas. Kadell et al. (2003) investigated noise levels in Kathmandu Valley and found that the maximum temporal distribution of average noise level was 83.5 dBA at ring road in the morning time and the maximum traffic noise level was 83.5 dBA at Putalisadak (Kadell et al., 2003; Sapkota et al., 1997). A recent study conducted by Chauhan et al. (2021) in 23 locations of four different zones (high traffic, low traffic, commercial, and residential) shows that 65.2% of the sampled sites had noise levels beyond the permissible limit of WHO and the National Sound Quality Standard of Nepal. Similar studies are lacking in rural and sub-urban areas even though the problem is not confined only to urban areas. Therefore, this study aims at measuring noise pollution in the sub-urban area, comparing the level of noise with established guidelines and standards, and assessing the control measures in the suburban setup.

Materials and Methods

Study site

The present study was carried out in Gauradaha Municipality in the Jhapa District. It is one of the growing urban centers in eastern Nepal. The incorporation of former VDCs Maharani Jhoda, Baigundhura, Juropani, Kohabara, and Gauradaha formed Gauradaha Municipality on 19th September 2015. Geographically it is located from 26.675 to 26.708 N latitude and 87.291 to 87.341 E longitude. According to the 2021 Nepal census, it has a total population of 60,459. There are nine wards within this Municipality. The Municipality is surrounded by Kamal Rural Municipality in the east and north, Ratuwamai Municipality in the west, and Gaurigunj Rural Municipality in the south. It is the plain Terai of Nepal. The residents of Gauradaha Municipality are mostly Brahmins, Chhetri, Rajbansi, Tajpuriya & Sataar (Santhaal). Most of the local people depend on agriculture. Rice is the main crop grown in this Municipality. Gauradaha, Gwaldubba, Schoolchaun, and Kohabara (Damuna) are the places for trade in this Municipality.

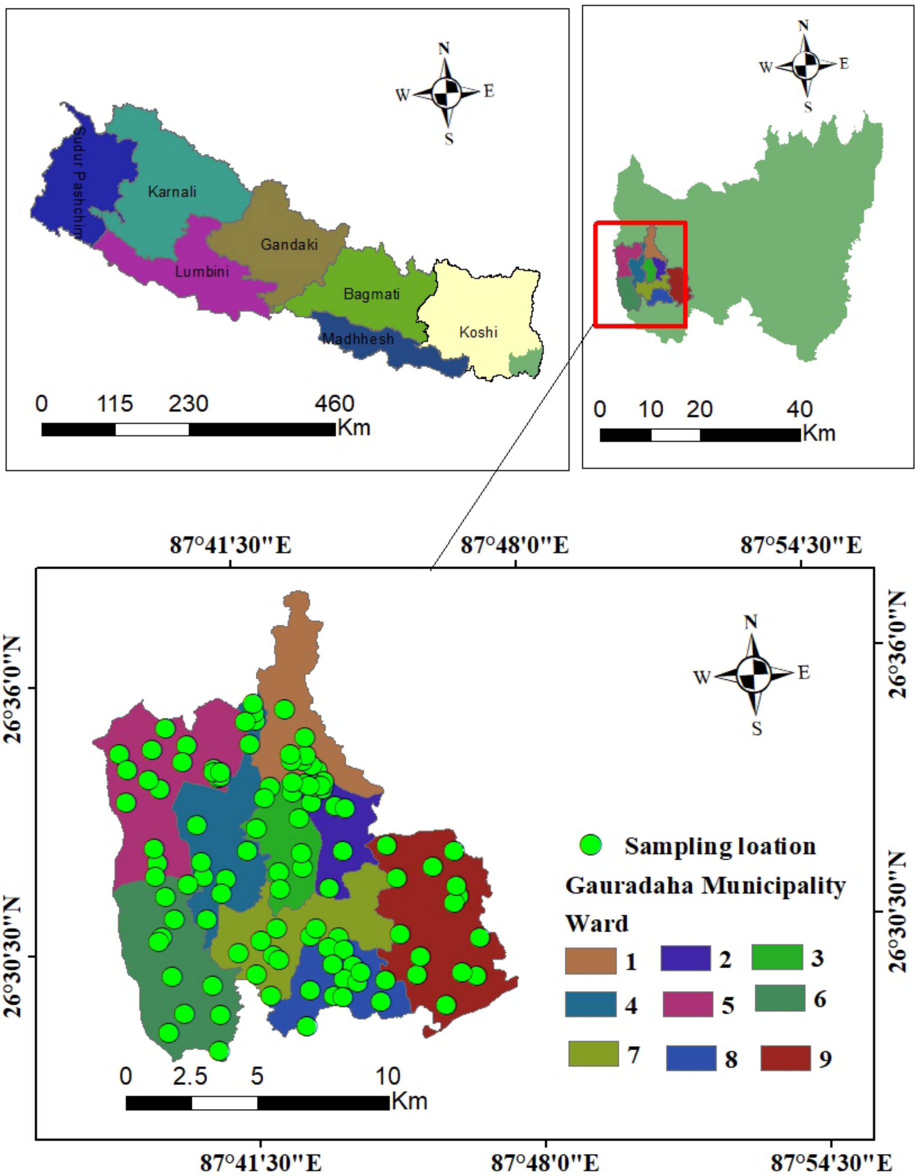

Figure 1: Location map of study Site

Sample Size

The sample size was selected by using a stratified sampling method. Five categorical areas in nine different wards were selected as commercial, industrial, quiet, rural, and urban areas. Data was collected from all 135 locations under the five different categories in nine wards (Table 1). To represent at least three to four respondents from each ward, 35 respondents were selected for the questionnaire. The respondents were local government representatives and officials like the Mayor, ward chairperson, planning officer, IT officer.

Figure 2: Auto ranged sound level meter with data logger

Table 1: Sample for data collection

Category	Number of measurement sites	Site Types
Quiet areas	3x9=27	Health post, social area (School, Clinic)
Commercial	3x9=27	Cloth store, food shop, market area
Industrial	3x9=27	Rice mills, Furniture
Rural	3x9=27	Rural residential areas
Urban	3x9=27	Urban residential areas
Total	135	

Data collection

The noise level was measured in decibels (dB) using the sound level meter (SLM) (Lutron, SL-4012) (Figure 2). It is used in the acoustic measurement. For the collection of primary data, the measurement instrument was carried out for the weighting scale. For the measurement of noise level, an SLM was taken in hand at a height of 0.5-1.7 meters at a distance of 1.5 meters from the window in an industrial area, and 5 meters from the roadside and hat bajar (local markets). The measurements were taken during sunny days having normal wind speed, atmospheric conditions, and devoid of rainfall. The measurement was done for 10 minutes with readings taken at 10 seconds interval. The process was carried out five times a day, which as shown in Table 2.

Table 2: Time allocation for data collection

Time	Duration
Morning	6am-9am
Morning- Afternoon	9am-12pm
Afternoon-Evening	12pm-3pm
Evening	3pm-6pm
Late evening	6pm-9pm

Data analysis

Collected data were analyzed by using Microsoft Excel for the quantitative and qualitative data analysis. The sound level was analyzed for different wards and categories and presented in bar charts, pie charts, and histograms. The temporal pattern of noise was also analyzed. All the results were compared with NSQS (Nepal Gazette,2012) & WHO (1999) guidelines. The given formula was used to calculate the equivalent sound level.

$$L_{eq} = 10log\left(\frac{1}{N}\right)\Sigma\frac{10^{SPL}}{10} \quad \text{............Equation (1)}$$

Where,

L_{eq} = Average sound level

N = Total number of observations

SPL = Sound Pressure Level

Results and Discussion

Various nations have different standards for noise levels. Nepal has established standards for noise levels in various categories. There have been a lot of studies conducted in municipal areas in other countries, but not many in Nepal.

Comparison of sound level by category

The bar chart below (Figures 3a, 3b, 3c, 3d, and 3e) shows the findings of each selected area. In Figures (3a, 3b, 3c, 3d, and 3e), The World Health Organization (WHO) and the National Sound Quality Standard, 2012 both have noise levels that are higher than the Leq sound levels at each of the locations shown. Ward 9 in the industrial area had a maximum Leq of 93.16 dBA while Ward 6 in the rural area had a minimum Leq of 44.15 dBA. In the other remaining areas category; falling between those figures is the Leq ranging from 45.61 to 92.12 dBA.

The present charts (Figures 3a, 3b, 3c, 3d, and 3e) show the sound levels from different categories commercial, quiet, industrial, urban, and rural. The maximum and minimum sound levels for commercial areas are given by ward-1 with a value of 69.47 dBA and ward-9 with a value of 58.90 dBA as shown in Figure 3(d). About this matter in the industry section, the highest peak and lowest troughs of sound have been recorded at ward-9 being equal to 93.15 while it stood at 87.02 in ward-1 for instance.

There were rural areas, which had sound levels ranging from a maximum of 50.13 dBA in Ward 7 to a minimum of 44.15 dBA in Ward 6. On the other hand, urban areas covered by these wards had their highest and lowest recorded sound levels at 60.96 dBA in Ward 1 and 53.78 dBA in Ward 9 respectively.

The graphic of the sound pattern in Figure 3(b) reveals that the quiet zone's highest and lowest sound levels were 56.15 dBA at Ward 2 and 46.07 dBA at Ward 4, respectively. Out of the three wards analyzed, Ward number nine in industries had the highest level of sound due to the absence of engineering control measures and machinery sounds.

The charts presented in Figures 3(a) to 3(b) depict the sound levels across various categorical areas such as commercial, quiet, industrial, urban, and rural. Figure 3(d) highlights that in the commercial area, the highest sound level recorded was 69.47 dBA in Ward 1, while the lowest was 58.90 dBA in Ward 9. In contrast, for the industrial zone, the maximum and minimum sound levels were 93.15 dBA in Ward 9 and 87.02 dBA in Ward 1, respectively.

Figure 3 displays the varying sound levels, in settings such as industries, health facilities, schools,

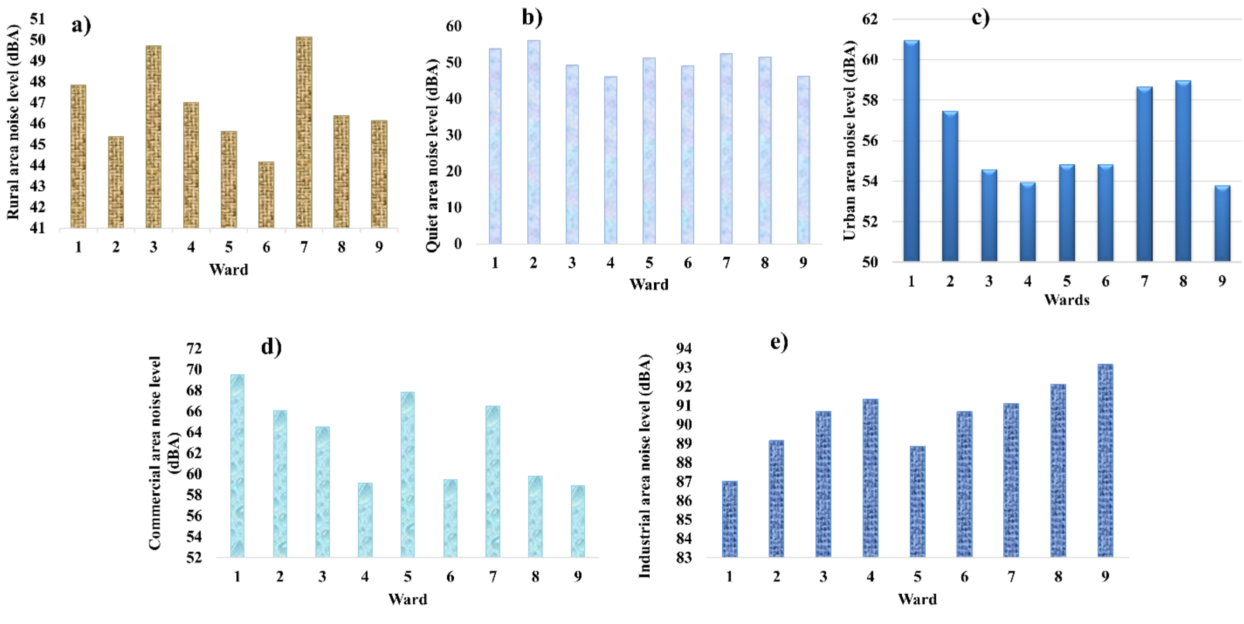

Figure 3: Noise level at rural areas (a), quiet area (b), urban area (c), commercial area (d) and industrial areas (e)

stores, rural regions, and urban areas. The initial column presents the levels while the second column indicates the National Sound Quality Standards. Upon reviewing Figures 3(a) to 3(e) it is evident that industrial sites generally exhibit noise levels compared to stores in tranquil environments, urban locales, and rural areas. Despite this observation all locations – be it establishments, industrial zones, serene spots, or urban and rural areas – surpass the recommended National Sound Quality Standards. This implies that noise pollution is prevalent, across settings even though industrial regions tend to be the loudest.

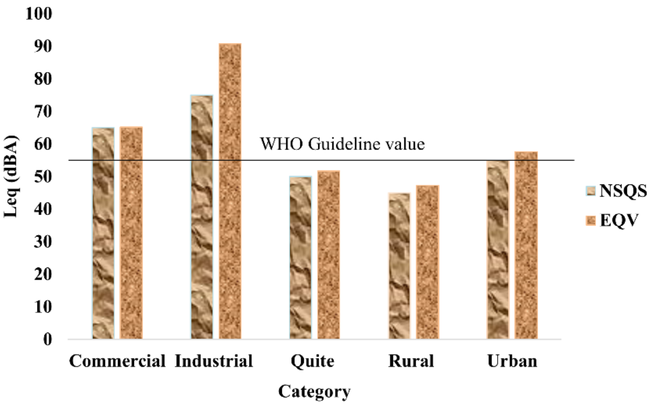

Figure 4: Comparison of L_{eq} of the different categorical areas with NSQS

In Gauradaha none of the types of areas have met the National Sound Quality Standard except, for the area, which has stayed within the recommended limit of 65 dBA during the day. Notably, the industrial area exhibits sound levels exceeding the standards set by the sound quality standard of 2012.

Additionally, sound levels, in the silence zone fail to meet the standard of 50 dBA as illustrated in Figure 4 where recorded sound values surpass this threshold.

Comparison of Sound Level within Nine Ward

Figure 5: Overall ward wise noise level comparison

The chart illustrates that sound levels recorded across different wards consistently exceed prescribed standards, with ward 9 notably exhibiting exceptionally high levels, particularly in the industrial area. Across various wards, noise levels surpass standards in commercial, industrial, quiet, and urban areas, while rural areas generally meet standards, except in a few instances such as ward 3 where industrial and rural areas exceed standards but others meet them. Notably, Ward 8 stands out as meeting National Sound Quality Standards in the Quiet zone.

Figure 6 demonstrates that the sound levels across all wards exceed the WHO community guideline of 55 dBA. By referencing Figure 8, we identify Ward 1 as having the lowest recorded sound value, while Ward 8 registers the highest sound value among all wards, surpassing levels observed in other areas.

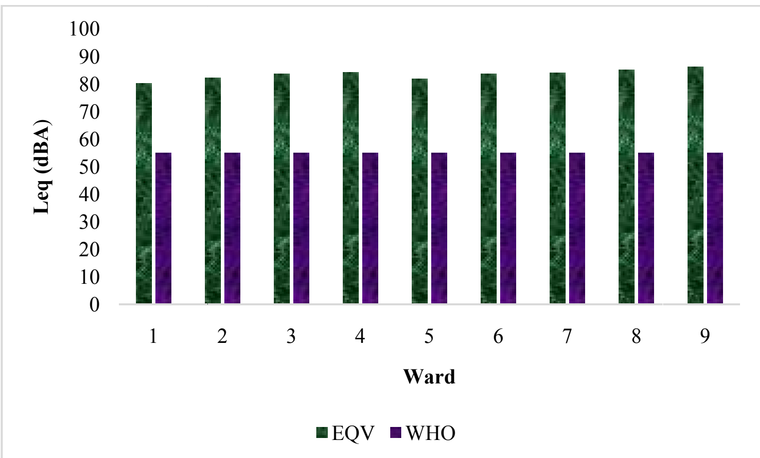

Figure 6: Comparison of noise level with its WHO Guidelines

Temporal pattern of noise pollution

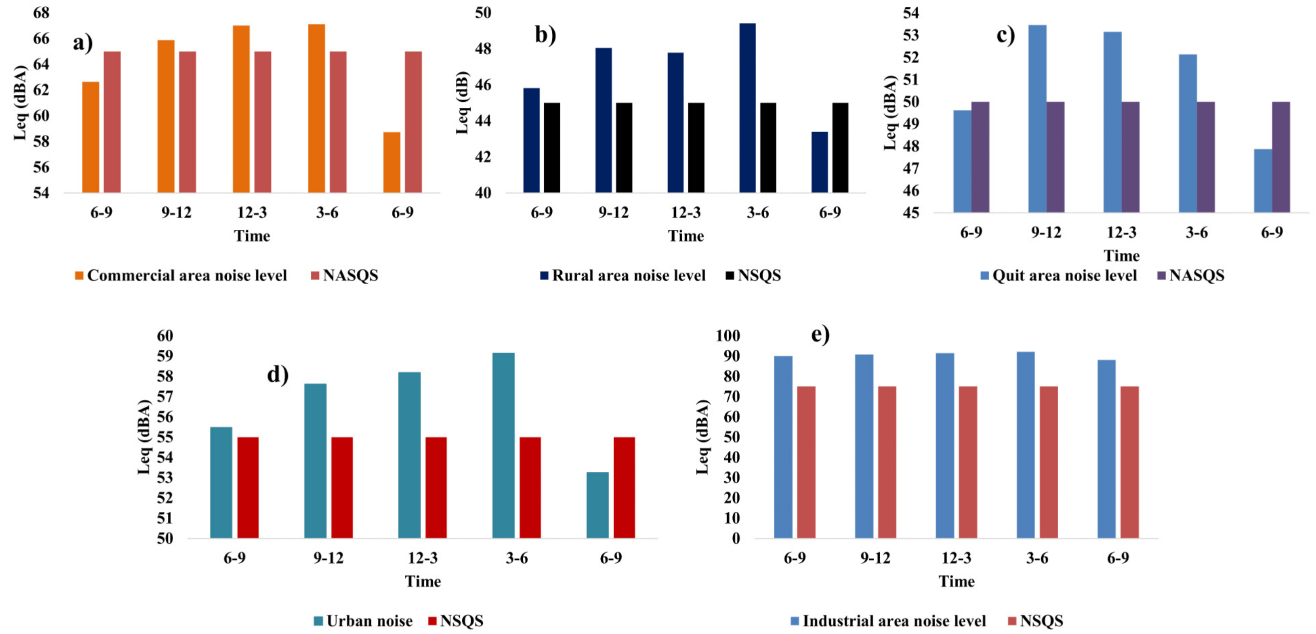

Figure 7: Comparison of temporal noise level for different category with NSQS (a. commercial, b. rural, c. quiet, d. urban and e. industrial)

Figures 7(a) to 7(e) depict various trends in sound levels across different periods and areas. The highest observed Leq during the observation period was 92.10 dBA in the industrial area from 3-6 pm, while the lowest was 43.39 dBA in the rural area from 6-9 pm. Notably, Figure 7 shows the highest noise level trend in the commercial area between 3-6 pm, exceeding the National Sound Quality Standard, whereas noise levels between 6-9 am and 6-9 pm meet the standard. Similarly, in rural areas, both maximum and minimum sound levels were observed between 3-6 pm and 6-9 pm, meeting the standard during other times. In the urban area, the maximum sound level was recorded from 3-6 pm and the minimum from 6-9 pm, meeting the standard during the latter period. Likewise, in the Quiet zone, maximum and minimum sound levels were observed from 9-12 pm and 6-9 pm, while meeting the standard between 6-9 am and 6-9 pm.

Assessment of Control Measures

In the assessment of control measures within the municipality, various stakeholders including local government officers, IT officers, the chairman, ward officers, the mayor, and health post officers participated in the survey. Findings revealed that 46% of respondents utilized barriers, while 41% did not employ barriers in residential areas, supermarkets, and the local market (hatbajar). Interviews with the mayor disclosed that only 13% of locations were designated as no-horn zones. Questionnaire surveys with local government officers from different sectors indicated the use of various barrier types, with most wards utilizing cemented and bamboo walls, while a minority opted for Tin (Galvanised tin sheet) barriers to mitigate noise pollution. The types of barriers employed in the municipality are illustrated in Figure 8 in a pie chart format.

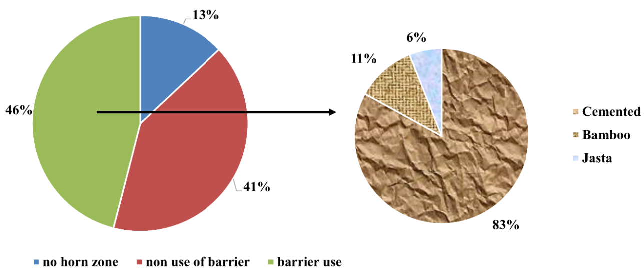

Figure 8: Noise pollution control methods

The maximum and minimum sound levels of the commercial area were 69.47 dBA at Ward 1 and 58.90 dBA at Ward 9 respectively due to maximum vehicle pressure, the crowd of people, construction work, trading market. The noise level of the industrial area recorded in 9 different wards is compared with past studies done in “Friendship Textile Mill Limited, Ubongo- Da (Yhdego, 1991) shows a similar result to this study, the noise level of industrial area is comparatively higher than the prescribed standard.

From the survey, it was found that within the nine wards, the maximum sound level of the rural area recorded at ward 7 was 50.13 dBA. It may be caused by farmers using the tractor for plowing land, harvesting products, over the volume of TV and speaker, birds and other animals added the sound level in a rural area, the minimum sound level was recorded at ward 6 that was 44.15 dBA. Similarly, for urban areas maximum and minimum sound levels were found at Ward 1 and Ward 9 it may be due to urban areas being very close to commercial areas, use of old and noisy vehicles, and urban areas roads being very wide which is the main reason for the overflow of vehicles in the urban area at ward 1. The maximum and minimum sound levels in the urban residential area were 104.2 dBA and 60.0 dBA (Murthy et al., 2010). In the present study, it was found that the urban area noise level was beyond the prescribed standard. From the survey, it was found that the maximum and minimum sound levels of the peace area were 56.15 dBA in ward 2 and 46.07 dBA in ward 4. It may be due to the noise from students and people crowding in the hospital area. A similar reason was found by (Ibrahim et al., 2000) and (Chauhan & Bhatta, 2019) which showed that there are many sources to introduce noise pollution in the school environment, such as where the school is built, near the city Centre, traffic congestion, construction, people pass by and shop can affect on school and hospital activity. The sound value recorded in different wards crossed the national ambient sound quality standard. In ward 9, the industrial area has the highest sound level as compared to other commercial areas due to the big machines (mainly rice mill and furniture) working at very high speed with high noise intensity. (Vattanaprateep, 2020) suggested that heavy mechanical gears and machinery installed in industries contributed to the reduction of hearing abilities of people living in such industrial regions. Ward 2 in the rural area meets the noise level standard. It may be due to low vehicle pressure because of the narrow road, and most of the households of this area are made near the agricultural land, but other areas of these wards (commercial, industrial, urban) don’t meet the standard. At Ward 3 sound levels were high in the commercial area as compared to other areas (peace, urban, and rural) area. In the industrial area sound level of this ward is too high as compared to all the selected areas (commercial, industrial, rural, urban, and peace). Similarly, in different wards, 4,5,6,7 and 8 wards sound levels are too high as compared to other areas (commercial, industrial, peace, urban, and rural). It may be caused due to the use of high-noise intensity machines, and lack of engineering control. (Goswami & Swain, 2011) suggested that gathering people with their vehicles around any commercial or administrative regions was also a source of acute noise pollution. Indiscriminate noise that was created by the horns of vehicles and loudspeakers played near temples or in different rituals are also major contributors to noise pollution. Hypertension, heart disease, and mental breakdown were some of the immediate impacts of noise pollution on people (Singh & Davar, 2004). Poor road conditions and the increment of Tuk-Tuk vehicles in both cities and rural regions contributed to noise pollution (Datta et al., 2006, Vattanaprateep, 2020).

Comparison of sound level with guideline and standard

The noise level in all wards had exceeded the noise level standard prescribed by WHO due to the high noise level produced by the industrial area movement of vehicles, wider roads, trading market, in the urban and commercial areas, the sound produced by speakers and TV in a rural area, noise from students and people in a peace zone. Europen countries had developed community noise guidelines to control noise pollution, in comparison with these guidelines noise levels exceeded the guideline. Sound level in the commercial area between the period of 6-9, 9-12 noon, and 6-9 pm meet the standard but the period of 3-6 pm exceeded the sound level. It may be caused by the commercial area being near the industrial area and in the evening time (3-6 pm), the trading market gets too busy for selling and buying the product. In Australia, the noise level standard of the commercial was set at 55 dBA (Chauhan & Pande, 2010) which is ten times greater than Nepal's sound quality standard and it was revealed that the noise level of the commercial area didn't meet the Australian standard. Similarly, the level of sound in the peace zone in which the maximum level of sound is recorded between the morning and afternoon time (6-9 am & 9-'12 noon), and it is minimum in the evening time (6-9 pm). Around noon the noise level was statistically very low as compared to other times because at lunchtime people have their lunch in the canteen at work or they go to a hotel or food shop and home on foot if near so that noise level is decreased. In the U.S. (E.P.A) the noise level standard in silence areas during day time is 45 dBA (Chauhan & Pande, 2010). The temporal pattern of the urban sound level is just opposite to the peace zone. The high sound level in the urban area is recorded at 6-9 pm; the reason for obtaining this result may be due to the school and hospital area of that Municipality getting more engaged with children and people. The period between 6-9 am and 9-12 noon is regarded as the school and hospital starting time that's the reason that that time sound level in peace area is too high But in the urban area, only in the afternoon and evening time sound level is very high as the maximum vehicles are used by people to reach hatbazzar and other commercial areas in the afternoon time, and the crowd of people increases during duty off time in the evening time (3-6 pm). In Japan, the noise level standard of residential areas has been set at 50 dBA (Chauhan & Pande, 2010). Thus, the present sound level in Gauradaha Municipality is above than permissible level. According to a study done in Kathmandu Valley by Sapkota et al., (1997), recorded a harmful sound level was found above 80 dBA. Most of the different countries have different noise level standards for the different categorical areas while in Nepal there is no such variation in the standard for the different categorical areas.

Assessment of control measure

Control measures assessment carried out by a questionnaire method. For the assessment of control measures in that Municipality, the interview is taken with a total of 34 respondents and the mayor of that municipality. From the survey, it was found that the use of barriers is very high in peaceful areas as the area is regarded as a silent zone, and in these areas, noise should be controlled otherwise it will hamper on education and health of patients. Similarly, in industrial areas cemented walls, bamboo, and tin (Galvanized tin sheet) walls were used to control the noise produced by the machines such as saws, generators, and grinders. For the reduction of noise pollution, the local government hasn't made any policy and hasn't estimated the budget to control noise pollution except for the declaration of no horn zones in 5 places(Sen et al., 2015) surveyed noise pollution assessment in Greater Agartala city and found that different development activities like industrial development, growth of commercial complexes, huge crowed, construction and demolition of building activities produced the considerable noise problem in the city and highlights that the noise pollution can be controlled through the use of barriers, implementation of environmental protection law, pollution and discharge fees and awareness. (Singh & Davar, 2004) also suggested that local governing bodies should be made responsible for managing the emission of noise in the locality. The civil administration and police should be equipped with proper instruments so that they can measure and control unwanted noise emitted by public vehicles. (Vattanaprateep, 2020) also mentioned the implication of fines and taxes for people using old and noisy vehicles or creating loud noise in public places. Administrations were also encouraged to employ architects and engineers to prepare concrete plans to minimize the interference of noise from busy areas to local people. It also suggested keeping schools, residential areas, and hospitals as far from noise-inducing zones as possible. Schools and other residential areas should be declared as noise-free zones. Heavy and old vehicles should also be controlled during rush hours to minimize heavy noises from such vehicles. Along with this, workers who were working in noisy places should be recommended to wear appropriate gear to prevent damage to the ear from excessive noise. Along with the government, the non-governmental organization should also understand their responsibility to spread awareness among locals to make people aware of the impacts of noise pollution (Darshana et.al., 2013, Oluwasegun et.al., 2015).

Conclusion

The purpose of this study was to evaluate the noise pollution status in Gauradaha Municipality and to assess the control initiatives to control noise pollution. From this study, it was found that the noise level of this Municipality was above the level which is prescribed by WHO. Only the commercial area of the Municipality meets the NASQS. The result of this study indicates that a maximum noise level Leq of 93.16 dBA in the industrial area and a minimum of 44.15 dBA was recorded in the rural area. Among the entire ward, Ward 9 is a noisier area than all wards due to industrial activities. Comparatively 4, 5 & 6 wards are considered as less noisy areas. From the assessment, it was concluded that maximum noise level was observed at 3-6 pm in industrial areas and minimum between the periods of 6-9 pm

Authors Contribution

N.N. and R.C. conceptualized and designed the research; N.N. collected and processed the data; N.N. and R.C. analyzed the data, contributed to data interpretation, wrote and revised the manuscript. All authors have read, revised and approved the manuscript.

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