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Determination of Ambient Noise Levels in the Main Commercial Area of Cape Coast, Ghana

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Abstract: Noise pollution associated with urbanisation is an emerging environmental problem in many developing countries including Ghana. In comparison with other pollutants, the control of environmental noise has been hampered by insufficient knowledge of its effects on humans and of dose–response relationships, as well as by a lack of sufficient data. The study set to quantify noise and obtain the perceptions of residents in selected neighbourhoods in the main commercial area of Cape Coast, Ghana. The focus was on five selected areas: commercial centres, road junctions/busy roads, passengers loading stations, high-density residential areas, and low-density residential areas. The range of noise pollution levels, L_{NP}, at high-density residential areas is 58-68 dB (A), while that of low-density residential areas is 53-72 dB (A). The range of traffic noise index TNI at high-density residential areas is 34-107 dB (A), and that of low density residential areas is 27-65 dB (A). There is a wide disparity in the noise level exposure by the residents in high-density residential areas and that of low-density residential areas. At 90% confidence level, the Mean Square Ratio (MSR) calculated for L_{NP} is 65.02, while the tabulated value is 2.36. Similarly, at the same confidence level, the MSR calculated for TNI is 6.23 and the tabulated value remains as 2.36. Since, in the two cases, the calculated MSR is greater than the tabulated value, there is a significant difference ($p<0.05$) in the noise pollution level and TNI in the locations surveyed based on the data analyzed at 90% confidence level. About 82.1% of the respondents complained that the noise from the audio music shops and traffic is a nuisance. Noise levels at all the 10 measurement points exceeded the Ghana EPA recommended upper limit by values of 1-15 dB (A). This makes it imperative for the regulatory authority to enforce compliance on noise.

Key words: Ambient noise, Cape Coast, perception, pollution, traffic

INTRODUCTION

Environmental noise has been defined as an unwanted or harmful outdoor sound created by human activities. This includes noise emitted by means of transport and from sites of industrial activities (Defra, 2003; Anomoharan and Iserhein, 2004). Ebeniro and Abumere (1999) view environmental noise as an unwanted signal which in most cases is sound. People are becoming increasingly aware of and disturbed by the cacophony of sounds in the environment. More often than not these sounds are loud, intrusive and unwelcome side effects of our fast-paced, progress-motivated society. While tolerating noise in our urban and even suburban environment may seem like a necessary compromise for the services, improved construction and transportation we receive in return, noise in the natural environment is much less palatable.

Noise pollution as a by- product of urbanization and industrialization; is now recognized as a major problem for the quality of life in urban areas. The increase in the population and in the number of circulating vehicles has led to an increase in noise pollution but noise pollution has been considered less than other contaminants in the environment (Mansouri *et al*., 2006). In contrast to many other environmental problems, noise pollution continues to grow and is accompanied by an increasing number of complaints from people exposed to the noise. Leventhall (2003) in his view of public research work on low frequency noise and its effect asserted that noise is an undesirable sound and that both noise and sound are similar acoustic waves carried on oscillating particles in the air.

There is growing public awareness and even some progress in the fight against air and water pollution but a third jeopardy -noise pollution- has greatly begun to gain attention. The need for studies regarding urban noise pollution and its consequences on the environment has motivated various research works on the problem in several countries (Ugwuanyi *et al*., 2004; Zeid *et al*., 2000; Zheng, 1996). Many researchers have reported that road traffic is the most predominant and most generalized sources in urban areas (Saadu *et al*., 1998; Nelson, 1998).

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Braj and Jain (1995) reported that commercial areas have the highest noise levels, followed by industrial and residential areas. It has been generally accepted that noise pollution particularly road traffic noise issues is widespread in rapidly expanding cities, such as those in southeastern Nigeria (Onuu, 1992) where insufficient control is exercised and cities are poorly planned.

Ghana shares these characteristics especially in the major cities of Accra, Kumasi and other rapidly urbanising areas such as Cape Coast. Armah *et al*. (2010) found that religious activity-related ambient noise levels in many areas in Cape Coast were higher than the Ghana Environmental Protection Agency (EPA) upper limits for day and night. Kotokuraba, the main commercial area of Cape Coast is not an exception to this environmental hazard. Extreme noise levels may startle individuals, interrupt sleep, cause physiological stress, and contribute to physiological distress, cause temporary or permanent loss of hearing (Saadu *et al*., 1998). In comparison with other pollutants, the control of environmental noise has been hampered by insufficient knowledge of its effects on humans and of dose-response relationships, as well as by a lack of sufficient data, especially in developing towns like Cape Coast. The effects of noise in developing towns are just as widespread as those in developed towns, and the long-term consequences for health are the same.

Cape Coast has been subjected to persistent road traffic and commercial activities due to overall increase in prosperity, fast development, and expansion of the economy. Apart from the work of Armah *et al*. (2010), very few studies have been carried out to investigate and assess noise pollution in the Cape Coast metropolis. Even so, Armah *et al*. (2010) focused on noise emanating from religious activities in the metropolis. Many recent surveys suggest that changes in demography and urban boundaries in the city have taken place, and consequently, further investigation of this phenomenon is needed. Consequently, this study thus sought to quantify noise and obtain the perceptions of residents in selected neighbourhoods in Kotokuraba, Cape Coast about noise in the area, assess the levels and distributions of urban noise produced in these neighbourhoods and also draw policy makers' attention to it. Specifically this study set out to:

- Evaluate the noise levels in strategic locations (commercial centers, busy roads/junction, passenger loading parks, and residential areas in the city of Cape Coast.
- Compare the measured noise levels to the Ghana EPA standards for noise
- Investigate if there is a significant difference in noise pollution levels (L_{NP}) in the locations surveyed throughout the day time and night time.
- To compare the noise levels with traffic noise index (TNI) to determine the risk zones of the various locations.

MATERIALS AND METHODS

Study area: Cape Coast is the capital of the central region of Ghana. It lies on a low promontory jutting into the Gulf of Guinea of the Atlantic Ocean about 75 miles (120 km) southwest of the Ghanaian capital of Accra. Economic activity includes fishing, trade, and government administration. Kotokuraba (Fig. 1) is a small settlement found in the Mfantsipim community. Majority of the settlers are traders, drivers, and workers in the various institutions found within the area.

Materials: This research is based on measurements of outdoor sound level carried out from December to March 2011. Questionnaire, Sound level meter and Global Positioning System (GPS) were used in the collection of the primary data at 10 different locations (two commercial centers, two road junctions and busy roads, two passenger loading parks, two high-density areas, and two low density areas) in Kotokuraba, Cape Coast. The study population included people of both sexes within the age group of 15 to 60 years, and capable of providing authentic information for the study. In all 100 respondents were randomly selected for interview.

Methods: The measurements were made at street level (at road junctions, market centers, passenger loading parks, and residential areas). The instrument was held in hand with the microphone pointed at the suspected noise source at a distance not less than one meter away from the reflecting object. L_{Ai} (A-weighted instantaneous sound pressure level) measurements were recorded twice every week taking three replicates for each area i.e. 120 readings per day .This procedure was carried out for morning (5:30-6:00 a.m.), afternoon (11:30-12:00 p.m.), evening (4:30-5:00 p.m.), and night (10:30-11:00 p.m.) measurements. From these readings, commonly used community noise assessment quantities like the exceedence percentiles L_{10} and L_{90}; the A-weighted equivalent sound pressure level, L_{Aeq}; the daytime average sound level, L_D ; the nighttime average sound level, L_N ; the day–night average sound level, L_{DN}; the noise pollution level, L_{NP}; traffic noise index TNI ; were computed. These noise measures are defined as follows (Saadu *et al*., 1998):

$$L_{Aeq} = 10\log \left[\frac{1}{N}\sum_{i=1}^{N}\left(\text{antilog}LAi / 10\right)n_i \right] \quad (1)$$

$$L_D = 10\log \left[1/2(\text{antilog } L_{AeqM}/10 + \text{antilog }_{LaeqA}/10)\right] \quad (2)$$

$$L_N = 10\log \left[1/2(\text{antilog } L_{AeqE}/10 + \text{antilog }_{LaeqN}/10)\right] \quad (3)$$

$$L_{DN} = 10\log [1/24(15\times\text{antilog } (L_{N/}10 +9) + \text{antilog } (L_D/10+10))] \quad (4)$$

$$L_{NP} = L_{Aeq} + (L_{90} - L_{10}) \quad (5)$$

$$TNI = (L_{90} - L_{10}) + (L_{90} - 30) \quad (6)$$

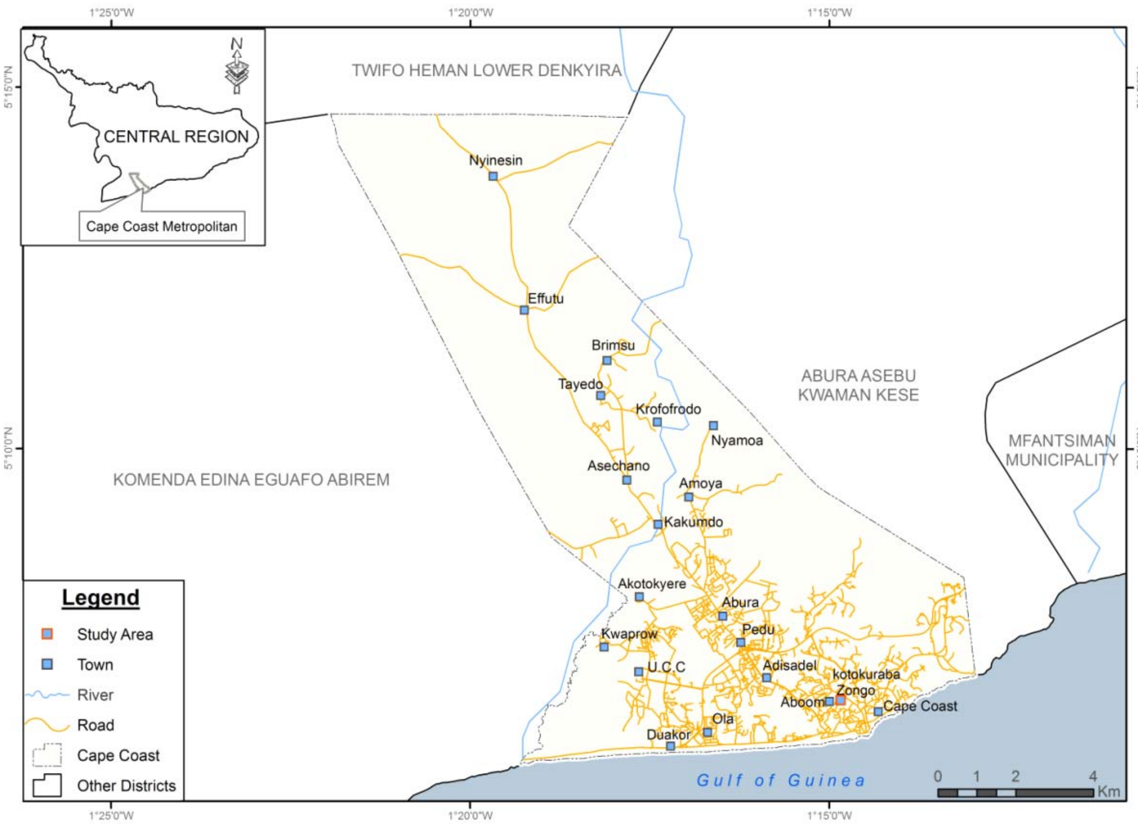

Fig. 1: Map of study area

where; L_{Ai} is the *i*th A-weighted sound pressure level reading decibels, *N* is the total number of readings, L_{Aeq} is the A-weighted equivalent sound pressure level, L_{AeqM} is the equivalent sound pressure for the morning measurement, L_{AeqA} is the equivalent sound pressure level for the afternoon measurement, L_{AeqE} is the equivalent sound pressure level for the evening measurement, L_{AeqN} is the equivalent sound pressure level for the night measurement, L_N is night time noise level, L_D is daytime noise level, L_{10} is the noise level exceeded 10% of the time, L_{90} is the noise level exceeded 90% of the time, L_{NP} is noise pollution level, L_{DN} is day–night noise level, and TNI is the traffic noise index. Questionnaires were sorted, numbered and data coded before entering data into SPSS version 16 software. The data were categorized and presented in the form of tables and pie charts. L_{Ai} values obtained from the noise level meter were analyzed and the daytime average sound level, L_D; the day–night average sound level, L_{DN}; the noise pollution level, L_{NP}; TNI; traffic noise index were computed.

RESULTS

From Table 2, L_{NP} ranges from 58-88dB for the commercial centre, 70-99dB for busy roads, 70- 105dB for passenger loading, 58-88 dB for high density area and 53-72dB for low density area. TNI ranges from 27-65 dB for low density area, 34-107dB for high density area, 72-154 dB for passenger loading, 50 to 136 dB for the busy roads and 46-141 dB for commercial centers. Generally, these values exceeded the Ghana EPA location specific guideline values (Table 1). The factors responsible for differences in noise level in the centers surveyed include location site and presence of sources of intrusive noise. The high noise pollution levels and TNI at Elmina GPRTU and Mankessim GPRTU stations is due to the audio music shops around the area advertising their products. Therefore, apart from noise due to commercial activities, there is traffic noise from vehicle horns, engines, and traffic volume. In addition to these, noise from a loudspeaker in a mosque located within the vicinity constitutes an intrusive noise at the time of prayer.

Many people living in urban centres are exposed to intractable road traffic noise every day; the most affected being the traders, commercial vehicle drivers, traffic wardens and police men, and school children who attend schools close to the main road. This group may be exposed to day noise levels in excess of 75 dB (A). Similarly, the residents living close to the main road

Table 1: Ambient noise level guidelines of Ghana EPA

		Permissible noise level IN dB (A)	
		Day	Night
ZONE	Description of area of noise reception	0600 - 2200	2200 - 0600
A	Residential areas with negligible or infrequent transportation	55	48
B1	Educational (school) and health (hospital) facilities	55	50
B2	Area with some commercial or light industry	60	55
C1	Area with some light industry, place of entertainment or public assembly and place of worship such as churches and mosques	65	60
C2	Predominately commercial areas	75	65
D	Light industrial areas	70	60
E	Predominately heavy industrial areas	70	70

Table 2: Noise levels descriptors computed for day and night in the study area

			Noise level description[dB(A)							
Sample area	Site	Period of day	L_{Aeq}	L_{10}	L_{90}	TNI	L_{NP}	L_D	L_N	L_{DN}
Commercial centre	Kotokuraba	Morning	53	51	56	46	58			
		Afternoon	68	63	69	63	74	65		
		Evening	67	55	66	80	78			
		Night	64	51	75	141	88		65	75
	Kuturuka	Morning	66	73	78	68	71			
		Afternoon	65	52	66	92	79	66		
		Evening	61	57	64	62	68			
		Night	61	56	78	136	83		61	74
Busy road	UTC	Morning	62	57	64	62	69			
		Afternoon	77	56	78	136	99	74		
		Evening	75	75	76	50	76			
		Night	71	67	74	72	78		73	74
	Sonturk	Morning	61	55	64	70	70			
		Afternoon	68	76	84	86	76	66		
		Evening	76	75	77	55	78			
		Night	70	74	65	71	79		73	82
Passenger loading	Elmina GPRTU station	Morning	60	52	62	72	70			
		Afternoon	80	59	84	154	105	77		
		Evening	76	56	78	136	98			
		Night	72	53	78	148	97		74	86
	Mankessim GPRTU station	Morning	68	52	71	117	87			
		Afternoon	74	71	76	126	79	69		
		Evening	74	68	77	83	83			
		Night	75	52	76	146	99		74	83
High density area	Wangala lane	Morning	56	57	59	34	58	63		
		Evening	73	70	77	75	80			
		Night	65	62	68	62	71		71	79
	Zongo	Morning	65	52	69	107	82			
		Afternoon	73	71	74	56	76	71		
		Evening	76	68	78	88	86			
		Night	65	65	67	45	67		73	83
Low density areas	Antem	Morning	51	50	54	40	55			
		Afternoon	67	66	69	51	70	64		
		Evening	66	61	67	61	72			
		Night	52	52	53	27	53		63	74
	Sikafoanbantem	Morning	51	50	53	35	54			
		Afternoon	66	65	66	40	67	63		
		Evening	62	60	67	65	69			
		Night	51	50	53	35	54		59	72

junctions or busy roads may be exposed to night noise levels in excess of 75 dB (A).

The noise level descriptors for some selected major road junctions and busy roads in the city surveyed are shown in Table 2.The intractable traffic can be slow moving (as in approach to a junction), congested (as in traffic hold-ups), or interrupted (by traffic lights or warden at a junction). Whichever is the case, the noise emanating from intractable traffic is usually high depending, of course, on the traffic volume and magnitude of commercial activities in the area. For example, Sonturk junction, UTC road, and Maggi road are examples of road junctions and busy roads with high traffic volume. In the afternoon and evening, the traffic is slow and congested. There is interruption by traffic warden, and in such areas, road traffic is the main source

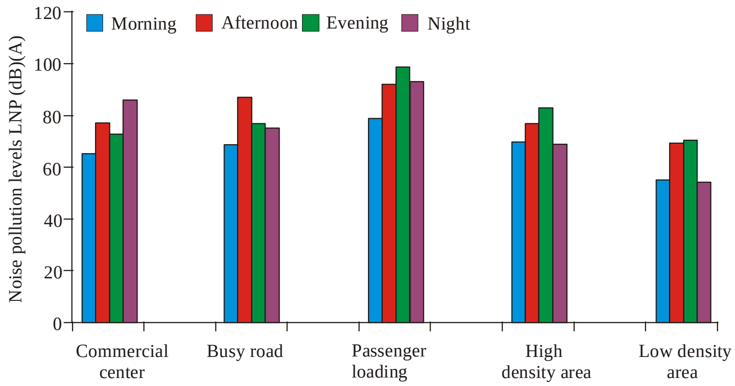

Fig. 2: Variation of noise pollution level (LNP) with location and period of day

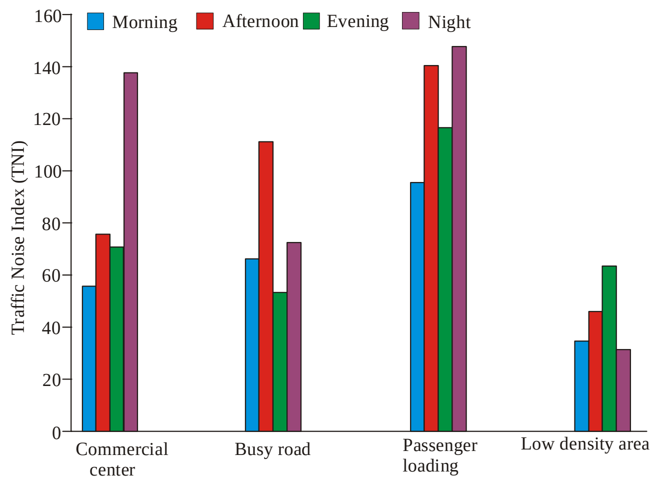

Fig. 3: Variation of Traffic Noise Index (TNI) with location and period of day

of the ambient noise, while vehicle horns, human voices (in conversation), and radio players are the sources of intrusive noise. The L_{NP} values for this type of district are in the range of 70- 99 dB (A).The passenger loading station had the highest TNI of 72-154dB. This is as a result of intrusive noise from audio music shops within these stations and noise from loudspeakers used in calling passengers into the commercial vehicles. Residential area noise levels in Kotokuraba urban areas (Fig. 1) can be grouped into two: the high-density areas (well developed areas with clustered buildings and high number of people living together) and low-density areas (developing areas with scattered buildings and few people living together). In a densely populated area, high noise levels are generated compared with those of a sparsely (low density) populated area.

The major sources of noise in residential areas in Kotokuraba urban city include noise from generator plants, record players, street dances, open parties, human conversation, noise from religious worship centers located around the residential areas, etc. All these contribute greatly to environmental noise pollution. Table 2 shows the range of noise pollution levels, L_{NP}, at high-density residential areas is 58-68 dB (A), while that of low-density residential areas is 53-72 dB (A). The range of TNI at high-density residential areas is 34-107 dB (A), and that of low density residential areas is 27-65 dB (A). There is a great disparity in the noise level exposure by the residents in high-density residential areas and that of low-density residential areas.

Figure 2, 3 and 4 show results on noise pollution, noise index and residents perception of noise as intrusive and loud.

Urban noise at Kotokuraba (Fig. 1) was loud on market days and weekends. Consequently about 50% of the respondents felt that noise is loudest on the afternoon of market days. 15% of them felt however that noise is loudest on weekends while 9% considered it loudest on weekdays.

From the ANOVA table it can be seen that the sum of squares between is 16717 while the sum of squares

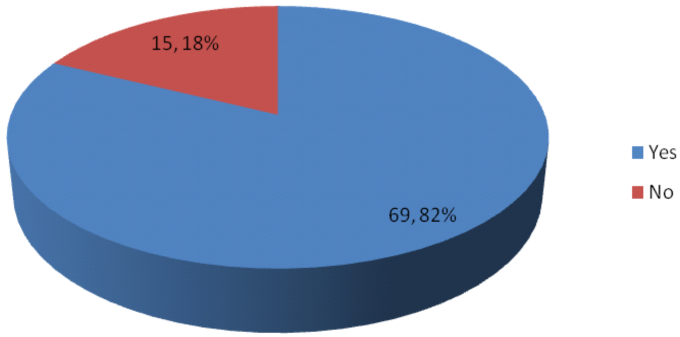

Fig. 4: Residents perception of noise as loud and intrusive

Table 3: Analysis of variance for L_{NP}

Source of variation	SS	df	MS (MS = SS/DF)	MSR MSRc = MSc/MSr)	MSR (tabulated) (F0.1, 4, 15)
Between	16717	C-1 = 4	4179.25	65.02	2.36
Within	964.25	(N-1)-(C-1) = 15	64.28		
Total	2630.95	N-1 = 19			

SS: sum of squares, df: degree of freedom, MS: mean square

Table 4: Analysis of variance for TNI

Source of variation	SS	df	MS (MS = SS/DF)	MSR MSRc = MSc/MSr)	MSR (tabulated) (F0.1, 4, 15)
Between	14164.8	C-1 = 4	3541.2	6.23	2.36
Within	8532	(N-1)-(C-1) = 15	568.8		
Total	22696.8	N-1 = 19			

SS: sum of squares, df: degree of freedom, MS: mean square

within is 964.25. This gives us mean square values of 4179.25 and 64.28, respectively.

From the ANOVA table it can be seen that the sum of squares between is 14164.8 while the sum of squares within is 8532. This gives us mean square values of 3541.2 and 568.8, respectively.

To ascertain the whether there is significant difference in the noise level exposure in all the sites surveyed throughout the day (from morning to night time), statistical analysis of variance for single factor experiment, using F-distribution, was carried out on L_{NP} and TNI. Table 3 and 4 are analysis of variance tables for noise pollution levels (L_{NP}) and TNI, respectively. At 90% confidence level, the Mean Square Ratio (MSR) calculated for L_{NP} is 65.02, while the tabulated value is 2.36. Similarly, at the same confidence level, the MSR calculated for TNI is 6.23 and the tabulated value remains as 2.36. Since, in the two cases, the calculated MSR is greater than the tabulated value, there is a significant difference ($p<0.05$) in the noise pollution level and TNI in the locations surveyed based on the data analyzed at 90% confidence level.

DISCUSSION

Computed values of noise level descriptors for the various sampling area surveyed: The environmental sound levels measured at a given location depend on a number of specific variables. In particular, many authors have found that the observed sound levels are mainly related to road traffic characteristics, and especially traffic volume, vehicle horns, rolling stock , vehicles which have not been properly maintained, etc. (Saadu *et al*., 1998; Amando and Jose, 1998; Mansouri *et al*., 2006). Several studies have demonstrated that the urban conditions of a given area are also a very important factor influencing the environmental noise levels (Nelson, 1998).

There is variation in the noise levels with the period of the day and the nature of the location. In general, there are high noise pollution levels (L_{NP}) in the daytime (6:30 am-10:00 pm), except in the residential areas where the majority of the residents are not always at home during the working days of the week; hence, the noise levels are low at residential areas (especially in low-density residential areas) in afternoon time. Figure 2 and 3 show the variations of noise pollution levels and TNI with location and period of the day. At commercial centers, road junctions, passenger loading parks, and high-density areas, both the L_{NP} and TNI rise from morning and reach peak values in the afternoon and evening to night time. The high noise pollution levels in the morning and evening at these locations can be justified as a result of morning rushing hours of office workers and business men and women, to resume work at offices and open shop for customers. The noise pollution levels in the afternoon time (11:30 pm-3:30 pm) at low-density residential areas are generally low. This is because the majority of the residents are not always available at home in the afternoon. Some are in their offices, markets, or shops while children are in their schools by this time of the day. Moreover, most of the low-density residential areas are developing areas,

The numbers of vehicles that ply the roads in these areas are very minimal. Blaring of horns is not much in these areas since fewer vehicles ply this road. At the time of this measurement, the highest and lowest LNPs and TNI respectively were 70 dB (A) and 53 dB (A) for Antem; 69 dB (A) and 54 dB (A) for Sikafoanbantem; 27 dB for Antem and 35 dB (A) for Sikafoanbantem. Antem road and Sikafoanbantem road each had 40dB(A) , (low-density residential area), busy roads and passenger loading were both found to be the noisiest sites with peak noise levels(L_{90}) of 84 dB (A). The high noise pollution values of these sites maybe a result of the noise produced by audio music shops and the proximity of these sites to the high traffic density on roads and presence of siren and unnecessary blowing of horns. Interestingly, the noise levels in all the locations surveyed were higher than the recommended level. The noise level was about 1to 15 dB (A) above the recommended upper limit stipulated by the Ghana EPA in all the locations surveyed (Table 1).

Perception of the respondents concerning the noise levels: About 82.1% of the respondents complained that the noise from the shops, traffic and horn blowing disturbs them. Some said it disturbs them and sometimes it does not allow easy communication since one has to shout for another individual to hear you. Others felt indifferent about the noise from the commercial activities. This group represents about 17.9%, and their reason was that they were used to these noise levels. They also indicated that since it is a commercial centre such noise is expected to be normal.

Days and time noise is produced most by the community: The distribution showed that about 50% of the respondents said that market days were noted for high noise levels because on these days most people from the nearby villages also come and trade. This increases both movement of vehicles and population of people within the town. Also since it's a weekend and most government workers don't go to work and so come and shop for all they need for the weekdays.

CONCLUSION

This study was carried out to evaluate the noise pollution levels in Kotokuraba commercial area of Cape Coast, Ghana. The focus was on five selected areas: commercial centers, road junctions/busy roads, passengers loading parks, high-density residential areas, and low-density residential areas. The investigation revealed that noise levels at all the 10 measurement points exceeded the Ghana EPA recommended upper limit by values of 1-15 dB(A). Hence, the present status of noise pollution in the city potentially poses a severe health risk to the residents. Furthermore, discomfort and irritation being caused by the pollution can drastically reduce productivity, both in public service and private sectors. In addition, some areas may soon reach the threshold of pains and possibly lead to permanent loss of hearing if noise pollution is left unchecked by the regulatory authority.

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