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EVALUATION OF SOUND ATTENUATION EFFECT IN RECORDING STUDIOS: CASE OF ANGEL FM STATION IN KUMASI, GHANA

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Abstract

Cities in developing countries like Ghana experience severe environmental noise pollution resulting predominantly from a blend of exponential increase in road traffic volume, industrial, commercial and residential activities that are associated with thick population trends. High levels of noise pollution can have detrimental effects on human beings. Buildings that house noise sensitive activities such as recording studios in city centres need to be designed to provide protection from high ambient noise levels that may interfere with speech communication. Cities and towns in Ghana have about one hundred and eighty Frequency Modulation (FM) stations that are invariably sited in the Central Business Districts (CBD) that happen to be in very noisy environments. The study investigated prevailing sound levels in the recording studio and associated spaces in an FM Station in Kumasi, the second largest city in Ghana. Data collection approaches involved monitoring of indoor and outdoor sound levels, interviewing of residents and workers of the community to assess their perception of noise levels. In addition measured drawings of the facilities and some observations were undertaken. The data was analysed within the context of the study objectives. Monitored sound levels were compared to set standards by World Health Organization (WHO). The WHO permissible ambient noise level limits of 45dB to 55dB and 55dB to 65dB for residential and commercial zones respectively were exceeded for all outdoor monitored values. However, the sound attenuating capabilities of the FM Station building maintains sound levels in the recording studios that are within permissible sound limits. It is expected that the findings of this study will contribute in assisting designers to make more objective design decisions at the preliminary phase of a studio building project, especially in very noisy urban environments.

Keywords: CBD, Ghana, Kumasi, noise, sound attenuation, sound level, recording studio.

Background

Technological breakthroughs and advancements in commerce, communication and education of the modern world have enhanced urban growth both in developed and developing countries (Gayathri et al, 20102). More efficient internet-based access gadgets like smart phones, I-pads and digital television among others have come to reduce the extensive dependence on devices such as fax machines, telegrams and fixed telephone lines to enhance information flow. However, one prominent tool, which has been present from ages past, and which can also be described as a pioneer in information flow is the FM Radio. It has been in existence for decades and has proven to be a very effective means of sharing information. It is still a relevant source of information today and hence its importance cannot be overemphasized. The design of a structure accommodating an FM Radio station involves many considerations. However, a studio's sound quality is its number one asset and plays a significant role which cannot be compromised within an urban environment exposed to noise pollution.

Many developing countries, such as that of Ghana, have experienced an exponential growth of population during the last two decades, which is causing an extensive escalation in urbanization, rapid increase of automobile use and energy consumption all of which collectively results in air quality deterioration (Aina *et al*., 1989; Montgomery, 1990; Carbajo and Faiz, 1994; Bharwana et al, 2014). Transportation systems have contributed significantly to the development of human civilization. On the other hand, transportation has an enormous impact on the ambient air quality in several ways (Mehboob and Makhshoof, 2008). Out of many environmental problems, road traffic noise pollution has emerged as one of the major urban environmental pollution issue and poses a new threat to the inhabitants of cities (Martin et al, 2007). Continuous exposure to high levels of noise can cause serious stress on the auditory, non-auditory, and the nervous system of city dwellers (Alam et al, 2006; Murthy and Khanal, 2007). Road traffic noise is a challenge for urban planners and environmental engineers to overcome in cities (Li et al, 2002). The main sources of noise pollution are Traffic noise, Community noise, Industrial noise (Nigam, 2008; Jamrah et al, 2006; Murthy and Khanal, 2007). Vehicular noise is produced by a combination of sources including engines, exhausts and tires, and is a source of harmful noise (Li et al, 2002). Moreover, the loudness of vehicular noise can also be affected by the condition and type of roadway, road grade, and the condition and type of vehicle tires (Baaj et al, 2001).

In Ghana, most FM stations are located within the central business districts of towns and cities and are near busy places such as bus terminals, market areas, busy roads, etc. Sound recording studios of FM stations in such environments suffer from noise that interfere and reduce the quality of sound that is transmitted. Recording studio of FM stations are sound-sensitive spaces and do not operate like any other building, as such their construction requires further details than the conventional mode of building design. This is only possible to achieve through what is known as "Sound Attenuation." Sound attenuation comprises methods and mechanisms that are aimed at reducing the sound or noise levels from a source to appreciable limits before it gets to a specified destination (Long, 2006). With this knowledge in mind, it becomes expedient and very necessary to design FM Radio premises such that they have the characteristics and the ability to eliminate or reduce the amount of noise that enters the studio space to the barest minimum.

This study is aimed at evaluating the noise level in various spaces of Angel FM in Kumasi. Specifically, the study investigates sound levels in the recording studio and associated spaces in the FM Station and the techniques and planning arrangements employed in design. It is expected that the findings of this study will assist designers to make more objective design decisions on studio building projects, especially in very noisy urban environments.

A perusal of the growth of FM stations all over the world, especially in the developing countries reveals a very high growth trend in the number of FM radio stations over the last few years (Doeven, 2013). In Ghana alone, the National Communications Authority gives the number of registered stations to be two hundred and twenty-five in operation with a lot still pending on their list awaiting accreditation (NCA, 2012). This affirms the relevance of information to the public, and the role FM radio stations are playing to fulfill this demand.

Noise has been conveniently and concisely defined as unwanted sound that creates annoyance and interferes in conversation, and can induce temporary or permanent hearing loss ranging from slight impairment to total deafness (Khan et al, 2002; Debnath et al, 2012). Noise greater than 90 dB in the mid night frequency has been reported by Ahmad (1997), to reduce the auditory sensitivity of listeners. However, the damage to hearing depends upon the exposure time and the intensity of noise. The International Standards Organization identifies noise levels of more than 85 dB as dangerous for the ears and exposures of 8 hours per day will produce permanent hearing loss after many years (Banerjee, 2009). The World Health Organization has recommended a nighttime average level of 35-40 dB for undisturbed sleep (WHO, 1999). Carter (1996) identified intermittent noise to create more interference to sleep than continuous noise. FM studios are considered to be quite zones to transmit clear sound to the audience, and this study assesses the FM studio environ as such with sound levels within the range of 20-25dB set by the World Health Organization. Permissible sound level limits for various zones at specified periods of the day are presented in Table 1.

Following this introductory background, the next (second) section discusses the general overview of the study area as well as sound attenuation features of Angel FM Station. The study approach and data collection methods as the third section also follow. The fourth section presents results and discussions. Conclusions and recommendation are then drawn to guide designers to make more objective design decisions at the conceptual phase of sound related building projects.

Table 1: Permitted noise level in different zones during different times of the day

Zone Ambient Noise Levels	Day-time (dB)	Night-time (dB)
Silent Zone	<50	<40
Residential Zone	<55	<45
Commercial Zone	<65	<55
Industrial Zone	<70	<70
Reception / Lobby	<35	<40
Recording Studio	<20	<25

(Source: WHO, 1999; EPA, 1996)

Study Area and Sound Attenuation Features of Angel FM Station

The surveyed environment is within Bantama Sub-Metropolitan Area of the Kumasi Metropolis in the Ashanti Region of Ghana (Figure 1), and includes multiple population trends with a blend of light-industrial, mixed residential and commercial facilities on either side of the roads, as well as heavy road traffic (Figure 2).

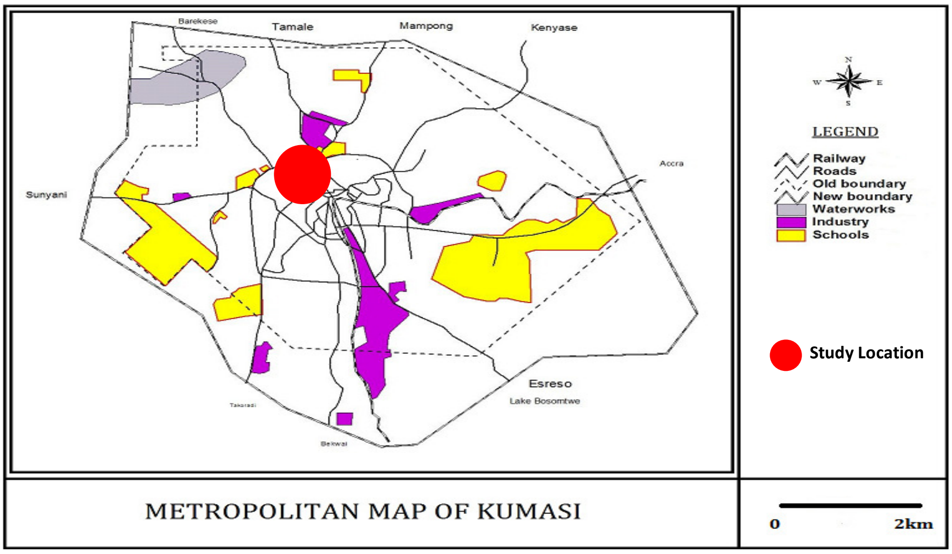

Figure 1: Study Location within the context of the Kumasi Metropolis
(Source: Kumasi Metropolitan Assembly, 2013)

(a) (b)

(c) (d)

Figure 2(a-d): Commercial and vehicular activities around the study area.

The building housing the FM station is situated on a corner site at the intersection of a dual carriage way and two other busy roads (Figure 3). The site is bounded on the southwest by the Abrepo Road and to the south east by the Western By-Pass. The Western By-Pass connects the Suame Magazine, which is a major mechanical hub that serves the city and the Sofoline Interchange. The Abrepo Road meets the Bantama High Street at the intersection. The Bantama High Street leads to the Komfo Anokye Teaching Hospital, a national referral and a teaching hospital. A bus terminal of the Metro Mass Transit Company is sited just 20 metres across the site.

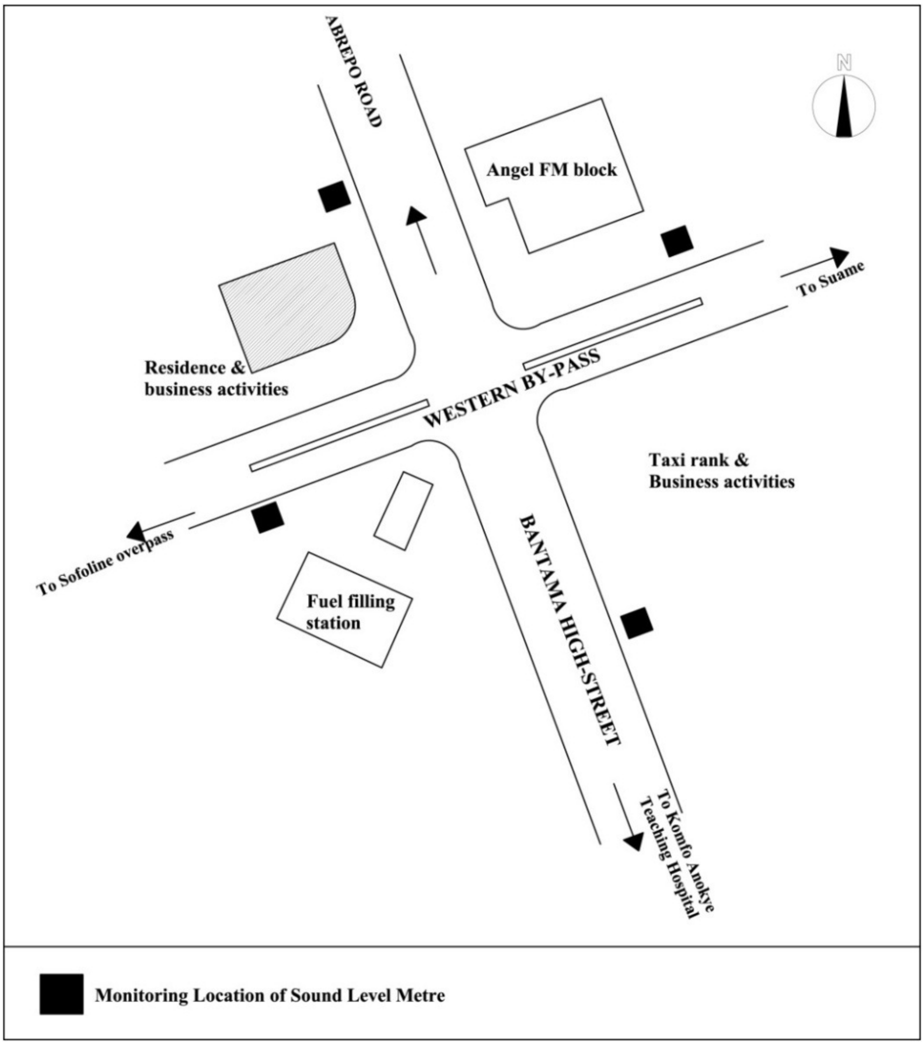

Figure 3: Layout of Study Area showing location of sound level meters

The area was originally zoned for residential use, but the current high land value assumed has lead to conversion of parts of most residential facilities into commercial use. Adjacent to the building housing the FM Station to the northeast and northwest ends are residential buildings that have their ground floors rented out for commercial activities with petty trading activities all around them. Opposite the FM Station and across the Western By-pass is a poorly controlled taxi rank and a variety of brisk commercial activities. A fuel filling station is sited diagonally across the intersection. All types of vehicles including private cars, heavy trucks, public transport, taxis, motor cycles, ambulances, tankers and many others ply the adjoining roads (Figure 1). The above listed facilities and activities on and along the adjoining roads to the FM Station serve as major source of noise pollution.

The FM station occupies the last two (2) floors of a three-storey building with the recording studios on the second floor (Figure 4). The ground floor is rented out for commercial use. The sound attenuating capability of the office spaces depends on the design of the premises and the details of the spaces (Long, 2006).Several useful architectural design considerations have been integrated in the design of the recording studio that compliments the acoustic treatment employed in the provision of the spaces. The recording studios which are the most essential spaces on the premises have been placed far from the reception that receives the highest level of outdoor noise, with the other office spaces serving as a barrier. The studio lobby is positioned to serve as a sound lock between the recording studio and the rest of the spaces.

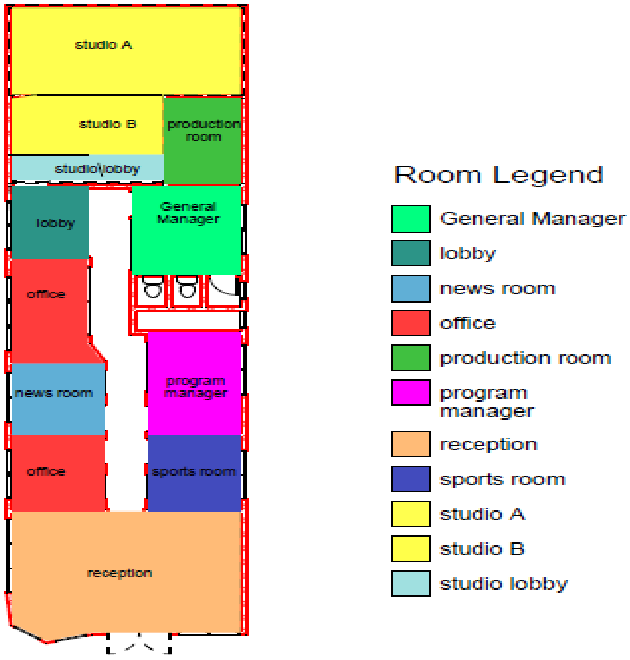

Figure 4: First floor plan of Angel FM with offices and recording studio

All the windows in the reception area are glazed to reduce the amount of noise that infiltrates the space. There are curtain drape on all the windows to help reduce the noise that comes into the space by means of absorption. The lobby also has very thick curtains and glazed panels to eliminate reflection of any sound that is generated within. There are no windows in the studio lobby to ensure very minimal infiltration of outdoor noise.

The recording studios have a variety of detailed measures to foster sound attenuation. They include the use of increased thickness of partitions, use of acoustic panels, acoustic foams, very thick sound blankets and glazed panels. There is the use of dropped ceilings that has been heavily padded to avoid transmission of sound from the upper floor into the studio. The floor of the studio has also been padded to eliminate any form of impact reflections from movement of people. The recording studios have no windows that may admit noise into the space (Egan, 1988). Heavier solid core doors are used for the recording studios to seal the space against transmission of noise the corridor and sound lobby which is well sealed. A conscious effort through design has been made with the above measures to curtail all sources of noise from outdoors.

Study Approach and Data Collection Methods

The key method employed in the study was empirical monitoring of outdoor and indoor sound levels. Secondary to the empirical quantitative assessment of the noise levels from the environment of the community of study, a social survey employing interviews was also conducted on the workers and residents on their perception of noise level in the community. This was motivated by the fact that, assessment of noise level must embrace both quantitative and qualitative approach to be seen as adequate. Observations and empirical measurements of spaces were also employed to aid the study.
Monitoring of sound levels were done daily over a two week period from the 26th December, 2012 to 10th January; 2013. Three sets of recordings were monitored for each day to cover different circumstances in terms of amount of traffic and the rate of commercial activities. Time periods covered morning (8:00-12:30 hrs), afternoon (12:30-16:00 hrs) and evening (16:30-19:30 hrs). A well calibrated PCE222 Digital Sound Level Meter, having a accuracy of +/-1.5dB and a measuring range between 30 to 130dBA was used to monitor sound levels (Baaj et al, 2001; Murthy and Khanal, 2007). Outdoor sound level was monitored during the day time at four locations on the crossroads bounding the site. Outdoor sound level measurement locations are presented in Figure 2. Sound levels were monitored from a point at a distance 3 metre from the curb side of roads studied (Pamanikabud and

Chaisri, 1999). Sound level meters were placed at a height of 1.6 m above ground level on an iron stand to avoid reflection of sound waves off the ground surface.

Indoor recordings were conducted at the reception, corridor, general manager's lobby and the studio lobby. Sound level monitoring in the studios were not possible because all the sound that is transmitted from the studios are simultaneously played back into the studio for feedback purposes. This made it difficult to isolate the background sound resulting from intrusion of noise into the studio space. Due to the inability to measure the sound levels in the studio, the sound levels in the studio lobby were used as a basis to assess the attenuation ability of the main studio.

Sound level was continuously monitored in each space with an interval of 2 minutes. The monitored data were filled in at the spot in pre-designed formats. At each location, monitoring of sound level was started at the same time and completed in a similar way. Raw data were pooled together for thirty minutes timeframes and classified as morning, afternoon and evening sound levels. Average sound level for each timeframe was calculated using the formula (Shahid et al, 2013):

$$Leq = 20 \log (1/N) \Sigma 10\ Lj/20 \ldots\ldots\ldots\ldots\ldots\ldots \text{Eqn. (1)}$$

Where N is the number of observations and Lj is the jth noise level.

The interpretation of noise levels and the cut-off level to which the measured sound levels were compared with the prescribed basic noise level during day-time in the different specified zones such as residential and commercial (Gayathri et al, 2012). In order to identify the magnitude of increased level of sound above the permissible sound level, the percentage increase was calculated and incorporated in the results. All the findings were then compared with the WHO standards and guidelines (WHO, 1999; EPA, 1996). The activities and equipment within the various offices were observed within the context of the research objective. The design of the offices with respect to the type, number, sizes and location of the doors and windows were studied alongside the size of office spaces, construction materials and mechanisms used in soundproofing or attenuating sound.

The first segment of the interview focused on personal and demographic data of the respondents. Respondents were also interviewed on the activities undertaken and their length of stay in the community. Information on residents and workers within the study was documented, whilst their views on sources, level and frequency of noise in the community was also sought. The last segment focused on their perceived level of exposure, disturbance and any adverse effect of noise.

Results and Discussions

Sound levels were monitored for outdoor and selected indoor spaces within the Angel FM station in three different time frames within a day. The selected spaces are the reception, corridor, managers lobby and studio lobby. The data obtained in the various spaces together with that of the outdoor are presented in Table 2. Computed mean sound levels in decibels of the maximum and minimum sound levels data monitored outdoors and in selected indoor spaces within the Angel FM station over the study period are presented in Table 3.

The observed mean values of outdoor for all the three time periods spanning morning to evening fell between 74 -77db. A low mean of 74.1 db occurred outdoor during morning time period and a high mean of 76 db during evening time period. The outdoor had a minimum sound level of 67.4 db and the maximum of 94.3 db which occurred during the morning and evening time periods respectively. With the area of study zoned as a residential area, the permissible ambient sound limit is 45 - 55 dB (WHO, 1999; EPA, 1996). This means the monitored sound levels exceeded the permissible limit in all time periods of the study. The observed high sound levels could be attributed to human activity, heavy traffic that floods the adjoining roads and increased commercial activity within the vicinity. Several types of vehicle ranging from private cars, public vehicles through to trucks and heavy duty ones use the roads. The mean outdoor sound values exceed the permissible limit by 34.9%, 36.0% and 39.5% for the morning, afternoon and evening periods respectively.

The environment has over the years been arguably transformed from a residential to commercial one with the introduction of business establishments, commercial banks and financial institutions, light industrial activities, petty trading and many others. Under this scenario, the permissible limit is 55 - 65 dB (WHO, 1999; EPA, 1996). This range has been exceeded by the observed sound levels with percentage increments of 14.0%, 15.1% and 18.0% for morning, afternoon and evening time periods respectively. The above figures may be typical of several other locations in the CBD of Ghanaian towns and cities, and for that matter in many developing countries.

Table 2: Patterns of sound levels in decibel for selected spaces of Angel FM Station at different time periods

Time (Hours)		Spaces									
		First Week					Second Week				
		Ot	Rc	Cr	M L	S L	Ot	Rc	Cr	M L	S L
Morning	8:30	69.14	61.8	51.1	43.6	23.8	74.73	65.9	53.8	44.9	25.3
	9:00	77.3	66.1	55.3	44.2	27.6	71.2	63.8	64	54.4	35.9
	9:30	71.8	65.6	54.4	45.5	22.3	71.5	65.5	65.6	55.4	35.8
	10:00	73.4	66.5	54.1	46.4	25.3	71.8	67.9	66.8	55.3	34.4
	10:30	74.7	66.2	52.6	46.1	26.1	72.7	68.2	66.8	57.2	36.3
	11:00	76.1	67.2	54.6	44.6	26.4	73.9	67.3	68	57.7	37.5
	11:30	77.1	66.3	53.6	44.3	26.5	74.8	67.7	66.8	56.7	36.8
	12:00	78.3	67.6	54.8	44.7	24.6	76.7	66.9	66.9	56.1	35.8
Afternoon	12:30	76.2	65	53.8	44	25.6	73.8	64	55.9	43.5	35.6
	13:00	74.4	66.2	52.3	45.7	25.7	75.5	65.7	55.3	46.3	33.9
	13:30	75.6	64.6	56.3	44.5	25.7	75.3	65	55.3	45.2	35.9
	14:00	75.6	66.3	55.4	45.4	25.3	74.6	65.4	55.6	43.7	36.6
	14:30	74.7	66.4	54.2	45.2	26.2	75.7	65.1	55.6	44.8	35.1
	15:00	73.9	66.5	55.4	45.8	25.7	75.2	65.2	55.8	46	35
	15:30	71.6	62.9	53.2	43.8	27.1	75.5	64.2	56	45.2	35.4
	16:00	75.4	65.9	55.6	44.7	24.4	74.2	66	53.8	44.3	35.3
Evening	16:30	71.7	67.8	53.8	44.9	25.6	73	66.8	67.1	54.8	36.8
	17:00	74	66.6	54	45.1	25.4	74.1	69.4	67	55.8	34.7
	17:30	75.3	68.1	53.7	46.3	25.3	75.5	71.1	65.9	54.3	36.8
	18:00	75.4	67.6	54.3	44.8	25.2	80.7	70.7	67.1	55.9	35.4
	18:30	77.4	68.8	54.1	45.3	25.2	77.5	72.7	67.3	54.9	37.2
	19:00	75.6	67.6	54.4	46.6	25.3	82.3	75.1	65.1	54.9	36.2
	19:30	77.4	68.5	54.3	45.9	25.3	84.3	74.6	63.2	51.7	31.5

Ot - Outdoor; Rc - Reception; Cr - Corridor; ML - Managers Lobby; SL - Studio Lobby

Table 3: Mean sound levels in decibel for selected spaces of Angel FM Station at different time periods. The values indicated in the parenthesis are the percent increase of sound level than the permissible level.

Time (hours)		Spaces				
		Outdoor	Reception	Corridor	Managers Lobby	Studio Lobby
Morning (8:30am-12:00)	Min	67.4	59.6	43.5	37.9	19.5
	Max	86.8	74.2	76.4	60.3	40.7
	Mean	74.1 *(14.0%)* *(34.7%)*	66.3	59.3	49.8	30.0 *(-14.0%)* *(-25.0%)*
Afternoon (12:30-16:00)	Min	70.5	61.5	51.3	41.0	21.2
	Max	83.4	69.7	59.9	49.9	40.1
	Mean	74.8 *(36.0%)* *(15.1%)*	65.3	55.0	44.9	30.5 *(-13.0%)* *(-24.0%)*
Evening (16:30-19:30)	Min	69.5	64.8	57.3	42.3	21.8
	Max	94.3	82.3	70.2	61.4	38.4
	Mean	76.7 *(39.5%)* *(18.0%)*	69.7	60.1	50.1	30.4 *(-13.0%)* *(-24.0%)*
Allowable Noise Levels for Spaces		< 55 (Residential) < 65 (Commercial)				< 35 (Day) < 40 (Night)

It can also be appreciated that sound level rises from morning through afternoon to evening. This could be attributed to activities that pick up during the course of the day.

Sound levels in the indoor spaces primarily reduced as sound proceeded from the reception through to the studio lobby. Sound sources within the premises can be attributed to two main sources - inherent noise generated inside the premises by the activities of staff and that generated from equipment.

The reception which has the highest exposure to the outdoor has a lowest mean of 65.3 dB and highest mean of 69.7 dB occurring during the afternoon and evening time periods respectively. A minimum sound level of 59.6dB was recorded in the reception during the morning time period and a max of 82.3 dB during the evening time period. The corridor recorded the next highest set of values with the lowest mean of 55dB and a highest mean of 60.1dB. The general manager's lobby was next with values of highest mean of 50.1db occurred during the evening time period. The studio lobby being the furthest from the reception and adjacent to the recording studios had the lowest recorded minimum, maximum and mean sound levels. The studio lobby had a minimum of 19.5 dB and a maximum of 40.7 dB both occurring in the morning time periods.

The studio lobby maintains a lowest mean sound level of 30 dB and a highest mean of 30.5dB, which gives an indication of the effectiveness of the sound attenuating mechanisms employed in its design. Sound levels in the studio lobby were maintained below the WHO set standards by 14%, 13% and 13% in the morning, afternoon and evening time periods respectively during the day. This can be attributed to the low level of activity in the studio lobby, its strategic location such that there is little sound penetration into this space, and the sound attenuating capability of the design. The maintained levels in the studio lobby implies that the recording studio, with its soundproofing techniques, could maintain sound levels less than 25 dB, which will be in compliance with the permissible range of sound limit for a recording studio of a maximum of 25dB (WHO, 1999; EPA, 1996). Soundproofing techniques employed in the recording studio includes increased thickness of partitions, heavily padded floor and dropped ceilings, and elimination of windows to curtail all sources of noise. Actual sound levels in the recording studio could not be monitored because sound that is transmitted from the studios are simultaneously played back into the studio, and makes it difficult to isolate and monitor intrusive noise into the recording studio.

It can be appreciated that in all the different time periods that sound levels were monitored, the sound levels reduced decreasing from a maximum mean in the region of 74.8dB occurring outdoors to less than 25dB within the recording studio.

A total of 34 respondents were involved in the qualitative interview. They including 3 workers of offices, 1 resident, 2 drivers, one each of commercial and private vehicles, and 1 station officer, 3 shop owners and 7 people involved in trading and hawking. Respondents indicated that they have lived and worked in the community on average between 5 to 10 years. They affirmed that they are indeed, on daily basis, exposed to high noise levels emanating from sources such as hawking activities, commercial cars, musical shops, delivery vans, passing ambulance vehicles and motor bikes. Consequently, they gave their assessment of the noise level as very high and unsatisfactory. The commercial (taxi) drivers interviewed indicated that they have been in the area for the last five years and also stated there is high level of noise in the area. Residents in the area indicated that having spent over 10 years in the area, the general noise level is found to be high in the morning, afternoon and late afternoon and occasionally during weekends when funerals are organized outdoors. The shop owners also gave an indication of unacceptable noise level in the area. Workers also gave an answer in the affirmative of experiencing high noise levels even in their office spaces. Generally, their assessment of the noise level was perceived as being very high. They also generally indicated that their offices, work places and homes did not have any form of insulation apart from the use of curtains in the window openings and doors.

Conclusion

The choice of the study was informed by the fact that even though FM stations have recording studios that are noise sensitive spaces, in Ghana, several of them are housed in buildings that are sited in very noisy environments within central business districts of towns and cities with high ambient noise levels that could interfere with speech communication. The objective of this study was to investigate prevailing sound levels in the recording studio and associated spaces in the Angel FM Station in Kumasi, Ghana. Monitoring of indoor and outdoor sound levels, measured drawings and observations were employed and data was analysed within the context of the study objectives. Monitored sound levels were compared to set standards by World Health Organization (WHO). The study revealed that high levels of noise pollution prevailed in the part city that was studied throughout the day with city dwellers being exposed to excessive noise levels higher than the WHO permissible limits. The prevailing ambient noise level exceeds the WHO permissible limits for residential zone by 34-40% and commercial zone limits by 14-18% respectively during the cause of the day. The sound lobby maintained sound levels below the WHO standards by about 13-14% and 23-24% during the daytime and nighttimes respectively. However, with the effective soundproofing techniques employed in the design of the studio such as increased thickness of partitions, heavily padded floor, dropped ceilings, and elimination of windows curtailed all sources of noise, sound levels within the range of the WHO set standards could then be maintained. The results of the qualitative interview indeed confirm the quantitative assessment of the noise level and thus could be suggested that there is perceived agreement on the noise types and levels experienced in the study area.

The following recommendations are outlined based on the findings to guide designers and the subsequent development of noise sensitive buildings, making them more cost effective with respect to sound attenuation:

- More research should be carried out to investigate the effects of ambient noise on other noise sensitive facilities such as auditoria, music centres, television stations and FM stations in different environments.
- There is the need to conduct further research on available acoustic materials so as to broaden the knowledge base of building designers on the extent to which noise-sensitive spaces can be protected. This would ensure that designers are not limited no matter the location where an investor or a client intends to put up a television, radio or an FM station.
- The Metropolitan, Municipal and District Assemblies should enforce laws and regulations to control land-use development to keep noise pollution levels within permissible limits.

It is expected that the findings of this study will contribute in assisting designers to make more objective design decisions at the conceptual phase of sound related studio building projects, especially in very noisy urban areas.

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