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A Survey of Noise Pollution in Ado-Ekiti Metropolis Using Mobile Phone

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Abstract

Noise is considered as the most pervasive pollutant, it constitutes the most disturbing among the city pollutants and is a serious urban crisis in Ado Ekiti metropolis. Noise pollution was monitored at five different locations in Ado-Ekiti, the capital town of Ekiti State of Nigeria. The study was done using a Virtual Instrument; a Sound Pressure Level mobile application installed on a mobile phone. The equivalent noise level using A-weighting was taken every fifteen minutes in each location between 6:00 am and 9:00 pm and the $L_{Aeq,T}$ of each location was calculated. Maximum $L_{Aeq,6h}$ of 105.40 dB was obtained in marketplace between 6:00 am and 12:00 pm while the minimum value of $L_{Aeq,6h}$ obtained for a residential area in the same period is 69.51 dBA. The residents are exposed to average noise levels of 75 - 98 dB (A) or more every day which is higher than the recommended value of 60 dBA by WHO. This is very dangerous to the health of the people in these areas, and the results obtained in this study are useful as reference and guideline for future regulations on noise limit to be implemented for urban areas in Nigeria.

Keywords

Noise, Pollution, Sound Pressure, A-Weighting, Equivalent Noise Level

1. Introduction

Noise generally, is an unwanted or undesired sound, as result of its loudness or because it is unpleasant and annoying or it is intrusive and distracting, the differentiation between wanted sound (music) and noise is greatly subjective. National Institute for Occupational Safety and Health (NIOSH) in 1991 described noise as any unwarranted disturbance within a useful frequency band; it is present in every human activity and is usually classified as either occupational noise or environmental noise. As a result of modernisation, people are being exposed to large amount of noise from industrial machines like generators, compressors; aircrafts and articulated vehicles.

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Noise from construction activities, household chores and social events can be excessive. Noise affects human being physically, psychologically and physiologically. Hearing losses (acoustic trauma, temporary hearing losses and permanent hearing loss) are the most common effects among the physiological effects [1]. Blood pressure increases, heart beat accelerations, appearance of muscle reflexes; sleeping disorders are few among the other physiological effects. Some of the psychological effects of noise are annoyance, stress, anger and concentration disorders as well as difficulties in resting and perception [2]-[4]. Noise as a pollutant is dangerous to man and the environment [5] [6].

Sound is the result of pressure variations, or oscillations, in an elastic medium, generated by a vibrating mechanical system. It propagates in the form of longitudinal waves, which consists of a succession of compressions and rarefactions in an elastic medium. When a sound wave propagates in air, the oscillations in pressure are above and below the ambient atmospheric pressure. Sound waves which consist of a pure tone only are characterised by sound pressure amplitude "p" measured in Newton per square metre (N/m^2) or Pascal (pa), wavelength "λ" measured in metre (m) and frequency "f" measured in Hertz (Hz). Sounds encountered in nature are not pure tones; they are generally complex mixtures of pressure variations that vary with respect to phase, frequency, and amplitude. The total sound energy emitted by a source per unit time is the sound power, *W*, which is measured in watts. Sound intensity is a measure of the rate of power transmission through a surface normal to the direction of its propagation; it is expressed as watts per square metre (W/m^2). When there is no reflected sound wave and at a location away from any sound sources, the intensity of sound from a source is related to the root mean square of sound pressure as follows:

$$I = P_{rms}^2 / \rho c \tag{1}$$

where ρ is the density of air measured in kg/m^3, and c is the speed of sound in m/s. The quantity, c is called the "acoustic impedance". If a source of sound is producing uniform spherical waves, the Intensity of sound produced at distance r from the source is given by:

$$I = W / 4\pi r^2 \ . \tag{2}$$

Thus intensity of sound varies as the square of root-mean-square value of sound pressure and inversely as the square of distance from the source sound [7].

1.1. Sound Pressure Level

The minimum acoustic pressure audible to the young human ear judged to be in good health is approximately 20×10^{-6} Pa. The minimum audible level called the threshold of hearing. For the normal human ear, pain is experienced at sound pressures of the order of 60 Pa, this level is the threshold of pain. The Bel which is the logarithm of the ratio of two quantities, one of which is a reference quantity is employed in sound measurement: to avoid a scale which is too compressed over the sensitivity range of the ear, the decibel is introduced. The sound pressure level (SPL), in decibels (dB); which is often measured with a sound level meter, is obtained from the equation:

$$SPL(\mathrm{dB}) = 10\log\left(P_{rms}^2 / P_{ref}^2\right) \tag{3}$$

where the reference sound pressure is P_{ref}. P_{rms} is the root-mean-square of the sound pressure being measured, when the threshold of hearing is made the reference, it corresponds to *SPL* of 0 dB, while the *SPL* at the threshold of pain is about 130 dB.

The degree of loudness of any sound above the threshold of hearing is a subjective interpretation of sound pressure level or intensity. Loudness level is expressed in phons, which have the same numerical value as the sound pressure level at 1000 Hz. Pitch is the subjective response to frequency. Sounds of low frequencies are described as "low-pitched", while sounds of high frequencies are said to be "high-pitched". Since the human ear is not equally sensitive to sound at different frequencies, in order to adequately evaluate human exposure to noise, sound measuring system should be able to account for the difference in sensitivities over the audible range. Therefore frequency weighting networks, which are "filters" have been developed, they "weight" the contributions of the different frequencies to the over-all sound level, so that sound pressure levels are adjusted as a function of frequency before being combined together to give an overall level. There are three international

standard weighting networks in common use, these are “A”, “B” and “C”; the “B” network is no longer used in noise evaluations ; when frequency weighting networks are used, the measured noise levels are expressed as dBA or dBC.

1.2. Noise Measurement and Control

The most common measurement in environmental noise is the sound pressure level which can be measured with a Sound Level Meter having an A-weighting filter to simulate the subjective response of the human ear. Industrial and environmental noise often fluctuates, the equivalent sound level ($L_{\mathrm{Aeq,T}}$) (or average sound level L_{AT}) is the steady sound pressure level which over a given period of time T, has the same total energy as the actual fluctuating noise. $L_{\mathrm{Aeq,T}}$ is calculated from:

$$L_{\mathrm{Aeq,T}} = 10\log\frac{1}{T}\int_0^T\left(\frac{p(t)}{p_{ref}}\right)^2 \mathrm{d}t \tag{4}$$

where $p(t)$ is the time-varying sound pressure. The simplest instrument for measuring $L_{\mathrm{Aeq,T}}$ is an Integrating Sound Level Meter, which performs the averaging over the entire period. However the period T, can be split into a number of subintervals N, each of period T_i and $L_{\mathrm{Aeq,T}}$ can be calculated as follows:

$$L_{\mathrm{Aeq,T}} = 10\log\frac{1}{T}\sum_{i=1}^{N}\left[T_i \times 10^{\left(\frac{L_{\mathrm{Aeq,T}}}{10}\right)}\right] \tag{5}$$

The limitations of traditional method for collection of noise data at a sparse set of locations hence the development of wireless sensor networks (WSN) for environmental monitoring [8] and urban sensing [9]; in recent time, a novel approach to noise pollution monitoring involving the use of mobile phones had been reported [10].

The widespread appreciation of harmful effects of noise in developed countries, has led to the introduction of protective measures against noise pollution. The maximum noise exposure for workers in U.S.A. is 90 dBA [11] [12] for one 8-h period which should be followed by at least 10 hours of 65 dBA [20], in the U.K it is 85 dbA for 8-h period, while in Turkey, the limit is less than 75 dBA for 7.5-h period [13] [14]. Generally, minimum noise exposure is less than 85 dBA, noise exposure between 85 and 90 dBA is moderately high, while noise exposure above 90 dBA is high [15] [16]. In Nigeria, the problem of noise pollution is wide spread. Several studies report that noise level in metropolitan cities exceeds specified standard limits. A study by [17] conducted in Makurdi, Nigeria found that the noise pollution level in the city was about 3 dB(A) to 10 dB(A) above the recommended upper limit of 82 dB(A). [18] also found that the peak noise level at road junction in Abraka, Nigeria to be 100 dB(A). This noise level is higher than the recommended level of 60 dBA for commercial and residential areas. A similar result was reported by [19].

Ado Ekiti became the capital town in 1996; when Ekiti state was created out of Ondo state by the Federal Government of Nigeria. Since then, the town has been passing through many phases of development; this has contributed to an increase in the level of environmental noise over the years. This study investigated the noise level in Ado Ekiti metropolis, using mobile phones as a quick and cheap means of collecting accurate noise data.

2. Materials and Method

Ado-Ekiti is located between latitude 7˚34'N to 7˚44'N and longitude 5˚12'E and 5˚16'E, it has a population of 2,384,212 according to 2006 census. The locations used for the study are King’s market, Bisi market, Ijigbo roundabout, Falegan area and NTA road. The markets are the most popular in the town where commercial activities take place on daily basis, they are located close to major roads in the town. Ijigbo roundabout has been a busy area in the town even before the creation of Ekitistate, it is on the major road that links Ado Ekiti with Akure the capital town of Ondo state.The other two locations are residential areas, in the eastern part of the town, located far away from the major roads. The locations are labelled A, B, C, D and E respectively in **Figure 1**.

A sound Pressure Level mobile application by BorceTrajkovski, was downloaded from Google store and installed on a mobile phone; Tecno P3 (android version 2.3.5). The settings used for measurement are shown in **Table 1**.

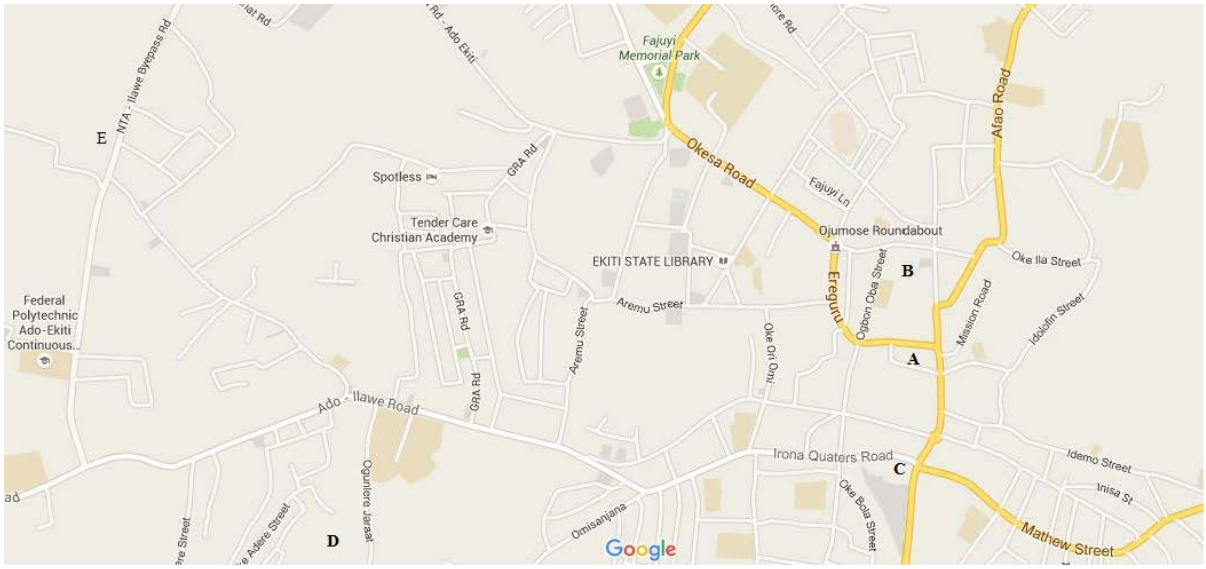

Figure 1. Map of the study area obtained from Google map.

Table 1. Settings of parameters used for measurement.

Parameters	Settings
Meter fall-off speed	100 ms
Average interval between measurement	1 s
Sampling rate	High
Weighting	A
Automatic Gain Control	By-passed
Microphone	Enabled

The application was launched on the phone in a quiet office and in a room in a quiet residential area for the purpose of calibration. The period of measurement was divided into three sections: 6:00 to 12:00, 12:00 to 18:00 and 18:00 to 21:00. Readings of average noise level were taken every fifteen minutes with the mobile phone held at ear level in each of the locations. Equivalent noise level for each location, in each section was calculated using Equation (5).

3. Results

Values of average noise level measured at the locations every fifteen minutes in each section are shown in **Figures 2-4** respectively.

The average noise level for each location in the sections is presented in **Table 2**.

4. Discussion

Average noise level in the three major Markets in the city ranged from 93.33 to 105 dBA, 89.65 to 97.30 dBA and 89.89 to 92.3 dBA during the morning hours (6:00-12:00), afternoon hours (12:00-18:00) and evening hours (18:00-21:00) respectively. Noise in the markets is mostly from horns of vehicles, sound from loudspeakers of hawkers of different kinds of goods and noise from conversation between people. As a result of the high level of background noise, traders have to shout to make themselves heard by customers. This accounts for the high level of equivalent noise level in the markets from morning till evening (6:00 to 18:00) compared to the residential areas as shown in **Table 2**. The average noise level in the three residential areas under study in the city ranged from 81.75 to 96.04 dBA, 75.1 to 89.65 dBA and 85.71 to 98.09 dBA during the morning hours, afternoon hours and evening hours respectively. The noise level is higher at Ijigbo roundabout compared to other residential areas because it is at the heart of the city. Noise in this location, is caused by vehicles and commercial activities,

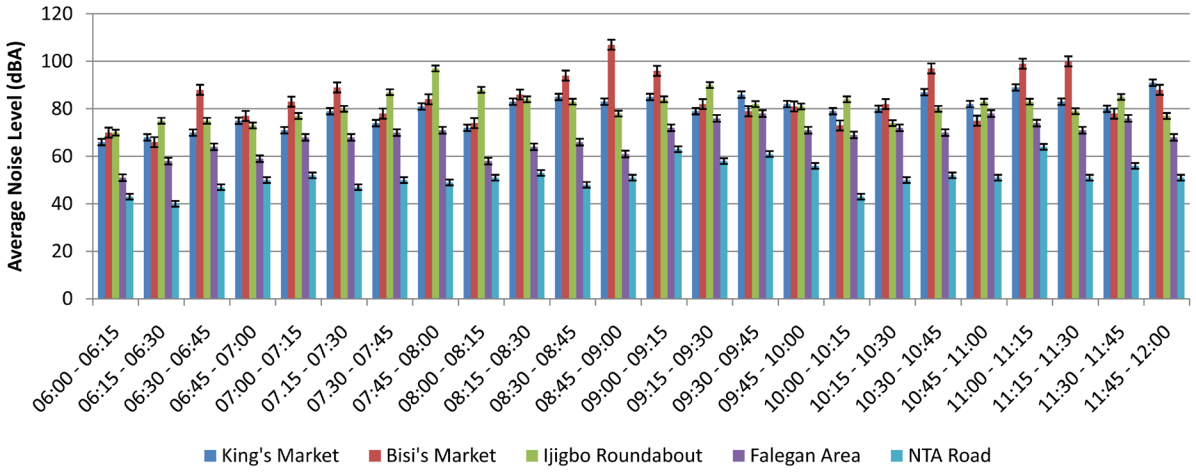

Figure 2. Average noise level at the locations from 06:00 and 12:00.

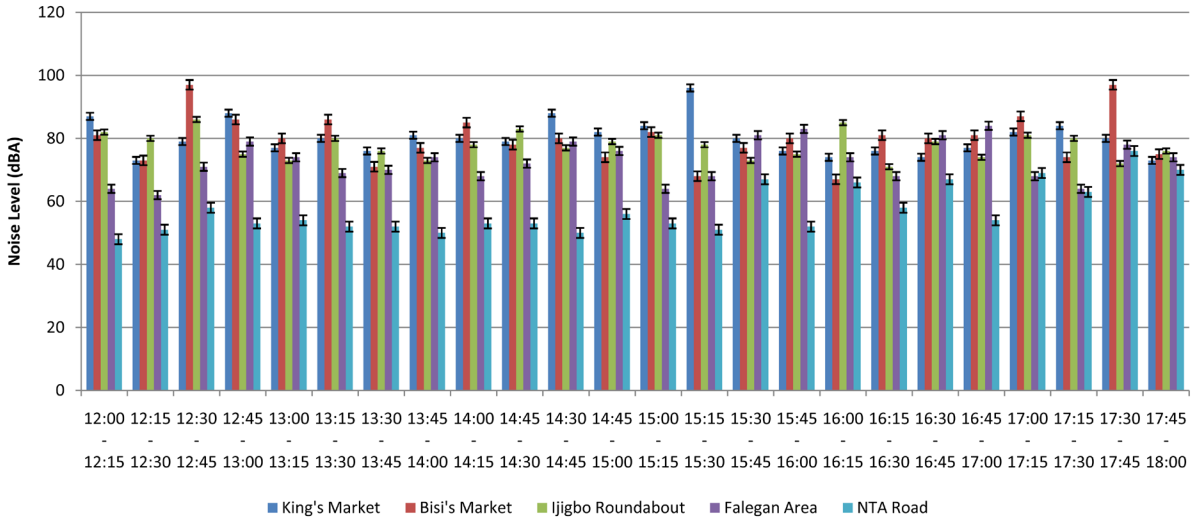

Figure 3. Average noise level at the locations from 12:00 and 18:00.

however between 6:00 to 9:00, and 18:00 to 21:00, the place is used as Motor Park by transporters; the frequency of traffic is also higher during these periods due to movement of commuters to and from their places of work, this is responsible for higher noise level in this location both in the morning and evening than in the afternoon. Noise levels in the residential areas are higher than the recommended values of 55 and 70 dbA for interior and exterior limits respectively according to the US Federal Highway Administration (FHWA) as presented in **Table 2**. Traffic noise, other intrusive noise sources; noise from record players, loud speakers, hawking and human conversation, power generators is usually high in the evening may contribute majorly to environmental noise pollution in the residential areas. This is not peculiar to Ado Ekiti alone, many authors have found that the observed sound levels are mainly related to road traffic characteristics, and especially traffic volume, vehicle horns, rolling stock and tires, unmuffled vehicles, etc. [22]-[24]. The high level of noise in these areas is as a result of improper planning or failure to comply with government regulations by residents; many commercial and some industrial activities do occur in these areas thereby increasing the background noise level.

The residents are exposed to noise levels of 75 - 98 dB (A) or more every day. This is very dangerous to the health of the people in these areas. According to the World Health Organization, generally 60-dB (A) sounds can result in temporary hearing impairment and 100 dBA sounds can cause permanent impairment [25]. In developing countries industrialization is not always accompanied by protection, data of noise pollution and control are scarce, and average noise levels are well above the recommended values of many developed nations. In

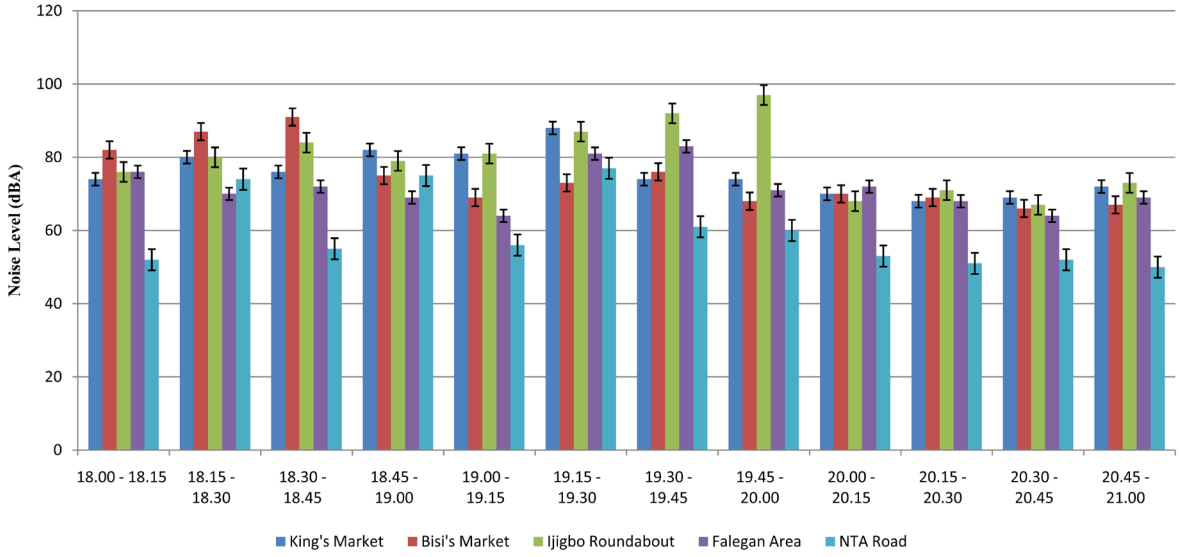

Figure 4. Average noise level at the locations between 18:00 and 21:00.

Table 2. Values of average noise level for the locations in Ado Ekiti.

Locations	Time of Measurement		
	6:15 hr-12:00 hr	12:15 hr-18:00 hr	18:15 hr-21:00 hr
	Average (dbA)	Average (dbA)	Average (dbA)
King's Market	93.33	94.98	89.89
Bisi Market	105.40	97.30	92.30
Ijigbo Roundabout	96.04	89.65	98.08
NTA Road	85.71	75.10	79.64
Falegan Area	81.75	86.78	85.71
Average	92.45 ± 9.24	88.76 ± 8.70	89.13 ± 6.94

Nigeria, people do not pay attention to the seriousness of noise pollution and its consequences hence the exposure to high noise level every day [20]. "As regards the statutory control of noise, it is surprising that there exists no law under the Nigerian legal system exclusively, dealing with the problem of noise or its control" [21]. The noise level values obtained in this study compare well with reported values from Nigeria and other countries of the world [25]-[29].

5. Conclusion

This study reveals that the noise levels measured at the locations exceeded the recommended limit of 60 dBA (**Table 3**). This study has been able to show that noise levels in the selected locations are generally high; this 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 lead to permanent loss of hearing and death as suggested by [25]. A number of action plans can be taken to abate the environmental noise pollution in Nigeria. People are not expected to spend more than four hours per day in the markets; those whose major sources of income involve selling in these markets may consider the use of ear protective devices. Awareness about harmful effects of noise among people is very low, hence the generation and exposure to excessive noise. Further research work is in progress in order to

Table 3. FHWA noise standards [28].

S/no	Land Use	Noise Level (dbA)	Description of Land use category
1	A	60	Parks and Open Spaces
2	B	70	Residential area, Hotels, Schools, Libraries, Hospitals etc
3	C	75	Developed area
4	D	55	Residential area, Hotels, Schools, Libraries, Hospitals etc

have an accurate noise map of Ado Ekiti metropolis.

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