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*Keywords :* *noise pollution, electric generators, work environment.*

*GJMR-K Classification :* *NLMC Code: WA 776*


*Strictly as per the compliance and regulations of:*

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*Conclusion:* Public enlightment on use of ear plugs and ear muffs while working in this commercial areas is advocated.

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## I. Introduction

Noise is derived from the Latin term nausea. It is an inescapable part of everyday life and can be defined by various ways, but essentially it can be described as "wrong sound, in the wrong place at the wrong time" (Thompson, 1994). A major distinction between sound and noise is that sound is regarded as noise when it becomes a source of inconvenience to another individual. Noise is a number of tonal components disagreeable to man and more or less intolerable to him because of the discomfort, fatigue, disturbances and, in some cases, pain it cause (Singh and Davar, 2004).

Noise originates from human activities, especially during urbanization and the development of transport and industry. Noise is becoming an increasingly omnipresent, yet unnoticed form of pollution even in developed countries. According to Brigitte and Lindvall (1995), road traffic, construction equipment, manufacturing processes, and lawn mowers are some of the major sources of these unwanted sounds that are routinely broadcasted into the air.

Increase in vehicular traffic is a source of noise pollution around the globe especially in most urban cities around the world. Traffic related noise pollution accounts for nearly two-third of the total noise pollution in an urban area (Birgitta and Lindvall, 1995), other sources include jet planes, garbage trucks, construction equipments, manufacturing processes and lawn mowers. Any sound which is annoying or level of sound exceeds 75 dB (A) may be conceived as noise. The threshold for noise annoyance varies. It depends on the conditions, including the sensitivity and mental state of an individual (Mokhtar et al., 2007). Generally, noise can create negative emotions, feeling of surprise, frustration, anger and fear.

According to Maduemezia (2002), noise pollution is one aspect of environmental pollution that is taken rather lightly in Nigeria. He asserted that greater part of the sources of noise in the society is of a social origin. However, noise, as a polluting agent in the environment, has been recognized in recent years as a serious threat to the quality of life enjoyed by people in most industrialized nations (FTA, 1995). In developing nations, however, noise pollution has not been seen as dangerious and having adverse effect on the life of the people (Abumere et al., 1999). This is probably the reason why not much research into environmental noise pollution has been carried out within Nigeria cities.

Electric energy occupies the top grade in energy hierarchy as it finds innumerable uses in homes, industry, agriculture, and defense and of course in some nations, transportation. Nigeria's electricity power situation is very poor because of erratic power supply. As a result there is an upsurge in the use of electricity generating plant with its attendant noise pollution on the environment and human health (Akande and Olonge, 2001). Most workplaces and homes use generating plants 24 hours in alternative to power supply. The noise

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from generated plants in Nigeria coupled with its accompanying smoke emission to the sky which has greatly contributed to the breaking of the ozone layer in the sky (Deepak, 2009).

Occupational noise is considered to be a major cause of adult-onset hearing loss worldwide (Nelson, 2005). Workers across the world are at risk of hearing loss due to the presence of a high level of noise at their workplaces (Verbeek et al., 2009). In USA, more than 30 million workers (almost 1 in 10) are exposed to unsafe noise levels on the job (McReynolds, 2005). In Europe, about 35 million people are exposed to detrimental noise levels (> 85 dB-A) in industrial plants (Sulkowski et al., 2004). A recent study in Nigeria reported high levels of occupational noise (>90dB) among traders and 100% of workers exposed for a period of 14 years developed hearing impairment (Ighoroje et al., 2004 and Bisong et al., 2004).

However, the Federal government of Nigeria formed the Federal Environmental Protection Agency (FEPA) back in 1990 and entrusted it with the responsibility of law formulation, control and regulate impact of noise in the country (FEPA, 1991). Unfortunately, the impact of FEPA is yet to be felt (Onuu, 1999). Very few reports of noise pollution studies are available in Nigeria. This study is considered necessary because it would allow a comparison of the measured levels with known levels already considered safe for man according to WHO guideline limit. According to this guideline, the recommended noise levels in commercial environment should be 65-70 dB (A).

Therefore, an assessment of the work environment noise levels and development of risk map for noise in these commercial locations would help focus future government interventions in the area of noise abatement in these areas. Furthermore, it would serve as information for people working in these areas so as to take necessary precaution towards protecting themselves from the adverse effect of noise

## II. Materials and Methods

This study was conducted in Agbowo and Ajibode business areas of Ibadan, Nigeria after proper compulsory ethical review by the University of Ibadan (UI) and University College Hospital (UCH) Ethical review committee, Ibadan. Participants in these business locations were duly informed and consent was obtained. This study also went through proper required institutional review board procedures at the College of Medicine, University of Ibadan prior to its initiation.

### *a) Study Design*

A comparative cross-sectional design was used which involved repeated field measurements of environmental noise levels at specific recorded geographical coordinates and the development of risk map for noise using the google earth software package.

### *b) Study Area*

Agbowo and Ajibode are both located in Ibadan, the capital of Oyo State in Nigeria. Ibadan, one of the largest metropolitan cities in West Africa, is a primarily indigenous city with millions of inhabitants, most of which are Yoruba; other ethnic groups constitute smaller proportions of the population. The Agbowo business area is situated directly opposite the University of Ibadan and is a high commercial activity area encouraging small scale businesses (Tomori, 2006). The Ajibode business area is also at close proximity to the University of Ibadan campus, but experiences relatively lower daily business activity.

### *c) Study Site*

The shops in Agbowo and Ajibode were each classified into three similar study sites based on the nature of the surrounding environment, they include; enclosed shops (EC), roadside shops (RSS) and single street shops (SSS). This was done to ensure that noise all other environmental noise sources were put into consideration.

### *d) Survey*

An observational checklist was used to collect data on other environmental noise sources located outdoors and indoors in the classified locations as stated above. Information on the number of shops and workers were also obtained using the observational checklist. (Data not reported).

### *e) Traffic Density Estimation*

This was obtained by manually counting the number of vehicles every 15 minutes within a one hour time interval between 6-8am, 11am-1pm, and 4-6pm. The obtained number is then multiplied by 4 to obtain the hourly traffic density. Information on the types of automobiles observed in Agbowo and Ajibode were also noted.

### *f) Noise Measurements*

The environmental noise levels in the classified locations were measured using a factory calibrated TECPEL Model 330 series sound level meter (SLM), which was set at the slow response mode with A-weighting (A-weighted decibels or dBA). Measurements obtained was compared with the International norms (WHO recommended sound levels) . Measurements were obtained at three sampling points outdoors (identified hereafter as L1, L2, and L3) within each of the surveyed business locations. Three complete sets of sound level measurements were taken:

- One complete set of measurement before the start of commercial activity (6-8am).
- One complete set of measurement at the peak of commercial activity (11am - 1pm).
- One complete set of measurement at the close of commercial activity (4-6pm).

i. *Frequency of Noise Measurements*

Noise readings were obtained at 10 minute Intervals. The outdoor noise level measurement was carried out for three days weekly for a period of three months for both groups. Noise levels were obtained from sampling points L1, L2 and L3 on Monday, Wednesday and Saturday.

ii. *Noise Measurement at Worker Position*

A noise assessment form was used to obtain information on the hours spent at work as well as the noise level at the position of worker. A sound meter was positioned at 10 and 30cm from the worker's ear to obtain the actual noise level filtering into the ear. The sound level meter was set at slow and measurements were done in A-weighting scale. The noise levels obtained at 10cm and 30cm were summed and the average was obtained as the mean noise level at which the worker was exposed to at work.

*g) Development of Risk Map for Noise in the Classifed Business Locations*

A hand-held, battery-powered factory calibrated gamin GPS was used to determine the geographic coordinates of the sampling points in classified locations in Agbowo (AG1-AG3) and Ajibode (AJ1-AJ3) for noise level assessment. The coordinates of the locations which appeared on the display screen of the GPS after signal is acquired from the satellite in space were recorded and then inserted into a Google Earth Software package to develop the risk map. The risk map was interpreted based on the mean noise level measured for each of the classified commercial locations in Agbowo (AG1, AG2 and AG3) and Ajibode (AJ1, AJ2 and AJ3).

| | |
|---|---|
| High Risk | 80 – 90 dB(A) |
| Medium Risk | 70 – 80 dB(A) |
| Low Risk | 60 – 70 dB(A) |

*h) Statistical Analysis*

Data were entered into Microsoft Excel and then managed and analyzed using the Statistical Package for Social Sciences (SPSS) version 15. Data were analyzed using descriptive statistics, Chi-square, T-test, MANOVA and logistic regression with a 5% level of statistical significance.

## III. Results

*a) Identified Environmental Noise Sources*

In Ajibode, all three classified locations (AJ1-3) recorded low number of generators as compared to Agbowo where AG1 and AG2 recorded the presence of greater than 25 generators. Other noise sources such as music recording houses, automobile and motorcycles and religious centres showed variation in their numbers across the classified locations in Agbowo and Ajibode commercial areas. See table 3.1 for details.

*b) Traffic Density Estimation*

A significant difference in the number of vehicles across the sampling time frame were observed for Agbowo and Ajibode commercial areas respectively. Generally, Agbowo had high traffic counts/hour (2760, 3175, 3992) across the sampling time frame as compared with medium range traffic counts/hour in Ajibode (804, 819, 694). Automobiles observed included; Motorcycles, cars, trucks and buses but variation occurred in the density/volume. See Table 3.2 for details.

*c) Noise Measurements*

The mean noise level in Agbowo was 78.5 ± 3.9 dB (A) which significantly exceeded the WHO standard (60-70 dBA) as compared to the mean noise level in Ajibode 65.7 ± 4.4 dB (A).

i. *Daily Noise Levels*

At 6-8am; the highest mean noise levels recorded in Agbowo (70.5dBA) and Ajibode (60.8dBA) were obtained on Saturday and Wednesday respectively. At 11am-1pm; the highest mean noise levels recorded in Agbowo (93.7 dB) and Ajibode (90.3 dB) were obtained on Wednesday and Saturday respectively. At 4-6pm; the highest mean noise levels recorded in Agbowo (80.8 dBA) and Ajibode (82.8 dBA) were both obtained on Wednesday. See Figures 3.1, 3.2 and 3.3

ii. *Noise Levels per Location*

In Agbowo; Enclosed location had the highest mean noise level (98.7dBA) as compared to roadside (80.4dBA) and street (69.2dBA) locations. In Ajibode; Roadside location had the highest mean noise level of 81.7dBA as compared to Enclosed (98.7dBA) and Street (72.8dBA) locations. See figure 3.4 for details.

*Table 1.0 :* Major Sources of Environmental Noise in Classified locations in Agbowo and Ajibode

| Commercial Area | Location | Number of electric generators | Sources of Noise | | |
|---|---|---|---|---|---|
| | | | Car | Music Houses | Motorcycles |
| Agbowo | AG1 | ≥ 25 | Low | High | Low |
| | AG2 | ≥ 25 | High | None | High |
| | AG3 | < 25 | Low | Low | Low |
| Ajibode | AJ1 | < 25 | None | Low | None |
| | AJ2 | < 25 | Low | None | High |
| | AJ3 | < 25 | Low | High | Low |

*Table 2.0 :* Traffic Counts (density) during sampling period

| LOCATION | TYPES | 6am – 8am | | 11am – 1pm | | 4pm – 6pm | | p-value |
|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | |
| Agbowo | Motorcycle | 951.6 | 482.3 | 1397.1 | 651.6 | 1571.4 | 789.6 | P=0.000 p<0.05 |
| | Cars | 1423.4 | 705.6 | 1829.8 | 514.1 | 2001.2 | 554.2 | |
| | Truck | 32.9 | 20.1 | 84.9 | 50.71 | 47.6 | 24.2 | |
| | Buses | 351.7 | 135.7 | 403.8 | 167.8 | 373.4 | 125.0 | |
| Ajibode | Motorcycle | 201.7 | 69.7 | 550.5 | 201.2 | 222.9 | 150.7 | P=0.000 p<0.05 |
| | Cars | 564.2 | 221.4 | 177.3 | 60.9 | 409.8 | 150.6 | |
| | Truck | 15.4 | 7.9 | 33.7 | 14.9 | 40.8 | 26.2 | |
| | Buses | 22.9 | 10.5 | 57.9 | 20.6 | 20.7 | 12.8 | |

*SD: Standard deviation*

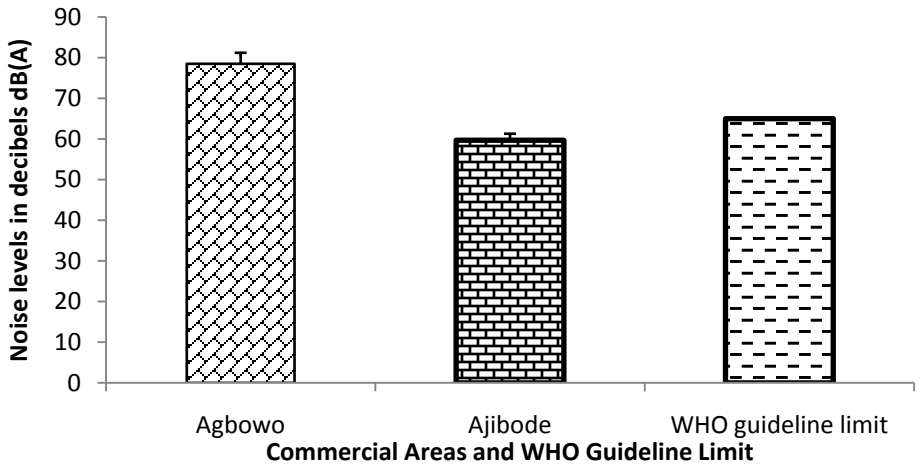



*Figure 1.0 :* Mean Noise levels in Agbowo and Ajibode compared with WHO guideline Limit.

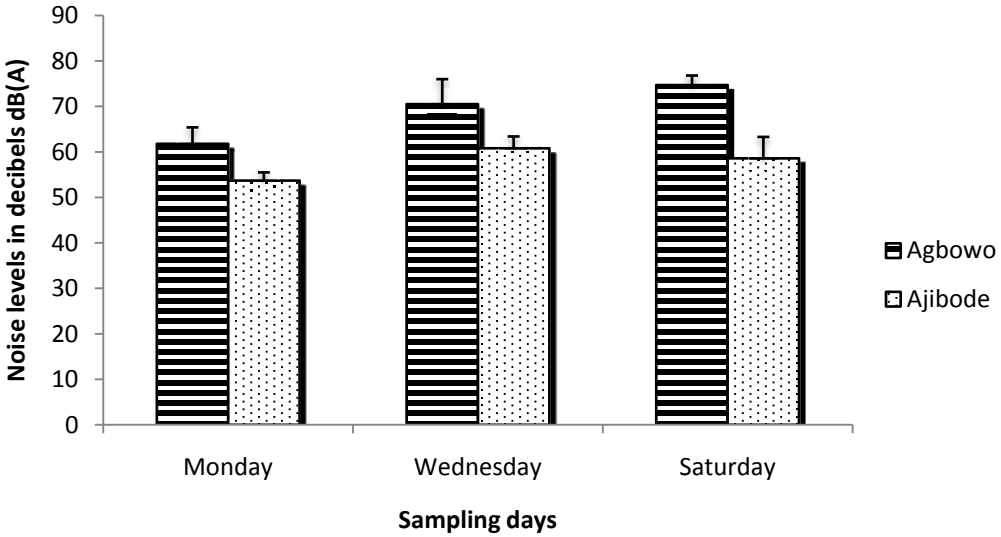



*Figure 2.0 :* Mean noise levels between 6am – 8am at Agbowo and Ajibode during a three day sampling period

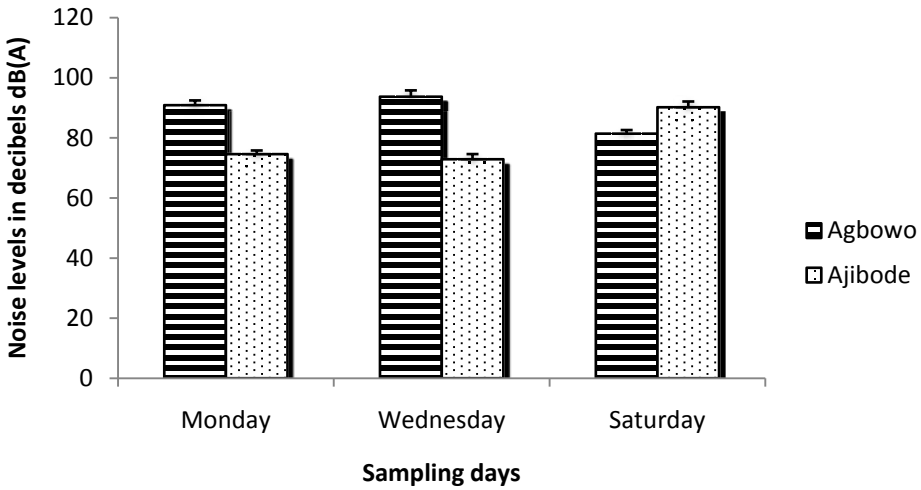



*Figure 3.0 :* Mean noise levels between 11am – 1pm at Agbowo and Ajibode during a three day sampling period

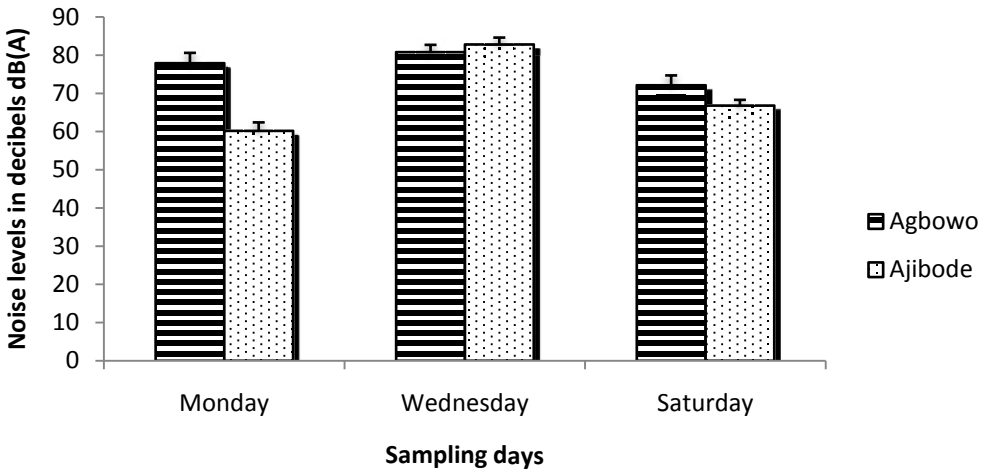



*Figure 4.0 :* Mean noise levels between 4pm – 6pm at Agbowo and Ajibode during a three day sampling period

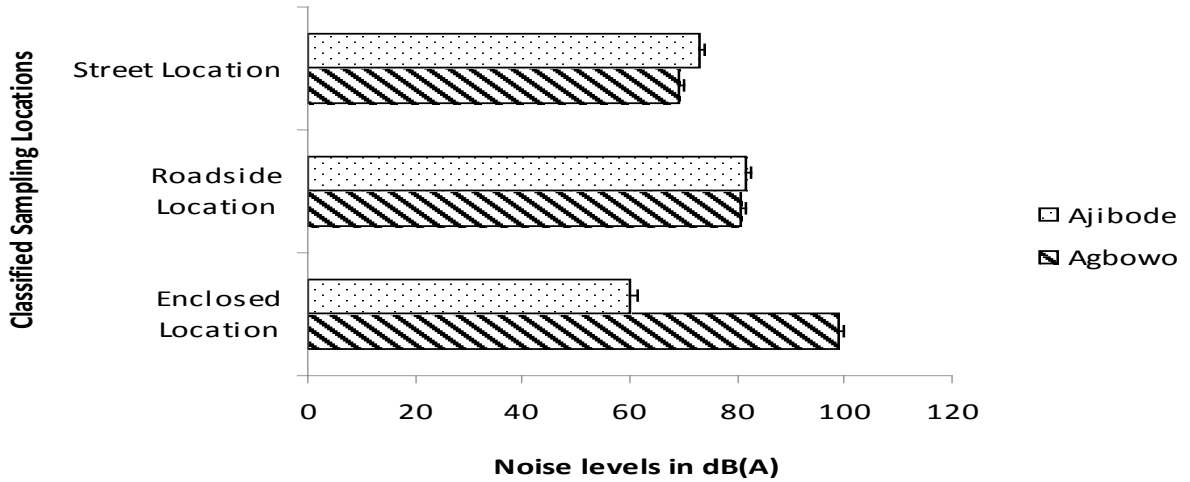



*Figure 5.0 :* Mean noise levels at the three sampling points in Agbowo and Ajibode

*d) Noise levels at Workers Position*

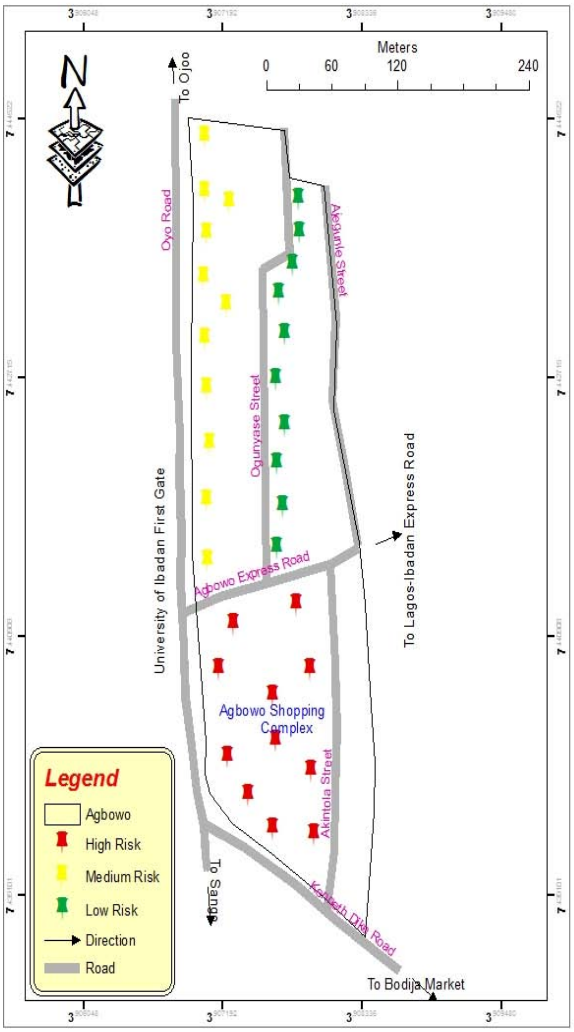
The workers at Agbowo were exposed to mean noise level of 81.0dBA which exceeded the WHO guideline limit of 70dBA. The maximum and minimum values ranged from 63.6 dB(A) to 99.2 dB(A). In Ajibode, workers were exposed to mean noise level of 62.5 dBA which was below the WHO guideline limit of 70dBA. The maximum and minimum values ranged from 60.0 dB(A) to 82.7 dB(A). The mean hour at work in Agbowo was 5.5±1.7 hours as compared to 2.1±1.1 hours in Ajibode. See Table 3.3

*Table 3.0 :* Mean Noise Level at Workers position Business Area Noise level dB(A) p-value

| Business Area | Noise level dB(A) | | | | p-value |
|---|---|---|---|---|---|
| | Mean | Standard deviation | Minimum | Maximum | |
| Agbowo | 81.0 | 8.74 | 63.6 | 99.2 | p<0.05 |
| Ajibode | 62.5 | 4.65 | 60.0 | 82.7 | |

*e) Risk Map for Noise*

The global Positioning system(GPS) facility was used to determine all the coordinates of the measurements points (MPs). The noise levels of MPs and the coordinates were used to develop a risk map showing high, medium and low risk areas based on noise levels obtained. See Plate 3.1, 3.2 and Table 3.4



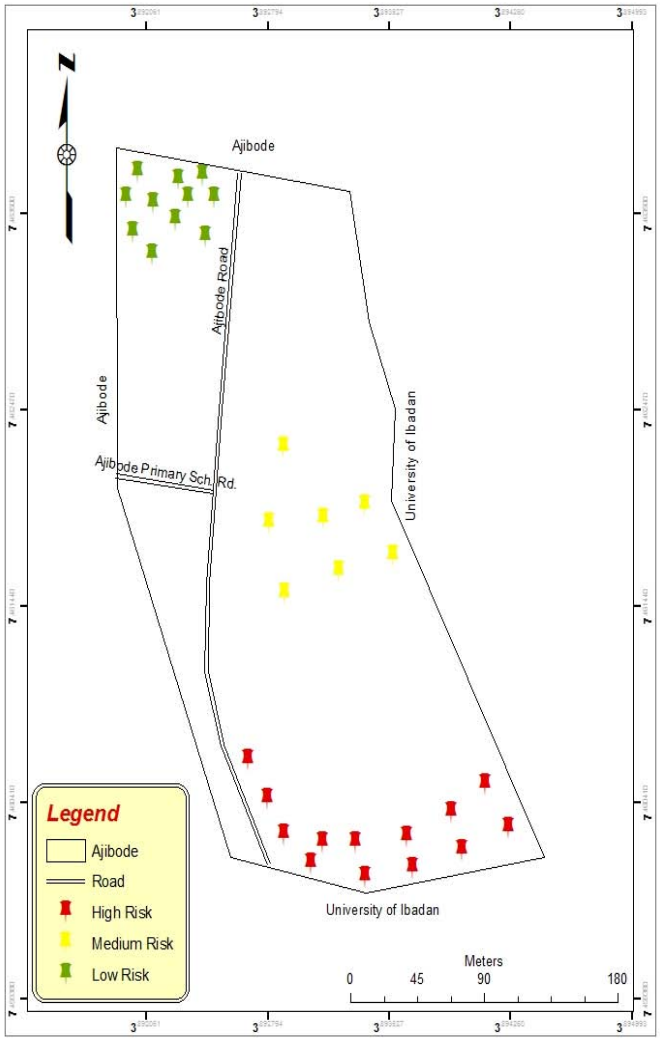




*Plate 1 and 2:* Risk Map for Generator Users in Agbowo & Ajibode Commercial Environmen

*Table 4.0 :* GPS spatial mapping data for Agbowo Commercial area

| Business Area | Classified location | Sampling Points | Longitude (°N) | Latitude (°E) | Elevation (m) |
|---|---|---|---|---|---|
| Agbowo | AG1 | EC1 | 7°26'27.00"N | 3°54'26.35"E | 783 |
| | | EC2 | 7°26'25.17"N | 3°54'26.42"E | 613 |
| | | EC3 | 7°26'23.81"N | 3°54'26.92"E | 692 |
| | | EC4 | 7°26'25.30"N | 3°54'28.25"E | 759 |
| | | EC5 | 7°26'27.38"N | 3°54'28.34"E | 680 |
| | AG2 | RSS1 | 7°26'29.27"N | 3°54'25.36"E | 675 |
| | | RSS2 | 7°26'30.78"N | 3°54'25.33"E | 613 |

| | | | | |
|---|---|---|---|---|
| | RSS3 | 7°26'31.93"N | 3°54'25.59"E | 690 |
| | RSS4 | 7°26'33.85"N | 3°54'25.37"E | 680 |
| | RSS5 | 7°26'35.26"N | 3°54'25.46"E | 696 |
| AG3 | SSS1 | 7°26'29.76"N | 3°54'27.39"E | 765 |
| | SSS2 | 7°26'30.89"N | 3°54'27.48"E | 751 |
| | SSS3 | 7°26'31.78"N | 3°54'27.41"E | 700 |
| | SSS4 | 7°26'33.01"N | 3°54'27.47"E | 769 |
| | SSS5 | 7°26'34.43"N | 3°54'27.47"E | 748 |

*Table 5.0 :* GPS spatial mapping data for Ajibode Commercial area

| Business Area | Classified location | Sampling Points | Longitude (ºN) | Latitude (ºE) | Elevation (m) |
|---|---|---|---|---|---|
| Ajibode | AJ1 | EC1 | 7°27'45.77"N | 3°53'34.35"E | 621 |
| | | EC2 | 7°27'45.48"N | 3°53'34.85"E | 617 |
| | | EC3 | 7°27'46.58"N | 3°53'34.90"E | 626 |
| | | EC4 | 7°27'47.07"N | 3°53'34.80"E | 667 |
| | | EC5 | 7°27'46.99"N | 3°53'34.07"E | 698 |
| | AJ2 | RSS1 | 7°27'37.25"N | 3°53'33.32"E | 768 |
| | | RSS2 | 7°27'37.31"N | 3°53'33.74"E | 677 |
| | | RSS3 | 7°27'37.80"N | 3°53'33.52"E | 657 |
| | | RSS4 | 7°27'36.49"N | 3°53'34.20"E | 665 |
| | | RSS5 | 7°27'36.50"N | 3°53'34.23"E | 661 |
| | AJ3 | SSS1 | 7°27'40.41"N | 3°53'35.55"E | 633 |
| | | SSS2 | 7°27'40.98"N | 3°53'34.75"E | 723 |
| | | SSS3 | 7°27'42.49"N | 3°53'35.60"E | 711 |
| | | SSS4 | 7°27'40.99"N | 3°53'37.21"E | 743 |
| | | SSS5 | 7°27'42.51"N | 3°53'34.77"E | 717 |

## IV. Discussion

The high numbers of environmental noise sources such as electric generator, cars, music houses and motorcycles observed in Agbowo location as compared with Ajibode is predicated on the increased level of commercial activities present in this area. A similar study on environmental noise within Delta state campus, Nigeria conducted by (Oseji, 2011) revealed heavy noise pollution during business activities and attributed this to the indiscriminate use of electric generators. Another study conducted by (Omubo-Pepple, 2010) in Nigeria revealed that the main noise pollution sources in Port Harcourt metropolis came from generators, road traffic and the use of loudspeakers mainly in religious and social gatherings. Frequent power failure has resulted in proliferation of electric generators in Agbowo, hence urgent government intervention and health education is required to employ noise control strategies.

Traffic Density in Agbowo significantly exceeded those in Ajibode. The noise from vehicles may be termed road traffic noise. Suter, 1991 identified the principal noise sources in a vehicle as the power unit and its auxillaries, transmission system, tires and braking system. This may have contributed to the high level of noise observed in Agbowo as compared with Ajibode due to the increased presence of automobiles.

The highest noise level measured in both Agbowo and Ajibode was around 11am -1pm, which was above the WHO guideline limit of 70dB (A) for a commercial environment. This may not be unconnected with the fact that respondents have the highest level of patronage and majority of the generators are in operation around that time frame. In addition, Agbowo and Ajibode are close to traffic prone areas, which could contribute to the overall noise levels. Yusoff and Karim (1997) revealed high noise level (104.3 dB) emanating from vehicular traffic.

High noise level in enclosed location in Agbowo exceeded those recorded in Ajibode and other classified locations (Roadside and Street). Suter (1991) suggested that narrow streets and tall buildings can augment noise and produce a “canyon” in which traffic noise or any other type of noise reverberates. Therefore the the nature of the environment and surrounding buildings may be responsible for the overall noise levels measured in this location.

The risk map showed that noise levels were significantly different in all classified locations. High risk areas were represented by enclosed and road side locations in Agbowo and Ajibode respectively. The noise levels within this location is between 80-90 dBA, which is capable of inducing hearing impairment (WHO, 1993). This is not surprising considering the fact that traffic noise (Suter, 1991) and electric generators in operation (Makinde et al., 2008) produce heavy noise pollution which significantly contributes to the overall work environment noise levels. This calls for urgent government intervention in the area of health education of workers on the hazards of noise exposure. Low risk areas in Agbowo (street location) and Ajibode (enclosed location) were characterized by noise levels between 60-70 dBA. Individuals within such location are at low risk of developing hearing impairment, because its still within the guideline limit set by (WHO, 1993).

Workers in Agbowo were exposed to mean noise levels of 81.0 dBA which ranged from (63.5 dBA to 99.2 dBA) as compared with their counterparts in Ajibode 62.5 dBA which ranged from (60.0 dBA to 82.7 dBA). The workers in Agbowo generally work for 5.5±1.7 hr/day as compared to 2.1±1.1 hr/day in Ajibode. Therefore they are both exposed over 36 hr/wk to high noise levels. The noise exposure levels in Agbowo are excessively high as compared to the maximum permissible noise exposure limit of 85-90 dB(A) for 40h/wk as suggested by ISO, 1971. This high level of noise interferes with communication between workers, and prolonged exposure could lead to hearing impairment.

## V. Conclusion

In this study, we described the level of noise pollution in selected/classified business locations. Environmental noise sources such as generators, automobiles (traffic) and music shops were observed to be higher in Agbowo as compared to Ajibode, this may have contributed to the overall noise levels observed in Agbowo as the mean noise levels in Agbowo were found to be significantly higher than the WHO guideline limit of 70 dB(A) for commercial work environment. High risk areas as described by the risk map were enclosed and roadside locations in Agbowo and Ajibode respectively. These areas were characterized by noise levels within 80-90 dB(A). The workforce in these locations are at high risk of developing noise induced hearing loss (NIHL) and other associated ailments due to excessive noise exposure.

Therefore there is an urgent need for the government to design and implement a well defined, comprehensive and enforceable noise regulation. In Nigeria, total working hours per week are around about 20% more than those in USA or European countries (Olayinka, 2009), therefore the limit of 90 dB(A) for 8 h/d stated by OSHA and Nigerian factories Act (FEPA, 1991) has to be followed with caution. Furthermore, workers in these locations need to be provided with personal safety devices such as ear plugs or ear muffs. Position of worker at work is also important as surrounding surfaces need to be covered with sound absorbent material e.g glass. Enclosure of power generating sets would provide more attenuation than leaving it exposed.

*a) Competing interest*

The authors declare that they have no competing interest

*b) Authors' contributions*

All the authors contributed to this study in ways consistent with The International Journal of Public Health and Epidemiology (IJPHE) authorship criteria. All the authors read and approved the final version of this manuscript.

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We want to thank all respondents and research assistants who participated in this study. We are grateful to the University of Ibadan who provided official approval for this study. I am particularly grateful to Captain & Mrs Umoru Yesufu for their financial support.

*Conflict of Interest:* None to declare.

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