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# Multivariate Analysis of Noise from Religious Houses in Mgbuoba community, Nigeria

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## Abstract
*Noise levels from religious houses in Mgbuoba community Rivers State Nigeria were measured and analyzed using statistical tools. The activities of religious houses have the capacity to cause noise pollution especially those situated in among residential homes. Noise levels were measured using a sound level meter at nine carefully chosen locations which are residences around three of such religious houses. The sampling was done hourly from 8am to 8pm for five days. The minimum daily equivalent noise level "$L_{eq}$" was 57.32dBA and the maximum was 84.30dBA occurring on a Sunday. These noise levels associated with the activities of the religious houses are above the recommended 45dBA for indoors. Analysis of variance "ANOVA" was used to determine the effect of time of day, location of residential house and the day of the week on the observations made. Results show that the null hypothesis was rejected and the alternate hypothesis accepted at 5% level of significance in all cases. An exception was Tuesday, a day on which location of residence was not significant because no religious activity occurred on that day. Distance Biplots were used to visually analyze all the possible relationships between time of day, location of residential house and the day of the week as different variables. The plots generally show agreement with the ANOVA results.*

***Keywords:****Equivalent noise levels, Biplots, Analysis of variance, Religious houses*

## 1. Introduction

Nigeria is a multi-religious country with lot of sentiments attached to matters of religious practice. Traditionally, it was common for places of worship to be sited away from residential homes. However, in recent times either due to need for proximity or competition for members it is a common practice in the country for religious houses to be located within residential areas. The religious activities take the form of congregational worships or prayers both in the daytime and sometimes throughout the night (Akinpelu, 2014). Unpublished observations revealed that the level of noise from these religious houses is becoming a major concern to the public. Very scarce literature is available on noise from religious houses in Nigeria (Babawale, 2011). Santra et al. (1996) reported that festival noise in India is a source of concern to the residents. They observed that sound levels as high as 112dBA from loud speakers up to eight hours at a stretch was recorded. The sound level was above the limit (85dBA) recommended by World Health Organization even for industrial workers. Noise pollution is a global concern especially road-traffic noise (JEA, 1994; Santra et al., 1996). Other sources of noise

include but not limited to schools, shopping malls, air-traffic, rail traffic, farm machinery and so on.

The perception of sound in our daily lives is very important to human wellbeing. Some experts have described noise as unwanted sound however it is subjective to an individual's choice. Depending on the volume and duration of noise, it could be a potential hazard to man's health (Akinpelu, 2014; Chepesiuk, 2005). It is well documented that exposure to noise can have non-auditory effects such as interference with sleep, physical, psychological and social performance behavior. Hearing impairment is defined as an increase in the threshold of hearing and is assessed by threshold audiometry (Chepesiuk, 2005).

Therefore, noise can affect the quality of life (WHO 1993; Chepesiuk, 2005; Akinpelu, 2014; Babawale, 2011; Goines and Hagler 2007). The unit of measurement of sound is in decibels (dB) and the instrument used for measurement is sound level meter. Although the sound pressure perceived by the ear differs from that recorded by the sound meter, a weighting network is incorporated into the meter to produce readout similar to a human response. The A network is commonly used, since it approximates human response to low intensity sound (Sincero, 2006) and is represented as (dBA).

Different indices have been used to define noise level but commonly used is 'equivalent noise level' ($L_{eq}$). $L_{eq}$ uses a steady sound in single decibel to describe sound levels that vary over time and takes into account the total sound energy.

This study was carried out in a residential area known as Road 4 Mgbuoba in Port Harcourt metropolis, Rivers State Nigeria. It investigated the relationship between times of day, days of the week and various locations in the study area.

## 2. Materials and methods

### 2.1 Study area

The area (Road 4, off Okania Road) is a largely residential area in Mgbuoba, Port Harcourt in Rivers State. The study area is a 500m long street with private housings accompanied with 3 religious houses, the first located just at the entrance into the street, the second located 180m from the entrance and the third 90m from the second. The location of the study area is shown in Figure 1.

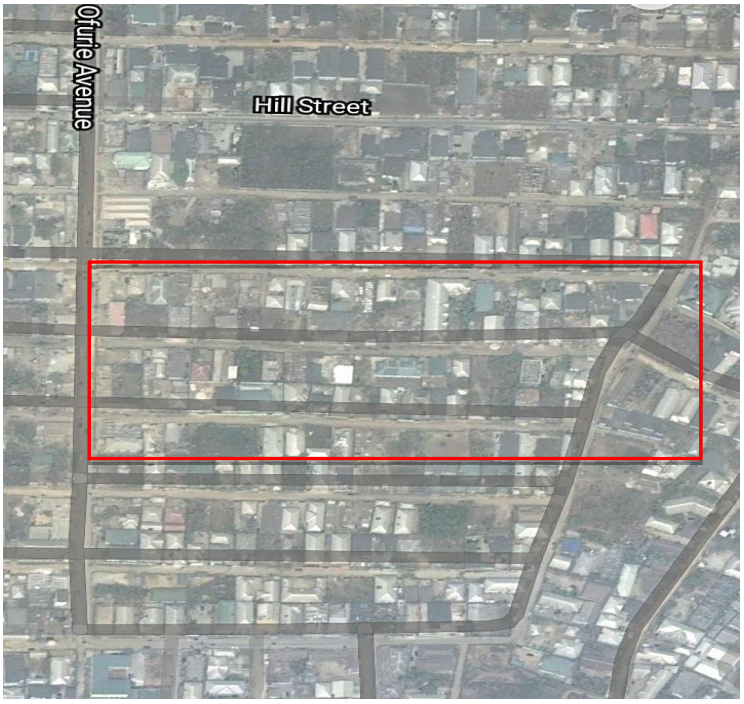


**Figure 1:** The study area at Mgbuoba

## 2.2.Data collection

The WENSN1361 digital sound level meter with computer USB interface and SD card compatible was used for the measurement of noise levels at selected points on the street. The meter ranges from 30 – 130dB with a MAX range button. It is packaged as a single-function handheld test device. The sound meter can be held at arm's length during measurement or secured to a tripod stand for more stability to reduce reflection of sound.

The street for study was divided into nine different sampling stations. The three religious houses made up three stations and directly opposite each of the religious houses another three, then two stations between the churches and one station at the end of the street, totaling nine stations. The study was done for five days and hourly readings were taken at an interval of six minutes at each station for a total of twelve hours on a daily basis.

The data obtained were analyzed with XLSTAT to produce a visual representation of the relationships existing between the different variables and the measured data.

## 3. Results and discussion

The daily equivalent noise levels for the five sampling days and for all locations are presented in Table 1.

**Table 1:** Daily Equivalent Noise Levels

| | Equivalent Noise Levels, $L_{eq}$ (dBA) | | | | |
|---|---|---|---|---|---|
| | Friday | Saturday | Sunday | Monday | Tuesday |
| Location 1 | 72.98 | 73.63 | 73.83 | 73.21 | 73.61 |
| Location 2 | 76.02 | 72.63 | 73.04 | 72.06 | 72.29 |
| Location 3 | 63.86 | 62.53 | 72.60 | 63.50 | 62.13 |
| Location 4 | 61.33 | 64.26 | 84.30 | 63.26 | 66.16 |

| | | | | | |
|---|---|---|---|---|---|
| Location 5 | 62.16 | 63.44 | 77.41 | 60.21 | 62.93 |
| Location 6 | 59.37 | 60.64 | 64.37 | 57.32 | 57.67 |
| Location 7 | 58.70 | 59.49 | 81.06 | 70.07 | 57.74 |
| Location 8 | 63.81 | 62.54 | 77.21 | 66.34 | 61.13 |
| Location 9 | 59.67 | 57.73 | 63.39 | 58.23 | 61.60 |

It is observed that on Friday, the $L_{eq}$ range from 59.37dBA at location 6 to 76.02dBA at location 2. The trend changed on Saturday with location 9 recording the lowest $L_{eq}$ of 57.73dBA and location 1 the maximum of 73.63dBA. On Sunday which is a general worship day, location 9 had a $L_{eq}$of 63.39dBA while location 4 had the maximum for the day of 84.30dBA. Noise levels up to 80dBA can cause annoyance to receptors. On Monday and Tuesday the lowest $L_{eq}$ of 57.32 dBA and 57.67dBA respectively was recorded at location 6, while the maximum of 73.21dBA and 73.61dBA respectively was recorded at location 1. These noise levels are higher than the recommended noise level for indoor residences of less than or equal to 45 dBA (Williams and Langley, 2000; EPA, 1972).

Two hypotheses were postulated and tested to determine the effect of time of day, day of week and the location of residential home on the noise levels measured.

**Hypothesis 1:**

$H_o$ = The noise levels are not affected by time of day and/or location of the residence for the different sampling days

$H_1$ = The noise levels are affected by time of day and/or location of the residence for the different sampling days

**Hypothesis 2:**

$H_o$ = The noise levels are not affected by day of the week for the different locations

$H_1$ = The noise levels are affected by day of the week for the different locations

A two-way analysis of variance was done to test the first hypothesis. Table 2 shows the F and the p values obtained.

**Table 2:** Two-way ANOVA to test the effect of time of day and location of residence

| | | **F** | **P - value** | **F critical** |
|---|---|---|---|---|
| Friday | Time of day | 8.494221 | 5.16E-10 | 1.899171 |
| | Location of home | 24.82651 | 1.52E-19 | 2.045414 |
| Saturday | Time of day | 12.80483 | 4.08E-14 | 1.899171 |
| | Location of home | 30.84761 | 1.95E-22 | 2.045414 |
| Sunday | Time of day | 15.33626 | 3.46E-16 | 1.899171 |
| | Location of home | 6.065425 | 3.34E-06 | 2.045414 |
| Monday | Time of day | 8.725524 | 8.06E-10 | 1.915305 |
| | Location of home | 11.27594 | 9.55E-10 | 2.13099 |
| Tuesday | Time of day | 4.396504 | 0.00045 | 2.093254 |
| | Location of home | 2.041497 | 0.127109 | 2.891564 |

It is observed from Table 2 that the F values for the time of day are all greater than the F critical and the p-values less than 0.05 implying that the results are statistically significant. Hence the null hypothesis is rejected and alternate hypothesis accepted. The noise level varies according to the time of day, which could be as a result of some religious activities taking place in the area of study at

different times of the day. The F values for location of residences are all greater than the F critical and the p-values less than 0.05 except for day 5 which showed a deviation in the trend. This signifies that the noise levels reaching every residential home are affected by their locations every day except day 5 which is a Tuesday. This is so because the religious houses are unevenly distributed and they have some of their activities on different days of the week and different time of the day. However, Tuesdays seem to be the only religious activity free day, therefore, all noise levels recorded was due to prevailing ambient noise.

A distance biplot showing the projection of different observation times onto and location of home which is a variable vector on a 2-dimensional factor space is shown as Figures 2 to 6.

The position of observations projected onto a variable vector can be used to determine their relative level for this variable. Figure 2 shows that on Friday the observations made from 5pm to 8pm are closely tied to 5 locations. This is a strong indication that the religious activity for that day affecting Locations 1, 6, 7, 8 and 9 started from 5pm and runs through to 8pm. However, this effect may be experienced more by residences in Location 6, 7 and 8 as they are closer to the observations in the biplot. The clustering of locations 2, 3, 4 and 5, locations 6, 7 and 8 and location 1 and 9 shows significant correlation of observations between clustered locations. Figure 3 indicates a close relationship between observations made from 4pm to 8pm with all locations. However, locations 3, 4, 5, 6, 7, 8 and 9 are clustered and closer to the observations in the biplot. This means that those locations are correlated, and religious activities on Saturday may affect these locations more than the others. The clustering of locations 1 and 2 shows that the observations made at these locations are correlated.

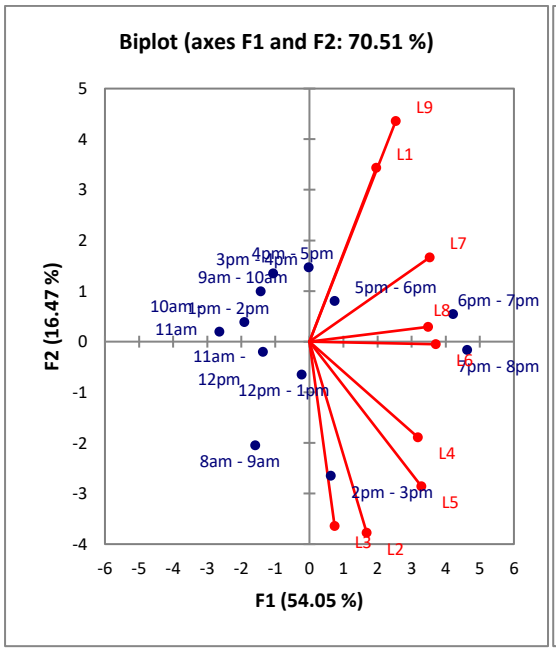


**Figure 2:** Biplot of observation time and location on Friday

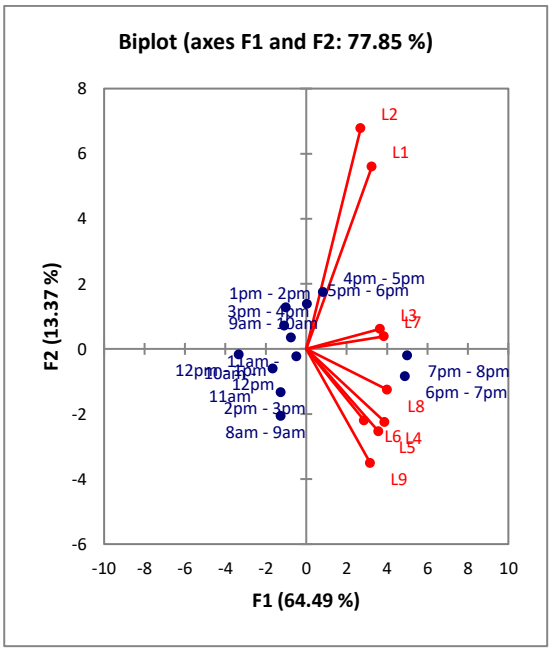


**Figure 3:** Biplot of observation time and location on Saturday

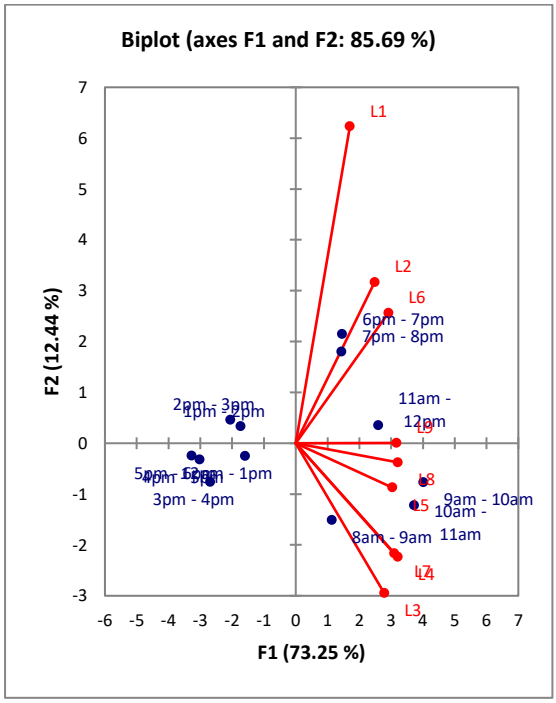


**Figure 4:** Biplot of observation time and location on Sunday

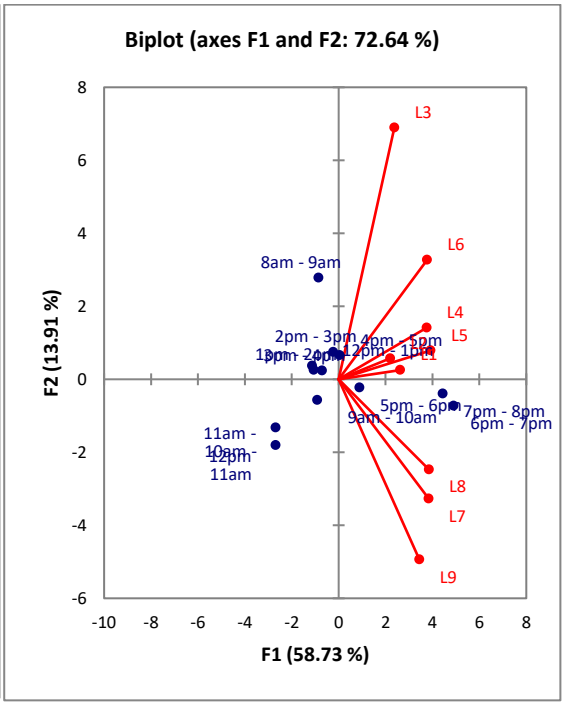


**Figure 5:** Biplot of observation time and location on Monday

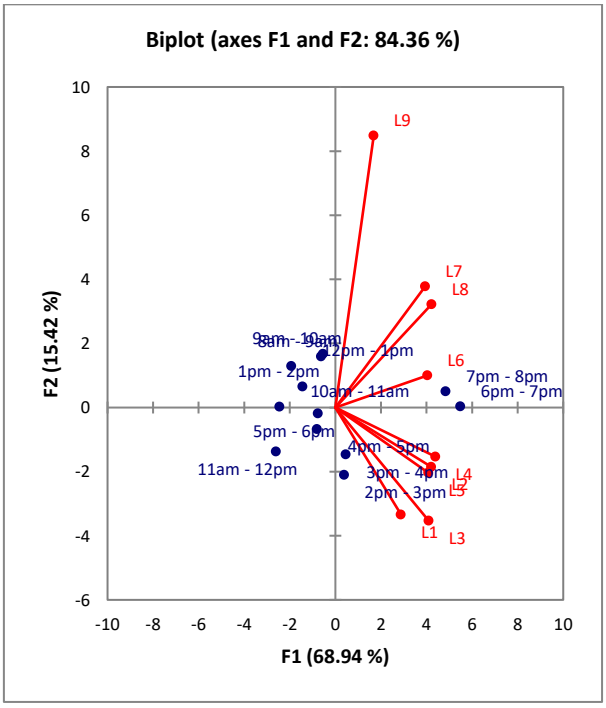


**Figure 6:** Biplot of observation time and location on Tuesday

On Sunday, all the locations have closely linked observations made from 8am to 12pm and from 6pm to 8pm as indicated in Figure 4. This is a general worship day, hence religious activities are expected to follow the observed trend. Residences located around location 1 seem to be the least affected. Figure 5 shows activities on a Monday. The observations are closer to the origin, except for observations made from 6pm to 8pm, which may be the time on that day when the religious activities for all the religious houses coincides. Observations made from 5pm to 8pm can be said to be closely linked to locations 1, 2, 4, 5, 7 and 8. The biplot of Tuesday shown as Figure 6 indicates that observations made from 12pm to 8pm are linked to all the locations. Because this accounts for more than half a day, these observations are said to be the prevalent ambient noise levels from other sources and not from the religious houses. The clustering of all locations with the exception of location 9 shows that the observations made at these different locations are correlated.

To test hypothesis 2, a correlation matrix for the different day as well as a two way analysis of variance was done. Table 3 shows the correlation matrix.

**Table 3:** Correlation matrix of observations made on the different measurement days

| **Variables** | **Friday** | **Saturday** | **Sunday** | **Monday** | **Tuesday** |
|---|---|---|---|---|---|
| Friday | 1 | 0.948 | 0.016 | 0.724 | 0.905 |
| Saturday | 0.948 | 1 | 0.180 | 0.724 | 0.936 |
| Sunday | 0.016 | 0.180 | 1 | 0.445 | 0.140 |
| Monday | 0.724 | 0.724 | 0.445 | 1 | 0.631 |
| Tuesday | 0.905 | 0.936 | 0.140 | 0.631 | 1 |

As observed in Table 3, the values in bold show correlations that are significant. The minimum correlation is 0.724 and the maximum correlation is 0.948. However, observations made on Sunday have insignificant correlation with observations made on every other day. This is because Sunday is a general worship day and observations made on this day are unique and do not correlate well with the other days.

Table 4 shows the result of a two-way analysis of variance done to determine the effect of location of residence and day of week on the observations made.

**Table 4:** ANOVA result for the effect of Location and Day of week

| ***Source of Variation*** | ***SS*** | ***df*** | ***MS*** | ***F*** | ***P-value*** | ***F crit*** |
|---|---|---|---|---|---|---|
| Location | 922.6813 | 8 | 115.3352 | 6.703413 | 3.83E-05 | 2.244396 |
| Day of week | 703.2826 | 4 | 175.8206 | 10.2189 | 1.91E-05 | 2.668437 |
| Error | 550.574 | 32 | 17.20544 | | | |
| Total | 2176.538 | 44 | | | | |

The F values are all greater than the F critical values and the p-values are both less than 0.05 which is the alpha value. The null hypothesis is rejected and the alternate hypothesis accepted. The

result shows significance of observations in the different days of the week and the different locations.

A distance biplot of locations projected onto the days of the week which are the variable vector space is shown as Figure 7.

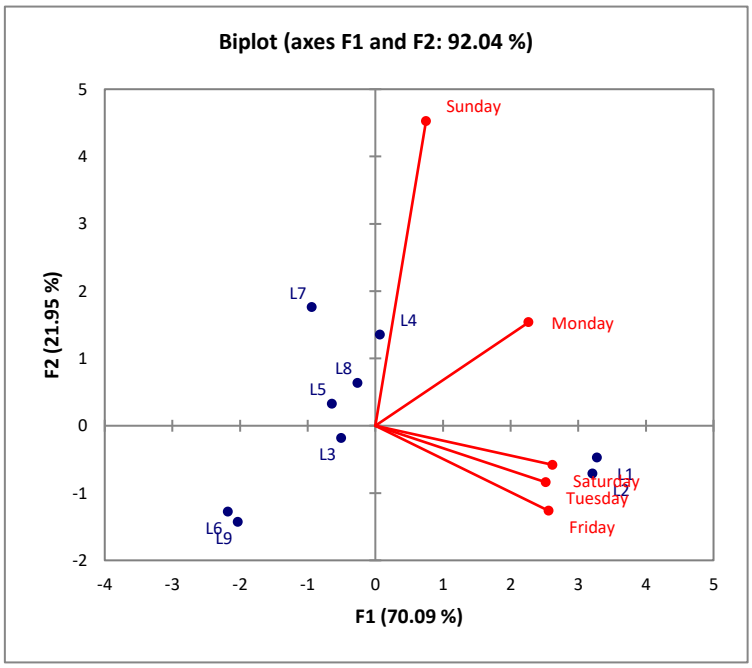


**Figure 7:** Biplot of location of home and day of the week observation was made

The biplot shows a visual representation of the different relationships existing between the different days and the different locations. Observations made at Locations 1 and 2 are closely correlated with Friday, Saturday and Tuesday as they are clustered in the biplot. Observations made on Sunday are not linked to a specific location as seen in the length and uniqueness of the vector in the biplot corresponding to Sunday. Observations made on Monday can be linked to Locations 1, 2 and 4. Monday also correlates well with the other days of the week except Sunday with a longer vector length.

## 4. Conclusions

This study shows that application of biplots in visualizing data. It is determined from the analysis of variance done that the location of a residence, the time of day and the day of the week are all factors interplaying in the effect of noise from the religious houses on the receptors. Sundays have been singled out to have unique observations that are very different from the other days in the area of study. Starting from 9am to 8pm, all the locations were affected by the religious activities on Sunday. On the other days, the religious activities are observed to affect selected locations at a time due to different timing for their activities. When such religious activity time coincides, there is the wide spread effect on more or all the locations.

Like other types of pollution, there are three key factors to be considered in the control of noise pollution namely; the source, the pathway and the receptor. In respect of this study, the sources need to be controlled to reduce the unacceptable noise levels recorded.

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