ISSN: 2634 - 8845

Journal of Earth and Environmental Sciences Research

Research Article

Open Access

# An Assessment of the Impact of Helicopter Noise: Case Study of Mgbuoshimini Community Nigeria

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## ABSTRACT

With the projected growth in demand for commercial aviation, it is anticipated that there will be an increased environmental impact associated with noise, air quality, and climate change. Against this backdrop, the noise levels experienced by the residents of Mgbuoshimini Community due to helicopters take-off and landing were studied. The study was carried out for 14 days at three different locations using a Class 2 Optimus sound level meter from 7am to 5pm daily. Analysis involved the equivalent noise levels, statistical measures for the background noise, aircraft flyover noise as well as the Noise Gap Index (NGI) . It was found that the equivalent noise levels of the background noise and aircraft flyover noise range from 67.7 dBA to 72.4 dBA and 88.4 dBA to 88.6 dBA respectively. The peak background noise and aircraft flyover noise ranged from 69.17 dBA to 79 dBA and 93.2 dBA to 94.8 dBA respectively. These values exceeded the recommended value of 60 dBA for residential areas. Two models to determine the NGI for both low noise areas and high noise areas were developed. A correlation coefficient of 0.70 and 0.88 were obtained between the actual and predicted values of NGI for both low and high noise areas. Therefore, it is recommended that buildings should be adequately insulated by use of noise-absorbing materials. Furthermore, environmentally friendly (quieter) aircrafts should be used by the airline company operating in that area.

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**Received:** May 24, 2020; **Accepted:** May 28, 2020; **Published:** June 03, 2020

## Introduction

Noise refers to an unwanted sound and the level or degree of noise is dependent on the mood or attitude of the individual to noise. Residents in Nigeria are exposed to noise from various means like generators, vehicles, aircrafts etc. and too much of this can cause impact on humans both psychologically and physiologically. Aircraft noise exposure has brought about serious effect to many individual's professional and family activities. Reports from many sources have said that majority of individuals and school that reside close to major airports are affected by the noise from the aircrafts which deprives people from sleeping at night, and affects the performance of school students.

Aircraft noise refers to the sound created by aircrafts during taxiing, run-up, take off, flying or landing. For about 100 sq km around the airport, aircraft noise is usually a major concern; after that, road traffic noise follows. Aircraft Noise reported that during take-off, aircrafts can produce a noise level that exceeds 100 dBA [1]. During landing in some cities, over 100 dBA can be produced due to the occurrence of landing at below 60 m above roof level. Additionally, running of the engine produces significant noise [2].

Vogiatzis et al. discussed about growing and severe problem created by operating aircraft from different airport [3]. Zhang, et al. also went further and stated that the most severe noise which disturbs communities in the vicinity of airport emanate from the engine of aircrafts [4]. He conducted a study in a school which was close to an airport; the result indicated that the noise generated from the airport impacted the children learning ability and outcome such as speech interference. The result indicated that indeed noise affect human health and thus reduces the quality of life.

Tauer invested some factors influencing aircraft noise pollution [5]. He stated that, the type and number of aircrafts operated in the airport, and the age of an aircraft engine play significant role in determining the amount of pollution that will be produced. Old aircraft engines are extremely loud as compared to the newer aircraft engines which utilize high turbo fan pass ratio engines. He went further to unravel that the method of operation of an aircraft also influence the amount of noise pollution generated and suggested that airports authorities should ensure that aircraft are operated in compliance with the noise abatement measures and Environmental Impact Assessment (EIA) should be conducted prior to building an airport to decrease the noise emanating from the airport.

Moreover, Horonjeff and Mckelvey discovered that, the magnitude of aircraft sound (loudness), frequency of the composition of the sound (the lower the frequency/pitch, the less irritating the sound and vice versa), noise duration (monotonous or repetitive sound is more irritating to perceive), the path flight utilized during landing and take-off (aircrafts taking the same routes on repeated basis will cause elevated noise levels for land users below these routes), the number of operations of aircraft (the more the number of flights undertaken, the higher the level of noise produced), Operations types, the procedure of operations, the time of operation, and meteorological circumstances are possible factors influencing aircraft noise on communities [6].

The ICAO secretariat reported that due to the continuous operation of aircrafts and airport' expansion in developed and developing nations, aircraft noise represents the major cause of adverse community reaction [7]. The reduction of the impact of aircraft noise on the environment and people has been amongst the major priorities of The International Civil Aviation Organization (ICAO).

According to Airports Council International, the noise of aircrafts can disrupt the lives of individuals that reside near airports. Across the globe, the impact of aircraft noise on individuals that live around airports is not uniform due to changes in aircraft type, location, housing types under a flight path, operational hours of an airport and flight numbers. Noise reported that a growth in airport operations would cause an attendant increase in the impact on residents living close to airports [8].

Horonjeff and McKelvey, opined that, the perception of individuals to noise depends on different factors such as varying sensitivity of the ear to various sound frequencies, level of sound, noise intrusions frequency, intrusion time and intrusion number over a particular period of time [6].

A study by Evans et al. revealed that elementary school children with a high exposure to aircraft noise were at risk of having an increased blood pressure and stress level, whilst affecting their ability to read and long-term memory [9]. A noise survey conducted by Bronzaft et al., indicated that about 70% of individuals that live around the flight paths of key airports were affected by aircraft noise [10]. Majority of the respondents that were affected by aircraft noise complained about sleep difficulties. Other health impacts of noise exposure includes reduced ability to concentrate, industrial accidents and gastrointestinal problems. Aftandilian posited that human health is harmed by noise, whilst it leads to a reduction in quality of life [11].

According to Occupational and Community Noise, about 1/3 of individuals in Europe experience sleep disturbances because they reside around noisy environments. Occupational and Community Noise also stated that an increased aggressive behaviour can be caused by noise levels that are above 80 dBA [8]. Davis and Cornwel reported that aircraft noise can induce substantial health impacts in individuals, which are categorised into psychological/sociological effects and auditory effects [12]. Psychological effects includes sleep disturbance, annoyance etc., while auditory effects includes speech interference and loss of hearing.

Aircraft Noise reported that heart diseases, immune deficiencies, asthma, neurodermatitis and increased blood pressure can be caused by exposure to high level of noise [13]. Hearing Impairment or Loss, Speech Interference stated by Berglund et al., Psychological/Sociological Impacts, Sleep Interference reported by Davis and Cornwell, Gokdogan et al., Sanchez, Samuels, Jones et al., and Woodman et al. are various health hazards of aircraft noise [12,14-17].

**Problem statement and purpose of the study**

The impact of aircraft noise on residents living within the vicinity of Agip Base Heliport, especially those living directly under or close to the flight path, was the major concern of this research. From several studies, it is generally believed that aircraft noise could be harmful to mental health and can cause tinnitus, noise-induced hearing loss, and annoyance. Aircraft noise could also affect activities such as sleep and reading, and interfere in communication. Additionally, high aircraft noise level may impact children learning ability and domestic animals. It was therefore the purpose of this study is to assess the impact of helicopter flyover noise on residents of Mgbuoshimini Community in Port Harcourt, Rivers State. The specific objectives are as follows:

1. To determine the hourly $L_{eq}$ of the noise data corresponding to the background noise for each location.
2. To determine the number of aircraft noise events by counting distinguishable peaks that drops back to the zone of background noise on the plots of the hourly data.
3. To show the distinction among a high background noise group and a low background noise group, by taking the energy average of the background noise $L_{eq}$ for the duration of sampling at each location.
4. To find Noise Gap Index for the research.

**Methodology**

The study is centred on Agip Heliport located at Mgbuoshimini community Rivers State. It involved determining, in a variety of residential areas, both typical ambient noise levels along with the noise levels associated with heliport over flights. For these noise data to suit the requirements of the research program, the effects of non-aviation noise sources had to be minimized. Consequently, noise stations were set up in randomly selected households that were mostly located in what could be termed local traffic areas.

Agip Helicopter Base was selected as a case study. The areas exposed to helicopter noise from Agip Base Helicopters are widespread around the Agip Region due to Busy Term Operating Plan (BTOP) at the heliport. Therefore, only the highly exposed areas where the average annual day of N70 of events per day was selected as the study population for the helicopter noise exposure area. The N70 is the number of aircraft/helicopter noise events that are louder than 70 dB(A). The threshold level of 70 dB(A) was chosen because, approximately, it will then be 10 dB(A) attenuated by the structure of house (with open windows) and that 60 dB(A), or above, is the indoor sound pressure level of a noise event that is likely to interfere with conversation or to the radio or the television.

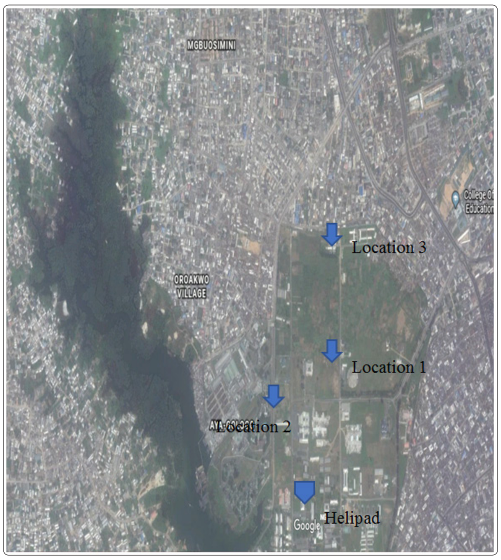


**Figure 1:** Map of the location (Source: Google Earth)

**Research Design**

In tackling the research problem, a mixed research approach was adopted involving both qualitative and quantitative data analysis (Figure 2). According to Bahl and Milne, the use of a mixed research design helps in generating a reliable outcome [19].

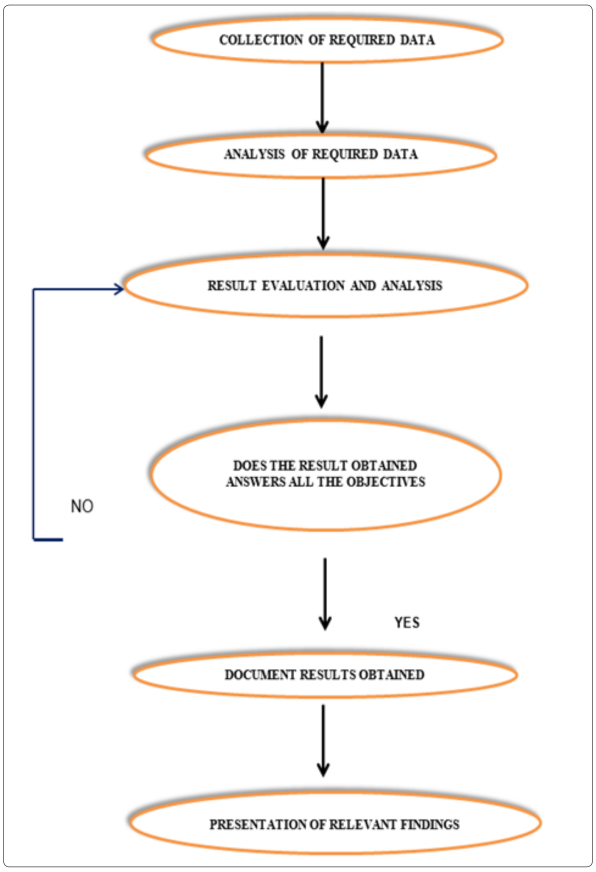


**Figure 2:** Summary of the research design

**Data Collection**

In conducting this research, various data sets were employed. These includes flight tracks, runways, aircraft noise and time. The data sets were classified into two namely; the measurement of noise level (runway/heliport vicinity) and input data used for modelling.

This research was aimed at measuring the effect of aircraft noise on human receptors with the aid of Noise Gap Index (NGI), Noise level exceeded n% of the time ($L_n$) and Equivalent Noise Level ($L_{eq}$). The noise readings were taken for 14 days at each location, starting from 7am to 5pm. The aggregate duration of the all experiments was 42 days.

The data collection location is Nigerian Agip Oil Company Heliport (with 4 S76C++ Helicopters operated by Bristow Helicopters, which convey Oil workers to various offshore facilities). The noise emanating from this location was measured in 3 different points at a nearby residential community called Mgbuoshimini Community in Port Harcourt, Rivers State, Nigeria.

At Location 1, traffic and generator noise contributed to the background noise, and there is an 8-10 meters gap between the residences and the shoulder of the road. This location is near the flight paths of helicopters. At the 2nd location, children (playing) had the most significant contribution to background noise, while vehicles and generators used in residences also contributed to background noise.

At the 3rd location, the background noise was similar to that of location 2. It was however more distant from flight path compared to the other two locations. Using class 2 sound level meters, the instantaneous sound pressure level was (dB) was measured at the different locations. Using a standard height of 150cm, the noise meters were used in a FAST mode. Using $L_{eq}$, every 1 second, the noise data was recorded for 1 hour, for each location. This was done in order to obtain a reliable average statistics for the outdoor noise level that is present in the residences close to flight path.

Although longer periods of measurements can give a more accurate result, Noise measurement was not done during the night in order to reduce the workload of the recorder. $L_{eq}$ was the primary index of interest for the quantification of background noise, and it was used in developing the Noise Gap Index (NGI) which helps to distinguish between aircraft noise and background noise. This would help in addressing the research questions. The NGI is calculated by assuming that individuals that live in environments with another background noise could have. As recommended by Issarayangyan et al., the Number-Above metric was used [20].

**Data Analysis**

Via a USB cable, the noise meter was connected to a laptop computer the dBA readings were extracted to Microsoft Excel 2010 using sound meter data logger software. The noise level (dBA) was displayed for each location with graphs and tables. Using Microsoft excel, statistical graphs were produced by plotting noise level (dBA) against time.

The following environmental noise descriptors were analysed as detailed in Section 2.7

1. Equivalent Noise Levels, $L_{eq}$.
2. Statistical Measures
3. Noise Gap Index
4. Energy average

Equation 1 is used to energy-average a number of sound levels such as the $L_{eq}$ of the same worker on different days.

$$L_{rms} = 10\log_{10}\left\{\frac{1}{n}\left[10^{L_1/10} + 10^{L_2/10} + 10^{L_3/10} + \cdots + 10^{L_n/10}\right]\right\} \quad (1)$$

Where L1 to n = separate noise levels an individual is exposed to.

**Results**

The results obtained from the field sampling are analysed to estimate the background noise, the aircraft flyover noise and the Noise Gap Index (NGI). A Two way analysis of variance was done to test the effect of time of day and day of week on both the background noise and aircraft flyover noise. A typical noise profile from the sample location is shown as Figure 3

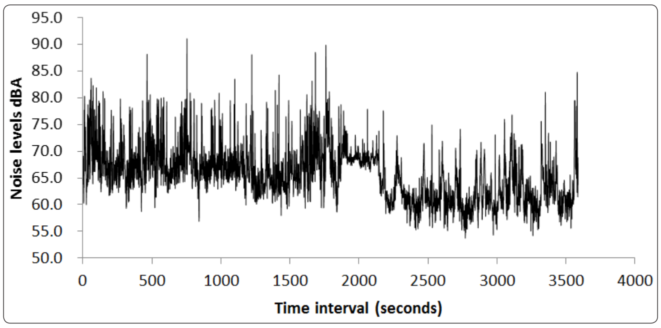


**Figure 3:** A typical noise profile at the sampling location

To estimate the background noise, a filter was applied to the data collected to separate noise levels lesser than 80 dBA from those greater than 80 dBA. This was done because the background noise was observed during data collection to be less than 80 dBA.

**Background Noise**
**Location 1**
The background noise estimated at location one after filtering is shown as Table 1. The hourly $L_{eq}$ as well as the daily $L_{eq}$ was determined using Equation 1.

**Table 1: Background noise for location one**

| | 7am - 8am | 8am - 9am | 9am - 10am | 10am - 11am | 11am - 12pm | 12pm - 1pm | 1pm - 2pm | 2pm - 3pm | 3pm - 4pm | 4pm - 5pm | Daily $L_{eq}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 67 | 70.3 | 72 | 72.5 | 70.9 | 70.6 | 71.1 | 70.7 | 71.7 | 71.2 | 71 |
| Day 2 | 74.3 | 73.2 | 70.8 | 72.5 | 71.3 | 70.8 | 73.9 | 74.6 | 72.6 | 74.2 | 73 |
| Day 3 | 74.5 | 73.1 | 73.2 | 73.3 | 72.6 | 73.5 | 74.6 | 75.5 | 75.5 | 76.9 | 74.5 |
| Day 4 | 74.8 | 71.7 | 71.2 | 71.5 | 70.5 | 69.3 | 67.2 | 69.1 | 72.3 | 76.9 | 72.3 |
| Day 5 | 75.1 | 72.3 | 71.9 | 72.1 | 66.9 | 67.2 | 70.2 | 72.9 | 73.3 | 73.5 | 72.2 |
| Day 6 | 74.7 | 71.7 | 72.2 | 66.9 | 67.1 | 69.6 | 72.5 | 73.3 | 73.7 | 68.4 | 71.7 |
| Day 7 | 67.1 | 69.6 | 72.5 | 73.3 | 73.7 | 74.6 | 72.5 | 72.1 | 73.6 | 71.2 | 72.4 |
| Day 8 | 73.3 | 72.4 | 73.3 | 71.6 | 72 | 71.8 | 72.6 | 72.7 | 74.5 | 76.1 | 73.2 |
| Day 9 | 75.2 | 71.9 | 73 | 72.5 | 71.4 | 71.5 | 70.4 | 68 | 68.3 | 71.2 | 71.8 |
| Day 10 | 75.6 | 72.4 | 72.5 | 70.8 | 70.7 | 71.7 | 73.7 | 70 | 68.8 | 75.6 | 72.7 |
| Day 11 | 76.7 | 75.9 | 73.6 | 71.3 | 70.4 | 70.2 | 72.7 | 69 | 70.2 | 73.8 | 73.1 |
| Day 12 | 74.2 | 73.5 | 71.3 | 70.8 | 70 | 68.2 | 68.8 | 70.1 | 73.2 | 72.5 | 71.7 |
| Day 13 | 70.36 | 75.6 | 67.6 | 65.1 | 57.4 | 66.2 | 69.6 | 63.4 | 53.4 | 63.5 | 68.7 |
| Day 14 | 73.3 | 70.7 | 74.2 | 76.5 | 72.6 | 70.7 | 71 | 73 | 62.6 | 72.5 | 72.7 |
| Hourly Leq | 74.0 | 77.6 | 79.2 | 75.3 | 74.8 | 74.9 | 75.8 | 75.9 | 72.1 | 73.7 | |

The hourly energy average for the fourteen days was determined and shown in Figure 4

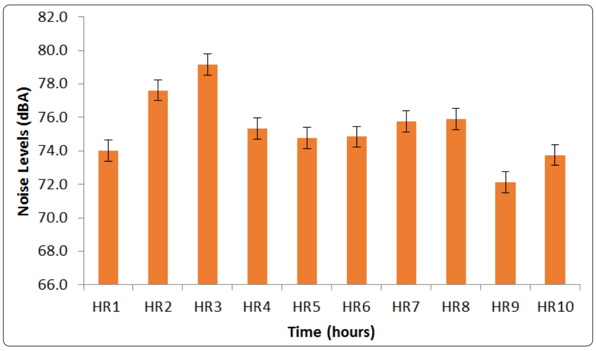


**Figure 4:** Error! No text of specified style in document. Hourly variation of background noise at location 1

The variation of the noise levels on a daily basis was determined and shown as Figure 5

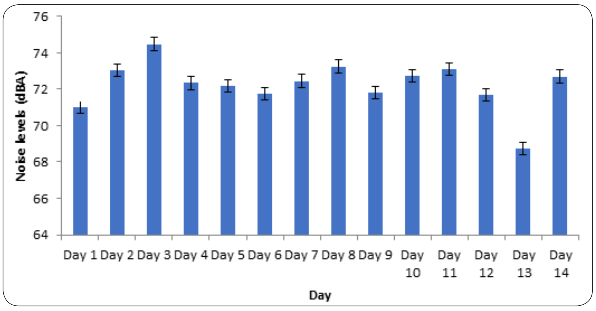


**Figure 5:** Daily variation of Background noise at Location 1

The results obtained from a two way ANOVA based on the hypothesis presented earlier is shown in Table 2

**Table 2:** Analysis of Variance at Location 1

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Day of Week | 536.1351 | 13 | 41.24116 | 5.778599 | 4.08E-08 | 1.804692 |
| Time of Day | 162.4492 | 9 | 18.04991 | 2.529104 | 0.010961 | 1.960818 |
| Error | 835.0148 | 117 | 7.136879 | | | |
| Total | 1533.599 | 139 | | | | |

The statistical measures which are $L_{10}$, $L_{50}$ and $L_{90}$ are calculated by ranking the noise levels from highest to lowest. Weibull's method is used to find the probability of exceedance for each ranked data as shown in Table 3. A plot is made of noise level against probability of exceedance as shown in Figure 6, and the values corresponding to 10%, 50% and 90% are read off from the plot.

**Table 3:** Statistical measure of the background noise

| Noise Level | Rank | Probability of Exceedance (m/n+1) |
|---|---|---|
| 79.2 | 1 | 9.09 |
| 77.6 | 2 | 18.18 |
| 75.9 | 3 | 27.27 |
| 75.8 | 4 | 36.36 |
| 75.3 | 5 | 45.45 |
| 74.9 | 6 | 54.51 |
| 74.8 | 7 | 63.64 |
| 74.0 | 8 | 72.73 |

| | | |
|---|---|---|
| 73.7 | 9 | 81.82 |
| 72.1 | 10 | 90.91 |

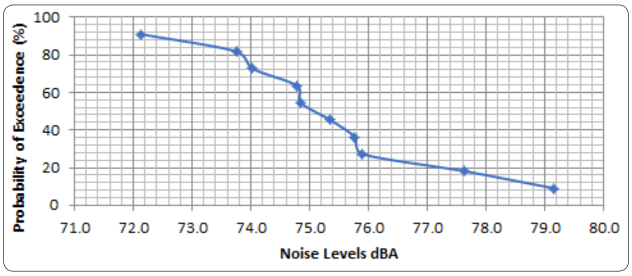


**Figure 6:** Probability of exceedance vs Noise levels (Location 1)

Noise levels corresponding to 10%, 50% and 90% are read from the Figure 6.

$L_{10}$ = 79 dBA
$L_{50}$ = 75.1 dBA
$L_{90}$ = 72.2 dBA

**Location 2**

The background noise estimated at location two after filtering is shown as Table 4. It is seen to vary hourly from a minimum of 65.5 dBA to a maximum of 69.4 dBA. The daily variation range from 63.6 dBA to 70.7 dBA.

**Table 4: Background noise for Location 2**

| | 7am - 8am | 8am - 9am | 9am - 10am | 10am - 11am | 11am - 12pm | 12pm - 1pm | 1pm - 2pm | 2pm- 3pm | 3pm- 4pm | 4pm - 5pm | Daily $L_{eq}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 67 | 70.3 | 72 | 72.5 | 70.9 | 70.6 | 71.1 | 70.7 | 71.7 | 71.2 | 71 |
| Day 2 | 74.3 | 73.2 | 70.8 | 72.5 | 71.3 | 70.8 | 73.9 | 74.6 | 72.6 | 74.2 | 73 |
| Day 3 | 74.5 | 73.1 | 73.2 | 73.3 | 72.6 | 73.5 | 74.6 | 75.5 | 75.5 | 76.9 | 74.5 |
| Day 4 | 74.8 | 71.7 | 71.2 | 71.5 | 70.5 | 69.3 | 67.2 | 69.1 | 72.3 | 76.9 | 72.3 |
| Day 5 | 75.1 | 72.3 | 71.9 | 72.1 | 66.9 | 67.2 | 70.2 | 72.9 | 73.3 | 73.5 | 72.2 |
| Day 6 | 74.7 | 71.7 | 72.2 | 66.9 | 67.1 | 69.6 | 72.5 | 73.3 | 73.7 | 68.4 | 71.7 |
| Day 7 | 67.1 | 69.6 | 72.5 | 73.3 | 73.7 | 74.6 | 72.5 | 72.1 | 73.6 | 71.2 | 72.4 |
| Day 8 | 73.3 | 72.4 | 73.3 | 71.6 | 72 | 71.8 | 72.6 | 72.7 | 74.5 | 76.1 | 73.2 |
| Day 9 | 75.2 | 71.9 | 73 | 72.5 | 71.4 | 71.5 | 70.4 | 68 | 68.3 | 71.2 | 71.8 |
| Day 10 | 75.6 | 72.4 | 72.5 | 70.8 | 70.7 | 71.7 | 73.7 | 70 | 68.8 | 75.6 | 72.7 |
| Day 11 | 76.7 | 75.9 | 73.6 | 71.3 | 70.4 | 70.2 | 72.7 | 69 | 70.2 | 73.8 | 73.1 |
| Day 12 | 74.2 | 73.5 | 71.3 | 70.8 | 70 | 68.2 | 68.8 | 70.1 | 73.2 | 72.5 | 71.7 |
| Day 13 | 70.36 | 75.6 | 67.6 | 65.1 | 57.4 | 66.2 | 69.6 | 63.4 | 53.4 | 63.5 | 68.7 |
| Day 14 | 73.3 | 70.7 | 74.2 | 76.5 | 72.6 | 70.7 | 71 | 73 | 62.6 | 72.5 | 72.7 |
| Hourly Leq | 74.0 | 77.6 | 79.2 | 75.3 | 74.8 | 74.9 | 75.8 | 75.9 | 72.1 | 73.7 | |

The hourly energy average for the fourteen days was determined and shown in Figure 4

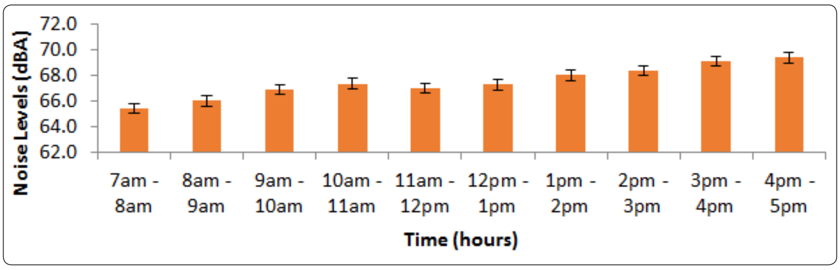


**Figure 7:** Hourly variation of Background noise Location 2

The results obtained from a two way ANOVA is shown in Table 5 from which conclusions can be drawn

**Table: 5 Analysis of Variance at Location 2**

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Day of Week | 369.2683 | 13 | 28.40525 | 4.488758 | 3.68E-06 | 1.804692 |
| Time of Day | 182.6038 | 9 | 20.28931 | 3.206232 | 0.001664 | 1.960818 |
| Error | 740.3862 | 117 | 6.328087 | | | |
| Total | 1292.258 | 139 | | | | |

The statistical measures which are $L_{10}$, $L_{50}$ and $L_{90}$ are calculated by ranking the noise levels from highest to lowest. Weibull's method is used to find the probability of exceedance for each ranked data. A plot is made of noise level against probability of exceedance as shown in Figure 8, and the values corresponding to 10%, 50% and 90% are read off from the plot.

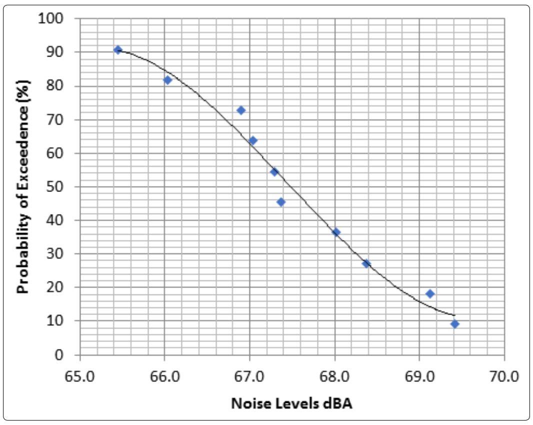


**Figure 8:** Probability of exceedance vs Noise levels (Location 2)

$L_{10}$ = 69.17 dBA
$L_{50}$ = 67.25 dBA
$L_{90}$ = 65.35 dBA

**Location 3**
The background noise estimated at location three after filtering is shown as Table 6.

**Table 6: Background noise for Location 3**

| | 7am - 8am | 8am - 9am | 9am - 10am | 10am - 11am | 11am - 12pm | 12pm - 1pm | 1pm - 2pm | 2pm- 3pm | 3pm- 4pm | 4pm - 5pm | Daily $L_{eq}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 79.1 | 69.2 | 67.8 | 69.4 | 70.7 | 69.5 | 71.1 | 77.2 | 77.1 | 75.2 | 74.4 |
| Day 2 | 66.8 | 68.1 | 66.9 | 66.8 | 66.0 | 66.5 | 72.5 | 74.2 | 73.7 | 72.4 | 70.6 |
| Day 3 | 68.9 | 70.2 | 72.3 | 70.9 | 71 | 71.4 | 73.1 | 70 | 71.9 | 70.8 | 71.2 |
| Day 4 | 69.3 | 67.4 | 73 | 69.3 | 70.4 | 68.6 | 68.1 | 69.7 | 68.2 | 72.1 | 70 |
| Day 5 | 69 | 68 | 68.6 | 70 | 69.8 | 70.3 | 68.2 | 71.1 | 71.8 | 72.5 | 70.2 |
| Day 6 | 69.2 | 73.7 | 68.7 | 67.5 | 67.9 | 71.5 | 69.6 | 70 | 74 | 73.6 | 71.2 |
| Day 7 | 73 | 71.9 | 71.6 | 69.2 | 70.1 | 70.2 | 70.6 | 69.9 | 68 | 69.7 | 70.6 |
| Day 8 | 70.3 | 70 | 70.5 | 71.6 | 69.3 | 68.6 | 69.9 | 71.3 | 71.1 | 73 | 70.7 |
| Day 9 | 50.3 | 61.8 | 63.6 | 68.2 | 65.5 | 67.5 | 67.5 | 68.7 | 67.8 | 66 | 66.3 |
| Day 10 | 44.2 | 44.6 | 43.3 | 41.8 | 44.3 | 46.6 | 45.1 | 41.3 | 52.8 | 43.1 | 46.2 |
| Day 11 | 70.5 | 68.9 | 66.7 | 73.1 | 69.9 | 70.8 | 69.6 | 68.6 | 69.4 | 71.5 | 70.2 |
| Day 12 | 45.9 | 48.5 | 48.5 | 52 | 49.2 | 46.7 | 43.6 | 50.2 | 50.2 | 50.6 | 49.1 |
| Day 13 | 74 | 71.8 | 70.7 | 71.8 | 74.2 | 72.9 | 71.6 | 72.8 | 72.3 | 69.2 | 72.3 |
| Day 14 | 72.6 | 72.3 | 71.1 | 74.6 | 70.4 | 71.6 | 73.6 | 72.9 | 71.2 | 68.6 | 72.2 |
| Hourly Leq | 71.7 | 69.6 | 69.3 | 70.1 | 69.5 | 69.6 | 70.2 | 71.5 | 71.6 | 71.1 | |

The Hourly energy average for the fourteen days was determined and shown in Figure 9

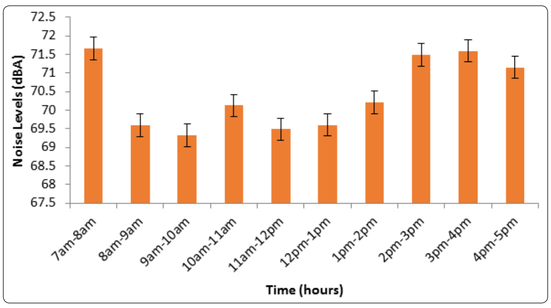


**Figure 9:** Hourly variation of Background noise Location 3

The results obtained from a two way analysis of variance is shown in Table 7

**Table 7: Analysis of Variance at Location 3**

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Day of week | 10075.67 | 13 | 775.0516 | 112.5102 | 1.21E-59 | 1.804692 |
| Time of Day | 95.30666 | 9 | 10.58963 | 1.537241 | 0.142832 | 1.960818 |
| Error | 805.9809 | 117 | 6.888726 | | | |
| Total | 10976.96 | 139 | | | | |

The statistical measures which are $L_{10}$, $L_{50}$ and $L_{90}$ are calculated by ranking the noise levels from highest to lowest. Weibull's method is used to find the probability of exceedance for each ranked data as shown in Table 9. A plot is made of noise level against probability of exceedance as shown in Figure 10, and the values corresponding to 10%, 50% and 90% are read off from the plot.

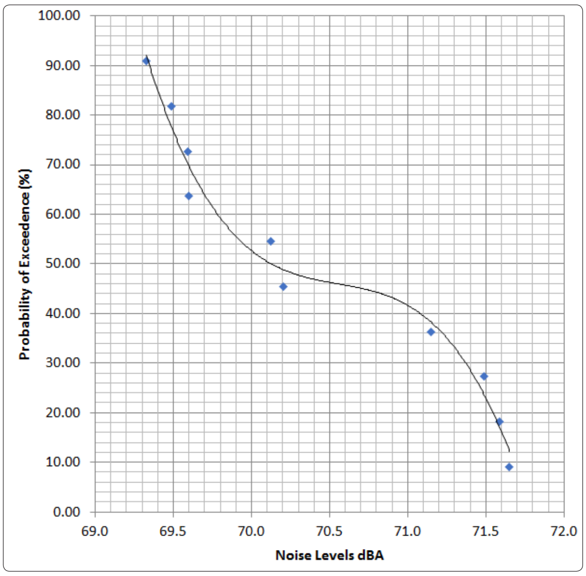


**Figure 10:** Probability of exceedance vs Noise levels (Location 3)

$L_{10}$ = 71.65 dBA
$L_{50}$ = 70.15 dBA
$L_{90}$ = 69.36 dBA
Figure 11 shows a summary of the indices estimated at the different locations for the background noise.

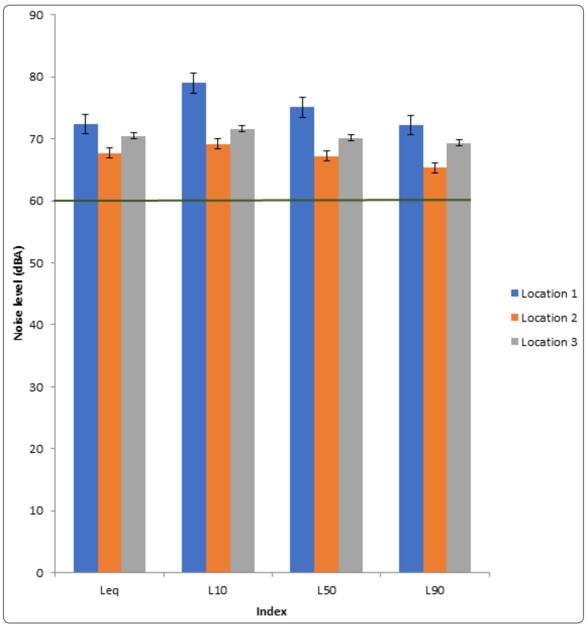


**Figure 11:** Background noise indices at the various locations

**Estimation of Aircraft Flyover Noise**
The aircraft flyover noise estimated at location 1 after filtering is shown as Table 8 where the variation with time and day is seen.

**Table: 8 Aircraft Flyover noise for Location 1**

| | 7am - 8am | 8am - 9am | 9am - 10am | 10am - 11am | 11am - 12pm | 12pm - 1pm | 1pm - 2pm | 2pm- 3pm | 3pm- 4pm | 4pm - 5pm | Daily $L_{eq}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 85.9 | 85.9 | 86.2 | 89.8 | 83.1 | 81.7 | 84.5 | 85.8 | 87.4 | 87.2 | 86.3 |
| Day 2 | 85.3 | 84.7 | 84.8 | 84.6 | 87.4 | 82.9 | 84.4 | 87 | 85.3 | 89.7 | 86 |
| Day 3 | 85 | 85.3 | 87.5 | 89.7 | 84.3 | 84.3 | 84.4 | 85.3 | 85.6 | 87.4 | 86.2 |
| Day 4 | 85.2 | 84.6 | 87.6 | 84 | 82.5 | 81.8 | 83.2 | 85.9 | 85.1 | 85.5 | 84.8 |
| Day 5 | 88.6 | 83.8 | 83.8 | 82.7 | 90 | 82.2 | 85.3 | 85.7 | 84.2 | 84.9 | 85.8 |
| Day 6 | 83.2 | 82.4 | 84.1 | 98.5 | 81.5 | 85.5 | 86 | 84.4 | 83 | 90.8 | 90.1 |
| Day 7 | 81.5 | 85.5 | 86.1 | 84.3 | 83 | 84.9 | 82.4 | 83.5 | 82.8 | 88.3 | 84.7 |
| Day 8 | 86.7 | 84.9 | 83.8 | 84.4 | 84.6 | 83.8 | 87 | 86.5 | 88.4 | 89.3 | 86.3 |
| Day 9 | 89.4 | 84.3 | 88.2 | 83.5 | 84.3 | 83.3 | 85.7 | 83.5 | 84.1 | 84.5 | 85.6 |
| Day 10 | 86.9 | 85 | 84.6 | 85.3 | 83.4 | 83.9 | 82.2 | 85.2 | 82.3 | 93.7 | 86.9 |
| Day 11 | 91.9 | 89.7 | 89 | 85.1 | 84.7 | 85.1 | 83.5 | 85.3 | 84.3 | 87.4 | 87.5 |
| Day 12 | 89.2 | 88.8 | 83.9 | 84.8 | 82.2 | 83.1 | 82.9 | 84.9 | 88.5 | 85 | 86.1 |
| Day 13 | 82.9 | 83.4 | 90.9 | 105.2 | 81.8 | 88.4 | 88.5 | 84.9 | 87.5 | 86.5 | 95.8 |
| Day 14 | 89.3 | 83.4 | 85.2 | 84.1 | 84.1 | 83.1 | 85 | 89.9 | 97.1 | 84.6 | 89.5 |
| Hourly Leq | 87.4 | 85.6 | 86.3 | 95.0 | 84.5 | 83.9 | 84.8 | 85.6 | 88.4 | 88.4 | |

The hourly energy average for the fourteen days was determined and shown in Figure 12

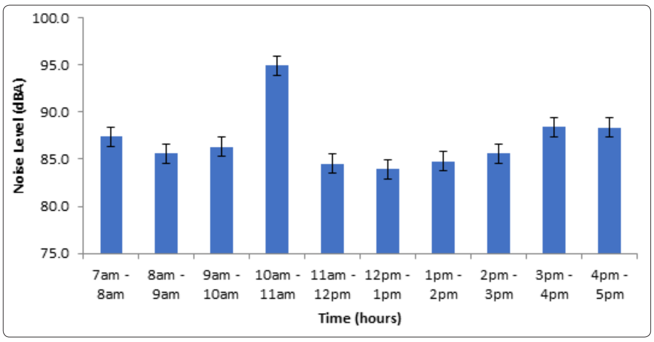


**Figure 12:** Hourly variation of Aircraft Flyover noise (Location 1)

The daily variation of the aircraft flyover noise at this location is as illustrated in Figure 13.

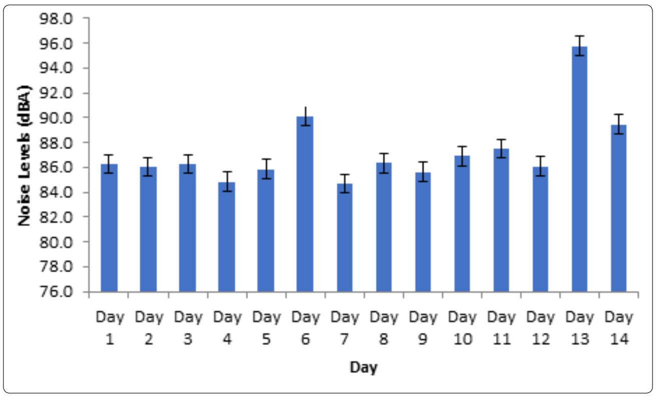


**Figure 13:** Daily variation of aircraft flyover noise at Location 1

The results obtained from a two way ANOVA is shown in Table 9 from which the F value is compared with the F critical value and conclusions drawn to accept or reject the hypotheses previously presented.

**Table 9:** Analysis of Variance at Location 1

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Day of week | 115.9939 | 13 | 8.922605 | 2.465224 | 0.525858 | 1.804692 |
| Time of Day | 213.1345 | 9 | 23.68161 | 0.928831 | 0.013053 | 1.960818 |
| Error | 1123.934 | 117 | 9.606272 | | | |
| Total | 1453.062 | 139 | | | | |

The statistical measures which are $L_{10}$, $L_{50}$ and $L_{90}$ are calculated by ranking the noise levels from highest to lowest. Weibull's method is used to find the probability of exceedance for each ranked data. A plot is made of noise level against probability of exceedance as shown in Figure 14, and the values corresponding to 10%, 50% and 90% are read off from the plot.

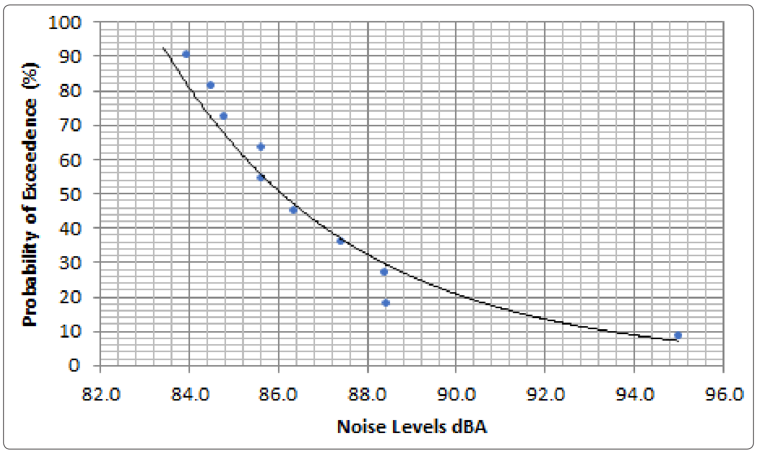


**Figure 14:** Probability of exceedance vs Noise levels (Location 1)

$L_{10}$ = 94.8 dBA
$L_{50}$ = 85.75 dBA
$L_{90}$ = 84 dBA

**Location 2**

The aircraft flyover noise estimated at location 2 after filtering is shown as Table 10.

**Table 10: Aircraft Flyover noise for Location 2**

| | 7am - 8am | 8am - 9am | 9am - 10am | 10am - 11am | 11am - 12pm | 12pm - 1pm | 1pm - 2pm | 2pm- 3pm | 3pm- 4pm | 4pm - 5pm | Daily $L_{eq}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 82.3 | 82.3 | 85.8 | 84.8 | 82.6 | 85.7 | 82.2 | 84.5 | 85.9 | 87.6 | 84.8 |
| Day 2 | 81.6 | 87.7 | 84 | 87.1 | 85.6 | 84.8 | 81.9 | 83.4 | 84.6 | 83.2 | 84.8 |
| Day 3 | 81.6 | 81.8 | 82.8 | 87.6 | 84.5 | 85 | 84.1 | 83.4 | 84.6 | 83.5 | 84.2 |
| Day 4 | 86.1 | 81.9 | 84.1 | 86.2 | 82.7 | 84.3 | 82.8 | 81.1 | 82 | 82.6 | 83.7 |
| Day 5 | 85.6 | 81.1 | 82.4 | 83.7 | 84.9 | 84.7 | 83.8 | 87.1 | 83.5 | 84.8 | 84.4 |
| Day 6 | 83.5 | 83 | 84.4 | 87 | 83.4 | 83.7 | 86.4 | 86.4 | 83.5 | 84.9 | 84.9 |
| Day 7 | 83.7 | 85.6 | 84.4 | 86.8 | 83.4 | 85.3 | 81.5 | 84 | 84 | 86.2 | 84.7 |
| Day 8 | 81.4 | 83.3 | 81.4 | 80.9 | 84.7 | 84.5 | 81.5 | 85 | 85.3 | 84.2 | 83.5 |
| Day 9 | 83 | 82.2 | 80.8 | 83.5 | 83.6 | 83.2 | 82.1 | 84.4 | 87.1 | 86.3 | 84 |
| Day 10 | 86.7 | 80.86 | 82.9 | 86.2 | 105.4 | 86.6 | 91.9 | 83.2 | 92.4 | 98.3 | 96.7 |
| Day 11 | 81.9 | 83.2 | 87.4 | 83.5 | 82.1 | 86.9 | 94.1 | 82.9 | 86.2 | 84 | 87.2 |
| Day 12 | 101 | 84.1 | 86.9 | 81 | 82.8 | 86.4 | 81.6 | 84.3 | 82.7 | 85.3 | 91.8 |
| Day 13 | 81.2 | 95.7 | 83.7 | 84.8 | 83.8 | 84.1 | 84.6 | 85.7 | 82.9 | 86.6 | 87.9 |
| Day 14 | 82 | 84.4 | 80 | 85.2 | 86.4 | 87.6 | 81.5 | 82.8 | 83.2 | 81.1 | 84.1 |
| Hourly Leq | 90.4 | 86.8 | 84.1 | 85.3 | 94.3 | 85.4 | 86.7 | 84.4 | 85.9 | 88.9 | |

The Hourly energy average for the fourteen days was determined and shown in Figure 15

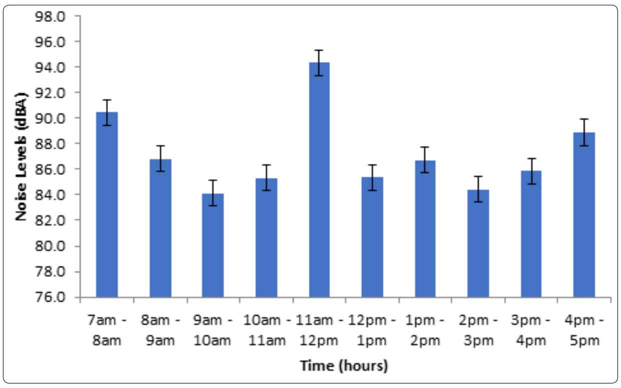


**Figure 15:** Hourly variation of Aircraft Flyover noise (Location 2)

The daily variation of the aircraft flyover noise at this location is as illustrated in Figure 16.

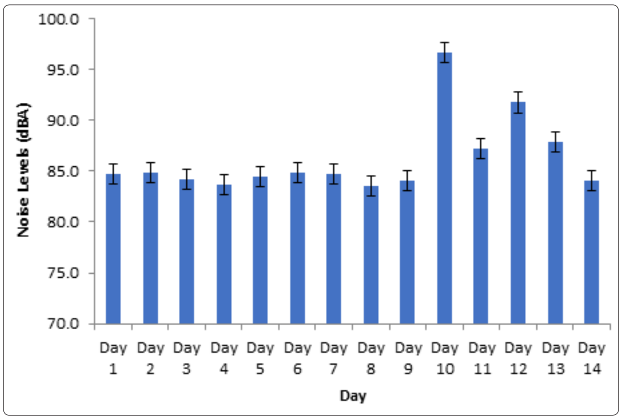


**Figure 16:** Daily variation of aircraft flyover noise at Location 2

**Table: 11: Analysis of Variance at Location 2**

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Rows | 319.0536 | 13 | 24.54259 | 2.14225 | 0.016364 | 1.804692 |
| Columns | 51.7116 | 9 | 5.745734 | 0.501528 | 0.870862 | 1.960818 |
| Error | 1340.405 | 117 | 11.45645 | | | |
| Total | 1711.17 | 139 | | | | |

The statistical measures which are L10, L50 and L90 are calculated by ranking the noise levels from highest to lowest. Weibull's method is used to find the probability of exceedance for each ranked data as shown in Table 11. A plot is made of noise level against probability of exceedance as shown in Figure 17, and the values corresponding to 10%, 50% and 90% are read off from the plot.

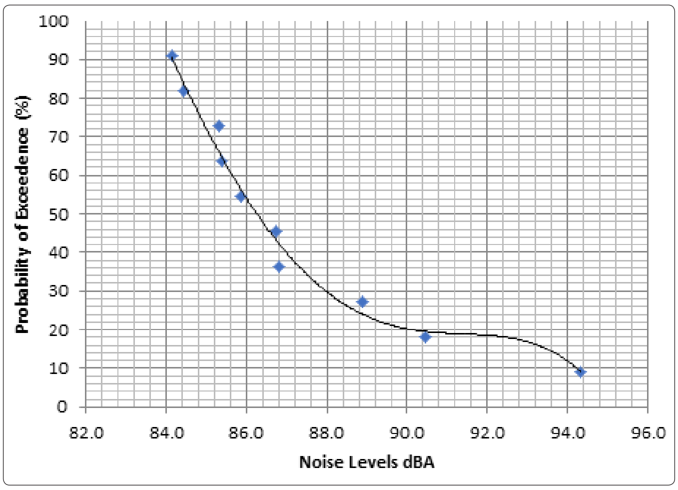


**Figure 17:** Probability of exceedance vs Noise levels (Location 2)

$L_{10}$ = 94.3 dBA
$L_{50}$ = 86.25 dBA
$L_{90}$ = 84.2 dBA

**Location 3**

The aircraft flyover noise estimated at location three after filtering is shown as Table 12.

**Table 12: Aircraft Flyover noise for Location 3**

| | 7am - 8am | 8am - 9am | 9am - 10am | 10am - 11am | 11am - 12pm | 12pm - 1pm | 1pm - 2pm | 2pm- 3pm | 3pm- 4pm | 4pm - 5pm | Daily $L_{eq}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 84.7 | 84.1 | 83.6 | 84.7 | 86.1 | 84.2 | 92.1 | 84.6 | 86.0 | 86.6 | 86.3 |
| Day 2 | 83.2 | 81.2 | 84.1 | 83.6 | 90.3 | 90.6 | 84.7 | 86.0 | 83.8 | 84.2 | 86.0 |
| Day 3 | 83.8 | 95.1 | 82.6 | 83.3 | 85.8 | 83.2 | 83.6 | 85 | 83.7 | 84.4 | 86.2 |
| Day 4 | 86.1 | 82.7 | 84.1 | 83.5 | 85.7 | 87.3 | 88 | 85.9 | 85 | 83.8 | 84.8 |
| Day 5 | 86.3 | 83.5 | 85.1 | 85.9 | 87.9 | 85 | 81.4 | 84.9 | 85 | 85.5 | 85.8 |
| Day 6 | 86.6 | 85.9 | 84.5 | 86.7 | 86.1 | 85.1 | 86.5 | 86.1 | 86.2 | 85.3 | 90.1 |
| Day 7 | 84.9 | 85.9 | 85.5 | 84.8 | 85.3 | 86 | 87.5 | 83.8 | 86.8 | 84 | 84.7 |
| Day 8 | 87.7 | 81.7 | 82.3 | 83.9 | 85.8 | 86.9 | 86.9 | 83.8 | 85.8 | 83.8 | 86.3 |
| Day 9 | 80.8 | 89.9 | 82.6 | 84.7 | 85.5 | 84.6 | 105.5 | 86.7 | 83.2 | 85.7 | 85.6 |
| Day 10 | 83.4 | 87.4 | 83.1 | 84.2 | 83.2 | 83.7 | 84.8 | 85.4 | 93.9 | 85.2 | 86.9 |
| Day 11 | 83.3 | 83.9 | 82.9 | 83.4 | 82.4 | 89.5 | 85 | 86.7 | 81.1 | 84.1 | 87.5 |
| Day 12 | 84.2 | 82.6 | 97.8 | 85.3 | 85.5 | 84.8 | 86.2 | 84.3 | 82.1 | 84.8 | 86.1 |
| Day 13 | 93.1 | 87 | 81.8 | 82.5 | 86.2 | 83.9 | 88 | 82.7 | 82.5 | 85.2 | 95.8 |
| Day 14 | 83.1 | 85.4 | 83.1 | 91.3 | 83.9 | 85 | 84.5 | 85.6 | 83.6 | 85.6 | 89.5 |
| Hourly Leq | 86.3 | 87.4 | 88.1 | 85.5 | 86.1 | 86.3 | 94.8 | 85.2 | 86.4 | 84.9 | |

The Hourly energy average for the fourteen days was determined and shown in Figure 18

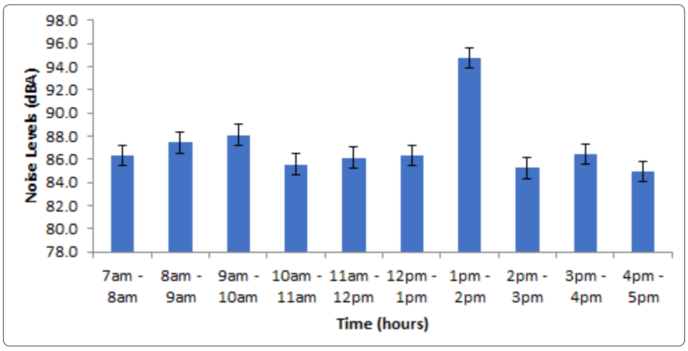


**Figure 18:** Hourly variation of Aircraft flyover noise (Location 3)

The daily variation of the aircraft flyover noise at this Location is as illustrated in Figure 19.

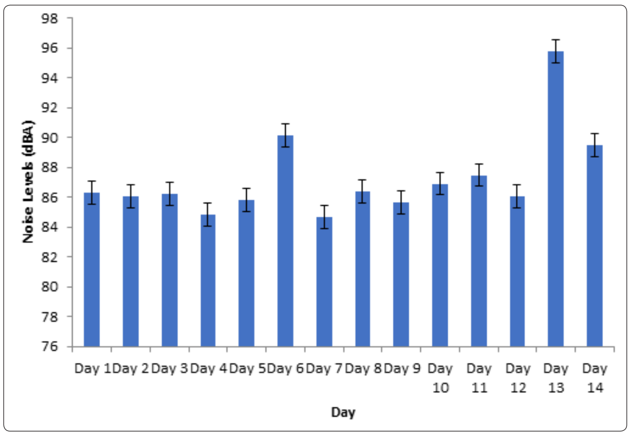


**Figure 19:** Daily variation of aircraft flyover noise at Location 3

The results obtained from a two way ANOVA is shown in Table 13.

**Table 13: Analysis of Variance at Location 3**

| Source of Variation | SS | Df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Rows | 48.36937 | 13 | 3.720721 | 0.364109 | 0.978241 | 1.804692 |
| Columns | 88.65686 | 9 | 9.850762 | 0.963994 | 0.473419 | 1.960818 |
| Error | 1195.588 | 117 | 10.2187 | | | |
| Total | 1332.614 | 139 | | | | |

The statistical measures which are $L_{10}$, $L_{50}$ and $L_{90}$ are calculated by ranking the noise levels from highest to lowest. Weibull's method is used to find the probability of exceedance for each ranked data as shown in Table 13. A plot is made of noise level against probability of exceedance as shown in Figure 20, and the values corresponding to 10%, 50% and 90% are read off from the plot

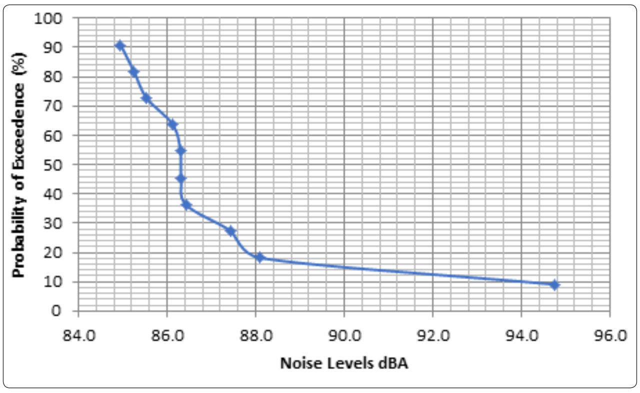


**Figure 20:** Probability of exceedance vs Noise levels (Location 3)

$L_{10}$ = 94.6 dBA
$L_{50}$ = 86.3 dBA
$L_{90}$ = 85 dBA
Figure 21 shows a summary of the indices estimated at the different locations for aircraft flyover noise.

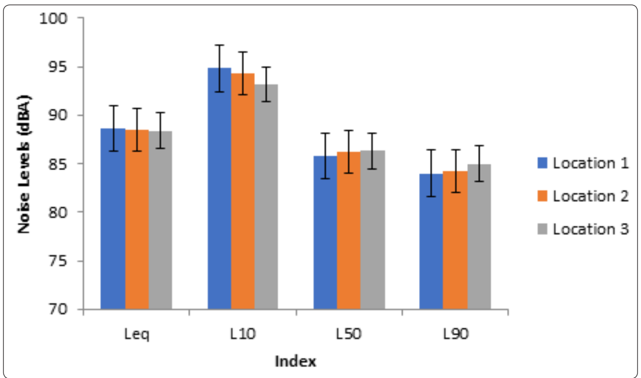


**Figure 21:** Aircraft flyover noise indices at the various locations

**Noise Gap Index (NGI)**
The Noise Gap Index (NGI) was calculated based on the difference between the aircraft noise and the background noise is shown as Equation 2

$$NGI = L^{A}_{eq} - L^{B}_{eq} \quad (2)$$

Where $L^{A}_{eq}$ = Aircraft flyover noise determined from 7am to 5pm
$L^{B}_{eq}$ = Background noise determined from 7am to 5pm

**Background Noise**
The background noise was classified into two groups, the high noise group and low noise group. High noise groups are those groups with 70 dBA and above while the low noise groups are locations with less than 70 dBA.

Using Equation 1, the $L_{eq}$ for location 1 to 3 was determined to be 72.4 dBA, 67.7 dBA and 70.5 dBA. Based on the aforementioned criteria, Locations 1 and 3 fell among the high noise groups while Location 2 is in the low noise group. Figure 22 shows the plot of both high and low groups from which the $L_{eq}$ was determined to be 72.9 dBA and 67.7 dBA respectively.

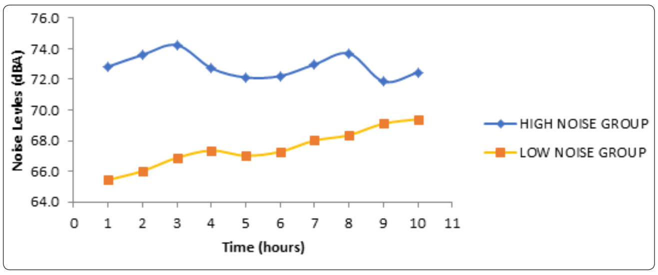


**Figure 22:** High and low noise groups

**Aircraft Noise**
The average Aircraft flyover noise was taken for the high noise groups as well as for the low noise groups as shown in Table 14. The relationship between Aircraft flyover noise ($L_{eq}$) and number of aircraft was found using a linear regression model (Appendix A). This is shown as Equation 3 for the high noise group and Equation 4 for the low noise group. Figures 23 and 24 illustrates relationship between the predicted values and the actual values

**Table 14: Average noise levels of Aircraft flyover noise at all locations**

| Noise Levels (dBA) | | No of Flyover |
|---|---|---|
| High noise group | Low noise group | |
| 86.4 | 84.8 | 13 |
| 86.2 | 84.8 | 11 |
| 86.8 | 84.2 | 13 |
| 85.2 | 83.7 | 8 |
| 85.6 | 84.4 | 12 |
| 88.0 | 84.9 | 15 |
| 85.1 | 84.7 | 9 |
| 85.8 | 83.5 | 5 |
| 90.7 | 84.0 | 12 |
| 87.0 | 96.7 | 30 |
| 86.2 | 87.2 | 16 |
| 87.7 | 91.8 | 21 |

| | | |
|---|---|---|
| 91.3 | 87.9 | 19 |
| 87.7 | 84.1 | 9 |

Noise level $L^A_{eq}$ dB(A) = 0.252*NF + 83.346 (3)

Where NF = Number of flyovers

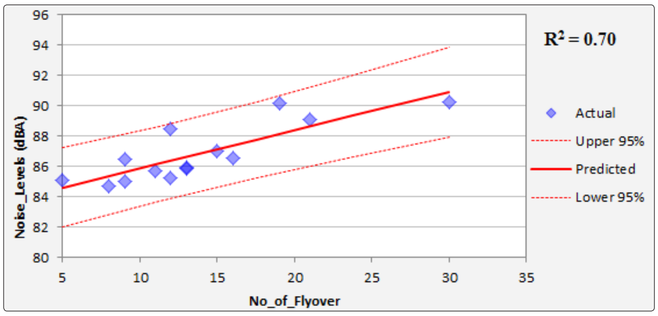


**Figure 23:** Aircraft noise levels Vs Number of Flyovers for high noise groups

Noise level $L^A_{eq}$ dB(A) = 0.554NF + 78.551 (4)

Where NF is the number of flyovers

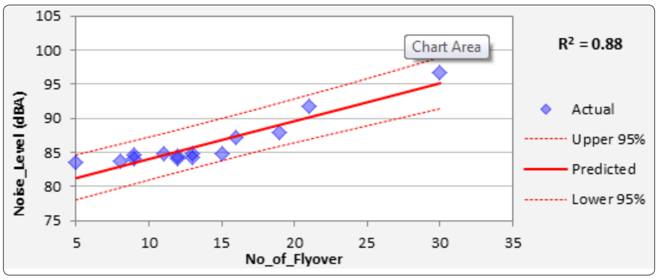


**Figure 24:** Aircraft noise levels Vs Number of Flyovers for Low noise groups

The coefficient of regression "$R^2$" for predicted aircraft flyover noise was determined to be 0.70 for the high noise groups and 0.88 for the low noise groups. Equations 3 and 4 were substituted into Equation 2 and the background noise level previously determined introduced. This resulted to Equation 5 for high noise groups and Equation 6 for low noise groups.

NGI = 0.252*NF + 10.45 (5)

NGI = 0.554*NF + 10.851 (6)

Where NF is the number of flyovers.

For easy estimates of NGI for high and low noise groups, Equations 5 and 6 were used to find the Noise Gap Index when the number of aircraft flyovers was from 1 to 30. The result plotted is as in Figure 25 from which the NGI is easily read off.

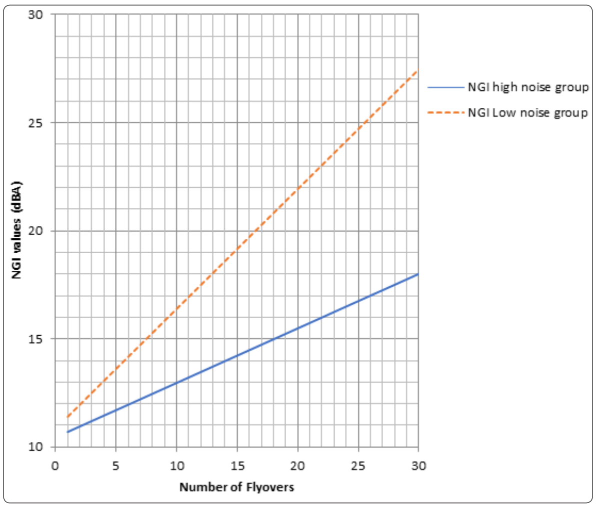


**Figure 25:** Noise Gap Index (NGI) Chart for high noise groups and low noise groups

## Discussion

### Location 1

As shown in Table 1 and Figure 4, the background noise at location 1 ranges from 72 dBA in the evenings to 79.2dBA in the mornings. The morning higher noise level could be attributed to the high vehicular traffic present at this location. The daily variation ranges from 68.7 dBA to 74.5 dBA as seen in Figure 5. Table 2 shows the analysis of variance done to test if the time of day or day of week has a significant effect on the noise levels observed. The F value for Day of week effect is seen to be 5.778599 which is higher than the Critical F value of 1.804692. Therefore, the alternate hypothesis should be accepted and null hypothesis rejected. This implies that the day of week at location 1 significantly affects the noise levels observed. The F value for time of day is observed to be 2.529101 which is also higher than the F critical value of 1.960818. The alternative hypothesis is accepted and the null rejected. This implies that the time of day when noise levels are observed affects the data acquired. These results could be related to the peaks in vehicular traffic observed in the mornings and late afternoons. The result of the statistical measures shows a peak noise of 79 dBA and a background noise of 72.2 dBA. These values are higher than the recommended 60 dBA by the National Environmental Regulations as seen in Table 2.2. This indicates a possible noise concern in the homes of residents at this location.

The aircraft flyover over noise at this location was seen to range from 83.9 dBA to 95 dBA in the mornings as seen in Figure 12. Figure 13 shows that the aircraft flyover noise is more over the weekends especially on Saturdays. To test the effect of time of day and day of week on the noise observed, a two analysis of variance was done as shown in Table 11. The F value for day of week is 2.47 which is greater than the F critical value of 1.8. This agrees with the fact that the day of week has significant effect on the noise levels observed due to aircrafts flyover. Whereas the F value for the time of day effect is seen be 0.93 which is less than the F critical value of 1.96, which implies that the time of day has no significant effect on the noise levels observed.

**Location 2**

As shown in Table 4 and Figure 7, the background noise at location 2 ranges from 65.5 dBA in the morning to 69.4dBA in the evenings. The high evening noise level could be attributed to increased human activities observed during the evenings such as children playing and music from vendors. The daily variation ranges from 63.6 dBA to 70.7 dBA. Table 5 shows the analysis of variance done to test if the time of day or day of week has a significant effect on the noise levels observed. The F value for Day of week effect is seen to be 4.49 which is higher than the Critical F value of 1.804692. Therefore, the alternative hypothesis should be accepted and null hypothesis rejected. This implies that the day of week at location 2 significantly affects the noise levels observed. The F value for time of day is observed to be 3.21 which is also higher than the F critical value of 1.960818. The alternative hypothesis is accepted and the null rejected. This implies that the time of day the noise levels are observed affects the data acquired. The result of the statistical measures shows a peak noise of 69.17 dBA and a background noise of 65.35 dBA. These values are higher than the recommended 60dB as seen in Table 2.2. However, the background noise may not interfere with speech communications in the homes of residents at this location as it is assumed that it is attenuated by about 10dBA by walls and compartments in homes.

The aircraft flyover over noise at this location was seen to range from 84.1 dBA to 94.3 dBA around noon as seen in Figure 15. To test the effect of time of day and day of week on the noise observed, a two analysis of variance was done as shown in Table 11. The F value for day of week is 2.14 which is greater than the F critical value of 1.8. This agrees with the fact that the day of week has significant effect on the noise levels observed due to aircrafts flyover. Whereas the F value for the time of day effect is seen to be 0.501 which is less than the F critical value of 1.96, which implies that the time of day has no significant effect on the noise levels observed.

**Location 3**

As shown in Table 6 and Figure 9, the background noise at location 3 ranges from 69.3 dBA in the mornings to 71.7 dBA. This is so because of the presence of light traffic around the vicinity and the minimal businesses around the location. The daily variation ranges from 46.2 dBA to 74.4 dBA. Table 7 shows the analysis of variance done to test if the time of day or day of week has a significant effect on the noise levels observed. The F value for Day of week effect is seen to be 112.5 which is higher than the Critical F value of 1.804692. Therefore, the alternative hypothesis should be accepted and null hypothesis rejected. This implies that the day of week at location 3 significantly affects the noise levels observed. The F value for time of day is observed to be 1.53 which is lower than the F critical value of 1.960818. The alternative hypothesis is rejected and the null hypothesis accepted. This implies that the time of day the noise levels are observed does not significantly affect the data acquired. These results could be related to the peaks in traffic observed in the mornings and late afternoons. The result of the statistical measures shows a peak noise of 71.65 dBA and a background noise of 69.36 dBA. This values are higher than the recommended 60 dBA as seen in Table 2. These values also indicate a possible noise concern in the homes of residents at this location as they may cause speech interference in the homes.

The aircraft flyover over noise at this location was seen to range from 84.9 dBA to 93.2 dBA in the afternoons as seen in Figure 18. Figure 19 shows that the aircraft flyover noise is more over the weekends especially on Saturdays. To test the effect of time of day and day of week on the noise observed, a two analysis of variance was done as shown in Table 13. The F value for day of week is 0.36 which is less than the F critical value of 1.8. This implies that the day of week has no significant effect on the noise levels observed due to aircrafts flyover. The F value for the time of day effect is seen be 0.96 which is less than the F critical value of 1.96, which implies that the time of day has no significant effect on the noise levels observed.

**Comparison between Noise Indices**

Figure 11 show the comparison between the background noise indices of the different locations. Location 1 had the highest background noise indices followed by location 3 and 2. This is so because Location 1 is close to a busy road with so many commercial activities going on there as well. The other two locations had light traffic and playing children as the major source of background noise. Figure 21 shows the comparison between the aircraft flyover noise indices of the different locations. Location 1 had the highest $L_{10}$ value of 94.8 dBA while Location 3 had the lowest value of 93.2. The $L_{eq}$ for all three locations were observed to be very close signifying that the three locations are experiencing the same aircraft flyover noise on the average.

**Noise Gap Index (NGI) Model**

From the result of Noise gap index analysis for the low and high background noise groups produced two models that can be used to quickly estimate the difference between aircraft flyover noise and the background noise by simply counting the number of flyovers observed. Figure 25 is very useful in graphically estimating the NGI of the high noise groups and low noise groups. The aircraft flyover is determined by counting, and finding the corresponding NGI by tracing up to the appropriate line. It can be inferred that individuals working and living in the areas of low background noise vicinities were more probable to be impacted and annoyed by the same helicopter noise exposure level than individuals around the high background noise vicinity. This is so because for a low background noise area, the difference between a helicopter flyover noise and the ambient noise level will be more than for a high noise area. The higher the NGI, the louder the perceived change in noise level leading to increased annoyance. However, individuals residing in the high noise locations could be more vulnerable to mental health effect and other health related issues due to prolong and perpetual helicopter noise.

**Conclusion**

The research focused on the impacts of the helicopter noise on the individuals specifically living in the areas adjacent and under the probable departure and arrival flight path or route. Because it is at this vicinity that the helicopters are extremely close to the ground, a greater noise effect is felt. The background noise for locations 1 - 3 was determined to be 72.4 dBA, 67.7 dBA and 70.5 dBA respectively. This made it possible for a high noise group and low noise group to exist with 70 dBA as the threshold of divide. The peak background noise ranged from 69.17 dBA at location 2 to 79 dBA at location 1. The aircraft flyover noise was determined to be 88.6 dBA, 88.5 dBA and 88.4 dBA for locations 1 to 3 respectively. The models for estimating NGI developed will aid in the quick assessment of the annoyance caused by aircraft flyover noise in Mgbuoshimini community.

The result of the analysis indicates that individuals working and living in the areas of low background noise vicinities were more probable to be impacted and annoyed by the same helicopter noise exposure level than individuals around the high background noise vicinity. However, individuals residing in the high noise locations could be more vulnerable to mental health effect and other health related quality of life due to prolong and perpetual helicopter noise than the other locations. Accordingly, it could be imperative that further epidemiological studies could be conducted to ascertain if the mental health of residences along the locations of the high background noise are impacted significantly [21-76].

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