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An Experimental-assessment of Human Exposure-levels to Aircraft Noise-hazards in the Neighbouring-environments of four Nigerian Airports

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Abstract. This paper reports a scientific-assessment of the exposure-levels of aircraft noise-hazards suffered by persons living/working within the neighbourhoods of four Airports [Ibadan, Benin-City, Warri and Owerri] in Nigeria. Physical measurements of selected aircraft and environmental noise parameters [Ambient Noise Level (ANL), Sound Pressure Level (SPL), Aircraft Take-off Noise-level ($ATNL$) and Aircraft Landing Noise-level ($ALNL$)]; were carried-out using the integrated CR811C Noise meter, during one hundred and twenty (120) periodic noise sampling-surveys; performed [from January to December 2017] at thirty (30) randomly-selected study-locations, within the vicinity of each of these four(4) airports in accordance with the Method/Standard-procedures specified by the International Standards Organisation's (ISO) relevant standards—ISO 3891, ISO 1996-1 and ISO 1996-2. The results showed that: while SPL ranged from 103-115 $dB(A)$, ANL ranged from 52.3 – 64.1 $dB(A)$, the $ATNL$ ranged from 69.6 – 87.7 $dB(A)$, and $ALNL$ ranged from 66.2 – 82.7 $dB(A)$. Actually, these results are alarming, since they significantly exceed the WHO Standard Recommended Maximum Noise-levels of: 35 $dB(A)$ [Indoor], 55 $dB(A)$ [Outdoor] to prevent Speech-intelligibility, Noise-annoyance & Sleep-disturbance; and 90 $dB(A)$ [being the Permissible Noise level/limit for 8hour daytime safe human exposure]. These and the results of the Statistical analysis (Wilcoxon Sign Rank Test) carried-out, clearly prove the existence of a generally ignored, but yet dangerous problem of continuous human-exposure to excessively high-levels of Aircraft noise-hazards to which residents of Airports' neighborhoods are subjected.
Keywords: Aircraft Noise-hazard, Airport, Environment, Exposure-level, Noise-level

1. Introduction

The problem of the marine environment is gaining widespread social attention. Bohai Sea is the The history of our modern world is unarguably incomplete without the repetitive mention of the 'generic word' "Aircrafts"—which refers to aeroplanes, helicopters, drones and the likes. Suffice it to say that, in almost every metropolitan city of the world today, [including Nigeria's big cities], the regular sights of flying aircrafts traversing our earth's atmosphere with their accompanying noise emissions, seem to have become a part of the daily lives of the citizenry.

Noise pollution—be it aircraft-generated or not, has been repeatedly proven to be a global health hazard, which may have motivated governmental leaders all over the world to champion the noble cause for 'Quieter Cities'—a worthwhile move, which would not only enhance human health-conditions, but would also foster positive country-to-country relations, while ensuring that tourism-related economic gains are reaped etc. [1]. Research evidence has proven that an alarming minority percentage of people living in big cities of developing countries like Nigeria, are gradually becoming partially aware of some of the dangers/health risks associated with hazardous noise exposure [2].

In 2008, Kaltenbach, M. et al showed that there is a dose-response relationship between arterial hypertension occurrence and exposure to aircraft noise; this was based on the findings of their empirical study on the 'Health Consequences of Aircraft Noise', from which they found out that: 'Increased risk of hypertension [for their human subjects] was linked to outdoor aircraft noise-induced equivalent Sound Pressure Levels of $45dB(A)$ in the night and $60dB(A)$ during the day[3]. There is a higher probability for persons living in areas with medium and high background environmental noise to suffer the same level of aircraft noise hazard, than their counterparts residing in low background environmental noise areas [4].

In 2004, Fransen, E. A. M. et al asserted that, there is a link between aircraft noise exposure level and certain health indicators [such as the use of medicinal drugs for high blood pressure or cardiovascular ill-health, general wellbeing/health condition, and the use of sedatives or sleep medicine(s), during the daytime; while the use of self-prescribed sedatives and sleep medicine(s) was prevalent among the experimental subjects when exposed to aircraft noise hazard late in the evenings [5].

It has now been established that, particularly at high levels of exposure to aircraft noise, there exists statistically significant relationship between the human cardiovascular health/wellbeing and exposure-level to aircraft noise-hazard [6]. This may have necessitated the world's apex health body—the World Health Organization (WHO) to adopt $40dB(A)$ as the desirable threshold value for people/persons subjected to chronic exposure to aircraft noise hazard [7]. At the moment, there is enough of scientific evidence to assert that, there is a strong positive relationship between several health challenges/issues [and particularly high blood pressure] and exposure to aircraft noise hazard—which according to several schools of thought, is generally considered a "nuisance and an environmental stressor" [8].

Whether in the civil aviation sector or in the military aviation sector of a nation's economy, aircrafts have visibly shaped the course of human history and more often than not, positively impacted virtually all sectors of the global economy including transportation, defence, Healthcare, Information Technology, Trade & Commerce and Power etc. However, it is sad to mention that, the merits of the aircraft notwithstanding, they also come with the accompanying demerits of aircraft-related environmental noise pollution—a situation which at the moment, cannot be completely eliminated, but can only be controlled or mitigated.

The Wikipedia online free encyclopaedia defined Aircraft Noise as that pollution generated by an aircraft or its parts, which occurs at different stages of an air flight i.e. on the ground when parked such as auxiliary power units, when taxiing, on run-up from the propeller and the jet-exhaust, while taking-off, under and beside the arrival and over-flying while enroute [9]. According to Mauskar J. M. (2008), Aircrafts are one of the major sources of noise, especially when they take-off and land. Thus, it is ideally in the health interest of the nearby residential human populace that, airports should be located at reasonable distances far away from people, to prevent them from being negatively affected by traffic noise [10].

The World Health Organisation (WHO) is seriously concerned about the many negative consequences of the aviation industry operation on the health conditions/general wellbeing of man. It has expressed genuine fears that a prolonged exposed to $65dB(A)-75dB(A)$ of aircraft noise for periods ranging from 5 – 30 years, could resulting hypertension and increased blood pressure [11]. So many research works have been carried-out, which reported the negative effects of aircraft noise exposure on human health. Some researchers have established the existence of a strong link/relationship between aircraft noise exposure and sleep disturbance, hypertension, headaches, stress & fatigue, increased risk of heart attack and noise-annoyance etc. [5], [12], [13], [14], [15].

According to Gualandi, N. and Manteccchini, L. (2008), aircraft operations actually constitute a major source of environmental externalities, particularly at the level of the local residents; also, noise pollution is now a serious concern to persons who reside near airports. It has been shown that, Noise— [including that emitted by an aircraft] can significantly affect the development of the cognitive capacity of children [16], [17].

Thus, from the above discourse, it is clear that aircraft noise negatively affects human health. Although, several studies have been conducted to investigate the noise pollution levels around some international airports in Nigeria [e.g. Muritala Mohammed International Airport in Lagos, Nnamdi Azikiwe

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International Airport in Abuja, Port-Harcourt International Airport in Port-Harcourt, and Margaret Ekpo International Airport in Calabar etc.]; little or no work has been done in relation to domestic airports in Nigeria.
Our primary research hypothesis was that: “Persons residing/working within the proximate neighbouring-environments of domestic airports in Nigeria are continuously subjected to hazardous levels of aircraft noise pollution, which on prolonged daily exposure, will most certainly result in a number of physiological and psychological ill-health conditions—as is scientifically proven by a multiplicity of scholarly research literatures, globally”.
Consequently, the aim of this study is to carry-out a scientific assessment of the aircraft noise hazard-levels [in terms of quantitative empirical estimates] that people/persons working/residing within the proximate neighbouring-environments of four domestic airports in Nigeria—Ibadan Airport in Ibadan city of Oyo state, South-Western Nigeria; Benin Airport in Benin-City of Edo state, South-Southern Nigeria; Owerri Airport [also called “Sam Mbakwe Airport”] in Owerri city of Imo state, South-Eastern Nigeria and Warri Airport [also called “Osubi Airport”] in Warri city of Delta state, South-Southern Nigeria.

2. Materials and Method

(i) <u>About the Study-areas</u>

The four (4) Study-areas were the Neighbourhoods [i.e. Neighbouring-environments] of Ibadan Airport, Benin Airport, Owerri Airport and Warri Airports—all in Nigeria.

Ibadan Airport [IATA: ‘IBA’, ICAO: ‘DNIB’] is located at coordinates (7°21’35’’N, 3°58’33’’E) has an average Mean Sea Level elevation of 221m (i.e. 725ft), and 2,400m (i.e. 7,874ft) cumulatively long asphalt run-ways. It is owned and operated by the Federal Airports Authority of Nigeria (FAAN), and mainly serves the civil aviation needs of residents of Ibadan—the economically viable metropolitan capital city of Oyo state in South-Western Nigeria. Ibadan is Africa’s second largest city [only next to ‘Cairo’ in Egypt], West-Africa’s largest city by land area (6,800Km^2 i.e. 2,600sq mi), and is Nigeria’s third most populous city with an estimated population of 3,565,108 as at June 2018 [18], [19].

Benin Airport [IATA: ‘BNI’, ICAO: ‘DNBE’] is located at coordinates (6°19’00’’N, 5°36’00’’E) has an average Mean Sea Level elevation of 79m (i.e. 258ft), and 2,400m (i.e. 7,874ft) cumulatively long asphalt run-ways. It is owned and operated by the Federal Airports Authority of Nigeria (FAAN), and mainly serves the civil aviation needs of residents of Benin-City—the economically viable metropolitan capital city of Edo state in South-Southern Nigeria. Benin-City is Nigeria’s sixth most populous city with an estimated population of 1,125.058 as at June 2018 [19], [20].

Owerri Airport also known as Sam Mbakwe Airport or Imo state Airport [IATA: ‘QOW’, ICAO: ‘DNIM’] is located at coordinates (5°25’35’’N, 7°12’20’’E) has an average Mean Sea Level elevation of 114m (i.e. 373ft), and 2,700m (i.e. 8,858ft) cumulatively long asphalt run-ways. It is owned and operated by the Federal Airports Authority of Nigeria (FAAN), and mainly serves the civil aviation needs of residents of Owerri—the economically viable metropolitan capital city of Imo state in South-Eastern Nigeria. Owerri is Nigeria’s forty-third most populous city with an estimated population of 215,038 as at June 2018 [19], [21].

Warri Airport also known as Osubi Airport [IATA: ‘QRW’, ICAO: ‘DNSU’] is located at coordinates (5°35’50’’N, 5°49’10’’E) has an average Mean Sea Level elevation of 8.2m (i.e. 27ft), and 1,800m (i.e. 5.906ft) cumulatively long asphalt run-ways. It is owned and operated by the Shell Petroleum Development Company (SPDC) Nigeria, and mainly serves the civil aviation needs of residents of Warri—the economically viable, metropolitan city and oil-rich business hub in Delta state in South-Southern Nigeria. Warri is Nigeria’s eighteenth most populous city with an estimated population of 536,023 as at June 2018 [19] [22].

Fig 1: Map of Nigeria showing the Ibadan, Benin, Owerri and Warri Airports [23]

(ii) Experimental Programmme

Real-time physical measurements of two environmental noise parameters [Ambient Noise Level (ANL) and Sound Pressure Level (SPL)] and two aircraft environmental noise parameters [Aircraft Take-off Noise Level ($ATNL$) and Aircraft Landing Noise Level ($ALNL$)] around each of four(4) domestic airports in Nigeria—Ibadan Airport (Lat. 7.3584°N, Long. 3.9751°E) in Oyo state, South-west Nigeria; Benin Airport (Lat. 6.3172°N, Long. 5.6037°E) in Edo state, South-South Nigeria; Owerri Airport (Lat. 5.4274°N, Long. 7.2029°E) in Imo state, South-East Nigeria; and Warri Airport (Lat. 5.5945°N, Long. 5.8193°E) in Delta state, South-South Nigeria; were repeatedly measured nine (9) times on a weekly basis during the one (1) year study-period, using the integrated $CR811C$ Noise meter in accordance with and ISO 3891:1978 standards [24], ISO 1996-1:2016 [25], and ISO 1996-2:2016 [26].

The integrated $CR811C$ Noise meter is a type 1 integrated sound level meter which is specially designed and equipped with the capacity to obtain and record precise field measurements of time-integrated sound level values. Having a measurement accuracy of $\pm 1dB(A)$, it measures sound levels from a minimum of $21dB(A)$ to a minimum of $140dB(A)$, with a measurement frequency which ranges from $25Hz$ to $16Hz$. Furthermore, this precision sound level meter measures sound levels using the ‘ A ’ weighting scale sound frequency, which is preferable to sound frequency weighting scales ‘ B ’ and ‘ C ’, since it is most suitably similar to the usual behavioural response (reaction) of the human ear to most sound frequencies.

Three hourly measurements [morning (7am – 11am), afternoon (12noon -3pm) and evening (4pm – 8pm)] were carried-out at thirty (30) selected locations in the neighbouring environments of each of these four (4) airports, thrice every week, on any weekday [from Monday through Friday], for twelve (12) months

[from January to December 2017]. All measurements were taken and recorded in ‘ $dB(A)$ ’ , where ‘ A ’ represents the A -weighting frequency for sound measurements.
Aircraft Take-off Noise Level ($ATNL$) and Aircraft Landing Noise Level ($ALNL$) were measured when the aircraft were taking-off and landing respectively. The Ambient Noise Level (ANL)—being the background noise level, was measured when the airports and the particular environments (neighbourhoods) were observed to be least busy, with no major activity taking place. The Sound Pressure Level (SPL) was measured when the normal and/or major activities/operations were carried-out in the airports.
For the purpose of these experimental measurements, this measuring device—the $CR811C$ Noise level meter, which was equipped with the inherent operational capacity to take multiple precision measurements of sound levels for the duration of a preset time, and then compute and record the average value; was first calibrated, and specifically set at the following configurations: (a) the ‘ A -weighting frequency network’ , (b) one (1) hour measurement time operation, and (c) the ‘fast’ response range—[corresponding to a time constant of $0.125s$]; after which, it was tripod-mounted at a height of $1.5m$ from the ground, with its microphone always pointing in the direction of the airport. When all necessary measurements of the four desired parameters had been performed, the daily/weekly averages were used to compute the monthly averages, and then these monthly averages were used to compute the yearly averages for each of both airports. Finally, the obtained yearly overall airport average values were analyzed by comparing them the three reference values stated by the World Health Organization (WHO), i.e.: WHO Standard Recommended Maximum Indoor Noise-level [$RINL_{WHO} = 35dB(A)$], WHO Standard Recommended Maximum Outdoor Noise-level [$RONL_{WHO} = 55dB(A)$], and the WHO Standard Recommended Noise-level/Sound Pressure Level for eight (8) hour daytime safe human exposure [$SPL_{WHO} = 90dB(A)$]. This was done to experimentally determine whether or not they conformed to these three standard values, and in the event that they did not conform, a rigorous statistical analysis was carried-out to evaluate the levels of deviations from the global standard values.
Also, the experimentally obtained data of the four acoustic parameters (‘ ANL ’, ‘ SPL ’, ‘ $ATNL$ ’ and ‘ $ALNL$ ’) were collated and tabulated in tables 1-4. As was earlier mentioned, the collated and tabulated data was then subjected to statistical analysis, using the ‘SPSS-23 (Software Package for Statistics & Simulation-23)’. This was carried-out to determine the levels (extents) by which the ANL as a parameter deviates (differs/varies) from the ‘World Health Organisation (WHO) Standard Recommended Maximum Outdoor Noise Level $(RONL_{WHO})$ ’ of $55dB(A)$, and also to ascertain the different levels (extents) by which each of the three other parameters [i.e. ‘ SPL ’, ‘ $ATNL$ ’ and ‘ $ALNL$ ’] deviate (differ/vary) from the ‘World Health Organisation (WHO) Standard recommended Sound Pressure Level for 8 hour daytime safe human exposure (SPL_{WHO}) ’ of $90dB(A)$
Thus, the levels (extents) of deviations (variations) of these four acoustic parameters ‘ ANL ’and (‘ SPL ’, ‘ $ATNL$ ’ and ‘ $ALNL$ ’), from the WHO Standard Recommended Maximum Noise-levels [i.e. ‘ $(RONL_{WHO})$ ’ and ‘ (SPL_{WHO}) ’ respectively], were obtained, by carrying-out a non-parametric statistical test called “The Wilcoxon Sign Rank Test” on the values of these four acoustic parameters (‘ ANL ’, ‘ SPL ’, ‘ $ATNL$ ’ and ‘ $ALNL$ ’). Thus, with respect to the ‘World Health Organisation (WHO) Standard recommended Outdoor Noise Level $(RONL_{WHO})$ ’ of $55dB(A)$, one(1) ‘Null-Hypothesis (H_0)’ and one(1) ‘Alternative Hypothesis (H_a)’ were all stated to a significance-level (α), as follows:
For parameter ’ ANL ’, $\rightarrow$ $H_0 : ANL = 55dB(A)$, $H_a : ANL > 55dB(A)$, $\alpha = 0.05$ [95% confidence level]
But with respect to the ‘‘World Health Organisation (WHO) Standard recommended Sound Pressure Level for 8 hour daytime safe human exposure (SPL_{WHO}) ’ of $90dB(A)$, three (3) ‘Null-Hypotheses (H_0)’ and three (3) ‘Alternative Hypotheses (H_a)’ were all stated to a significance-level (α), as follows:
For parameter ’ SPL ’, $\rightarrow H_0 : SPL = 90dB(A)$, $H_a : SPL > 90dB(A)$, $\alpha = 0.05$ [95% confidence level]
For parameter ‘ $ATNL$ ’, $\rightarrow H_0 : ATNL = 90dB(A)$, $H_a : ATNL > 90dB(A)$, $\alpha = 0.05$ [95% confidence level]
For parameter ‘ $ALNL$ ’, $\rightarrow H_0 : ALNL = 90dB(A)$, $H_A : ALNL > 90dB(A)$, $\alpha = 0.05$ [95% confidence level]

3. Results and Discussion

Below are nine (9) tables and eight (8) figures in which are contained and illustrated the results obtained during this twelve (12) months study. Specifically, Table 1 and Figure 2 display the results for Ibadan domestic Airport in Oyo state, South-Western Nigeria; Table 2 and Figure 3 display the results for Benin domestic Airport in Edo state, South-Southern Nigeria; Table 3 and Figure 4 display the results for Owerri domestic Airport in Imo state, South-Eastern Nigeria and Table 4 and Figure 5 display the results for Warri domestic Airport in Delta state, South-Southern Nigeria.

Table 1: Average Values of Noise Parameters Measured at Thirty (30) Study-locations within the Neighbourhoods of Ibadan Domestic Airport, in Oyo state, South-Western Nigeria.

Airport Neighbourhood Study-location S/No.	Ambient Noise Level (ANL) [dB(A)]	Sound Pressure Level (SPL) [dB(A)]	Aircraft Take-off Noise Level (ATNL) [dB(A)]	Aircraft Landing Noise Level (ALNL) [dB(A)]	SPL-RONL$_{WHO}$ [dB(A)]	% by which SPL exceeds RONL$_{WHO}$ (%)
1	63.5	107.0	77.0	85.7	17.0	94.5
2	64.0	116.0	88.4	89.4	26.0	110.9
3	62.0	113.0	81.7	78.0	23.0	105.5
4	57.2	116.0	84.6	92.8	26.0	110.9
5	65.2	108.0	84.2	70.6	18.0	96.4
6	61.3	115.0	90.7	85.4	25.0	109.1
7	64.5	113.0	78.6	77.3	23.0	105.5
8	54.5	112.0	84.4	84.9	22.0	103.6
9	74.2	114.0	85.0	75.4	24.0	107.3
10	54.9	110.0	77.0	84.1	20.0	100.0
11	59.8	115.0	73.9	80.0	25.0	109.1
12	65.9	111.0	80.6	81.7	21.0	101.8
13	61.1	114.0	80.8	74.2	24.0	107.3
14	68.0	112.0	77.5	92.3	22.0	103.6
15	47.5	113.0	87.8	75.3	23.0	105.5
16	72.1	115.0	71.4	91.4	25.0	109.1
17	56.0	108.0	86.5	82.7	18.0	96.4
18	71.4	109.0	77.8	84.5	19.0	98.2
19	54.8	113.0	77.3	83.0	23.0	105.5
20	69.1	114.0	77.0	80.8	24.0	107.3
21	55.6	110.0	84.2	79.5	20.0	100.0
22	66.4	117.0	89.5	83.7	27.0	112.7
23	59.8	115.0	78.3	84.0	25.0	109.1
24	73.3	115.0	83.5	84.8	25.0	109.1
25	61.2	113.0	77.0	79.8	23.0	105.5
26	58.6	104.0	86.7	77.7	14.0	89.1
27	67.5	98.0	84.1	88.9	8.0	78.2
28	56.3	112.0	79.3	87.8	22.0	103.6
29	72.1	106.0	85.8	75.3	16.0	92.7
30	73.8	112.0	89.6	81.1	22.0	103.6
Average	**63.1**	**112.7**	**82.0**	**82.4**	**21.7**	**103.0**

Ibadan Domestic Airport:

As could be seen from Table 1, the mean Ambient Noise level (ANL) within thirty (30) neighbourhoods of Ibadan domestic Airport ranged from a minimum value of $47.5dB(A)$ to a maximum value of $74.2dB(A)$, with an average value of $63.1dB(A)$. Also, the mean Sound Pressure Level (SPL) within these same thirty (30) airport neighbourhoods ranged from a minimum value of $107.0dB(A)$ to a maximum value of $117.0dB(A)$, with an average value of $112.4dB(A)$. Thus, it is obvious that, all six (6) values of both environmental noise parameters were far greater than the Standard Maximum Values of $35dB(A)$ and $55dB(A)$ recommended by the World Health Organisation (WHO) for indoor and outdoor activities respectively.

The mean Aircraft Take-off Noise level ($ATNL$) within thirty (30) neighbourhoods of Ibadan domestic Airport ranged from a minimum value of $71.4dB(A)$ to a maximum value of $90.7dB(A)$, with an average value of $82.0dB(A)$. Also, the mean Aircraft Landing Noise level ($ALNL$) within these same thirty (30)

Table 2: Average Values of Noise Parameters Measured at Thirty (30) Study-locations within the Neighbourhoods of Benin Domestic Airport, in Edo state, South-Southern Nigeria.

Airport Neighbourhood Study-location S/No.	Ambient Noise Level (ANL) [dB(A)]	Sound Pressure Level (SPL) [dB(A)]	Aircraft Take-off Noise Level (ATNL) [dB(A)]	Aircraft Landing Noise Level (ALNL) [dB(A)]	SPL-RONL$_{WHO}$ [dB(A)]	% by which SPL exceeds RONL$_{WHO}$ (%)
31	69.4	114.0	78.5	81.5	24.0	107.3
32	54.6	114.0	78.1	87.5	24.0	107.3
33	69.0	105.0	83.2	76.2	15.0	90.9
34	53.1	117.0	72.9	94.5	27.0	112.7
35	63.8	114.0	87.8	81.9	24.0	107.3
36	58.9	116.0	73.4	72.9	26.0	110.9
37	67.7	113.0	83.9	73.6	23.0	105.5
38	57.9	110.0	74.9	74.0	20.0	100.0
39	63.3	109.0	70.8	80.0	19.0	98.2
40	61.7	109.0	85.6	76.3	19.0	98.2
41	60.8	114.0	81.4	84.1	24.0	107.3
42	71.4	106.0	76.6	69.6	16.0	92.7
43	61.8	104.0	86.3	85.9	14.0	89.1
44	57.3	110.0	78.2	79.6	20.0	100.0
45	63.4	117.0	86.5	70.4	27.0	112.7
46	64.7	109.0	87.8	72.7	19.0	98.2
47	61.6	115.0	82.9	80.8	25.0	109.1
48	64.2	104.0	82.1	79.6	14.0	89.1
49	58.8	111.0	75.8	81.6	21.0	101.8
50	59.9	110.0	79.5	85.6	20.0	100.0
51	63.5	112.0	76.8	78.4	22.0	103.6
52	58.6	114.0	73.6	89.7	24.0	107.3
53	67.0	107.0	91.6	70.9	17.0	94.5
54	59.4	113.0	78.4	92.3	23.0	105.5
55	69.3	116.0	83.0	77.7	26.0	110.9
56	63.7	114.0	90.8	93.8	24.0	107.3
57	70.3	109.0	83.6	85.7	19.0	98.2
58	68.8	114.0	89.7	92.1	24.0	107.3
59	65.9	112.0	91.4	93.8	22.0	103.6
60	67.2	110.0	73.5	92.4	20.0	100.0
Average	**63.2**	**111.4**	**81.3**	**81.8**	**21.4**	**102.5**

airport neighbourhoods ranged from a minimum value of $70.6dB(A)$ to a maximum value of $92.8dB(A)$, with an average value of $82.4dB(A)$. Thus, it is obvious that, all six (6) values of both aircraft noise parameters and environmental noise parameters were far greater than the Standard Maximum Values of $35dB(A)$ and $55dB(A)$ recommended by the WHO for indoor and outdoor activities respectively; but were lesser than the Standard Maximum Noise level of $90dB(A)$ recommended by the WHO for eight (8) hour daily safe human exposure.

As is pictorially represented in Figure 2 and shown in Table 1, twenty-one (21) out of thirty (30) neighbouring-environments of Ibadan domestic airport had mean SPL values that deviated upward from the $RONL_{WHO}$ [i.e. WHO Recommended Outdoor Noise Level of $55dB(A)$] by over 100%, while seven (7) out of same thirty (30) neighbouring-environments had SPL values that deviated downward from the $RONL_{WHO}$ by less than 100%, and the remaining two (2) neighbouring-environments had SPL values that deviated upward from the $RONL_{WHO}$ by exactly 100%.

Table 3: Average Values of Noise Parameters Measured at Thirty (30) Study-locations within the Neighbourhoods of Owerri Domestic Airport, in Imo state, South-Eastern Nigeria.

Airport Neighbourhood Study-location S/No.	Ambient Noise Level (ANL) [dB(A)]	Sound Pressure Level (SPL) [dB(A)]	Aircraft Take-off Noise Level (ATNL) [dB(A)]	Aircraft Landing Noise Level (ALNL) [dB(A)]	SPL-RONL$_{WHO}$ [dB(A)]	% by which SPL exceeds RONL$_{WHO}$ (%)
61	53.8	107.0	78.3	76.6.	17.0	94.5
62	64.3	114.0	88.9	86.3	24.0	107.3
63	71.4	116.0	78.8	73.2	26.0	110.9
64	59.2	106.0	81.3	75.4	16.0	92.7
65	64.2	114.0	73.2	69.1	24.0	107.3
66	55.8	107.0	72.5	82.7	17.0	94.5
67	70.0	108.0	88.5	85.7	18.0	96.4
68	55.5	111.0	73.4	71.5	21.0	101.8
69	63.5	112.0	86.7	87.9	22.0	103.6
70	51.7	116.0	89.5	79.1	26.0	110.9
71	69.5	106.0	74.3	82.4	16.0	92.7
72	67.7	112.0	82.0	81.6	22.0	103.6
73	51.0	110.0	91.6	71.7	20.0	100.0
74	66.2	113.0	77.6	81.8	23.0	105.5
75	53.7	111.0	90.6	68.5	21.0	101.8
76	74.6	114.0	89.5	86.7	24.0	107.3
77	59.7	107.0	76.2	92.3	17.0	94.5
78	65.5	115.0	83.4	87.3	25.0	109.1
79	68.0	109.0	85.3	78.6	19.0	98.2
80	58.9	111.0	79.9	87.7	21.0	101.8
81	53.6	104.0	90.5	72.3	14.0	89.1
82	61.1	112.0	81.4	83.5	22.0	103.6
83	66.8	115.0	82.0	79.3	25.0	109.1
84	53.1	108.0	82.3	82.6	18.0	96.4
85	72.2	110.0	92.6	80.9	20.0	100.0
86	73.7	106.0	87.4	69.2	16.0	92.7
87	68.5	102.0	91.8	89.6	12.0	85.5
88	57.2	99.0	88.5	85.7	9.0	80.0
89	71.7	110.0	90.7	86.4	20.0	100.0
90	69.9	105.0	86.4	91.1	15.0	90.9
Average	**63.1**	**109.7**	**83.8**	**81.0**	**20.5**	**101.3**

Benin Domestic Airport:

The experimental results shown in Table 2, revealed that, for all thirty (30) neighbourhoods of Benin domestic Airport, mean Ambient Noise Level (ANL) peaked at $71.4dB(A)$, averaged at $63.2dB(A)$, and recorded its five lowest values of $53.1dB(A)$, $54.6dB(A)$, $57.3dB(A)$, $57.9dB(A)$ and $58.6dB(A)$. It was noted that, the peak ANL, average ANL and three(3) of the five(5) lowest ANL values, [not to mention the other twenty-five (25) ANL values] were higher than the Maximum Value of $55dB(A)$ recommended by the World Health Organisation (WHO) for outdoor activities $(RONL_{WHO})$. In the same vein, while mean Sound Pressure Level (SPL) peaked at $117.0dB(A)$, averaged at $111.4dB(A)$, and recorded its five lowest values of $104dB(A)$ [twice], $105.0dB(A)$, $106.0dB(A)$ $107.0dB(A)$ and $109.0dB(A)$ [four times]. It was noted that, the peak SPL, average SPL and all five(5) lowest SPL values, [excluding the other twenty-five (25) SPL values] were higher than the Standard Maximum Noise level of $90dB(A)$ recommended by the WHO for eight (8) hour daily safe human exposure.

Table 4: Average Values of Noise Parameters Measured at Thirty (30) Study-locations within the Neighbourhoods of Warri Domestic Airport, in Delta state, South-Southern Nigeria.

Airport Neighbourhood Study-location S/No.	Ambient Noise Level (ANL) [dB(A)]	Sound Pressure Level (SPL) [dB(A)]	Aircraft Take-off Noise Level (ATNL) [dB(A)]	Aircraft Landing Noise Level (ALNL) [dB(A)]	SPL-RONL$_{WHO}$ [dB(A)]	% by which SPL exceeds RONL$_{WHO}$ (%)
91	57.1	112.0	69.5	73.3	22.0	103.6
92	69.8	105.0	81.7	82.7	15.0	90.9
93	56.3	112.0	82.9	85.4	22.0	103.6
94	75.7	109.0	73.7	78.7	19.0	98.2
95	64.8	103.0	78.6	88.9	13.0	87.3
96	71.5	113.0	80.7	80.2	23.0	105.5
97	53.1	114.0	82.9	81.7	24.0	107.3
98	62.1	112.0	87.8	72.4	22.0	103.6
99	57.9	111.0	82.8	85.2	21.0	101.8
100	72.4	116.0	80.9	78.8	26.0	110.9
101	55.1	116.0	80.5	78.5	26.0	110.9
102	75.2	105.0	82.7	89.0	15.0	90.9
103	64.9	117.0	88.9	92.3	27.0	112.7
104	69.0	108.0	79.8	80.1	18.0	96.4
105	62.3	114.0	76.5	87.8	24.0	107.3
106	59.6	108.0	72.2	79.5	18.0	96.4
107	63.5	108.0	87.3	74.6	18.0	96.4
108	62.5	109.0	73.4	83.1	19.0	98.2
109	65.9	114.0	87.6	80.0	24.0	107.3
110	73.2	110.0	76.2	77.2	20.0	100.0
111	64.2	113.0	83.8	82.8	23.0	105.5
112	66.9	110.0	72.4	74.6	20.0	100.0
113	67.6	106.0	89.6	92.3	16.0	92.7
114	75.6	103.0	84.2	87.8	13.0	87.3
115	62.8	102.0	77.0	79.5	12.0	85.5
116	73.6	107.0	85.5	90	17.0	94.5
117	74.9	109.0	78.2	91.7	19.0	98.2
118	75.4	110.0	80.3	78.6	20.0	100.0
119	72.8	108.0	87.6	83.7	18.0	96.4
120	74.6	109.0	88.1	85.2	19.0	98.2
Average	**66.7**	**109.8**	**81.1**	**82.5**	**19.8**	**100.0**

Similarly, in this same Table 2, is presented the mean Aircraft Take-off Noise level ($ATNL$) and mean Aircraft Landing Noise level ($ALNL$) results, from which it was observed that, the mean $ATNL$ peaked at $91.6dB(A)$, averaged at $81.3dB(A)$, and recorded its five lowest values of $70.8dB(A)$, $72.9dB(A)$, $73.4dB(A)$, $73.5dB(A)$ and $73.6dB(A)$. It was noted that, the peak $ATNL$, average $ATNL$ and all five(5) lowest $ATNL$ values, [not to mention the other twenty-five (25) $ATNL$ values] were higher than the Maximum Value of $55dB(A)$ recommended by the World Health Organisation (WHO) for outdoor activities $(RONL_{WHO})$. Likewise, the mean $ALNL$ peaked at $94.5dB(A)$, averaged at $81.8dB(A)$, and recorded its five(5) lowest values of $69.9dB(A)$, $70.4dB(A)$, $70.9dB(A)$, $72.7dB(A)$ and $72.9dB(A)$. It was noted that, although, all these values of $ALNL$ [with exception to its peak value] were lower than the Standard Maximum Noise level of $90dB(A)$ recommended by the WHO for eight (8) hour daily safe human exposure (SPL_{WHO}); yet, they all significantly exceeded the Standard Maximum Values of $35dB(A)$ and $55dB(A)$ recommended by the World Health Organisation (WHO) for indoor and outdoor activities respectively.

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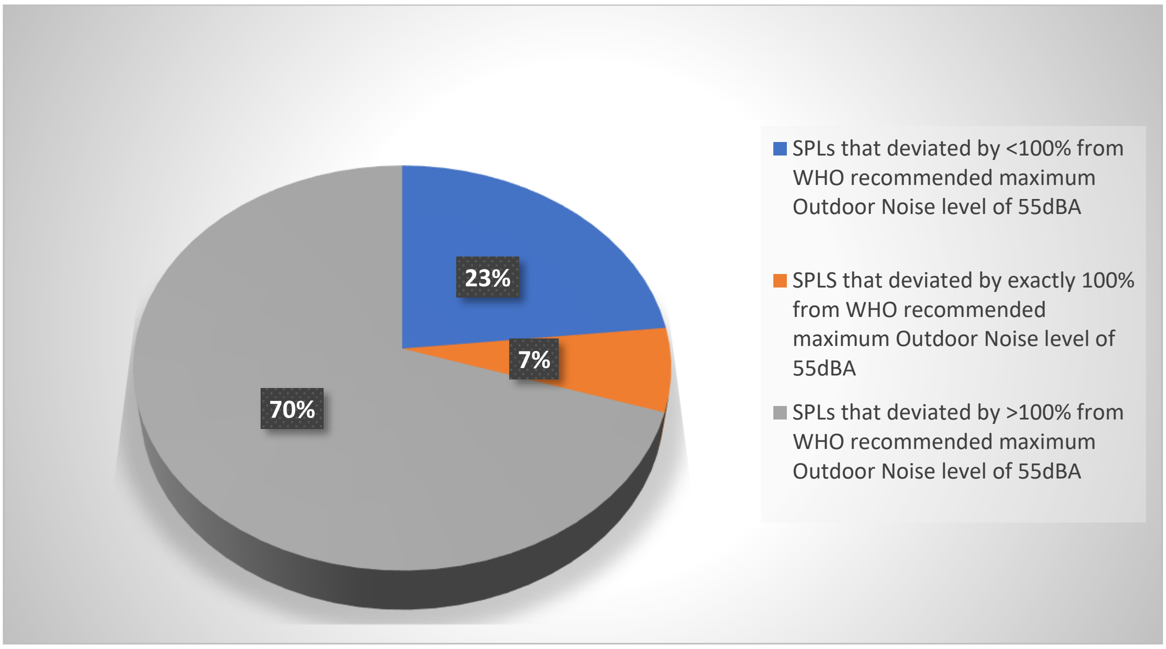

Fig. 2: Percentages by which the SPL-values in thirty (30) Neighbouring-environments of Ibadan Airport exceeded the WHO Recommended Maximum Outdoor Noise-level of 55dB(A)

Also, depicted in Figure 3 and shown in Table 2, is the fact that: seventeen (17) out of thirty (30) neighbouring-environments of Benin domestic airport had mean SPL values that deviated upward from the $RONL_{WHO}$ [i.e. WHO Recommended Outdoor Noise Level of $55dB(A)$] by over 100%, while nine (9) out of same thirty (30) neighbouring-environments had SPL values that deviated downward from the $RONL_{WHO}$ by less than 100%, and the remaining four (4) neighbouring-environments had SPL values that deviated upward from the $RONL_{WHO}$ by exactly 100%.

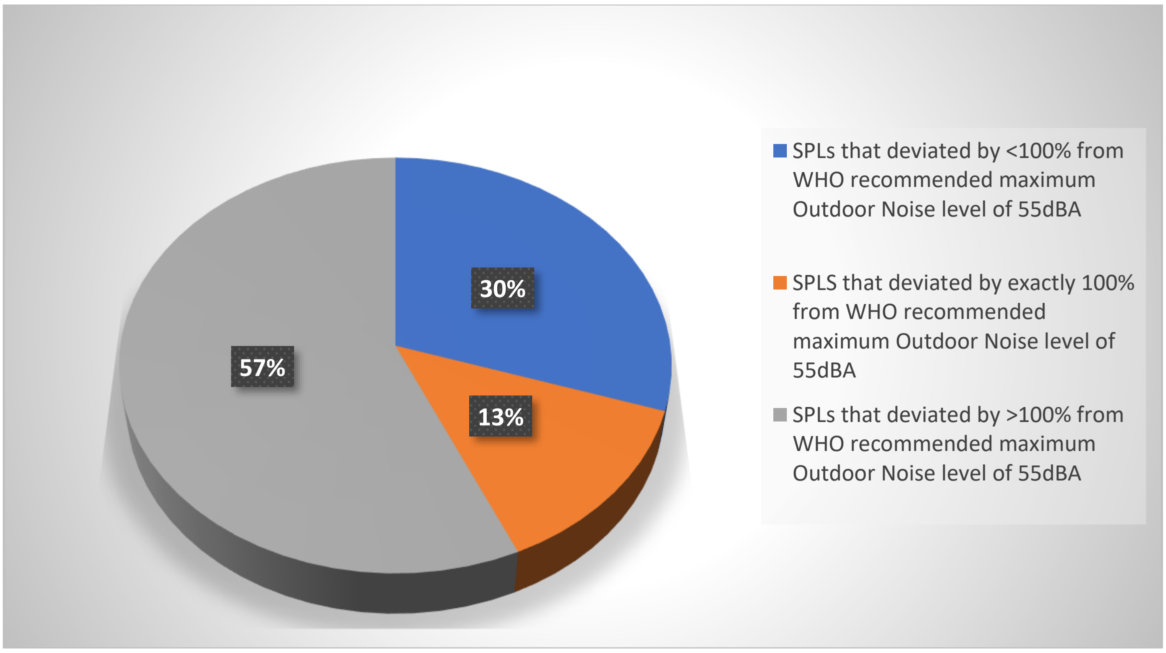

Fig. 3: Percentages by which the SPL-values in thirty (30) Neighbouring-environments of Benin Airport exceeded the WHO Recommended Maximum Outdoor Noise-level of 55dB(A)

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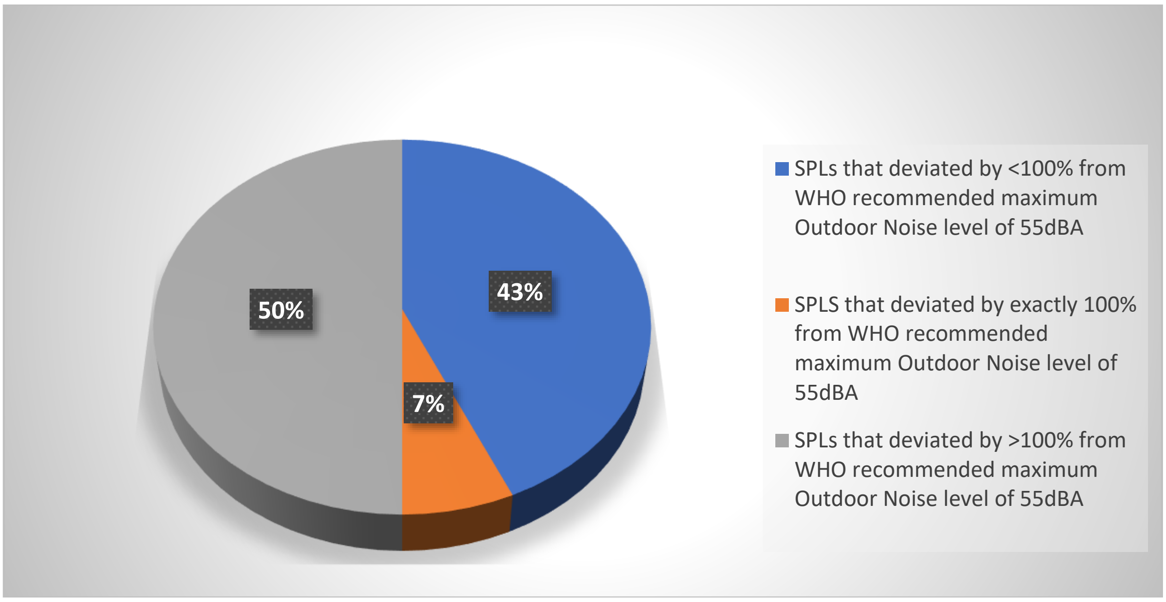

Fig. 4: Percentages by which the SPL-values in thirty (30) Neighbouring-environments of Owerri Airport exceeded the WHO Recommended Maximum Outdoor Noise-level of 55dB(A)

Owerri (Sam Mbakwe) Domestic Airport:

As could be seen from Table 3, the mean Ambient Noise level (ANL) within thirty (30) neighbourhoods of Owerri domestic Airport ranged from a minimum value of $51.0dB(A)$ to a maximum value of $74.6dB(A)$, with an average value of $63.1dB(A)$. Also, the mean Sound Pressure Level (SPL) within these same thirty (30) airport neighbourhoods ranged from a minimum value of $104.0dB(A)$ to a maximum value of $116.0dB(A)$, with an average value of $109.7dB(A)$. Obviously, all six (6) values of ANL and SPL were larger than the Standard Maximum Values of $35dB(A)$ and $55dB(A)$ recommended by the World Health Organisation (WHO) for indoor and outdoor activities respectively.

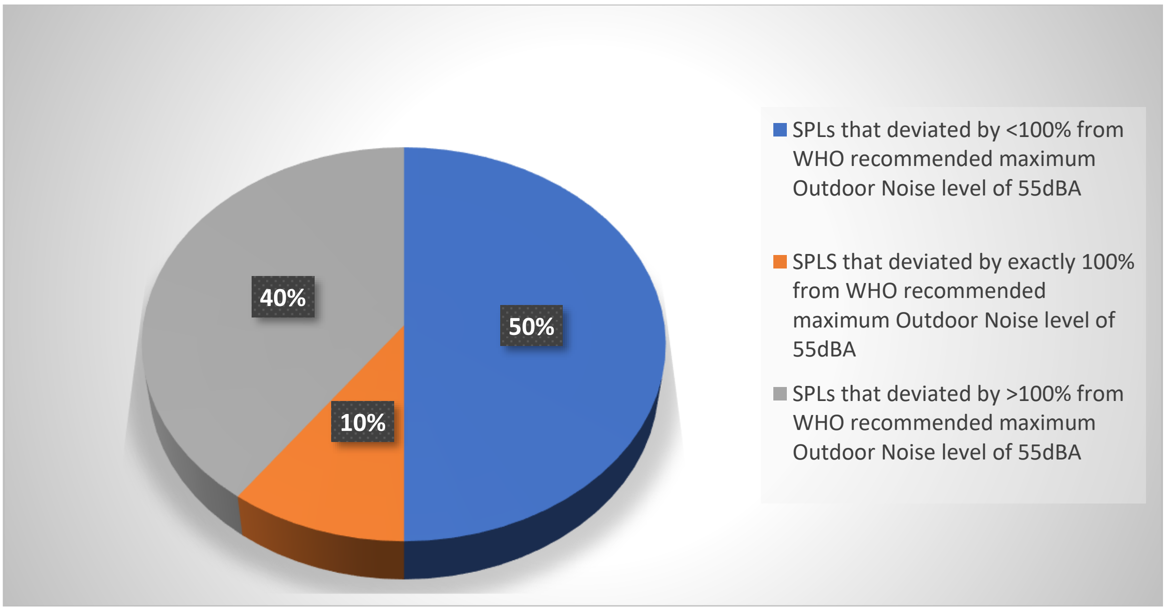

Fig. 5: Percentages by which the SPL-values in thirty (30) Neighbouring-environments of Warri Airport exceeded the WHO Recommended Maximum Outdoor Noise-level of 55dB(A) The mean Aircraft Take-off Noise level ($ATNL$) within thirty (30) neighbourhoods of Owerri domestic Airport ranged from a minimum value of $72.5dB(A)$ to a maximum value of $92.6dB(A)$, with an average value of $83.8dB(A)$. Also, the mean Aircraft Landing Noise level ($ALNL$) within these same thirty (30) airport neighbourhoods ranged

from a minimum value of $68.5dB(A)$ to a maximum value of $92.3dB(A)$, with an average value of $81.0dB(A)$. Again, it is obvious that, all six (6) values of both aircraft noise parameters and environmental noise parameters were greater than the Standard Maximum Values of $35dB(A)$ and $55dB(A)$ recommended by the WHO for indoor and outdoor activities respectively; but were lesser than the Standard Maximum Noise level of $90dB(A)$ recommended by the WHO for eight (8) hour daily safe human exposure.

Moreover, based on the experimental results illustrated in Figure 4 and presented in Table 3; fifteen (15) out of thirty (30) neighbouring-environments of Owerri domestic airport gave SPL values that deviated upward from the $RONL_{WHO}$ [i.e. WHO Recommended Outdoor Noise Level of $55dB(A)$] by over 100%, while thirteen (13) out of same thirty (30) neighbouring-environments had SPL values that deviated downward from the $RONL_{WHO}$ by less than 100%, and the remaining two (2) neighbouring-environments had SPL values that deviated upward from the $RONL_{WHO}$ by exactly 100%.

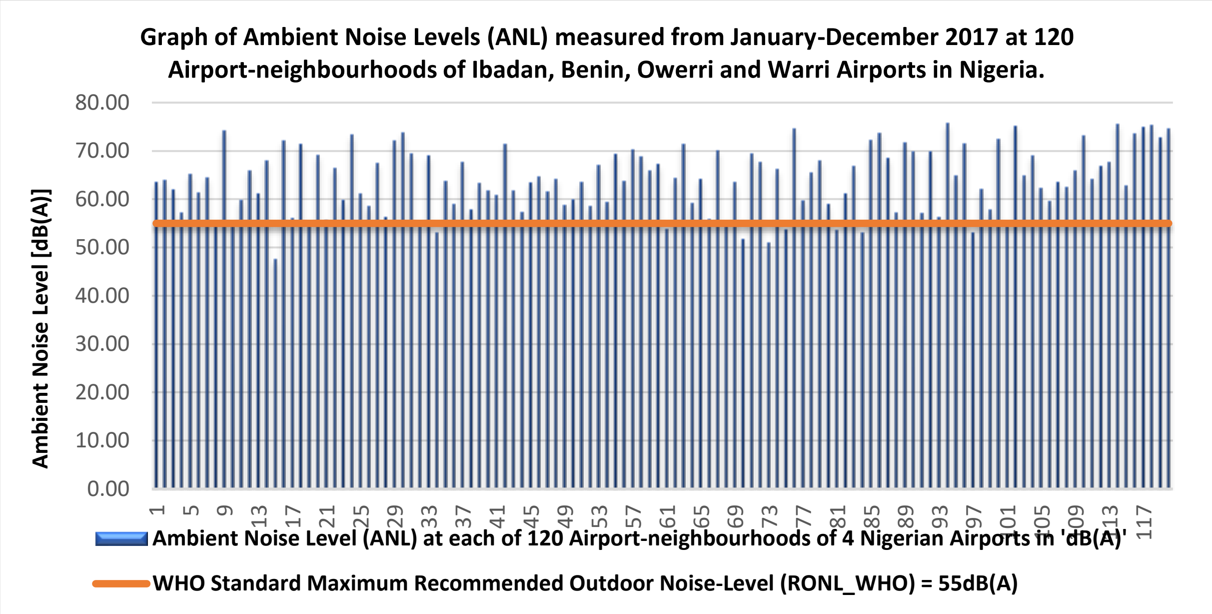

Figure 6: Graph of Ambient Noise Levels (ANL) measured from January-December 2017 at 120 Airport-neighbourhoods of Ibadan, Benin, Owerri and Warri Airports in Nigeria.

Warri (Osubi) Domestic Airport:

The experimental results shown in Table 4, revealed that, for all thirty (30) neighbourhoods of Warri domestic Airport, mean Ambient Noise Level (ANL) peaked at $75.7dB(A)$, averaged at $66.7dB(A)$, and recorded its five lowest values of $53.1dB(A)$, $55.1dB(A)$, $56.3dB(A)$, $57.1dB(A)$ and $57.9dB(A)$. It is noteworthy that, the peak ANL, average ANL and four(4) of the five(5) lowest ANL values, [not to mention the other twenty-five (25) ANL values] were higher than the Maximum Value of $55dB(A)$ recommended by the World Health Organisation (WHO) for outdoor activities $(RONL_{WHO})$. Furthermore, while the mean Sound Pressure Level (SPL) peaked at $117.0dB(A)$, averaged at $109.8dB(A)$, and recorded its five lowest values of $102dB(A)$, $103dB(A)$ [twice], $105.0dB(A)$ [twice], $106.0dB(A)$ and $107.0dB(A)$. It was noted that, the peak SPL, average SPL and all five lowest SPL values, [excluding the other twenty-three (23) SPL values] were higher than the Standard Maximum Noise level of $90dB(A)$ recommended by the WHO for eight (8) hour daily safe human exposure.

Again, in this same Table 4, is presented the mean Aircraft Take-off Noise level ($ATNL$) and mean Aircraft Landing Noise level ($ALNL$) results, from which it was observed that, the mean $ATNL$ peaked at $89.6dB(A)$, averaged at $81.1dB(A)$, and recorded its five lowest values of $69.5dB(A)$, $72.2dB(A)$, $72.4dB(A)$, $73.4dB(A)$ and $73.7dB(A)$. Thus, It was noticed that, the peak $ATNL$, average $ATNL$ and all five lowest $ATNL$ values, [not to mention the other twenty-five (25) $ATNL$ values] were higher than the Maximum Value of $55dB(A)$ recommended by the World Health Organisation (WHO) for outdoor activities $(RONL_{WHO})$. Similarly, the mean $ALNL$ peaked at $92.3dB(A)$, averaged at $82.5dB(A)$, and recorded its five lowest values of $72.4dB(A)$,

$73.3dB(A)$, $74.6dB(A)$ [twice], $77.2dB(A)$ and $78.5dB(A)$. Thus, it is worthy of note that, despite the fact that all these values of $ALNL$ [with exception to its peak value] were below the Standard Maximum Noise level of $90dB(A)$ recommended by the WHO for eight (8) hour daily safe human exposure (SPL_{WHO}); yet, they all were considerably higher than the Standard Maximum Values of $35dB(A)$ and $55dB(A)$ recommended by the World Health Organisation (WHO) for indoor and outdoor activities respectively.

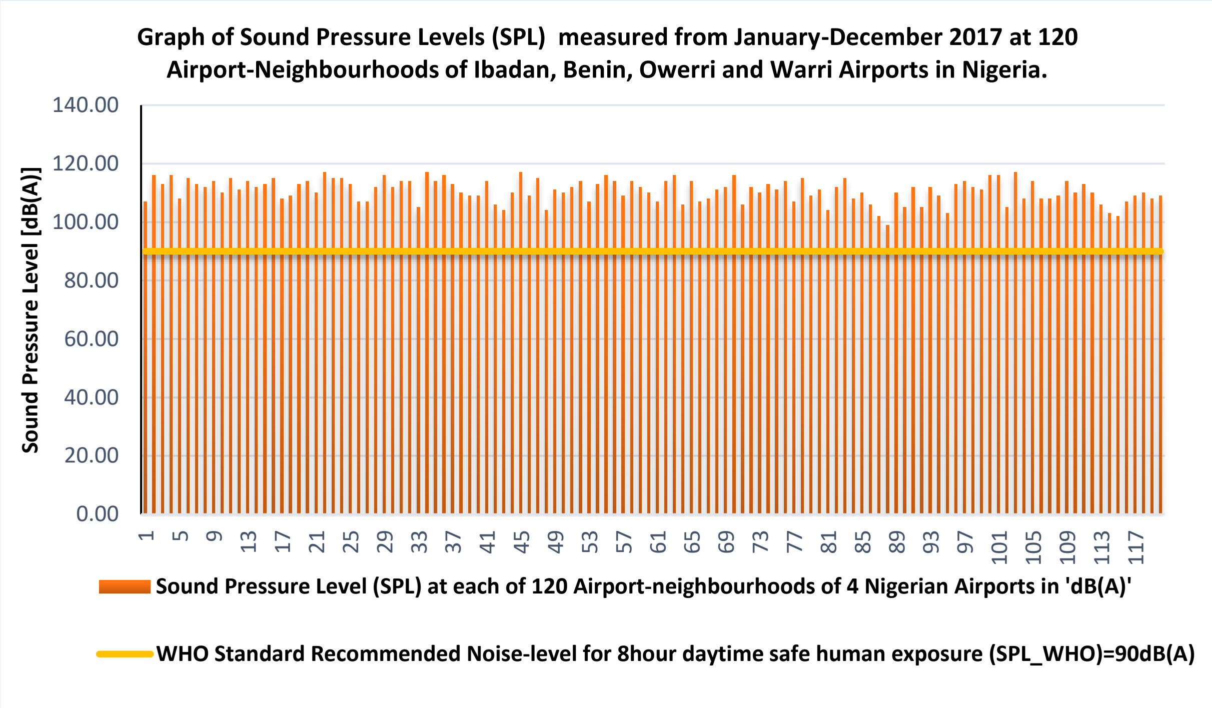

Figure 7: Graph of Sound Pressure Levels (SPL) measured from January-December 2017 at 120 Airport-neighbourhoods of Ibadan, Benin, Owerri and Warri Airports in Nigeria.

Furthermore, from the pictorial depiction in Figure 5 and the experimental results contained in Table 4, it could be inferred that: twelve (12) out of thirty (30) neighbouring-environments of Warri domestic airport gave SPL values that deviated upward from the $RONL_{WHO}$ [i.e. WHO Recommended Outdoor Noise Level of $55dB(A)$] by over 100%, while fifteen (15) out of same thirty (30) neighbouring-environments had SPL values that deviated downward from the $RONL_{WHO}$ by less than 100%, and the remaining three (3) neighbouring-environments had SPL values that deviated upward from the $RONL_{WHO}$ by exactly 100%.

Summarily, a careful look at Figures 6 - 9, shows that, for all one hundred and twenty (120) neighbourhoods of four (4) domestic airports in Nigeria, this periodic repetitive experimental acoustic assessment clearly revealed amongst other things that: 89.2% of the investigated Airports' neighbourhoods [i.e. 107 of 120 neighbourhoods] had ANL values which were higher than the WHO-

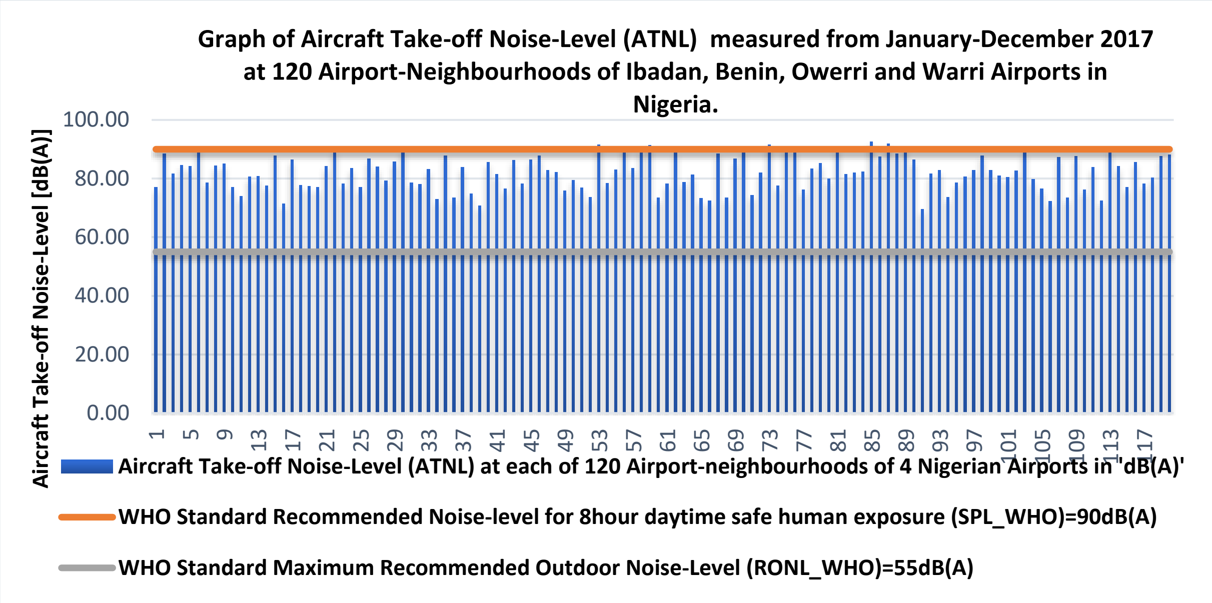

Figure 8: Graph of aircraft Take-off Noise-Level (ATNL) measured from January-December 2017 at 120 Airport-neighbourhoods of Ibadan, Benin, Owerri and Warri Airports in Nigeria.

recommended value ($RONL_{WHO}$) of $55dB(A)$; 100% of the investigated Airports' neighbourhoods [i.e. 120 of 120 neighbourhoods] had SPL values which were higher than the WHO-recommended value (SPL_{WHO}) of $90dB(A)$; 100% of the investigated airports' neighbourhoods [i.e. 120 of 120 neighbourhoods] had $ATNL$ values which were higher than the WHO-recommended value (SPL_{WHO}) of $90dB(A)$; and 87.5% of the investigated airports' Neighbourhoods [i.e. 105 of 120 neighbourhoods] had $ALNL$ values which were higher than the WHO-recommended value (SPL_{WHO}) of $90dB(A)$. Very importantly also, from a comparative stand-point, it was keenly observed from Tables 1-4, that: the highest level of exposure to Airport environmental noise hazard was recorded at Ibadan domestic Airport [with an SPL average value of $112.7dB(A)$], followed by Benin domestic Airport [$111.3dB(A)$], and Owerri domestic Airport [$110.7dB(A)$] and then, Warri domestic Airport [$110.0dB(A)$].

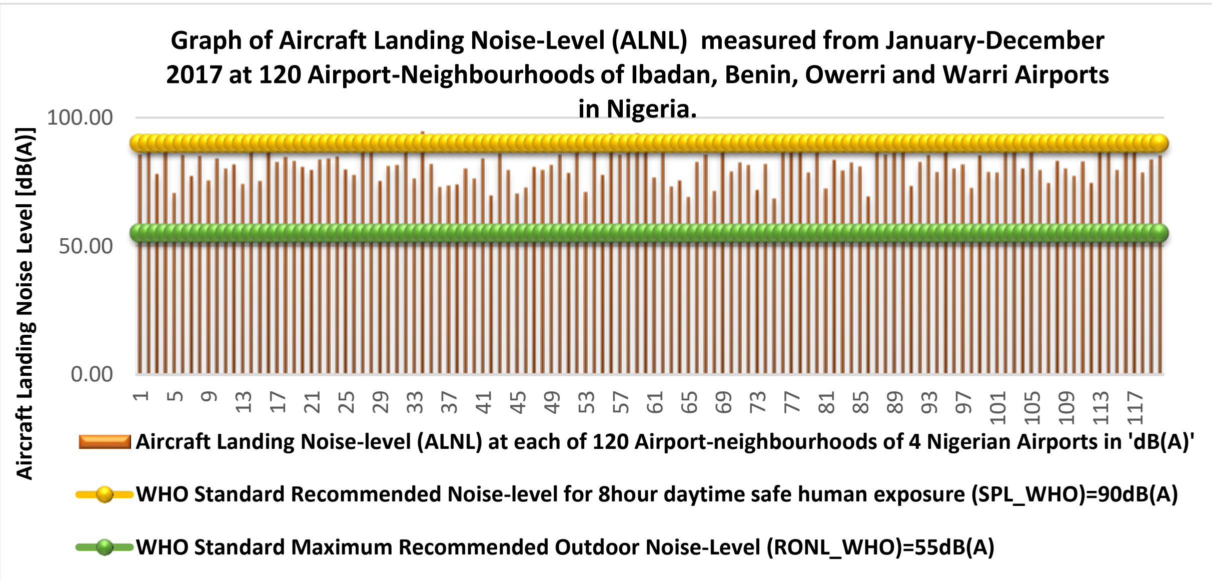

Figure 9: Graph of aircraft Landing Noise-Level (ALNL) measured from January-December 2017 at 120 Airport-neighbourhoods of Ibadan, Benin, Owerri and Warri Airports in Nigeria.

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Combined Statistical Analyses of Experimental Values of all Four (4) Acoustic Parameters ['ANL', 'SPL', 'ATNL' and 'ALNL'] Measured at 120 Distinct Airport Neighbourhoods [of Ibadan, Benin, Owerri and Warri Airports] in Nigeria:

Table 5: Basic Descriptive Statistics of all Ambient Noise Levels (*ANL*), Sound Pressure Levels (*SPL*), Aircraft Take-off Noise Levels (*ATNL*) and Aircraft Landing Noise Levels (*ALNL*) measured at 120 distinct Airport Neighbourhoods of Ibadan, Benin, Owerri and Warri Airports in Nigeria.

		ANL [dB(A)]	SPL [dB(A)]	ATNL [dB(A)]	ALNL [dB(A)]
N	Valid	120	120	120	120
	Missing	0	0	0	0
Mean		64.0075	110.8083	82.0600	81.9125
Median		64.1000	111.0000	82.2000	81.7500
Mode		63.50	114.00	77.00	92.30
Std. Deviation		6.63767	3.87904	5.76042	6.47985
Variance		44.059	15.047	33.182	41.988
Range		28.20	18.00	23.10	26.00
Minimum		47.50	99.00	69.50	68.50
Maximum		75.70	117.00	92.60	94.50
Sum		7680.90	13297.00	9847.20	9829.50

Shown in Table 5 above, are nine (9) common descriptive statistics of the combined data of these four acoustic parameters at all 120 investigated airport neighbourhoods in Ibadan, Benin, Owerri and Warri Airports. Although, some of these parameters may have been separately mentioned earlier, however, they will be re-discussed here briefly. In summary, while 'ANL' ranges from $47.5-75.5\ dB(A)$, with a mean of $64.0dB(A)$, a mode of $63.5dB(A)$, and a median of $64.1dB(A)$; 'SPL' ranges from $99.0-117.0\ dB(A)$, with a mean of $110.8dB(A)$, a mode of $114.0dB(A)$, and a median of $111.0dB(A)$; Also, while '$ATNL$' ranges from $69.5-92.6dB(A)$, with a mean of $82.1dB(A)$, a mode of $77.0dB(A)$ and a median of $82.2dB(A)$; and '$ALNL$' ranges from $68.5-94.5dB(A)$, with a mean of $81.9dB(A)$, a mode of $92.3dB(A)$ and a median of $81.8dB(A)$.

Table 6: Wilcoxon Signed Ranks Tests of measured *ANL* at 120 distinct Airport Neighbourhoods [of Ibadan, Benin, Owerri and Warri Airports] in Nigeria with respect to $RONL_{WHO}$

Ranks

		N	Mean Rank	Sum of Ranks
ANL [dB(A)] - RONL_WHO [dB(A)]	Negative Ranks	13[a]	15.50	201.50
	Positive Ranks	107[b]	65.97	7058.50
	Ties	0[c]		
	Total	120		

a. ANL [dB(A)] < RONL_WHO [dB(A)]
b. ANL [dB(A)] > RONL_WHO [dB(A)]
c. ANL [dB(A)] = RONL_WHO [dB(A)]

Test Statistics[b]

	ANL [dB(A)] - RONL_WHO [dB(A)]
Z	-8.979[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

Table 7: Wilcoxon Signed Ranks Tests of measured *SPL* at 120 distinct Airport Neighbourhoods [of Ibadan, Benin, Owerri and Warri Airports] in Nigeria with respect to SPL_{WHO}

Ranks

		N	Mean Rank	Sum of Ranks
SPL [dB(A)] - SPL_WHO [dB(A)]	Negative Ranks	0[a]	.00	.00
	Positive Ranks	120[b]	60.50	7260.00
	Ties	0[c]		
	Total	120		

a. SPL [dB(A)] < SPL_WHO [dB(A)]
b. SPL [dB(A)] > SPL_WHO [dB(A)]
c. SPL [dB(A)] = SPL_WHO [dB(A)]

Test Statistics[b]

	SPL [dB(A)] - SPL_WHO [dB(A)]
Z	-9.515[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

Following the 'SPSS-23' generated results of the 'Wilcoxon Signed Ranks Tests' analysis of the 'ANL data', shown in Table 6 above and Figures 10-12, with respect to the WHO Standard Recommended Maximum Outdoor Noise-level ($RONL_{WHO}$) of $55dB(A)$: for the 120 airport neighbouring-environments investigated around Ibadan, Benin, Owerri and Warri Airports, *n* is 119, *tie* is 0, Positive-Ranks i.e. $ANL[dB(A)] > RONL_{WHO}[dB(A)]$ is 107, and the Negative-Ranks i.e. $ANL[dB(A)] < RONL_{WHO}[dB(A)]$ is 13. Thus, the alternative hypothesis [$H_a : ANL > 55dB(A)$] is statistically significant and should be accepted at $Z = -8.979,\ n = 119,\ p = 0.000 < 0.05;$ while the null hypothesis [$H_0 : ANL = 55dB(A)$] should be rejected.

Table 8: Wilcoxon Signed Ranks Tests of measured *ATNL* at 120 distinct Airport Neighbourhoods [of Ibadan, Benin, Owerri and Warri Airports] in Nigeria with respect to SPL_{WHO}

Ranks

		N	Mean Rank	Sum of Ranks
ATNL[dB(A)] – SPL [dB(A)]	Negative Ranks	120[a]	60.50	7260.00
	Positive Ranks	0[b]	.00	.00
	Ties	0[c]		
	Total	120		

a. ATNL [dB(A)] < SPL [dB(A)]
b. ATNL [dB(A)] > SPL [dB(A)]
c. ATNL [dB(A)] = SPL [dB(A)]

Test Statistics[b]

	ATNL [dB(A)] – SPL [dB(A)]
Z	-9.507[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

From the 'SPSS-23' generated results of the 'Wilcoxon Signed Ranks Tests' analysis of the 'SPL data', shown in Table 7 above and Figures 10-12, with respect to the WHO Standard Recommended Noise-level/Sound Pressure Level for eight (8) hour daytime safe human exposure (SPL_{WHO}) of $90dB(A)$]: for the 120 airport neighbouring-environments investigated around Ibadan, Benin, Owerri and Warri Airports, *n* is 119, *tie* is 0, Positive-Ranks i.e. $SPL[dB(A)] > SPL_{WHO}[dB(A)]$ is 120, and the Negative-Ranks i.e. $SPL[dB(A)] < SPL_{WHO}[dB(A)]$ is 0. Thus, the alternative hypothesis [$H_a : SPL > 90dB(A)$] is statistically significant and should be accepted at $Z = -9.515,\ n = 119,\ p = 0.000 < 0.05;$ while the null hypothesis [$H_0 : SPL = 90dB(A)$] should be rejected.

Table 9: Wilcoxon Signed Ranks Tests of measured $ALNL$ at 120 distinct Airport Neighbourhoods [of Ibadan, Benin, Owerri and Warri Airports] in Nigeria with respect to SPL_{WHO}

Ranks

		N	Mean Rank	Sum of Ranks
ALNL[dB(A)] - SPL_WHO[dB(A)]	Negative Ranks	105[a]	65.53	6881.00
	Positive Ranks	14[b]	18.50	259.00
	Ties	1[c]		
	Total	120		

a. ALNL [dB(A)] < SPL_WHO [dB(A)]
b. ALNL [dB(A)] > SPL_WHO [dB(A)]
c. ALNL [dB(A)] = SPL_WHO [dB(A)]

Test Statistics[b]

	ALNL [dB(A)] - SPL_WHO [dB(A)]
Z	-8.780[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test

Likewise, based on the From the 'SPSS-23' generated results of the 'Wilcoxon Signed Ranks Tests' analysis of the '$ATNL$ data', shown in Table 8 above and Figures 10-12, with respect to the WHO Standard Recommended Noise-level/Sound Pressure Level for eight (8) hour daytime safe human exposure (SPL_{WHO}) of $90dB(A)$]: for the 120 airport neighbouring-environments investigated around Ibadan, Benin, Owerri and Warri Airports, *n* is 119, *tie* is 0, Positive-Ranks i.e. $ATNL[dB(A)] > SPL_{WHO}[dB(A)]$ is 120, and the Negative-Ranks i.e. $ATNL[dB(A)] < SPL_{WHO}[dB(A)]$ is 0. Thus, the alternative hypothesis [$H_a : ATNL > 90dB(A)$] is statistically significant and should be accepted at $Z = -9.507,\ n = 119,\ p = 0.000 < 0.05;$ while the null hypothesis [$H_0 : ATNL = 90dB(A)$] should be rejected.

Also, the 'SPSS-23' generated results of the 'Wilcoxon Signed Ranks Tests' analysis of the '$ALNL$ data', shown in Table 9 above and Figures 10-12, with respect to the WHO Standard Recommended Noise-level/Sound Pressure Level for eight (8) hour daytime safe human exposure (SPL_{WHO}) of $90dB(A)$]: for the 120 airport neighbouring-environments investigated around Ibadan, Benin, Owerri and Warri Airports, *n* is 119, *tie* is 1, Positive-Ranks i.e. $ALNL[dB(A)] > SPL_{WHO}[dB(A)]$ is 105, and the Negative-Ranks i.e. $ALNL[dB(A)] < SPL_{WHO}[dB(A)]$ is 14. Thus, the alternative hypothesis [$H_a : ALNL > 90dB(A)$] is statistically significant and should be accepted at $Z = -8.780,\ n = 119,\ p = 0.000 < 0.05;$ while the null hypothesis [$H_0 : ALNL = 90dB(A)$] should be rejected.

4. Conclusion

The average values of two (2) environmental noise parameters [Ambient Noise Level and Sound Pressure Level] and two (2) Aircraft Noise parameters [Aircraft Take-off Noise Level and Aircraft Landing Noise Level] have been scientifically assessed and studied for twelve (12) months, at one hundred and twenty (120) purposively selected neighbourhoods/neighbouring-environments of four (4) domestic airports [Ibadan, Benin, Owerri and Warri] in Nigeria. The results obtained showed that: at all one hundred and twenty (120) domestic airport neighbourhoods investigated, majority of the values of both 'the mean values of all Ambient Noise Levels (ANL)' [i.e. 89.0%] and 'the Aircraft Landing Noise Levels ($ALNL$)' [i.e. 87.9%], measured were far higher than 'the WHO Standard Recommended Maximum Noise-levels for both indoor and outdoor activities [i.e. ($RINL_{WHO}$) and ($RONL_{WHO}$)]' and 'the WHO recommended SPL value for 8hour daytime safe human exposure [(SPL_{WHO})]' respectively. Also, all of both 'the mean values of all Sound Pressure Levels (SPL)' [i.e. 100%] and 'the mean values of Aircraft Take-off Noise Levels ($ATNL$)' [i.e. 100%] measured, were higher than the WHO recommended SPL value for 8hour daytime safe human exposure (SPL_{WHO}). Interestingly, the authenticity of the fact that, majority of some of the ANL and $ALNL$ values exceed the $RONL_{WHO}$ and SPL_{WHO} , while all the SPL and $ATNL$ values exceed the SPL_{WHO} ; is further proven/validated by above published results of the descriptive Statistics and Non-parametric statistical test analyses. Also, the highest environmental noise hazardous exposures were experienced at the neighbouring environments of: Ibadan airport, followed by Benin airport, and Owerri airport, with the lowest at Warri airport. Consequently, people/persons living and/or working in the neighbourhoods of Ibadan, Benin, Owerri and Warri domestic airports in Nigeria, are most likely to experience frequent cases of Speech-unintelligibility, Noise-annoyance, Headache and Sleep-disturbance; after prolonged exposure to the environmental aircraft noise etc.

5. Recommendations

In order to mitigate the human exposure levels to aircraft noise-hazard in the neighbouring-environments of these four airports and others in Nigeria, we hereby make the following recommendations:

- Functional geo-physical planning of cities/towns hosting airports by professional experts such as Urban & regional planners etc.
- Adoption of Aero-polis instead of a simple airport, as applicable is most developed countries.
- Effective Land-use planning & management
- Adaptive architectural designs & orientation of buildings, with respect to local prevalent wind directions
- Use of anechoic and sound-proof wedges as wall-claddings
- Pre-design considerations for low noise emissions of aircraft
- Further research in certain related technical areas/fields such as Nano-technology, Reverse-engineering and Sound-spectra etc.

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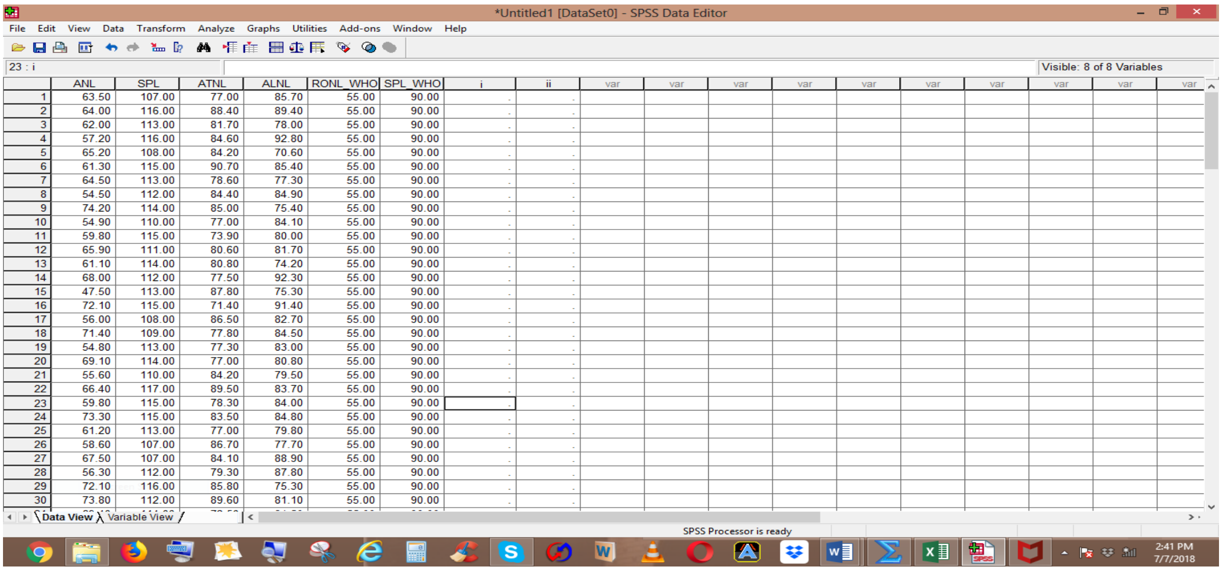

Fig. 10 Screen-shot of Acoustic data inputted into the SPSS sheet, prior to performing the Descriptive-Statistics' and non-parametric 'Wilcoxon Signed Ranks test' Analyses.

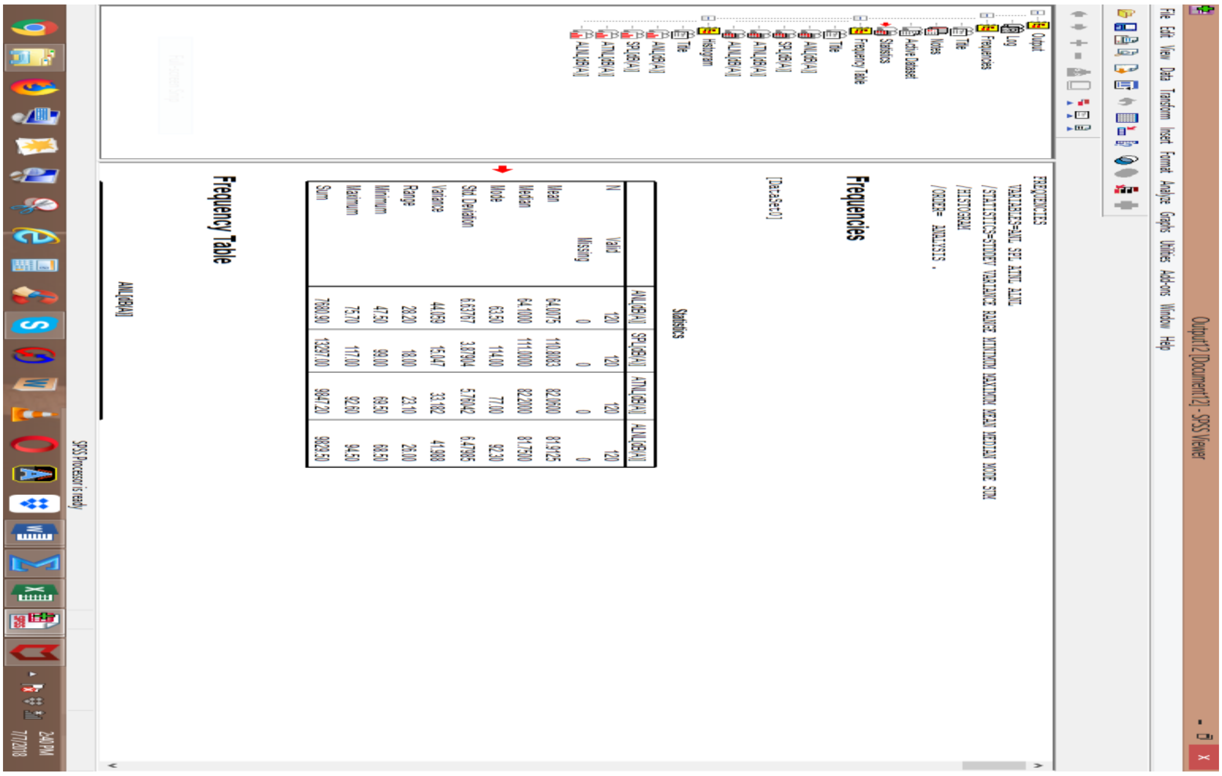

Fig. 11. Screen-shot of descriptive Statistics' results displayed on the SPSS sheet, after performing the descriptive Statistics analysis on the already inputted Acoustic data.

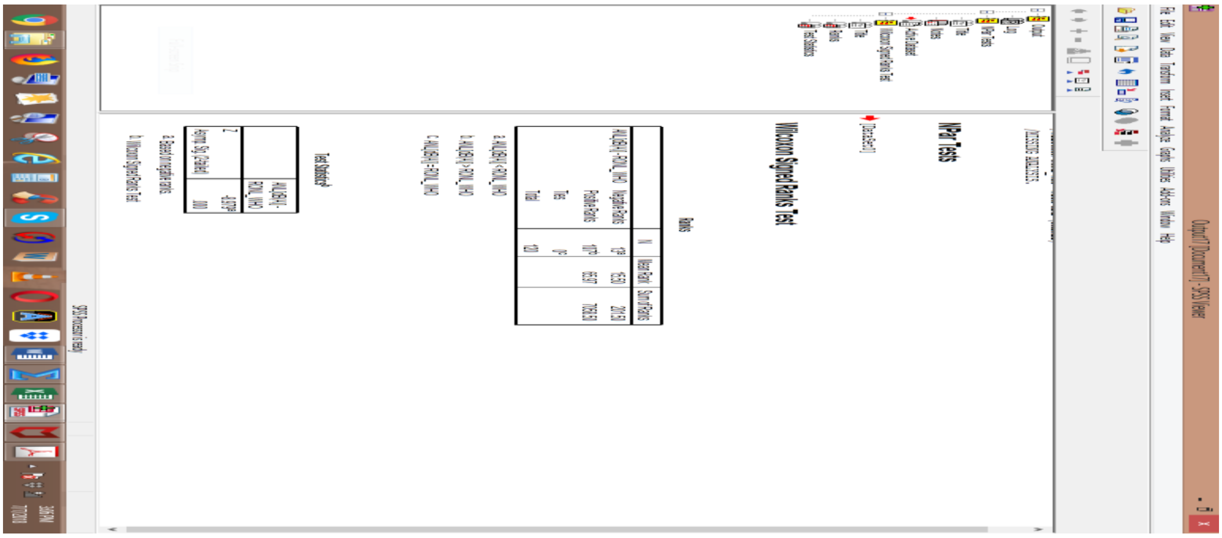

Fig. 12. Screen-shot of 'Wilcoxon Signed Ranks test' results displayed on the SPSS sheet, after performing the non-parametric two-related sample test analysis on the already inputted Acoustic data