Aircraft Noise Nuisance in Nigeria A Social and Acoustical Survey

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Abstract:

Community reactions to aircraft/airport noise was surveyed for about 12 months (from March 2002 to February 2003) around five of eighteen (18) Nigerian airports namely, Margaret Ekpo (MEIA), Port Harcourt (PHIA), Murtala Muhammed (MMIA), Jos (JIA) and Ilorin (IIA) international airports by means of interviews/questionnaires method (subjective) and noise measurements (acoustical) method. Results obtained from this study revealed that community residents' responses do not speak well of our Nigerian airports. The people seriously reacted over intense aircraft/airport noise in residential communities in Nigeria, and called for its total eradication or drastic control. Findings indicated that over 83% of the residents described aircraft noise as a public nuisance, 98% described Nigerian airports noisily disturbing, 94% admitted their lives are damaged in one way or the other, and 87% wanted airport/aircraft noise controlled. Aircraft/airport noise levels recorded exceeded recommended doses in all the Nigerian airports surveyed suggesting that the respondents suffer from serious psycho-social and physiological health problems by aircraft noise. Measured aircraft noise level such as Sound Pressure level (SPL) ranged from100.0 to 116.0 dB(A), L_{90} (74.6 to 87.1 dB(A)), L_{50} (78.8 to 94.5 dB(A)), and L_{10} (88.1 to 99.8 dB(A)); while calculated aircraft noise levels such as L_{Aeq} (84.9 to 95.4 dB(A), daytime and (76.5 to 88.2 dB(A), nighttime; L_{NP} (95.4 to 108.1 dB(A), daytime and (87.0 to101.0 dB(A), nighttime; and L_{dn} ranged from 74.8 to 79.0 dB(A). The correlation between the aircraft noise levels and respondents subjective (social) reactions to the noise levels were found to be +0.79, +0.54, +0.34, +0.85 and +0.78 around MEIA, PHIA, MMIA, JIA and IIA respectively.

Keywords: Public nuisance, aircraft noise; subjective method, acoustical method.

I. Introduction

The Nigerian environment today exposes residents to all sorts of noise pollution, including noise from domestic animals, humans, industrial machineries, electrical/electronic appliances, motor vehicles, aircrafts, among others. In most cases, noise from these sources affects community residents in many ways, ranging from physiological to psychological effects such as hearing impairment, communication interference, sleeplessness, annoyance, ear irritation, task interference and general discomfort [1- 2]. People suffer from psychosocial stress due to excessive exposure to high noise levels over extended period of time [3] which leads people to complain about this, sometimes very seriously. The kind of noise that affects community residents so much is the traffic noise such as aircraft and road traffic noise because noise levels from these sources are normally unacceptable by a large number of residents. Aircraft noise exposure interferes with a variety of activities and is perceived as annoying by the exposed population as it severely affects their normal family and professional life [4]. Many social surveys on community reactions to aircraft noise have been carried out near some large airports around the world such as Narita International airport (Tokyo, Japan) [5, 6], and the Yokota Air Base (Tokyo, Japan) [7]. The questionnaires used for these two studies were similar inasmuch as they contained same questions to make the comparison of residents' reactions to aircraft noise pollution at these two locations easier. It was found out that the community residents' responses to questionnaire items were the same. Researchers in both cities reacted against excessive aircraft noise as this bothered them so much, interfering with their speech communication, sleep and study concentration, among other effects [8-13].

The aims of this study were therefore (1) to measure, analyze and interpret the various aircraft noise levels/indices and compare them with prescribed, acceptable limits; (2) to assess the extent of damage caused to people living around the airports under study by aircraft noise based on the respondents' responses on the 10 variables used in this study and (3) to suggest some noise mitigation measures or control methodologies to arrest or reduce the harmful effect of intense aircraft noise in and around airports in Nigeria.

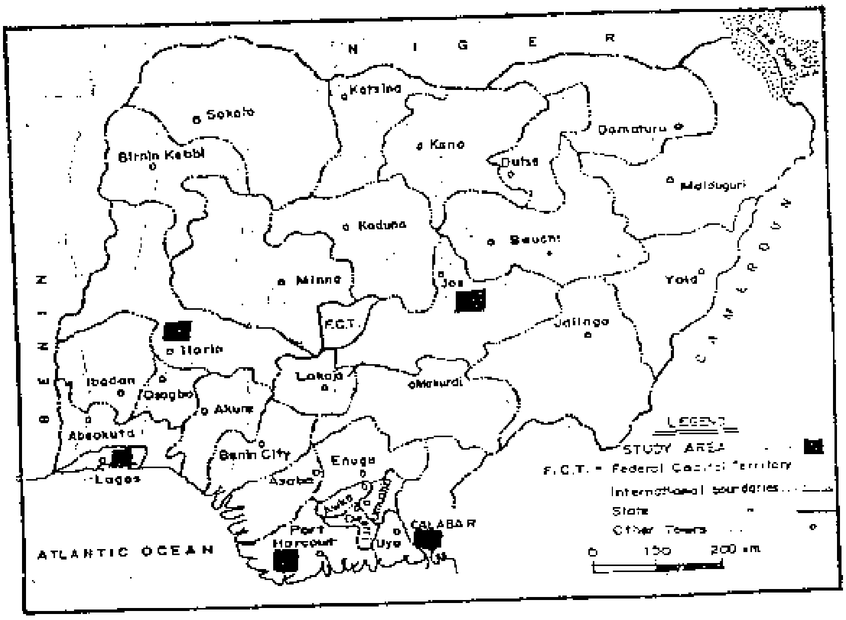
II. Materials and methods

2.1 Measurement Sites

A total of 25 measurements sites were randomly selected for this study with six (6) from MEIA, six (6) from PHIA, five (5) from MMIA, four (4) from JIA and four (4) from IIA (see Table 1- Description of measurement sites and codes). Study areas were as shown in Fig. 1 – Map of Nigeria showing locations of airports selected for the study.

Table 1: Description of Measurement sites and codes

Airport	Measurement Sites	Codes
MEIA Calabar	FAAN Nur/Sec. Schools	C1
	FAAN Staff Quarters	C2
	Federal Govt. Girls College	C3
	MCC Road Area	C4
	IBB Way/Marian Rd.	C5
	Airport Premises	C6
PHIA Port Harcourt	FAAN Staff Quarters I	PH1
	FAAN Staff Quarters II	PH2
	FAAN Staff Quarters III	PH3
	Mile 2	PH4
	Facades houses around airport	PH5
	Airport Premises	PH6
MMIA Lagos	Ikeja area	L1
	Agege area	L2
	Nigeria Police College Premises	L3
	Facades of Nigeria Airways Building	L4
	Airport Premises	L5
JIA Jos	Airport Premises	J1
	Facades of houses around airport	J2
	Nigeria Police Force (NPF) Office	J3
	Govt. Sec. School Premises	J4
IIA Ilorin	Airport Premises	I1
	Facades of houses around airport	I2
	FAAN Staff Quarter	I3
	Primary Sch. Mgt. Board	I4



■ Airports under study.

Figure 1. Map of Nigeria showing locations of the airports selected for the study

2.2 Materials for data collection

Bruel and Kjaer (B & K) type 2203 with a filter B & K type 1613. Other materials used in this study include stop clock used for taking sampling time, and measuring tape used in taking horizontal distances from aircraft landing and take-off points to measurement point, respectively. Materials for collecting subjective response noise ratings from respondents (social reaction data) were a well structured questionnaires/interview schedules, aircraft noise survey questionnaire (ANSQ). The questionnaire contained open-ended and close-ended questions to elicit needed aircraft noise effect information from the respondents.

2.3 Methods of data collection

2.3.1 Social survey/measurements:

Several measurement sites were selected for each of the airports under study for investigation. Households near each airport surveyed were randomly selected. Copies of the questionnaire were randomly distributed to people in these households who were aged fifteen years and above and who could read and write. For those who were not literate, oral interview using the questionnaire items were also conducted. Respondents were those who lived or did business in their present location for a period of not less than three (3) years. This was to eliminate or reduce response bias on the part of the respondents. A total of one thousand four hundred and forty eight (1,448) copies of the questionnaire were returned out of 1770 copies distributed with 389, 203, 294, 312 and 250 valid copies from Margaret Ekpo, Port Harcourt, Murtala Muhammed, Jos and Ilorin international airports, respectively, resulting in a return rate of about 82%. Three hundred and twenty two (322) copies of questionnaire were not used because of a number of reasons, namely, 158 copies were not returned, 67 copies were poorly completed, not containing the needed information; 59 copies were mutilated, and dirty while 38 copies were returned blank (no information whatsoever was on them). Table 2 shows the distribution patterns of questionnaire by socio-economic and demographic variables of sex, age, income level and educational status.

Table 2: Summary of statistics of population of people resident/doing business around the vicinity of the airports under study, sample of the study and sample distribution pattern by socio-demographic variables

/N	Airports	Population around airports under study			No of respondents (sample) n			Respondents (sample) distribution pattern														
								Age (Years)								Income level			Education Status		
								15-29		30-39		40-49		50+							
		M	F	Total	M	F	Total	M	F	M	F	M	F	M	F	High	Middle	Low	P	S	T
1	MEIA	334	193	527	263	126	389	70	38	97	41	72	30	24	17	95	118	176	31	178	18
2	PHIA	201	171	372	109	94	203	26	13	43	37	22	29	18	15	62	60	81	37	70	9
3	MMIA	229	224	453	112	182	294	23	49	44	58	32	50	13	25	107	84	103	29	158	10
4	JIA	303	206	509	198	114	312	42	25	69	46	57	28	30	15	81	102	129	63	154	9
5	IIA	217	193	410	113	137	250	34	39	35	42	30	42	14	14	55	86	109	52	113	8
	TOTAL	1284	987	2271	795	653	1448	195	164	288	224	213	179	99	86	400	450	598	212	666	57

where M = Male respondent, F = Female respondent, P = Primary school, S = Secondary school, T = Tertiary school.

2.3.2 Physical (acoustical) survey/measurements:

Acoustical measurements were made over a period of five (5) days (Monday to Friday) at each chosen airport at morning, afternoon and night times from 7 am to about 12 midnight) for about 12 months. A well calibrated precision sound level meter, [Bruel and Kjaer (B & K) type 2203] calibrated with a filter (B & K type 1613) was used in line with ISO 1996-1 [14], ISO 1996-2 [15], ISO 3981[16], IEC 651[17] and IEC 804[18]. The sound meter was held at arm's length, some distance away from the body of holder, about 1.5 meters high from the ground to correspond to the ear position of an average person. Five (5) persons were used to hold sound level meter in position, since a tripod stand was not available at the time of field measurements, until the whole measurement time of sixteen (16) hours per day were covered. The five (5) persons were to hold the sound level meter in position, one after the other, only during recording (sampling) time. This is to reduce the labour of one person holding it althrough. The microphone of the meter was made to point directly to the source of noise to avoid any sound reflecting and absorbing structures/materials on the sound transmitting path according to ISO Standard [14]. One (1) noise readings was taken every twenty (20) minute interval for a period of about sixteen (16) hours of a day at each measurement location (site), and was written down in a notebook provided for this purpose. About forty eight (48) readings were obtained at each location within the measurement time of 16 hours. In all, one thousand two hundred (1200) noise readings were obtained from the 25 measurement sites used in this study.

The meter was set at A-weighting frequency network and at "fast" response range. The fast-response corresponds to the time constant of 0.125s and is intended to approximate the time constant of the human hearing system.

Measurement sites were close to the airports to make correlation of social survey responses with the acoustical survey responses possible. Horizontal distance between the noise measurement site and the airports ranges between about 150 metres and 200 metres.The Pearson Moment Correlation coefficient r, between social survey responses and acoustical survey responses on annoyance for the airports under study was computed following standard statistical measures and using standard correlation coefficient formula. Noise levels measured in this study included (i) Background noise levels (BNLs) at each measurement site. Background noise level is the noise level obtained when no noise source is under operation. The knowledge of BNLs helps in estimating the actual aircraft noise level at each measurement site. It was measured at each measurement site by use of sound level meter early enough before the operation of aircrafts or any other noise source(s). (ii) Percentile noise levels L_{10}, L_{50}, L_{90} were obtained from cumulative distribution curves plotted from noise data generated in this study. (iii) Noise levels during aircraft landings and take-offs. Take-off noise levels were obtained directly from the sound level meter having its microphone pointed at point of take-off (microphone pointing towards the tail of the aircraft) about 400 to 700m horizontal distance from aircraft take-off measurement point. Landing noise levels were taken when aircraft was approaching noise recording personnel at landing measurement point (microphone pointing towards the head of aircraft as it was about to land on the ground) about 800 to 1000m horizontal distance from landing measurement point [2]. However, the expert advice of the airport personnel on aircraft noise measurement positions was very useful also. The people interviewed at the airport premises were those doing business/working at these airports on daily basis, while those interviewed at the school premises were the teachers/workers and students in these schools. The schools were found to be located along the flight paths of the aircraft, and we believed both students and workers would be disturbed by excessive noise from the aircrafts especially during daytime, while security guards on duty at nighttime were also disturbed at school premises at nighttime period. Fig. 2 shows respondents reactions on whether aircraft noise is a public nuisance or not. In Fig. 3 statistics of duration (in years) that the respondents live or do business around the airports surveyed were given, while Fig. 4 shows respondents' opinion as to whether the airport/aircraft noise pollution should be controlled or not. Fig. 5 shows statistics of respondents' opinion as to who should regulate or control airport/aircraft noises, while Fig.6 presents respondents' assessments as to what source of noise constitutes the greatest noise in Nigerian airports. Figs 7 and 8 indicate respondents' reactions on the general nature of Nigerian airports and on the time of the day aircraft noise disturbs most in the cities respectively. The respondents' reactions on the type of aircraft that produces most annoying noise in the community is shown in Fig. 9, while Fig. 10 indicates respondents' reactions on which aircraft operations causes most annoyance among the community people. Finally, Fig. 11 shows the respondents' assessments on the extent aircraft noise damaged their lives.

2.4. Data analysis/reductions.

For acoustic noise data (noise levels) analysis and reduction of results the following noise descriptors/indices were used:

Energy mean of A-weighted sound level (L_{Aeq}):

$$L_{Aeq} = 10\log_{10}\left[\sum_{n=1}^{N} f_i \times 10^{\left(Li/10\right)}\right] \quad (1)$$

Where Li = Sound pressure level (dB(A))

f_i = fraction of observation time that Li is present.

$L_{Aeq} \geq 45$ dB(A) is not acceptable, caused community complaints, annoyance, sleep disturbance and other physiological and psychological problems in human beings [20]. The World Health Organization Guidelines for Community Noise of 1999 stipulates that indoor L_{Aeq} > 35 dB(A) and outdoor L_{Aeq} >

55dB(A) causes speech intelligibility, serious annoyance and sleep disturbances among other psychological, physiological and sociological health problems [21].

Noise pollution level (L_{NP}):

$$L_{NP} = L_{Aeq} + (L_{10} - L_{90})\ dB(A) \quad (2)$$

Where L_{10} = sound level exceeded 10% of observation time (dB(A)).
L_{90} = sound level exceeded 90% of observation time (dB(A)).
$L_{NP} \geq 74$ dB(A) is not acceptable by community residents [1].

Day-night A-weighted sound level (L_{dn}):

$$L_{dn} = 10\log_{10}\left[\frac{1}{24}\sum_{i=1}^{N} f_1 \times 10^{\left(Li/10\right)}\right] \quad (3)$$

$L_{dn} > 45$ dB(A) is unacceptable to community residents [1].

For social noise data (questionnaire data) analysis to establish the correlation between noise exposure level and respondents noise reaction ratings the Pearson product moment correlation statistic r was used as expressed in Eqn. 4 according to Croxton, Cowden and Klien [22].

$$r = \frac{(N\sum XY)-(\sum X)(\sum Y)}{\sqrt{[N(\sum X^2)-(\sum X)^2][N(\sum Y^2)-(\sum Y)^2}} \quad (4)$$

where r = correlation coefficient.
X = noise levels (dB(A)) obtained by measurement by use of sound level meter.
Y = respondents' subjective (noise reactions) obtained by social survey by use of questionnaire/interview schedules.

III. Results

Results obtained from this study were as summarized in Tables 3-6 and Figs 2-11.
Table 3 summarized aircraft noise levels (both measured and calculated) obtained at each of the airports surveyed. The measured aircraft noise levels include background noise levels (BNLs) in (dB(A)), percentile noise levels L_{10}, L_{50}, L_{90} in dB(A) obtained from cumulative frequency curves of noise data plotted, and sound pressure levels (SPL) in dB(A) obtained by direct reading from the sound level meter scale used in this study. The calculated noise levels include L_{Aeq} (day and night), L_{NP} (day and night) and L_{dn}, all in dB(A). They were obtained applying Eqns (1), (2) and (3) respectively. Table 4 shows the summary of the types of aircrafts recorded during the study, with the corresponding take-off and landing noise levels. The types of aircraft operating at the time of the study were mainly jet transport aircrafts and helicopters. Table 5 provides statistics on the aircraft movement (aircraft traffic) at the airports under study obtained within 12 months of the study. Table 6 shows the correlation between social and acoustical data for the Margaret Ekpo (MEIA), Port Harcourt (PHIA), Murtala Muhammed (MMIA), Jos (JIA) and Ilorin (IIA) international airports. From the Table above the variable X is the measured A-weighting sound pressure level (SPL) in dB(A) and Y is the mean social response noise ratings at each measurement site. X variables were obtained by measuring SPLs at each measurement site directly using precision sound level meter stated above, while Y variables were obtained following Molino's statistical model [19] by adding the various noise response ratings (n) at each measurement site together, multiplying individual noise rating by its degree of response x, (5, 4, 3, 2, 1) representing Extreme Severe noise (ES), Very Severe noise (VS), Severe noise (S), Moderate noise (M) and Little noise (L) respectively; then adding up product (nx) together to get total (∑nx), at each measurement site, and

dividing ∑nx by n (number of data points at each site) to obtain mean social response noise rating Y at each measurement site as shown in Table 6 (column 5). Applying Eqn 4, correlation coefficients r, were obtained as shown on column 9 of Table 6. Fig. 2 shows respondents' reactions on whether aircraft noise is a public nuisance or not. In Fig.3 Statistics of duration (in years) that the respondents live or do business around the airports surveyed were given, while Fig. 4 shows respondents' opinion as to whether the airport/aircraft noise pollution should be controlled or not. Fig. 5 shows statistics of respondents' opinion as to who should regulate or control airport/aircraft noises, while Fig. 6 presents respondents' assessments as to what source of noise constitutes the greatest noise in Nigerian airports. Figs. 7 and 8 indicate respondents' reactions on the general nature of Nigerian airports and on the time of the day aircraft noise disturbs most in the cities respectively. The respondents' reactions on the type of aircraft that produces most annoying noise in the community is shown in Fig. 9, while Fig. 10 indicates respondents' reactions on which aircraft operations causes most annoyance among the community people. Finally, Fig. 11 shows the respondents' assessments on the extent aircraft noise damaged their lives.

Table 3. Summary of aircraft noise levels at measurement sites around the surveyed airports

Surveyed airport	Measured Noise Level (dB(A)					Calculated Noise Levels/Indices				
						L_{Aeq} (dB(A)		L_{NP} (dB(A)		L_{dn} dB(A)
	BNL	L_{90}	L_{50}	L_{10}	SPL ±dB(A)	Day	Night	Day	Night	
MEIA	58.5	83.5	91.0	98.0	102.0	91.6	79.8	106.1	94.3	77.5
PHIA	60.8	86.6	92.5	97.0	116.0	93.3	80.8	103.7	91.0	78.0
MMIA	63.6	87.1	94.5	99.8	109.0	95.4	88.2	108.1	101.0	79.0
JIA	51.4	76.4	85.2	91.6	100.0	87.7	79.3	102.9	94.5	75.4
IIA	50.9	74.6	78.8	88.1	105.0	84.9	76.5	95.4	87.0	74.8

Table 4. Summary of the types of aircraft recorded during the study with corresponding take-off and landing noise levels, at the airports under study.

S/N	Aircraft type/Model	Landing noise levels dB(A)	Take-off noise levels (dB(A))
1	ADC B737	86	106
2	NA B727	84	101
3	Albarka 727	85	109
4	Bellview 737	92	110
5	SN-BHL	80	92
6	Air France (A340)	90	114
7	Air Garbon B767-300	98	113
8	DC – 9	92	110
9	Chanchangi 727	84	110
10	Sosolisso Airline 737	96	112

Table 5: Summary of aircraft traffic at the airports under study during study period.

Airports	Arrival	Departure	Total movements	% Total movements
MEIA	23,091	19,454	42,545	2.5
PHIA	101,768	99,319	201,087	11.6
MMIA	690,437	770,923	1,461,360	84.3
JIA	11,313	10,825	22,138	1.3
IIA	1,845	2,394	4,239	0.3
TOTAL	828,454	904915	1,733,369	100
%	47.79	52.21	100.00	100.0

Table 6: Correlation between social responses and acoustical responses for MEIA , PHIA, MMIA, JIA and IIA

Airport	Measurement sites	Codes	SPL dB(A) X	Mean noise ratings. Y	XY	X^2	Y^2	r
MEIA Calabar	FAAN Nur./Sec Schools	C1	101.0	4.1	414.1	10201.0	16.81	+0.79
	FAAN Staff Quarters	C2	102.0	4.0	408.0	10404.0	16.00	
	Federal Govt. Girls College	C3	102.0	4.1	418.2	10404.0	16.81	
	MCC Road Area	C4	97.0	4.0	388.0	9409.0	16.00	
	IBB Way/ Marian Road	C5	96.0	3.8	364.8	9216.0	14.44	
	Airport Premises	C6	101.0	4.1	414.1	10201.0	16.81	
TOTAL			**599**	**24.1**	**2407.2**	**59835.0**	**96.87**	
PHIA Port Harcourt	FAAN Staff Quarters I	PH1	109.0	4.0	436.0	11881.0	16.00	+0.54
	FAAN Staff Quarters II	PH2	106.0	3.5	371.0	11236.0	12.25	
	FAAN Staff Quarters III	PH3	106.0	3.4	360.4	11236.0	11.56	
	Mile 2	PH4	109.0	3.7	403.3	11881.0	13.69	
	Facades of houses around airport	PH5	108.0	3.5	378.0	11664.0	12.25	
	Airport Premises	PH6	113.0	3.7	418.1	12769.0	13.69	
TOTAL			**651.0**	**21.8**	**2366.8**	**70667.0**	**79.44**	
MMIA Lagos	Ikeja area	L1	108.0	3.6	388.8	11664.0	12.96	+0.34
	Agege area	L2	113.0	3.7	418.1	12769.0	13.69	
	Nigeria Police College premises	L3	101.0	3.7	373.7	10201.0	13.69	
	Facades of Nigeria Airways Building	L4	111.0	3.7	410.7	12321.0	13.69	
	Airport Premises	L5	112.0	4.1	459.2	12544.0	16.81	
TOTAL			**545.0**	**18.8**	**2050.0**	**59499**	**70.84**	
JIA Jos	Airport Premises	J1	100.0	4.2	420.0	10,000	17.64	+0.85
	Facades of houses around the airport	J2	98.0	4.1	401.8	9604	16.81	
	NPF Office	J3	104.0	4.3	447.2	10,816	18.49	
	Govt. Sec. School Premises	J4	110.0	4.3	473.0	12,100	18.49	
TOTAL			**412.0**	**16.9**	**1742.0**	**42,520**	**71.43**	
IIA Ilorin	Airport Premises	I1	112.0	4.4	492.8	12544	19.36	+0.78
	Facades of houses around the airport	I2	105.0	4.5	472.5	11025	20.25	
	FAAN Staff Quarters	I3	109.0	4.4	479.6	11881	19.36	
	Primary Sch. Mgt. Board	I4	101.0	4.6	501.4	10201	21.16	
TOTAL			**427.0**	**17.9**	**1911.9**	**45,651**	**80.13**	

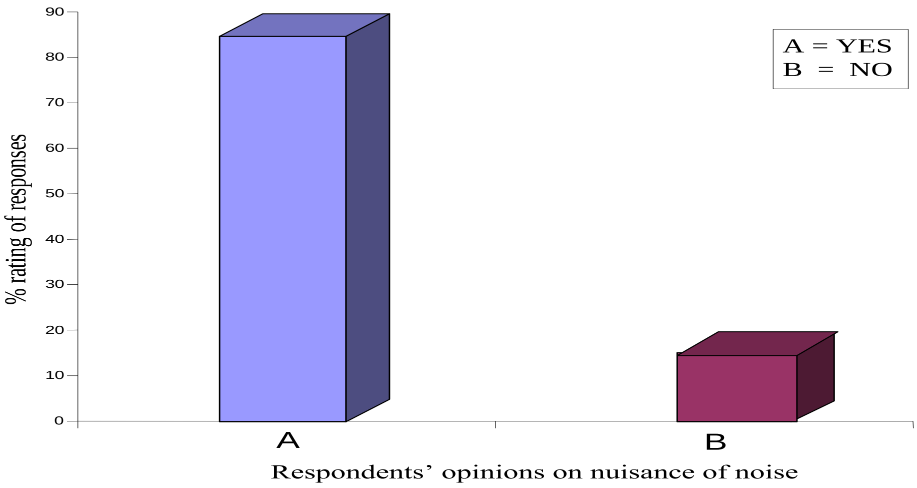


Figure 2. Respondents' reactions on whether aircraft noise is a public nuisance or not.

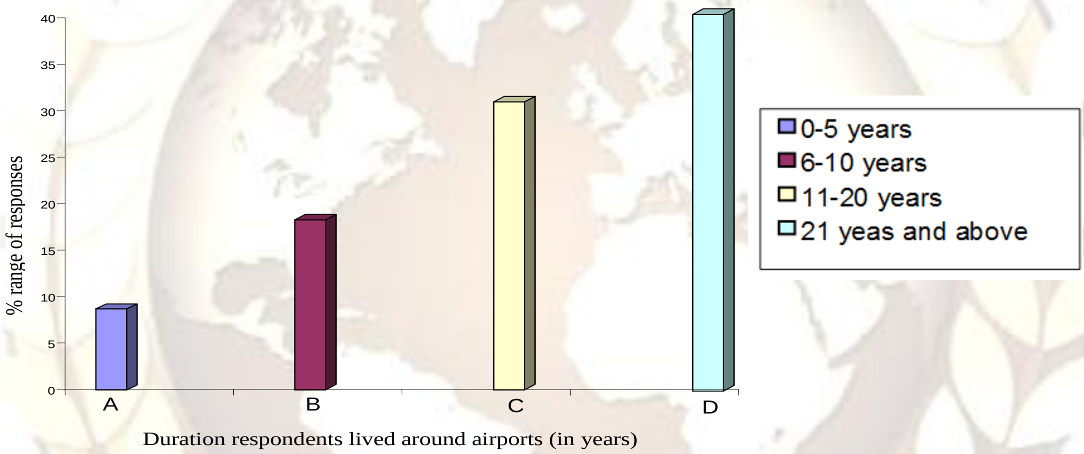


Figure 3. Statistics of duration that respondents' live or do business around airport surveyed.

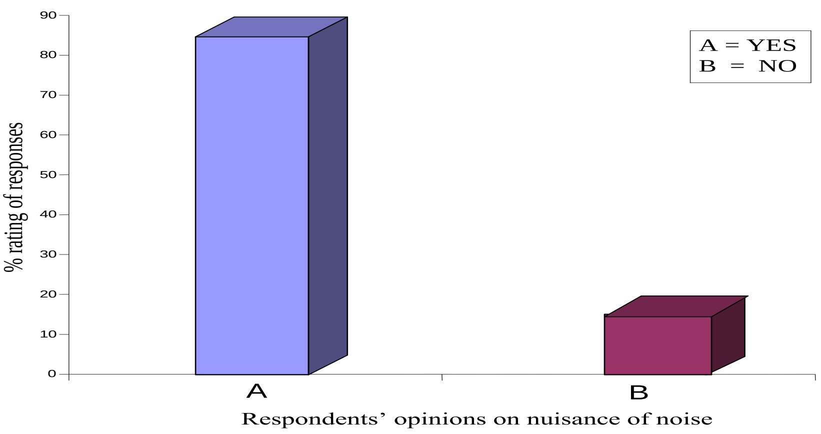


Figure 4. Statistics of responses on airport/aircraft noise pollution control.

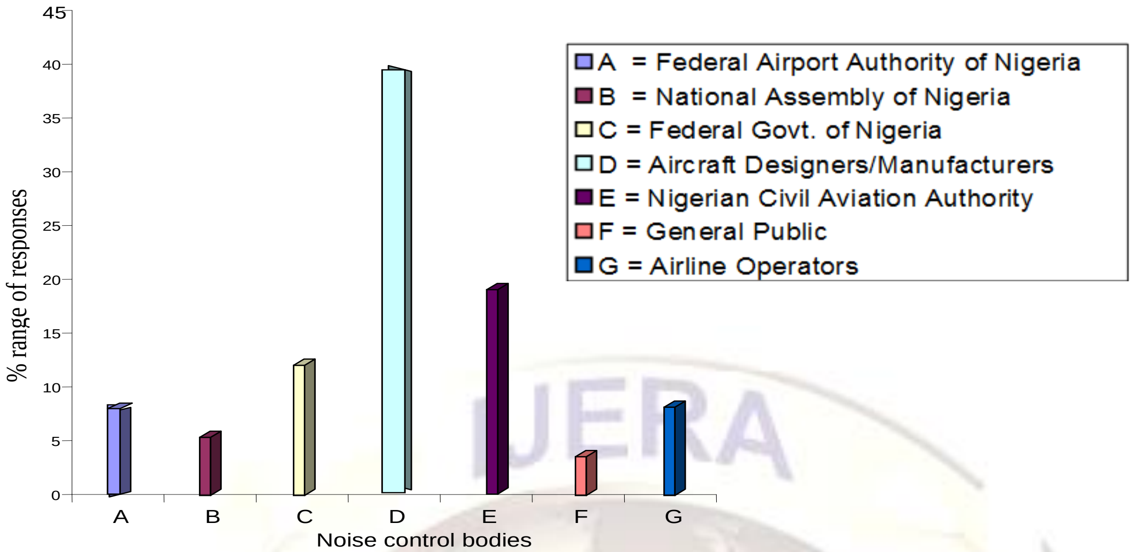


Figure 5. Statistics of respondents' opinion as to who should regulate or control airport/aircraft noises.

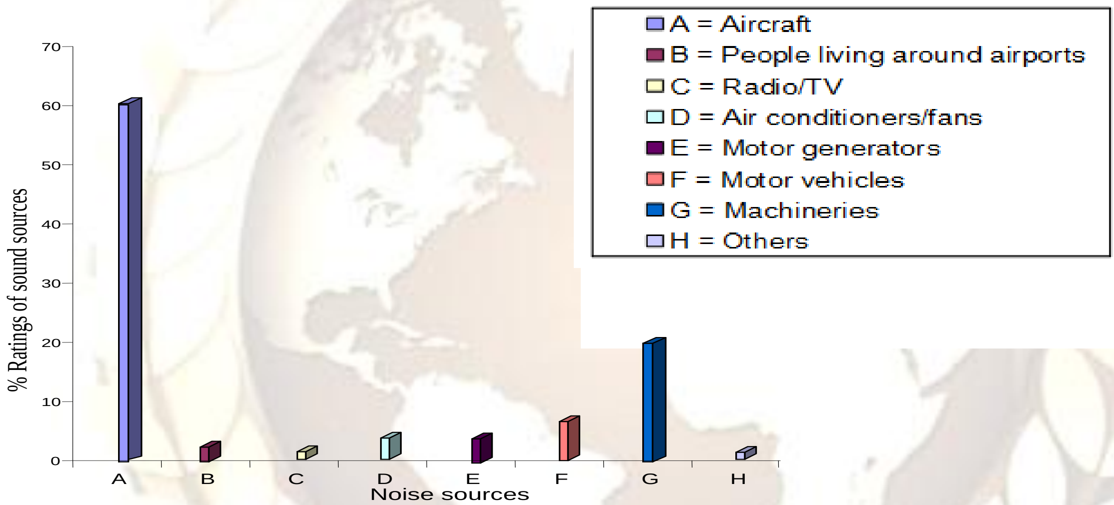


Figure 6. Respondents' assessments as to what source of noise constitutes the greatest noise in Nigerian airports.

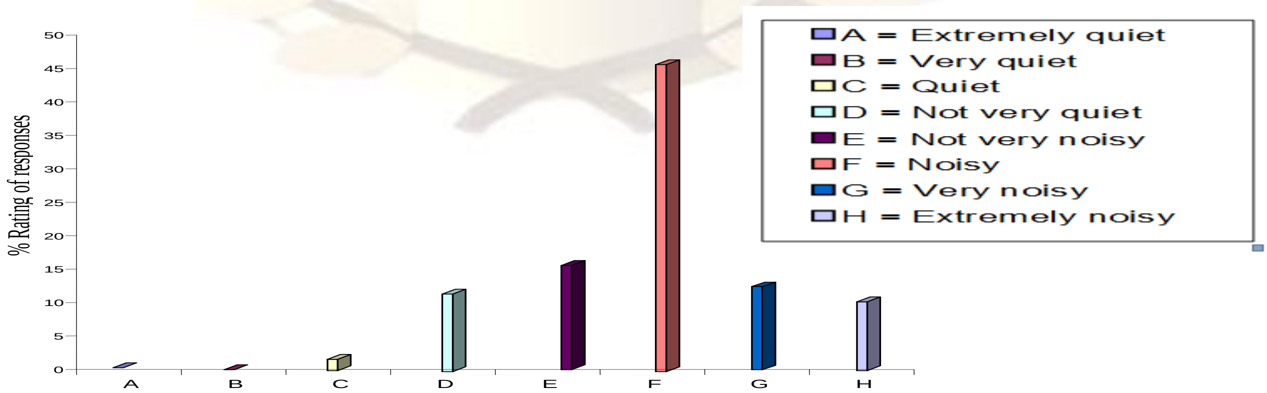


Figure 7. Respondents' reactions on the general nature of Nigerian airports

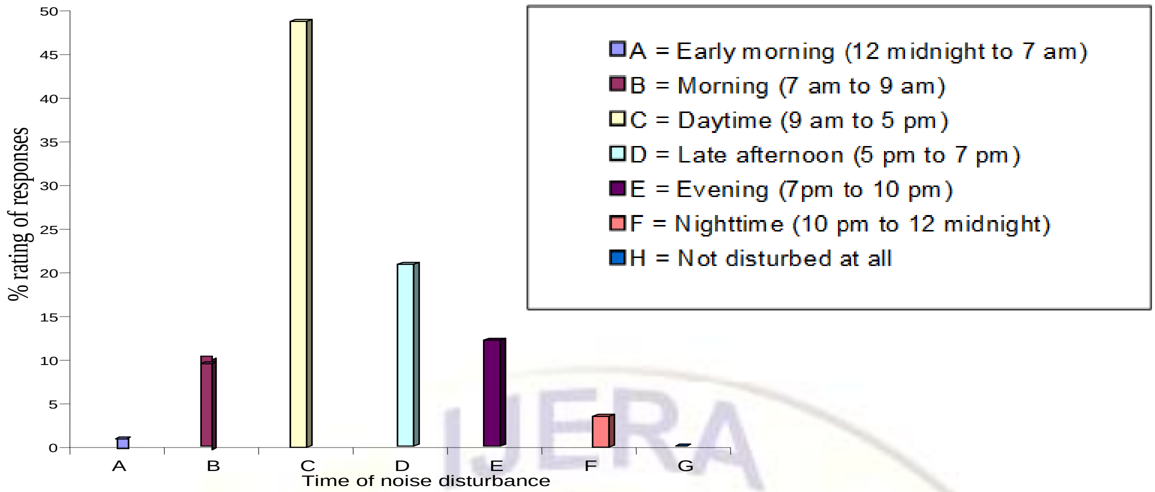


Figure 8. Respondents' reactions on the time of the day aircraft noise disturbs most

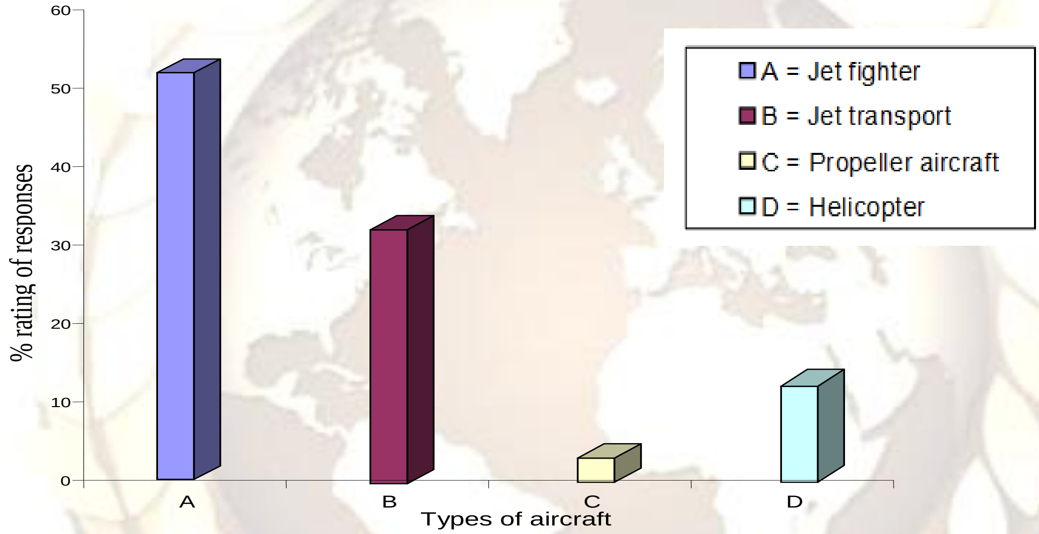


Figure 9. Respondents' reactions on the aircraft that produces most annoying noise

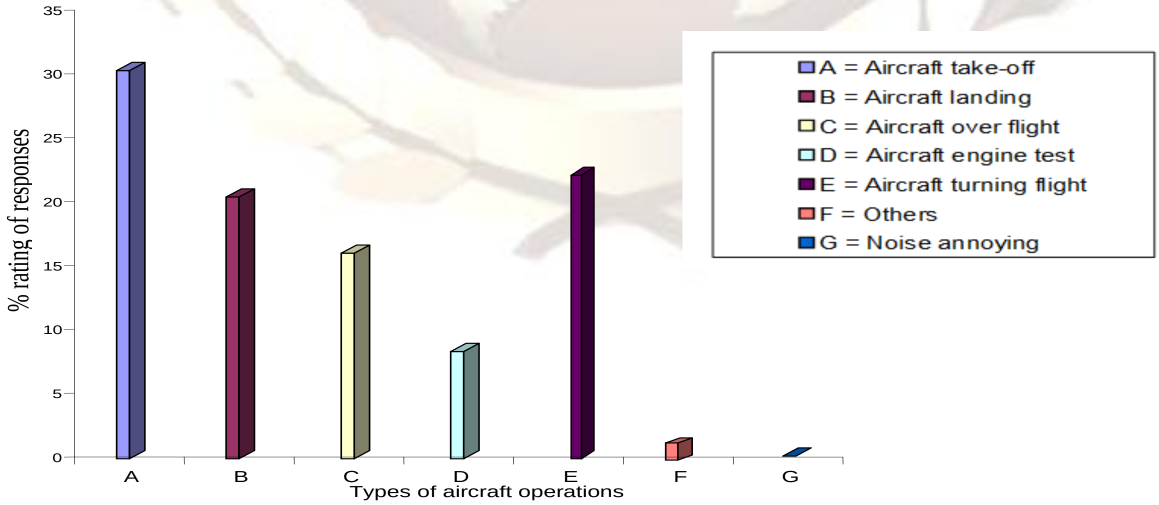


Figure 10. Respondents' reactions on which aircraft operation causes most annoyance

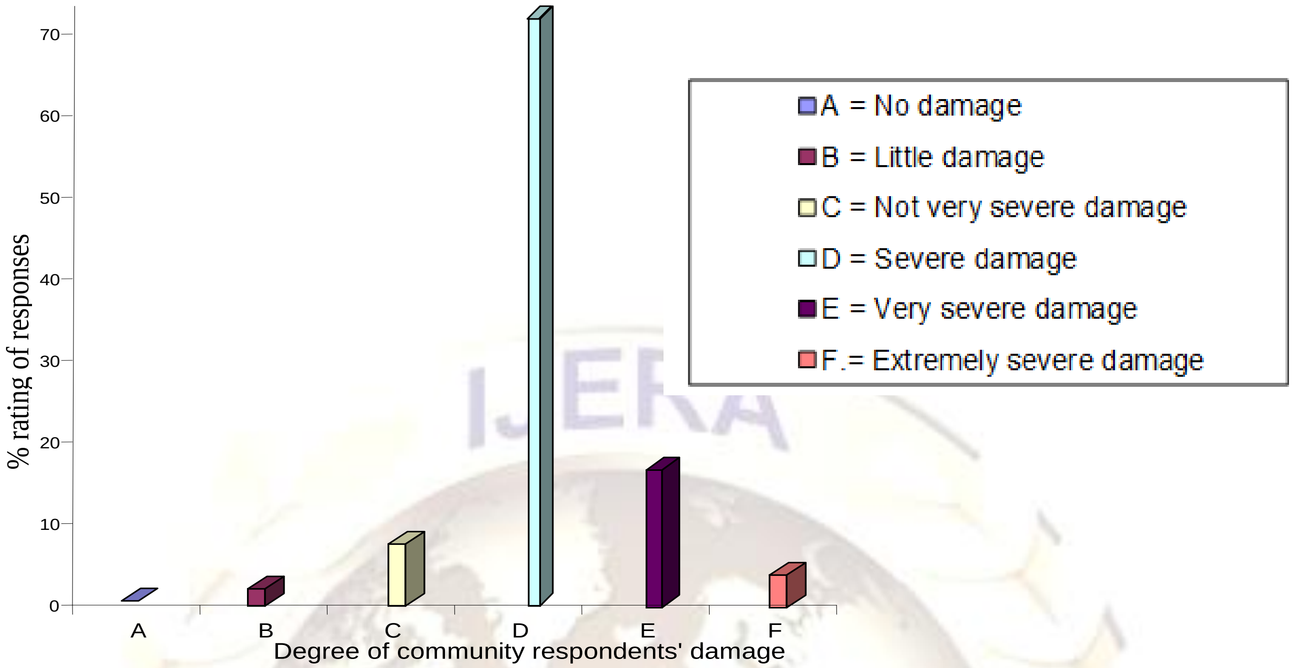


Figure 11. Respondents' assessments on the extent aircraft noise damaged their lives.

IV. Discussion

Results of this study were shown as in Figs. 2-11, and in Tables 3-6. Fig. 2 indicates percentage response on whether aircraft noise is a public nuisance or not. This Figure shows that over 83% of the people used for the survey described aircraft noise as a public nuisance. Fig. 3 indicates statistics of duration that respondents lived, worked or did business in and around airports. Here, over 40% of respondents lived, worked or did business around the airports for 21 years and above, and 31% had been around the airports for between 11 years and over 20 years. This means that well over 71% of respondents stayed near the airports for between 11 years and over 21 years. This has serious health implications. On whether aircraft/airport noise pollution should be controlled or not Fig. 4 shows that over 87% of the respondents wanted airport/aircraft noise controlled. On which establishment or authority should control airport/aircraft noise Fig. 5 indicates that aircraft designers/manufacturers should bear the direct responsibility to control this by taking care of this noise problem at the design stage of the aircraft as over 42% of respondents favoured this opinion. Nigerian Civil Aviation Authority (NCAA) with 19% and Federal Government of Nigeria (FGN) with 12% were also called upon to drastically control excessive airport/aircraft noise.

Fig. 6 shows respondents' assessments as to what constitutes the greatest noise in Nigerian airports. It was found out that aircraft, among all the sources of noise surveyed, constitutes the greatest noise in Nigerian airports, as it carries the highest percentage response of over 60%. Fig. 7 shows the percentage response on the general nature of Nigerian airports. Here, over 46% of the respondents described the Nigerian airports as noisy, 14% as very noisy, 10% as extremely noisy, 15% as not very noisy and 11% as not very quiet, generally showing that 98% of the respondents described the Nigerian airports uncomfortably disturbing. Fig. 8 shows that aircraft noise disturbs most in the daytime (between 9 am and 5 pm) with over 49% of respondents affirming. On which aircraft produces most annoying noise in and around the Nigerian airports, Fig. 9 reveals that over 54% of respondents declared jet fighter aircraft as producing the most annoying noise, followed by jet transport aircraft with over 32% response. Fig. 10 shows percentage of responses on which aircraft operation causes most annoyance. From this Figure, aircraft take-off operation causes most annoyance with over 30% of response followed by aircraft turning flight with over 22%, and aircraft landing operation with over 20%. On the respondents assessment of the extent aircraft noise damage their lives, 69% admitted that aircraft noise has caused much damage to their lives more than any other noise source as shown in Fig. 11. Generally, over 94% of the respondents' had their lives seriously damaged in one way or the other by aircraft/airport noise.

Table 3 shows a summary of noise levels/indices (both measured and calculated) obtained by acoustical measurements based on the acoustical data collected at the various measurement sites around the airports surveyed. From the results obtained as shown on Table 3 noise levels absorbed by the respondents on daily basis far exceed the recommended acceptable limits, and therefore, respondents' exposed to these high noise levels are likely suffering from serious psychological and physiological problems such as annoyance, sleep disturbances, communication interferences, temporary or permanent hearing impairment, rest/relaxation disturbances, communication and daily activity interferences, temporary or permanent hearing impairment, rest/relaxation disturbances, body fatigue, among other health problems.

Table 4 shows the summary of the types of aircraft recorded during the study with their corresponding take-off and landing noise levels at the airports surveyed. It was observed that landing noise levels of aircraft were lower than take-off noise levels since aircraft needed more energy to take-off than to land on the ground. Landing noise levels range between 80 and 96 dB(A), while take-off noise levels range between 92 and 114dB(A). Respondents were exposed to these excessive noise levels daily for many years, and so were likely to suffer serious health hazards. Table 5 summarized aircraft traffic at the airport surveyed for a period of three (3) months. Murtala Muhammed international airport (MMIA) recorded the highest traffic volume with 1,461,360 movements (84.3%), seconded by Port Harcourt international airport (PHIA) with 201,087 movements (11.6%), and lowest traffic volume was at Ilorin international airport (IIA) with 4,239 movements (0.3%). This implied that people living around MMIA tended to suffer more health damage than those around other airports because there is a positive correlation between traffic volume and noise level.

Table 6 summarizes the correlations between the sound levels measured at each study area and corresponding noise reactions ratings from respondents. Applying the Pearson moment correlation statistic described in Eqn (4) the correlation coefficients of +0.79, +0.54, +0.34, +0.85 and +0.78 were obtained at MEIA, PHIA, MMIA, JIA and IIA respectively, suggesting unhealthy noise impact on the respondents.

V. Conclusions

From the results obtained in this study, it is clear that people living, or doing business around Nigerian airports surveyed are definitely exposed to serious health hazard as a result of excessive aircraft noise which they are subjected to. Most of these people stayed around the airport for 10 years and above. The implication of this is that their health may be severely damaged over these years by intense and continuous exposure to aircraft noise pollution, although it may not be immediately noticeable to them. The findings of the study totally agree with results of earlier studies of other researchers [23-29] that aircraft noise pollution has negative impact on lives and health of residents near airports as measured A-weighted sound pressure levels (SPLs) of between 100 and 116 dB(A), recorded at facades of respondents' houses and calculated L_{Aeq}, L_{NP}, L_{dn} are too high, exceeding recommended limits (see Table 3).

This study reveals clearly that noise is, irrespective of which source(s) it comes from, is truly a public nuisance in Nigeria. It pollutes the environment and exposes community residents to serious health hazard. In the light of these findings there is therefore, the need for the Federal Government of Nigeria to faithfully implement existing anti-noise laws and ordinances in Nigeria, the general public to strongly agitate for noise control by government, aircraft designers/operators, Nigerian Civil Aviation Authority (NCAA), and other relevant authorities to regulate and monitor air transport services and ensure compliance with specifications and standards, including aircraft airworthiness in Nigeria [30-32]. Some other mitigatory measures suggested here based on the results of this survey are, control of noise at design stage of aircraft, regular maintenance of aircraft, use of suitable noise absorbing materials for walls, doors, windows, ceiling and floors of residential buildings, among other noise control methodologies.

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References and Notes

1. E. B. Magrab. *Environmental noise control*, John Wiley and Sons, New York, (1975), pp.55-58.
2. P. E.Cunnif. Environmental noise control, John Wiley and Sons, New York (1977), 32-40.
3. Y. Osada. Comparison of community reactions to traffic noise, *Journal of Sound and Vibration*, 151, 479-486 (1991).
4. R. Rylander, D. R Dunt. Traffic noise exposure planning. A case application, *Journal of Sound and Vibration*, *151*, 535-541. (1991).
5. K. D, Kryter. *The effects of noise on man*, Academic Press, Orlando, FL, USA, (1985).
6. *Study on community reaction to aircraft noise. Report of the study of aircraft noise hazards around Narita airport*, Committee of Environmental Survey: Shibayama, Japan, (1990).
7. *Influence of noise around Yokota airbase on residents life*; Tokyo Metropolitan Research

Institute for Environmental Pollution: Tokyo, Japan, (1971), pp. 2-11.
8. Y. Osada. Community reaction to airport noise in the vicinity of airport- a comparative study of the social surveys using interviews method. *Bulletin of the Institute of Public Health*, (1971).
9. *Report of epidemiological study of the influence of aircraft noise on residents*; Aircraft Nuisance Prevention Association: Tokyo, Japan, (1983).
10. *Study on consciousness of residents around airports, Bureau of Air Pollution Control*; Environmental Agency, Tokyo, Japan, 1975.
11. *Study on the effects of aircraft noise on living and health of residents*; Department of Environmental Health, Research Center, Aircraft Nuisance Prevention Association: Tokyo, Japan, (1983).
12. *Report on aircraft noise around the New Tokyo International Airport*. Department of Environment, Chiba Prefecture: Tokyo, Japan, (1988).
13. E. O. Obisung. Measurements and analysis of aircraft noise and community reactions in parts of Southern Nigeria. M.Sc Engineering Physics Thesis, University of Calabar, Nigeria, (2002).
14. ISO 1996-1: Acoustics-Description, measurement, and assessment of environmental noise-Basic quantities and assessment procedures.
15. ISO 1996-2: Acoustics-Description, measurement and assessment of environmental noise-Determination of environmental noise levels.
16. ISO 3891: Acoustics-Procedure for describing aircraft noise heard on the ground.
17. IEC 651: Sound level meters.
18. IEC 804: Integrating-average sound level meters.
19. J. A. Molino. Annoyance and noise. Handbook of noise control (2nd edition) London, McGraw Hill book company. (1979).
20. *Information on levels of environmental noise requisite to protect public health and welfare with adequate margin of safety*. USEPA: Washington DC; USA; 24-32 (1974).
21. WHO Guidelines for community health, (1999).
22. F. E. Croxton, D. J. Cowden and S. Klein. Applied general statistics. Prentice Hall, Inc. eagle Woods Cliffs, N. J; USA, 38 (1998).
23. C. M. Harris. Handbook of Noise Control, 2nd Edition, McGraw Hill, Inc, New York, USA, (1957).
24. A. I. Menkiti, D. O. Ajah. Reactions to aircraft noise near some airports in Nigeria. *J. W. Afri. Sc. Assoc*. *21, 10-13* (1993).
25. S. Morell, R. Taylor, D. Lyle. A review of health effects on aircraft noise. *N.Z.J. Public Health*, 21, 22-236 (1997).
26. U. E. Asuquo, M. U. Onuu, A. O. Akpan and A. U. Asuquo. Noise and Blood Pressure: A cross sectional and longitudinal study of the effects of exposure to loud noise on residents in Calabar, Cross River State, Nigeria. *International Journal of Acoustics and Vibration 14(2), 56-69 (2009).*
27. U. E. Asuquo, M. U. Onuu,Akpan, A. U. Asuquo. Effects of exposure to loud noise on hearing on people of Calabar, Cross River State. Electronic Journal of Technical Acoustics. *10 (2009).*
28 U. E. Asuquo, S. O. Inyang, N. O. Egbe and A. U. Asuquo. The effects of noise on human blood pressure. Global Journal of pure and Applied Sciences. *11(1), 149-152 (2004).*
29. A. O. Akpan, M. U. Onuu, A. I. Menkiti, U. E. Asuquo. Measurement and analysis of industrial noise and its impact on workers in Akwa Ibom State. Nigerian Journal of Physics, *15(1), 41-45 (2003).*
30. E. O. Obisung, A. O. Akpan, C. S. Davies-Ekpo. Measurement and analysis of aircraft noise and its impact on people around some Nigerian airports. *Global J. Pure Appl. Sci. 11, 433-438 (2005).*
31. E. O. Obisung, M. U. Onuu and A. I. Menkiti. A comparative study of community response to aircraft noise at Port Harcourt and Murtala Muhammed International Airports, Nigeria. African, *J. Environ Health, Nigeria, 6, 43-51* (2008).
32. M. U. Onuu. Noise levels and anti-noise laws. Newspaper Article, Hallmark, Lagos, Nigeria (2000).