ANALYSIS

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Acoustic survey of institutions of higher learning in the South-East and South-South geopolitical zones of Nigeria

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ABSTRACT

The concern of this paper is to investigate the level of noise pollution within the academic environment of higher education in the South-East and South-South geopolitical zones of Nigeria. The sources of noise in the institutions, the perception of the academic community about noise and suggested remedial measures were expounded. Four representative sample institutions of higher learning, comprising three universities and one polytechnic, within the study area, were selected for the survey and their random noise situation observed qualitatively. Based on the similarities of noise conditions in these institutions, a detailed noise study, using the grid sampling technique, was conducted in the study base location to elucidate the situation. Acoustic maps were developed to show areas of excessive noise and their sources. It was observed that many locations in the study area have their noise levels exceed the World Health Organization's recommended value by more than 10dB(A). More than 60% indicated high study interference and annoyance from these noises. The attention of government agencies and school managements are needed to address the noise pollution in the institutions to ensure a conducive academic environment.

Keywords: noise pollution level, higher learning, acoustic map, noise sources, perception, mitigations

1. INTRODUCTION

Noise is analogous to dirt as a matter out of place or a sound out of place (Agbo, 2020). There are many sources of noise within the institutions of higher learning in Nigeria. These include noise from mini electric power generators as a consequence of poor electric power supply from the mains, noise from road traffics especially motor vehicles and motorbikes, noise from religious activities (Omubo-Pepple et al., 2010) including those coming from churches holding services, fellowships and night vigils, and from mosques observing early morning and evening calls to prayers. Every of the noise sources produces a different amount of sound pressure level with different frequency and directional characteristics and might have spatial and time variations. The effects of the noise are linked to the noise characteristics especially the noise level and the frequency (Loreti et al., 2016).Noise causes many health challenges and interferes with communications (World Health Organization (WHO), 1999; WHO, 2018; Ajala, 2012; Eom et al., 2006). Noise affects the blood pressure of workers (Wokocha, 2013). Acoustic discomfort is shown to cause fatigue, headaches, annoyance, changes in behaviour and attitude leading to a decrease in intellectual working ability and sleep disorders (Ali, 2017).Noise affects the overall wellbeing of an exposed individual. Hammer et al. (2014) posited that people in noisy environments experience subjective habituation to noise, but their cardiovascular system does not habituate and still experience activations of the sympathetic nervous system and changes from deep sleep to a lighter stage of sleep in response to noise. People in noisy environments have poor school performance (Shield and Dockrell, 2008), which leads to stress and misbehaviour. Noise causes low speech intelligibility, decreased learning, lower reading comprehension, and concentration deficits (Poll et al., 2014; Liu et al., 2017). A minimum of 15dB(A) signal-to-noise ratio for full sentence intelligibility in listeners with normal hearing and noise above 55 dB(A) is quite disturbing (WHO, 1999). Servilha and Delatti (2014) identify the perceptions of university students about the noise in the classroom and its consequences on learning quality and indicated that students react to noise with an effort to listen, difficulty in concentration and irritation which interfere in learning, grades and health.

Onuu (2000) investigated road traffic noise in major cities in South-Eastern Nigeria and observed a steady increase in the environmental noise due to industrialization and commercialization. Many schools in South-Eastern Nigeria experience less than 45% sentence intelligibility with more than 40% of the school community been annoyed by road traffic noise. Wekpe (2020) looked at the problem of noise pollution around the communities of the University of Port Harcourt. Noise values were measured and the values were beyond threshold limits for acceptable noise levels across the study area. It was attributed to the rapid urbanization and industrialization which leads to a high number of automobiles, generating plants, industries, mobile advertisement vans and vendors. Amakom et al. (2019) conducted noise level measurement at the Federal University of Technology, Owerri (FUTO). The recorded average noise levels were 67.78 dB by 9.00am, 71.07 dB by 12.00pm and 67.79dB by 3.00pm respectively. Ntui (2009) determined levels of environmental noise and identified noise sources that inconvenience library users at the University of Calabar library. The study found that the levels of noise in the University library were high (43.5 – 88.5 dB(A)). Nte and Gbarato (2019) did a noise survey of the University of Port Harcourt Teaching Hospital for both classrooms and hostels environments of the University. The noise ranged from 52 dBA around the wards, 72 dBA around the motor park and 112 dBA at the generator yard of the utility unit. The university also recorded 52 – 75 dBA at lecture halls and 55 – 78 dBA at the hostels depending on the time and season.

The noise in these institutions surpasses the WHO (1999) maximum of 35 dB(A) and NESREA(2007)maximum of 45dB(A) in the day and 35 dB(A) at night recommendations for a school classroom environment. There is, therefore, need for more studies in the subject of noise pollution in Nigeria's higher institutions to avert the imminent consequences of students' academic performance and staff productivity. The study would likely be of benefit not only to Nigeria but also to other developing countries, as the noise situation might not be peculiar.

2. METHODOLOGY

Pilot acoustic surveys, predominantly subjective, were conducted in four selected institutions of higher learning within the South-East and South-South geopolitical zones of Nigeria, namely: the University of Nigeria, Nsukka (UNN), Institute of Management and Technology (IMT), Enugu State University of Science and Technology (ESUT) and University of Port Harcourt (UNIPORT). The two zones share common cultural and religious beliefs currently dominated by Christianity and had common geopolitical origin and governance under the Eastern Region of the 1960s. An open-ended questionnaire was prepared that contains the various noise sources and common effects, though not stereotyped. For UNN 200 respondents were projected, for ESUT 150 respondents were projected, in IMT 150 respondents were projected, and then for UNIPORT 120 respondents were projected making 620respondents in all, but, 535 responses were retrieved. A sample format of the questionnaire is shown in the Appendix. From the questionnaire, areas with precarious noise effects were noted.

Due to the similarities in the noise pattern within the two zones, a detailed study was then carried out at the University of Nigeria, Nsukka. UNN is located in the South-East geopolitical zone of Nigeria on latitude 6.8° and longitude 7.4°. It has a total area

of 8.7km^{2}excluding the vast arable land available for agriculture. The university has a student population of more than40,000 and a staff population of about 8000. The campus is majorly divided into three – staff residential quarters, students' residential hostels' area and academic (classrooms and offices) areas. Small commercial activity areas are also scattered on the campus. The sound level measurements were carried out in March 2017 and 2018, when the weather is the hottest, without rain and windows are normally kept wide open or ajar for natural ventilation. Noise, though, considered as a secondary issue compared to heat is also at the peak at this season with generators, fan, etc. working at full capacity most of the time.

Two methods were adopted in the selection of the location coordinates of the sampling/measurement points, – random sampling method and Grid method. The time periods of measurement are morning (6:00-9:00am), afternoon (12:00 – 15:00pm), evening (17:00-19:00pm) and night (20:00 – 23:00pm) for the first method. The second sampling method used three time periods due to a large number of sampling points compared to the first method. These are: morning (07:00 – 10:00am), afternoon (13:00 – 16:00pm) and evening/Night (19:00 – 22:00pm). A total of 57 sampling points was randomly selected in the first method. Figure 1 shows the location of sampling points.Points were chosen to accommodate major roads, road junctions, departments, faculties, commercial centres and recreational centres.

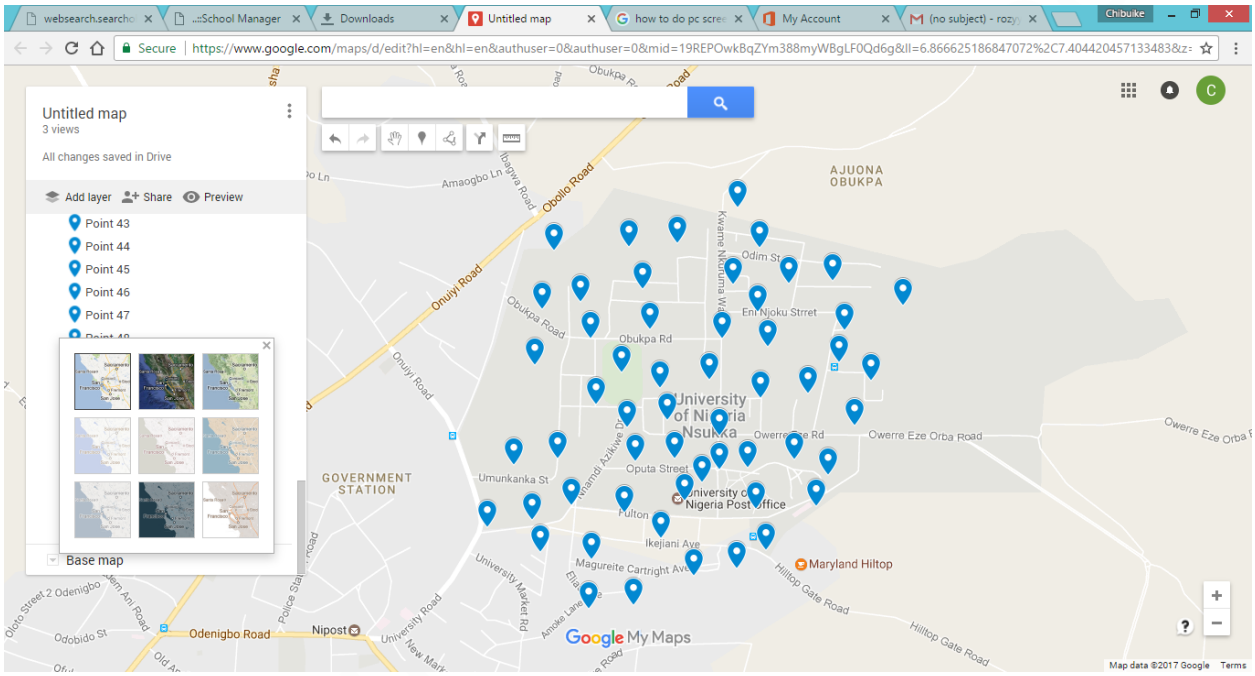

Fig.1 Google map of UNN showing the random sampling points

In the second method, the study area on Google map was overlaid with a uniform grid which divided the map into 208 sampling squares (see Fig. 2). However, only 121 effective sampling squares fall within the study area as some fall outside the University boundaries. The sampling point here is comparably larger than that for random sampling technique and hence expected to give a finer map.

The global positioning system (GPS) was deployed to ensure that noise level measurements were obtained within specific squares and sampling points using Benetech GM1351 digital sound level meter. The specifications include measuring range 30dBA-130dBA, accuracy+/-1.5dB, frequency response 31.5Hz-8kHz, frequency weighting A and resolution 0.1dB. For each sample point, the measurement was taken for approximately 10 minutes after which the maximum and minimum sound levels were obtained and the average recorded. The readings were taken with the instrument at arm's length and pointing to a suspected noise source. Microsoft excel package was used to plot a contour map of the grid sample points assembled data.

3. RESULTS AND DISCUSSION

Random sampling noise levels in UNN

The readings obtained from the random sample points are shown in Table 1.Major locations within the University environment were listed along with their noise levels in the morning, afternoon, evening and night. It has been observed that the academic faculties are mostly noisy in the afternoon when activities are at its peak with noise levels up to 65dB(A). Road junctions and roundabouts also

experience higher noise levels of up to 75dB(A) due to traffics, cars and motorbikes mainly. These are higher than recommended by WHO and NESREA and consequently will most likely disrupt academic activities by masking and distorting the desired communication speeches and logics in reasoning involved in academics.

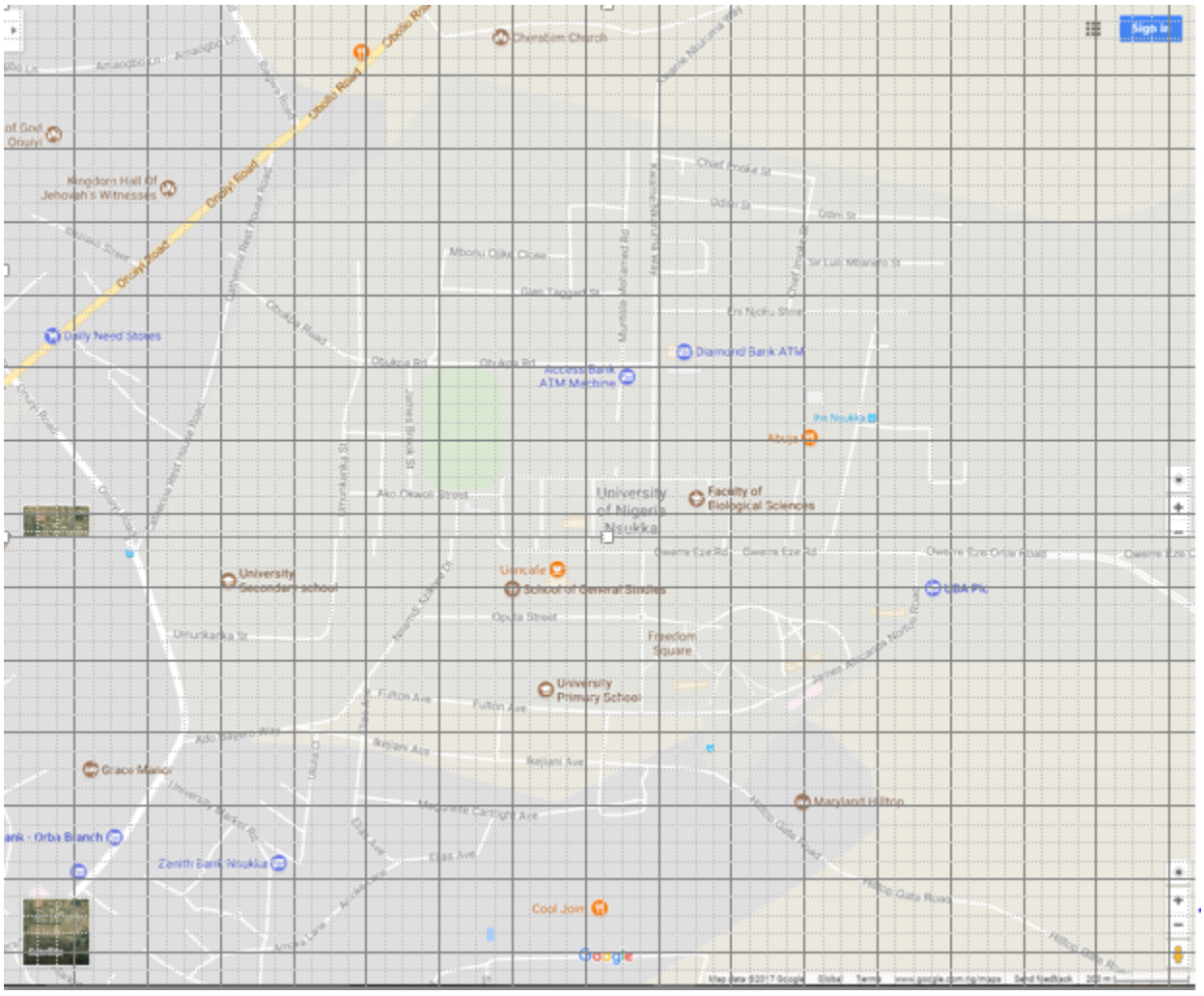

Fig.2 Grid method of sampling on overlaid google map

Table 1 Noise level readings from random sampling

S/N	Location/Description	Morning (6am-9am) dB(A)	Afternoon (12noon-3pm) dB(A)	Evening (5pm-7pm) dB(A)	Night (8pm-11pm) dB(A)
1	Umunkaka residential area	52.7	46.4	50.4	59.3
2	Freedom square	54.3	70.2	65.8	67.7
3	Library roundabout	55.6	75.1	67.4	66.5
4	Stadium roundabout	54.3	66.5	48.4	70.1
5	Chitis junction	54.6	72.4	54.8	63.4
6	Green house UNN Gate	47.5	68.2	49.4	60.2
7	Zoology department	50.7	65.4	53.5	45.9
8	Faculty of engineering	50.0	65.2	51.4	44.5
9	Engineering- ICT Junction	51.4	68.5	60.4	62.1

10	Eni Njoku street quarters	45.4	58.3	52.7	48.5
11	Odim Gate	61.2	71.2	77.5	73.6
12	Faculty of Agriculture	48.2	66.9	48.2	47.0
13	Faculty of veterinary medicine	51.0	61.0	55.5	44.9
14	Agric/Pharmacy Hall	47.5	65.2	58.3	53.4
15	Franco (male hostel)	64.5	50.1	68.5	69.3
16	PG Hostel	61.2	48.3	60.1	64.2
17	Princess Alexandria Auditorium	48.2	50.5	48.0	51.7
18	Fulton T-Junction	58.2	61.3	57.4	58.6
19	Faculty of Arts	52.5	50.2	51.4	43.6
20	Faculty of Education	48.2	62.8	52.4	49.3
21	Social Science (Pol. Sci. area)	49.4	65.7	53.8	44.7
22	GS Building	54.1	50.1	49.7	55.9
23	Fulton Avenue	62.4	48.5	48.2	44.8
24	Ikejiani street quarters	45.1	44.7	42.0	41.3
25	Okpara/Balewa Hostel	55.4	50.4	57.8	59.3
26	Mary Slessor Hostel	48.2	56.7	58.4	60.3
27	SUB	43.1	62.3	65.2	66.7
28	Okeke Hostel	60.8	49.0	55.1	57.0
29	Hill top gate/ St.Peter's Church	62.0	58.1	62.4	64.5
30	Medical centre/ Isa Kaita	58.7	50.4	47.4	45.9
31	Cartwright Flats	45.1	44.9	47.1	44.8
32	Cartwright Flats 2	45.2	44.2	46.3	48.1
33	Odenigwe Gate	63.7	58.2	65.4	62.0
34	VC's lodge arena	32.0	34.0	35.1	33.0
35	Cartwright senior staff quarters	40.1	34.8	40.0	38.5
36	Main Gate (Ado Bayero way)	68.6	60.4	65.4	54.5
37	Diamond/Micro finance Banks	65.2	75.4	69.4	58.7
38	Ukuta close	48.2	52.5	55.1	56.2
39	Basketball area	55.1	48.8	68.2	43.7
40	CEC	50.1	62.3	60.1	57.3
41	Stadium	58.2	50.1	64.5	56.2
42	Franco stadium junction	48.2	48.5	50.7	53.8
43	Hockey Pitch	42.1	49.1	58.2	44.9
44	Odim quarters	45.1	44.8	45.0	41.1
45	Kwame Nkrumah way (staff quarters)	48.0	48.2	49.0	43.2
46	Presidential lodge (by Louis Mbanefo street)	49.0	50.0	48.4	47.2
47	Mbanefo street quarters	48.0	48.7	50.2	45.6
48	Jimbaz (Biological sciences)	50.1	57.2	52.0	49.4
49	Vet. Hill foot	43.2	46.6	45.0	42.0
50	MbonuEjike Quarters	46.2	45.0	47.0	43.1
51	Children centre library	55.5	46.1	50.1	48.8
52	Junior staff quarters	46.0	45.2	50.1	43.6
53	Proposed University market area	40.1	44.2	42.3	41.5
54	SAANU filling station/Borehole area	65.7	52.5	58.4	61.1

55	Uni. Sec. Sch. Staff quarters	60.2	50.1	52.3	49.7
56	Energy centre	45.2	50.4	56.1	42.8
57	HSND- Pharmacy department	48.2	55.2	44.1	42.2

Grid sampling contour noise maps

The contour noise maps were obtained from the grid sampling data for the morning, afternoon and evening times, and also the day-evening-night equivalent noise level, L_{den}. The uncoloured boxes are areas that fall outside the study boundary.

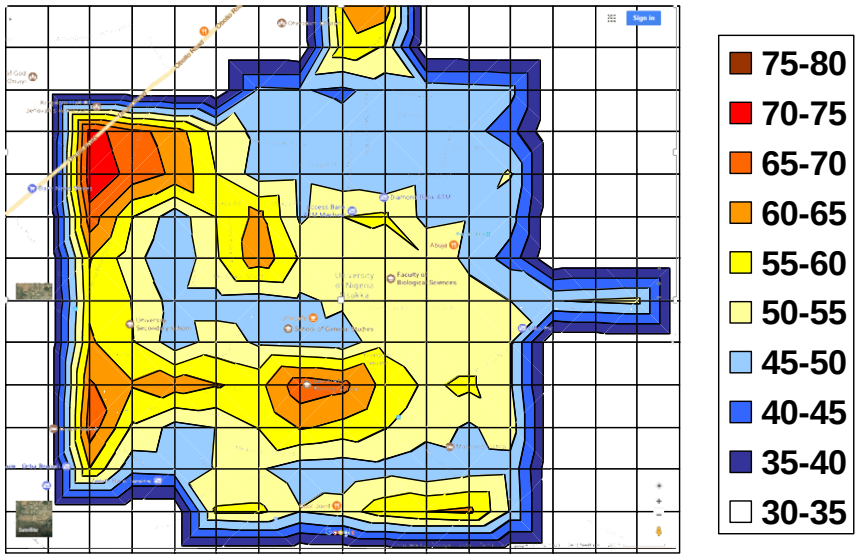

Fig.3 Morning Noise map of UNN

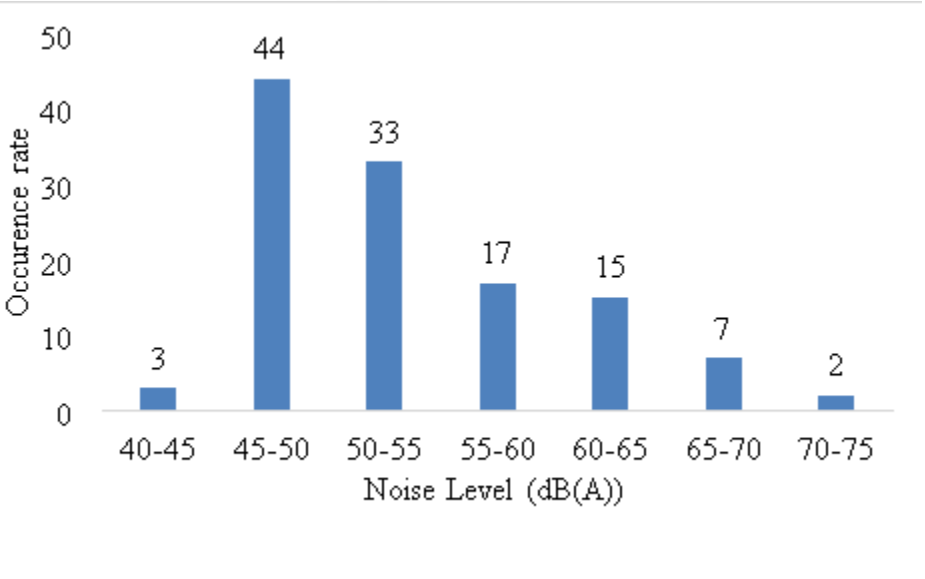

Fig. 4 Frequency distribution of morning time noise levels

Figures 3 and 4 are shows the morning time (7.00-10.00am) noise levels mapping and occurrence rate. Morning period is generally quiet across the Campus. The sound pressure level is on an average between 45 – 50dB(A). Notable areas above this average are University Primary school area; main gate area, second gate Franco area and stadium area (see Fig. 3). All these are mainly due to the population of people in the area during this period and also road traffic noise from parents and guardians bringing their wards to the school.

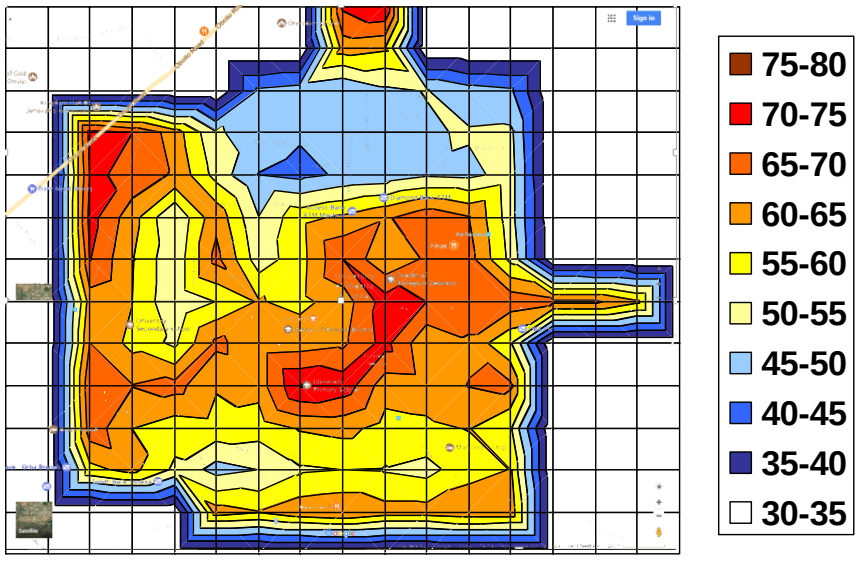

Fig. 5 Afternoon noise map of UNN

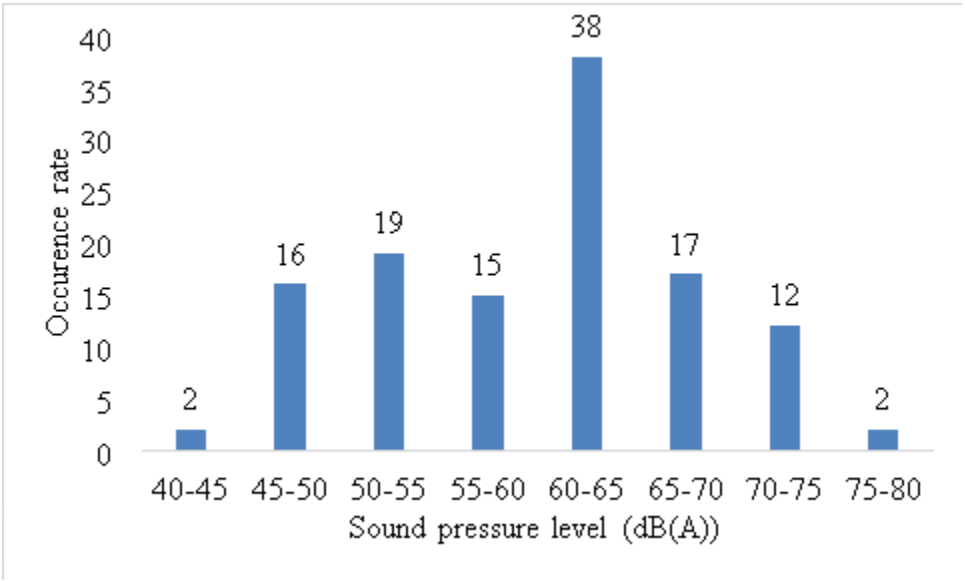

Fig. 6 Frequency chart of afternoon time noise levels

Figures 5 and 6 are shows the afternoon time 13.00-16.00pm noise levels mapping and occurrence rate. Sound pressure levels increase generally across the study area in the afternoon. This is due to active academic activities in the various departments and road traffics across the major roads in the Campus. The average noise levels during this period are in the range of 60 – 65dB(A). Notable locations within the upper limit include areas between CEC and Faculty of Agric (see Fig. 5). The higher level is attributed to the larger population of students in that area, the presence of the school generator. Areas toward the school main gate are also above the average due to road traffics. The area around the Faculty of Education to Fulton Avenue is also above the average mainly due to a high population of people going for the school run and subsequent huge presence of cars around the University primary school.

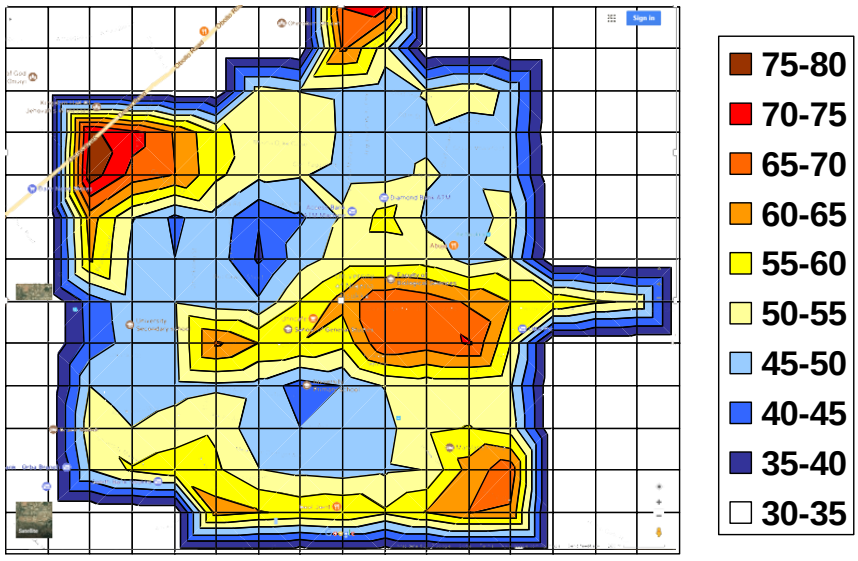

Fig.7 Evening/Night noise map of UNN

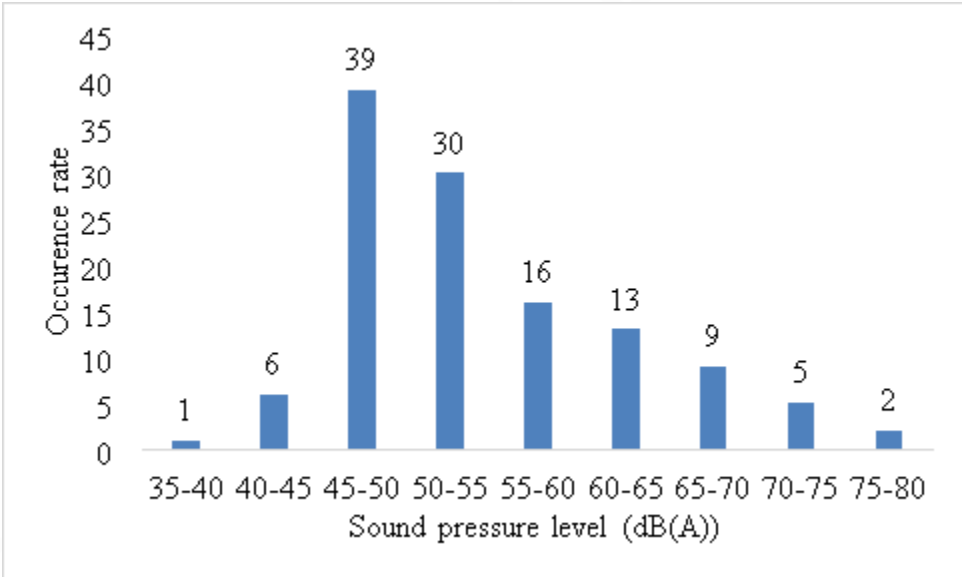

Fig.8 Frequency chart of grid evening time Noise levels

Figures 7 and 8 are shows the night time 19.00-22.00pm noise levels mapping and occurrence rate. Most areas fall between 45dB and 50dB. Prominent noisy areas are the north most part of the study areas which encloses Odim gate area and its immediate environs as depicted in Fig. 7. Sources of night-time noise in this area include loudspeakers, generators and numerous customers from commercial centres in the neighbourhood of Odim gate. Another area with prominent night time noise in the map is North West area which encloses Franco – Zik's flat area. The major sources of noise in that area are big school generator for the male undergraduate and PG hostels, loud music from commercial and recreational centres, and road traffic noise from Obukpa road. The east side of the map which encloses freedom square to greenhouse area is also a little bit noisy with noise levels reaching 65 -70dB. Major sources of noise here include the school generator, students socializing in their hostels, commercial centres like SUB, and road traffic to a lesser impact. SUB has a very high noise level of almost 75dB. The south-east part which encloses hilltop area is also noisy with noise levels approaching 70dB. This area is similar to that of Odim gate area of the map.

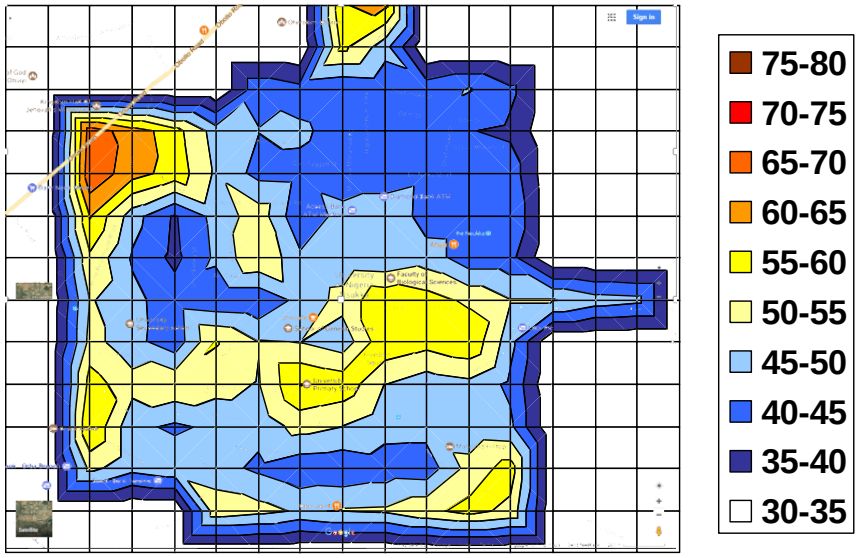

Fig.9 L_{den} noise map of UNN

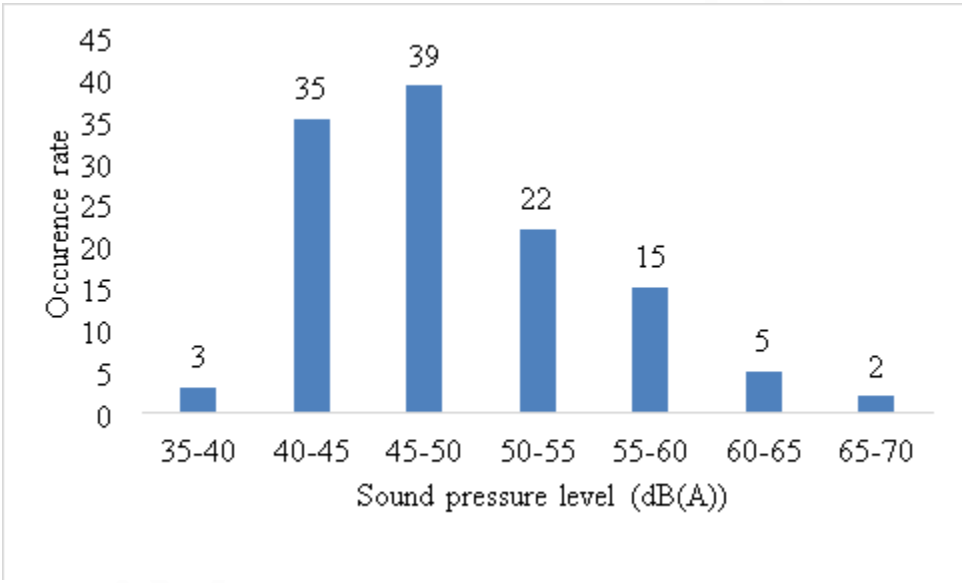

Fig.10 Frequency distribution chart of L_{den}

The effective overall noise level L_{den} is shown in Figs 9 and 10. The EU Noise Directive (END, 2002) defines a L_{den} threshold of 55 dB for reporting on the numbers of people exposed to noise annoyance. L_{den} is the day-evening-night noise indicator for overall annoyance. It is 'weighted' to account for extra annoyance in the evening and night periods. The L_{den} noise map, Fig. 9, shows that three areas exceeded this threshold, namely – Odim gate area, Franco to the second gate area and Library junction to SUB area.

Perceptions of noise pollution in the institutions

The subjective evaluations carried out in the institutions were presented as pie charts indicating the relative contributions of the various noise sources and the perception of their consequential effects. The survey at UNN (see Fig. 11) indicates the following percentages of major noise sources, modular electric generators 21%, road traffics 19%, commercial activities 18%, religious activities15% and occupants 10%. The epileptic electric power supply from the mains electricity is responsible for the generators been switched-on most of the time. Though the shuttle service in the school is well planned such that only designated routes are used by them, the private cars were not controlled which also constituted a nuisance. The business activities in the school are also distributed around the school premises at locations not so far from lecture halls while in the evenings most of the classrooms were been converted to fellowship venues.

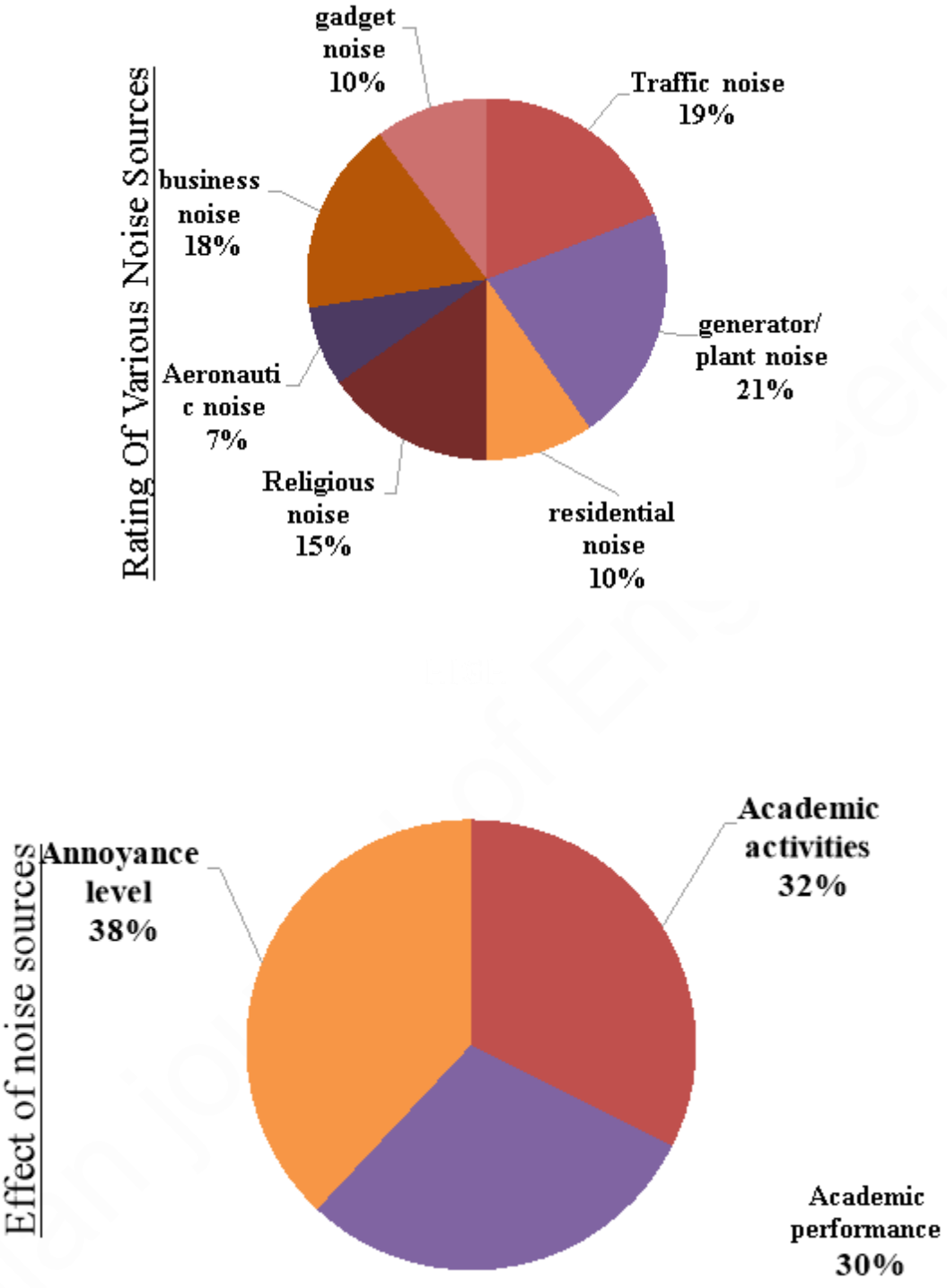

Fig. 11 UNN

The survey at ESUT (see Fig. 12) reveals the following result from the identified noise sources, business activity 25%, modular electric generator 21% and road traffic 17%. It was observed that the school has a specific location for business Centre's but this could not reduce the noise from this source due to the exponential dependence of noise. It was also observed that the main roads passing through the school have very sharp bends, such that, even if few vehicles ply the roads, horning is almost inevitable. Hence, the increase in the noise source.

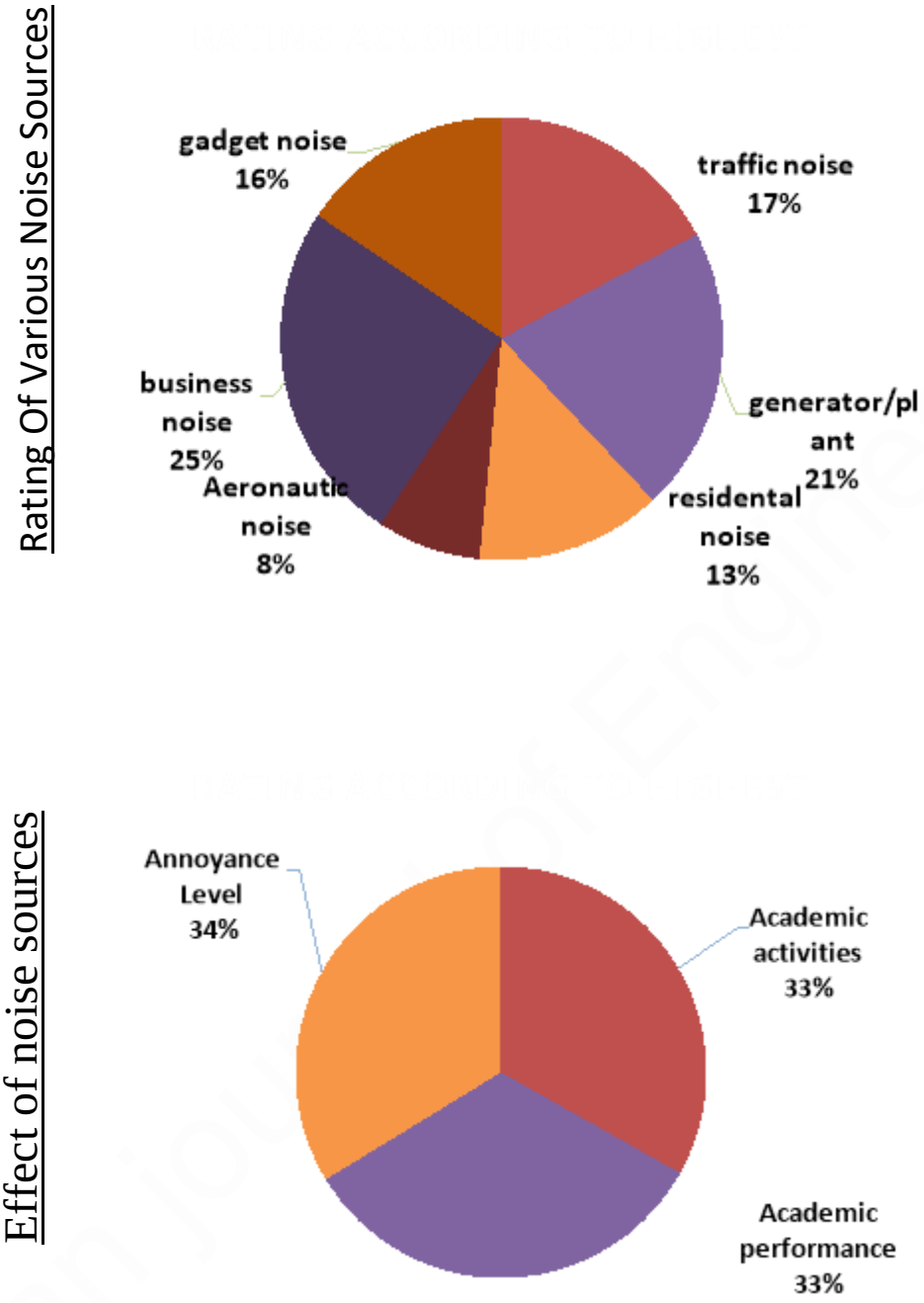

Fig. 12 ESUT

The survey at IMT (see Fig. 13) gave the following percentage result of the identified noise sources, generator noise 25%, traffic noise 25%, business activities / Centre's 13%, occupants 17%. From this result, we can deduce that noise sources from business activities, traffic and the generator are the predominant sources of noise in the institution. Was observed that the institution has smaller landmass when compared to other institutions and as such, the road network in the school is very small resulting to increase in the number of vehicles using the road per time and subsequently increase in noise. Occupants and neighbourhood noises were also significant.

The survey in UNIPORT (see Fig. 14) indicated that the following percentage contributions of the noise sources, generator noise 25%, traffic noise 25%, residential noise 17% and business activities/centres 13%. From these, we can deduce that modular electricity generators and road traffics are the predominant noise sources for the institution. The school traffic network is concentrated at one location thereby resulting in intense noise for people close to this location. The respondents also pointed out that business activities

are situated very close to lecture venues and the noise from these activities affect the students academically. Moreover, most of the student's lodges/hostels are situated outside of the school environment and consequently are subjected to the various neighbourhood noises associated with the urban city.

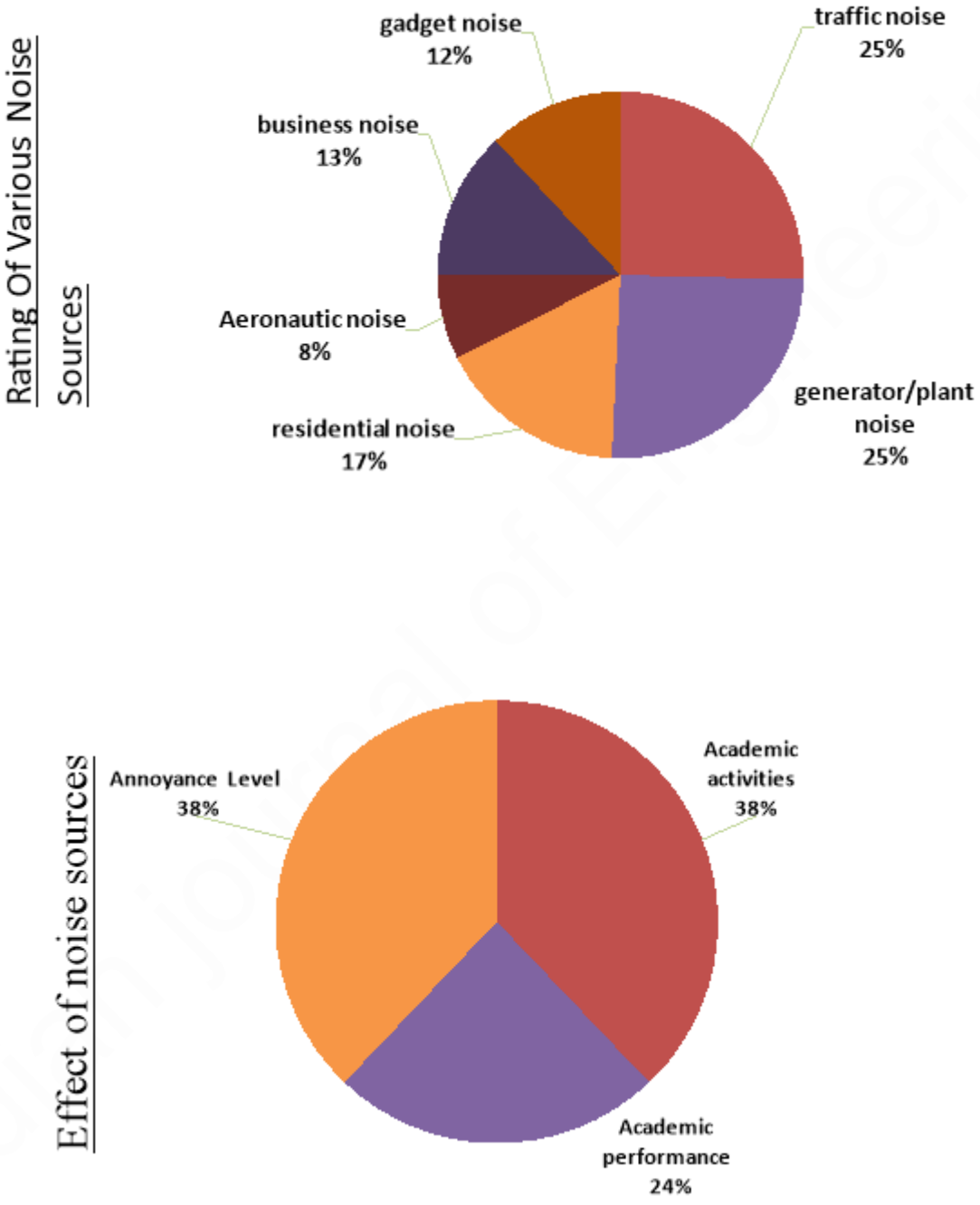

Fig. 13 IMT

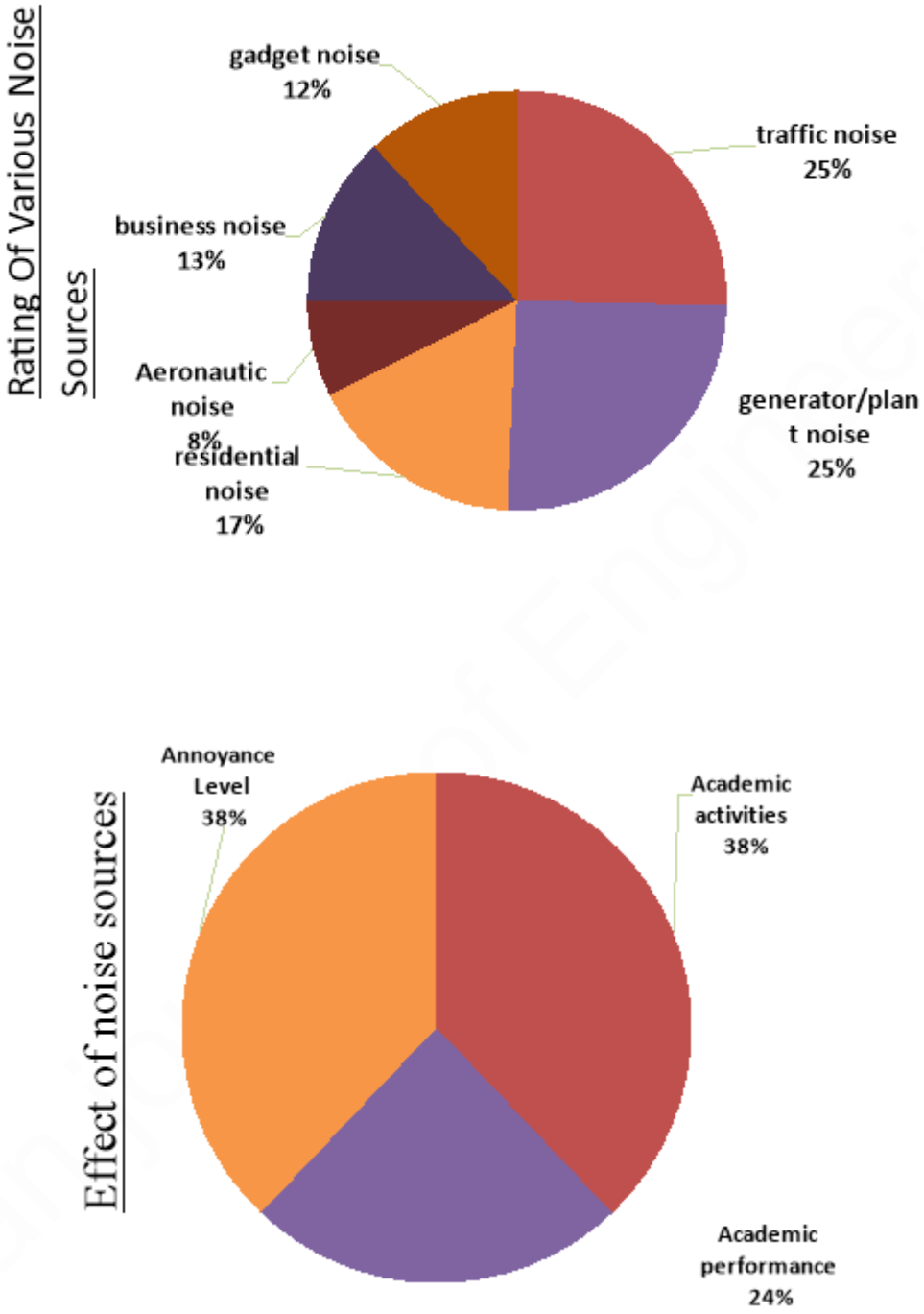

Fig. 14 UNIPORT

From the evaluations, it has been generally observed that the predominant noise sources in Nigeria institutions of higher learning include modular electric generators, road traffic noise, religious activities and commercial activities. The most effects were on annoyance level, academic performance and academic duties in that order.

4. CONCLUSION AND RECOMMENDATIONS

Investigations into the noise pollution in the institutions of higher learning within the South-East and South-South geopolitical zones of Nigeria have shown high sound pressure levels within these communities. Modular electric power generators have been indicated as the highest contributor to the noise pollution, followed by road traffic, then commercial activities and

occupants/religious activities which some people shy away from reporting due to faith-based issues. It has been noted that inappropriate levels of background noise, reverberation, and signal to noise ratios can inhibit speech intelligibility, academic performance and disrupt other academic activities. It is known that loud or reverberant classrooms may cause teachers to raise their voices, leading to increased teacher stress and fatigue, and risk voice impairment (CISCA, 2009).

The school management and the governments at all levels have roles to play in providing a conducive learning environment devoid of noise pollution. It is therefore imperative for the public power supply to be enhanced to curtail the use of modular electricity generators. Existing ones should be soundproofed. Installations of solar panels and inverters will do better than mini generators in maintaining a serene ambience.

Good physical planning that creates a master plan for the institutions will provide a panacea to the haphazard allocation of commercial outlets and business centres. Planning out business activities to have a specific location away from the academic area. Sound-absorbing walls should be installed around plots marked out for business purposes.

Environmental regulations coupled with a designated religious village will go a long way to checkmate the idea of academic and religious activities contending for limited space within the lecture halls and classrooms. Creating centralized parking lots for motor vehicles and planning plying routes will reduce road traffic noise. Speed limits and no horn regulations should be enforced. Mass enlightenment programmes on noise pollution effect are important in this direction.

There are also other technical noise abatement measures used in the developed countries though the cost implications may make some of the techniques inappropriate for many low-income developing countries (WHO, 1999). Nonetheless, the design of tall buildings and long buildings have been found to block the transmission of noise and reduce the spread around campuses (Destefani et al., 2016). Greenery systems on buildings have been associated with several benefits, such as energy savings, biodiversity support, storm-water control as well as noise attenuation (Azkorra et al., 2015).

Perimeter fencing of the university campuses will prevent noise intrusions from crossing the university boundary. The use of berms, concrete and block walls are necessary to both secure the university property and to reduce noise. Attaching noise-absorbing materials on the existing wall have been found effective (Tembhekar, 2012) Plantations and shrubs have been found to dampen noise levels to a certain percentage, especially, trees planted along the main roads or light vegetation around the learning environment.

Also, acoustic mapping that showcases areas of increasing activities that increases the noise levels should be produced to serve as a guide to any adoptable noise abatement measure of interest (Oyedepo, 2013). Noise has a transient behaviour; hence, with the aid of computer software's like Arc GIS, this transient fluctuation of noise can be well studied and monitored. Despite the noise pollution, the acoustic maps also revealed several islands of acoustic tranquillity on campus (Zannin et al., 2013) that can be taken advantage of in future planning strategies.

Appendix

Questionnaire on Noise Pollution in Nigeria Higher Institutions of Learning

Tick your institute: IMT ☐ UNN ☐ ESUT ☐ UNIPORT ☐

Gender: female ☐ male ☐

Age range: 14 – 25 ☐ 26 – 35 ☐ 35 – Above ☐

How would you rate the noise level produced by the following noise sources?

		Very high	high	moderate	normal
1.	Traffic noise	☐	☐	☐	☐
2.	Generators/plant	☐	☐	☐	☐
3.	Residential noise	☐	☐	☐	☐
4.	Religious activities	☐	☐	☐	☐
5.	Aeronautic noise	☐	☐	☐	☐
6.	business activities (e.g. cybercafé, photocopiers etc.)	☐	☐	☐	☐
7.	Gadgets (e.g. phones, Bluetooth speakers)	☐	☐	☐	☐

Suggest noise sources we did not mention. Rate them

8. _____

Have you ever experienced any health effect through noise pollution? Yes ☐ No ☐
Headache ☐ sleep Loss ☐ Loss of concentration ☐ Hypertension ☐ or specify _____

How would you rate the effect of noise on the following?

	Very high	high	moderate	no effect
Academic activities (teaching and learning)	☐	☐	☐	☐
Academics performance	☐	☐	☐	☐
Annoyance level	☐	☐	☐	☐

Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Data and materials availability

All data associated with this study are present in the paper.

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