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Assessment of Ambient Day Indoor and Outdoor Noise Levels in University of Science and Technology Port Harcourt

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Abstract: Indoors and outdoors ambient noise levels were measured within the RSUST to determine the levels and sources of noise pollution within the university campus in order to ascertain if the noise level has exceeded acceptable limit to affect the air quality of the environment and also access the impact of various activities in the university with regard to noise pollution. Noise levels were measured with a digital sound level meter model 407730 manufactured by EXTECH instruments with "A" weighting scale. The measured noise levels ranged between 47.8 dB (A) and 103.2 dB (A). The mean noise levels recorded around the 2000 KVA and 1275 KVA generators exceeded the permissible noise levels guideline of 90dB (A) recommended by Occupational Safety Health Agency and Federal Ministry of Environment while all the mean noise levels measured within the university exceeded the guideline values of 35 – 55 dB (A) set by World Health Organization. High positive correlation coefficients between indoor and outdoor were recorded. Analysis of variance on noise levels between hostels, road junctions, gates and Departments showed significant difference (P <0.05). Noise levels at outdoors were generally higher than indoors. t - test on the mean noise levels between indoor and outdoor were not significant (P > 0.05) but t - test between maximum and minimum noise levels and between the Departments were significant (P < 0.05). The measured noise levels were typical of urban communities in developing countries. In addition to steady electricity supply from National grid, solar plant or sound proof generators were recommended.

Keywords: Ambient, Noise, University, Road Junction, Occupational Exposure, Sound Meter, Indoor, Outdoor

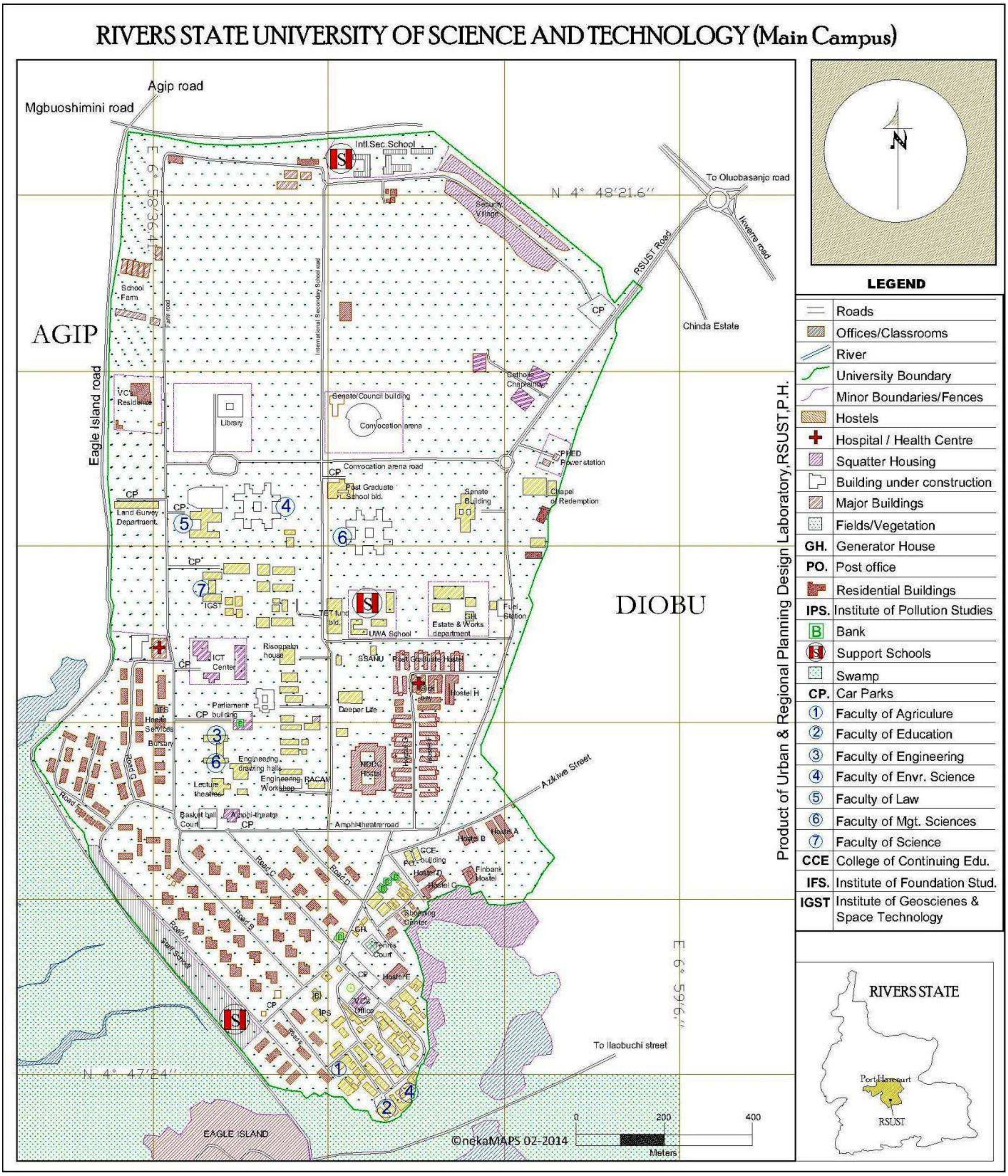
1. Introduction

The study area University of Science and Technology is located within Port Harcourt metropolis in the Niger Delta sedimentary basin of Nigeria. Port Harcourt lies within latitudes 4° 43′ 07″ and 4° 54′ 32″ N and longitudes 6° 56′ 04″ and 7° 03′ 20″ E with a mean annual rainfall of over 2000mm and mean annual temperature of 29°C (NMS, 1998). The university has staff strength of 1, 850 and a student population of 15, 376 (RSUST, 2013).

There is widespread and increasing excessive noise exposure everywhere especially in developing countries. In Africa, there are high noise expose levels in the formal (manufacturing and mining) and informal occupational sector (small industries such as vehicle repairing, metal - working and milling) as well as the non - occupational sector (urban environment and leisure). Awareness of hazard amongst employers, employees and the public is however very low.

The need for studies regarding urban noise pollution and its consequences on the environment has motivated various researchers in several countries (Ugwunyi *et al.,* 2005; Oyedepo and Saadu, 2009). Many researchers have reported that road traffic is the predominant noise source in urban areas (Bisio, 1996; Nelson, 1998). Singh and Jain (1995) reported that the measurements of noise levels in residential, industrial and commercial areas in the capital city of India, Delhi commercial areas have the highest noise levels followed by industrial and residential areas. This is contrary to the finding of Oyedepo and Saadu (2009) who carried out measurement of noise levels in busy road junctions, residential, industrial, commercial and passenger loading parks areas in Ilorin city, Nigeria. The result shows that industrial areas have the highest noise levels followed by busy roads and junctions, passengers loading parks and commercial areas. It has been generally accepted that noise pollution, particularly road traffic noise is rapidly expanding in cities such as those of South - eastern

Nigeria (Onnu, 1992).



Source: Urban & Regional Planning Dept. RSUST, P.H.

Fig. 1. *Map of RSUST showing the sampling stations.*

Noise does not only disturb sleep, interrupt conversation, and create stress and annoyance in the general population; it also reduces the efficiency and output of workers (Sinha and Sridharan, 1999). Noise is known to cause hearing loss, which at times may be irreversible. NIOSH (1996) attributed hearing loss among workers to their exposure in the industries while Smooreburg *et al.* (2003) identified prolonged equivalent daily exposures of at least 85 dB (A) as a contributing factor to increased blood pressure and hypertension. Loss of hearing due to exposure to noise can equally lead to tinnitus that is buzzing in the ear while insomnia and tiring can also be caused by noise exposure. Occupational hearing loss is often being overlooked because it usually occurs insidiously without dramatic consequence such as bleeding, deformity or death (Berger, 2000).

Environmental noise is a major issue in most countries especially in heavily populated or industrialized areas. Its sources and adverse effect on humans are varied and can range from sleep disturbances to increased stress levels, potentially leading to more major problem such as heart disease in the long run.

Noise pollution affects both health and behavior. Unwanted sound (noise) can damage psychological health. Noise pollution can cause hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances and other harmful effects (Rosen and Olin, 1995).

The most important factors raising noise pollution in urban areas include interalia appliances, vehicular traffic, neighbourhood electrical appliances, television and music systems, public address systems, railway and air traffic and generating sets. Even researchers fall prey to the noise generated by household equipments (Singh and Daver, 2004).

Noise in big cities is considered by the World Health Organization (WHO) to be the third most hazardous type of pollution, after air and water pollution (WHO, 2005). A study carried out by Goswami *et al.,* (2011) on traffic noise of two university campuses in Balasore, India, found noise levels beyond permissible limit of 70dB (A), during the day time. With increase in student population, staff and vehicular activities, the noise levels in RSUST campus is expected to increase. Thakur, (2006) in the study of noise around an educational institution reported that, there is need for proper land - use planning when traffic corridors are built in silence zone areas.

In most developing countries, occupational noise and urban, environmental noise (especially traffic noise) are increasing risk factors for hearing impairment. Many of these countries often lack both effective legislation against noise and programme to prevent noise - induced hearing loss (Demian *et al.,* 2008). Where these exist, they are often poorly enforced and implemented. Most especially in Nigeria none is at high level.

Noise pollution can cause hearing impairment, both temporarily and permanently noise can cause sleepless night which may lead to students not being able to concentrate during the day. People generate noise by the use of generators, cars, machines and students making noise during and after lectures. Indoor noise can be caused by machines, building activities and music performances especially in some workplaces. Noise induced hearing loss can be caused by outside (e.g. trains) or inside (e.g. music) noise. In animals, noise can increase the risk of death by altering predator or prey detecting and avoidance, interfere with reproduction and navigator and contribute to permanent hearing loss (Jefferson, 2013).

It is therefore important to determine the level and sources of pollution within the university campus in order to ascertain if the noise level has exceeded acceptable limit. This study therefore aims to measure and obtain data and determine the major sources of noise within the university campus.

2. Materials and Method

2.1. Measurement Instrument and Method

A Cole - Parmer Extech Model 407730 sound level meter was used to measure the noise levels within the campus. The equipment has a 2dB accuracy with 0.1dB resolution and a measuring range of 40 – 130 dB.

Table 1. *Geographical Location of Measurement Sites.*

Location	Geographical Locations	
	Northings (Lat.)	Eastings (Long.)
Main Gate	04° 48′ 14.1″	006° 59′ 07. 2″
Main Gate car park	04° 48′ 12.7″	006° 59′ 09. 8″
Azikiwe Back Gate	04° 47′ 36.6″	006° 59′ 03.0″
Chemistry Lab 1 inside	04° 47′ 52.2″	006° 58′ 44. 9″
Chemistry Lab 1 outside	04° 47′ 52.3″	006° 58′ 45. 4″
Chemistry Dept upstairs	04° 47′ 53.0″	006° 58′ 46. 4″
Physics Lab 1 inside	04° 47′ 53.3″	006° 58′ 44. 7″
Physics Lab 1 outside	04° 47′ 54.3″	006° 58′ 45. 6″
Physics dept upstairs	04° 47′ 54.3″	006° 58′ 46. 2″
Medical Lab Dept	04° 47′ 50.5″	006° 58′ 46. 2″
Biology Lab 1 outside	04° 47′ 49.5″	006° 58′ 45. 6″
Biology Lab 1 inside	04° 47′ 49.9″	006° 58′ 45. 5″
Love garden	04° 47′ 34.7″	006° 58′ 56.1″
UST Farm Site	04° 48′ 09.9″	006° 58′ 37.8″
Hostel B (Boys)	04° 47′ 34.7″	006° 58′ 59.1″
Hostel C (Girls)	04° 47′ 29.7″	006° 58′ 55.8″
Outside F	04° 47′ 41.8″	006° 58′ 55.6″
Front of law	04° 47′ 57.3″	006° 58′ 39.2″
Business Education	04° 47′ 17.6″	006° 58′ 51.8″
Urban & Reg. Plan	04° 47′ 15.1″	006° 58′ 53.2″
Estate Management	04° 47′ 16.7″	006° 58′ 55.0″
Chemical/Pet. Chem Eng.	04° 47′ 44.1″	006° 58′ 46.3″
Civil Engineering	04° 47′ 42.0″	006° 58′ 45.2″
Electrical Engineering	04° 47′ 40.5″	006° 58′ 45.6″
Mechanical Engineering	04° 47′ 50.4″	006° 58′ 50.4″
NEH	04° 47′ 46.2″	006° 58′ 46.5″
Eco bank Premises	04° 47′ 42.3″	006° 58′ 42.8″
MDR Outside	04° 47′ 39.7″	006° 58′ 43.5″
MDR Inside	04° 47′ 38.7″	006° 58′ 41.3″
EN 10 Outside	04° 47′ 40.7″	006° 58′ 40.1″
EN 10 Inside	04° 47′ 41.9″	006° 58′ 40.8″
ISS Gate	04° 48′ 22.4″	006° 58′ 50.1″
ISS senior block	04° 48′ 21.5″	006° 58′ 55.4″
ISS field	04° 48′ 23.6″	006° 58′ 51.2″
Library	04° 48′ 02.6″	006° 58′ 41.1″
Security village Power Min.	04° 48′ 22.5″	006° 58′ 51.3″
Security village Deeper life	04° 48′ 20.9″	006° 59′ 02.1″
Security village by car park	04° 48′ 17.5″	006° 59′ 07.0″

The equipment measures noise via a microphone probe that generates signal approximately proportional to the located sound waves. The meter has a weighting of "A" and "C" and "slow" and "fast" modes. The measurements were made using the slow mode and "A" weighting. With "A" weighting the meter responds as human ear. It is used for environmental measurements, Occupational Safety Health Agency (OSHA) regulatory testing, law enforcement and work place. Measurements were made outdoors. The meter was hand held at a height of 1.5 meters above ground and 3m away from buildings or other sound reflecting sources. Geographical positioning system (GPS) was used to determine the positions of the selected areas.

2.2. Measurement Locations/Duration/Frequency

This study will cover Hostels B, F & G (boys); Hostel C (girls), lecture halls of Faculties of Engineering, Science, Technical and Science, Environmental Management and Law. Also measurements will be made along major roads junctions in the campus, Farm Site and Library, International secondary school (ISS) and Security village. The noise levels (indoor and outdoor) at the selected areas were monitored daily within the hours of 8am to 5pm for 2 months.

3. Results and Discussion

3.1. Results

The results of noise levels measured in Rivers State University of Science and Technology are presented in Tables 3.1 – 3.7 and Figs 3.1 – 3.8. The ANOVA results and correlation matrices are shown in Tables 3.8 – 3.10.

Table 3.1 and Fig 3.1 show data obtained around the major university gates and car park. The results ranged from 73.1 – 85.4 dB (A) with a maximum mean of 80.2 dB (A) at the main gate, 70 - 83.0 dB (A) with a maximum mean of 77.4 dB (A) at the main car park and 70.8 - 85.0 dB (A) with a maximum mean of 78.3 dB (A) at Azikiwe back gate.

Table 3.2 and Fig. 3.2 show the results obtained at various major road junctions. The noise levels ranged from 57.9 - 79.9dB (A) at Chapel of Redemption roundabout, 57.0 - 81.4dB (A) at Love Garden, 78.5 – 79.1dB (A) at Fidelity Bank, 61.5 - 79.7dB (A) at ITC, 57.5 – 78.4dB (A) at Library roundabout, 51.9 - 68.3 dB (A) at Vice Chancellor’s Lodge, 62.0 – 73.4dB (A) at PG/Arena, 61.8 – 78.0dB (A) at TFC Building and 52.2 – 81.1dB (A) at RACAM with a maximum mean of 78.8dB (A).

Table 3.3 and Fig. 3.3 show the mean indoor and outdoor noise levels at various Departments in the University. The indoor noise levels ranged from 50.4 dB (A) (Law) to 83.0 dB (A) (Physics) with a maximum mean of 81.3 dB (A) (Physics). Outdoor noise levels ranged from 54.4 dB (A) (Business Education) to 85.8 dB (A) (Hostel F) with a maximum mean of 81.0 dB (A) (Hostel C).

Table 3.1. *Ambient Noise Levels at University Gates.*

Location	Date	Time	Noise Levels dB (A)		
			Maximum	Minimum	Mean
Main Gate	02/04/15	07: 55am	81.5	74.6	78.1
	03/04/15	11: 44am	82.6	75.2	78.9
	07/04/15	10: 22am	84.4	73.1	78.8
	08/04/15	02: 23pm	85.4	75.0	80.2
	10/04/15	02: 03pm	83.3	74.8	79.1
	28/04/15	02: 19pm	83.3	74.8	79.1
	30/04/15	02: 30pm	81.5	74.5	78.0
	01/05/15	03: 38pm	82.8	75.2	79.0
Main Gate Car park	02/04/15	08: 00am	81.7	70.4	76.1
	03/04/15	11: 39am	82.9	71.8	77.4
	07/04/15	11: 51am	81.6	70.4	76.0
	08/04/15	01: 56pm	81.8	70.7	76.3
	10/04/15	02: 28pm	83.0	71.2	77.1
	28/04/15	02: 29pm	80.8	70.7	75.8
	30/04/15	02: 37pm	81.8	71.6	76.7
	01/05/15	03: 33pm	82.2	71.2	76.7
Azikiwe Back Gate	08/04/15	08: 35am	84.5	70.9	77.7
	09/04/15	10: 52am	84.5	71.0	77.8
	10/04/15	01: 11pm	83.8	71.0	77.4
	28/04/15	02: 09pm	85.0	71.6	78.3
	30/04/15	02: 30pm	84.8	70.8	77.8
	05/05/15	02: 44pm	84.7	71.2	78.0

Table 3.2. *Ambient Noise Levels at Major Road Junctions in University of Science and Technology.*

Location	Date	Time	Noise Levels dB (A)		
			Maximum	Minimum	Mean
C/Redemption Roundabout	07/04/15	08: 08am	78.8	57.9	68.4
	10/04/15	11: 54am	79.4	58.6	69.0
	28/04/15	11: 58am	78.2	58.2	68.2
	30/04/15	01: 46pm	79.9	59.6	69.8
	01/05/15	03: 48pm	79.6	58.2	68.9
Love Garden	01/04/15	08: 26am	78.5	57.0	67.8
	03/04/15	12: 05pm	78.8	57.2	68.0

Location	Date	Time	Noise Levels dB (A)		
			Maximum	Minimum	Mean
		12: 10pm	78.2	57.6	67.9
	07/04/15	12: 21pm	78.0	57.5	67.8
	08/04/15	01: 04pm	78.0	57.2	67.6
	09/04/15	01: 10pm	78.0	57.2	67.6
	28/04/15	01: 20pm	81.4	64.7	73.1
	29/04/15	02: 51pm	78.1	57.6	67.9
	30/04/15	03: 04pm	77.9	57.1	67.5
	05/05/15	03: 33pm	78.4	57.8	68.1
Fidelity Bank	07/04/15	12: 28	79.1	78.5	78.8
Info Tech Centre	28/04/15	07: 46am	79.7	61.5	70.6
	01/05/15	08: 34am	76.2	62.0	69.1
	04/05/15	11: 49am	76.5	62.2	69.4
Library Roundabout	07/04/15	12: 13pm	78.4	57.8	68.1
	10/04/15	01: 22pm	77.9	57.7	67.8
	01/05/15	04: 07pm	77.6	57.5	67.6
VC Lodge	02/04/15	03: 00pm	68.3	51.9	60.1
P.G Sch. / Arena	03/04/15	08: 20am	73.0	62.3	67.7
	10/04/15	10: 30am	72.3	62.5	67.4
		12: 00pm	72.6	62.1	67.4
	28/04/15	01: 30pm	73.2	63.0	68.1
	30/04/15	02: 50pm	72.2	62.2	67.2
		03: 00pm	73.4	62.0	67.7
		04: 00pm	72.1	62.1	67.1
TFC Building	01/04/15	09: 18am	77.7	62.1	69.9
	07/04/15	11: 04am	77.2	62.5	69.9
	10/04/15	10: 20am	77.5	62.7	70.1
		10: 25am	77.3	62.3	69.8
	28/04/15	10: 49am	77.2	62.5	69.9
	29/04/15	01.42pm	77.6	61.8	69.7
		02: 20pm	76.9	62.0	69.5
		03: 02pm	77.2	62.3	69.8
	05/05/15	03: 08pm	78.0	62.9	70.5
RACAM	03/04/15	10: 17am	80.0	52.7	66.4
		12: 00am	79.3	52.6	66.0
	08/04/15	01: 00pm	79.0	52.2	65.6
	09/04/15	01: 30pm	81.1	59.3	70.2
	28/04/15	02: 00pm	79.4	52.5	66.0
		02: 30pm	79.6	52.6	66.1
		03: 30pm	79.8	52.7	66.3
	04/05/15	05: 00pm	79.6	52.5	66.1

Table 3.3. *Indoor and Outdoor Mean Noise Levels in Various Departments in the University of Science and Technology.*

Department/Location	Source	Noise Levels dB (A)		Mean
		Maximum	Minimum	
Chemistry Lab. I	Indoor	80.3	69.2	74.8
	Outdoor	78.4	75.9	77.2
Physics Lab. I	Indoor	83.1	79.4	81.3
	Outdoor	78.6	68.4	73.5
Biology Lab. I	Indoor	73.2	70.4	71.8
	Outdoor	75.9	64.1	70.0
SC 10	Indoor	78.0	63.3	70.7
	Outdoor	79.6	71.2	75.4
SC 7	Indoor	79.6	64.8	75.4
	Outdoor	77.6	65.5	71.6
Hostels	B (Boys)	79.6	69.8	74.7
	C (Girls)	82.8	79.1	81.0
	F (Outdoor)	85.8	62.8	74.3
	G (Outdoor)	84.4	68.1	76.3
Law	Indoor (LC 4, 5, 7)	67.0	50.4	58.7
	Outdoor	80.5	62.3	71.4
Library	Indoor	78.4	59.8	69.1
	Outdoor	79.1	63.8	71.5
Chem./Pet. Chem. Eng.	Indoor	80.1	58.2	69.2
	Outdoor	61.9	58.1	60.0
Civil Eng	Indoor	71.4	53.6	62.5

Department/Location	Source	Noise Levels dB (A)		Mean
		Maximum	Minimum	
	Outdoor	78.0	55.3	66.7
Electrical Eng	Indoor	71.0	57.3	64.2
	Outdoor	79.3	62.9	71.1
Mechanical Eng	Indoor	75.0	61.4	68.2
	Outdoor	59.9	55.2	57.6
EN 10	Indoor	81.1	72.4	76.8
	Outdoor	79.8	71.8	75.8
MDR	Indoor	60.6	58.8	59.7
	Outdoor	74.8	61.2	68.0
Business Education	Indoor	80.4	62.4	71.4
	Outdoor	74.2	54.4	64.3
Urban & Reg. Planning	Indoor	77.0	53.8	65.4
	Outdoor	81.7	58.6	70.2
Estate Management	Indoor	76.3	55.2	65.8
	Outdoor	80.7	58.3	69.5
Tech. & Science	Indoor	71.1	53.8	62.5
	Outdoor	75.8	55.2	65.5

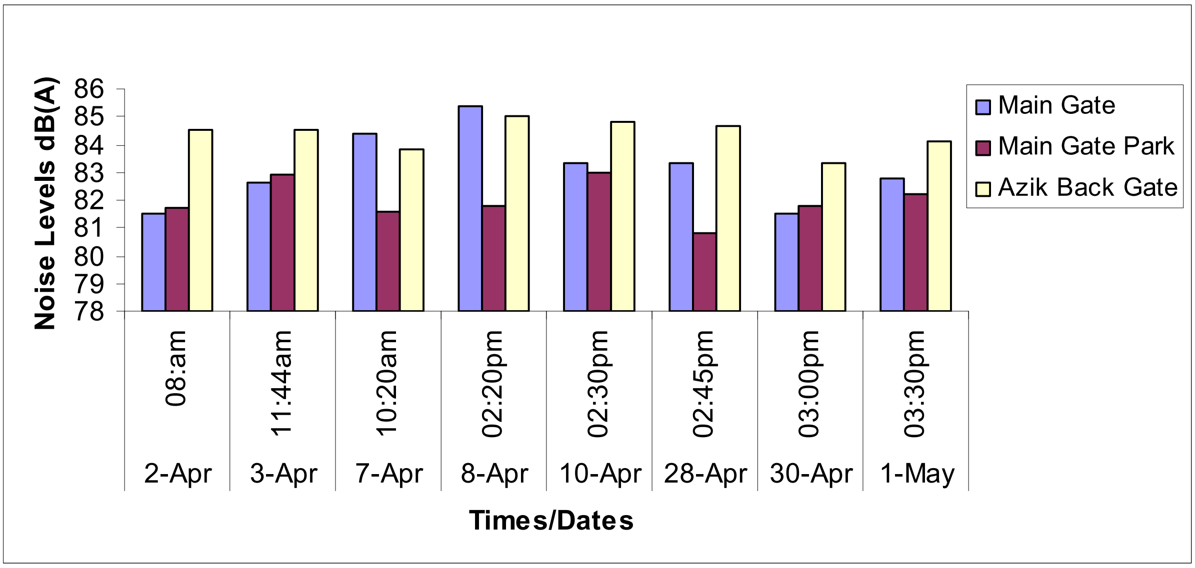


Fig. 3.1. Variations of Maximum Noise Levels with Time and Dates Around University Gates.

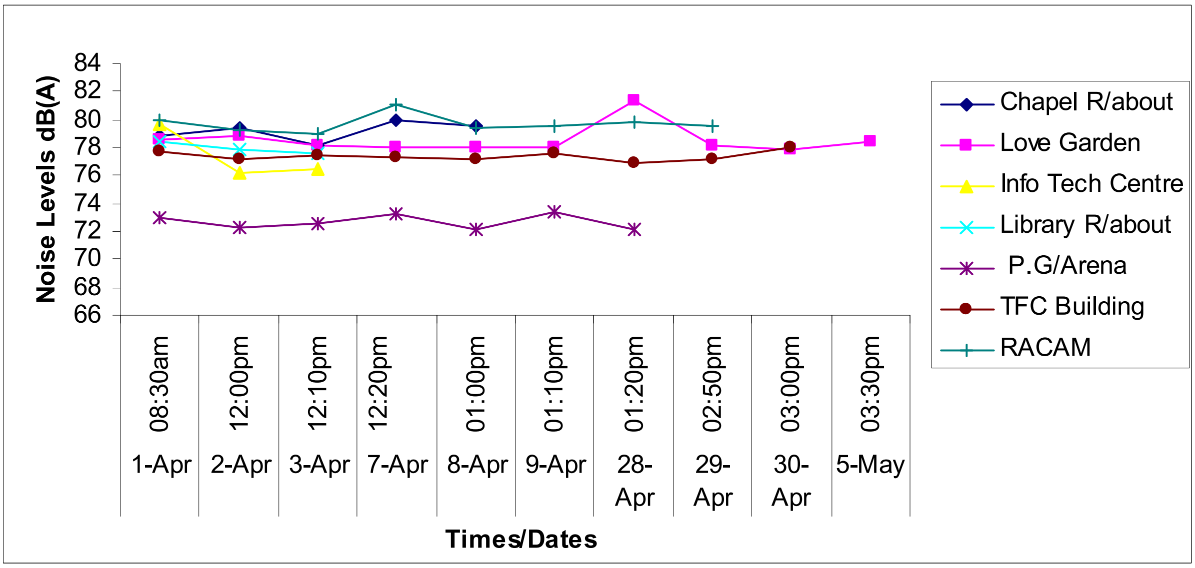


Fig. 3.2. Variations of Maximum Noise Levels with Time and Date along Major Road Junctions.

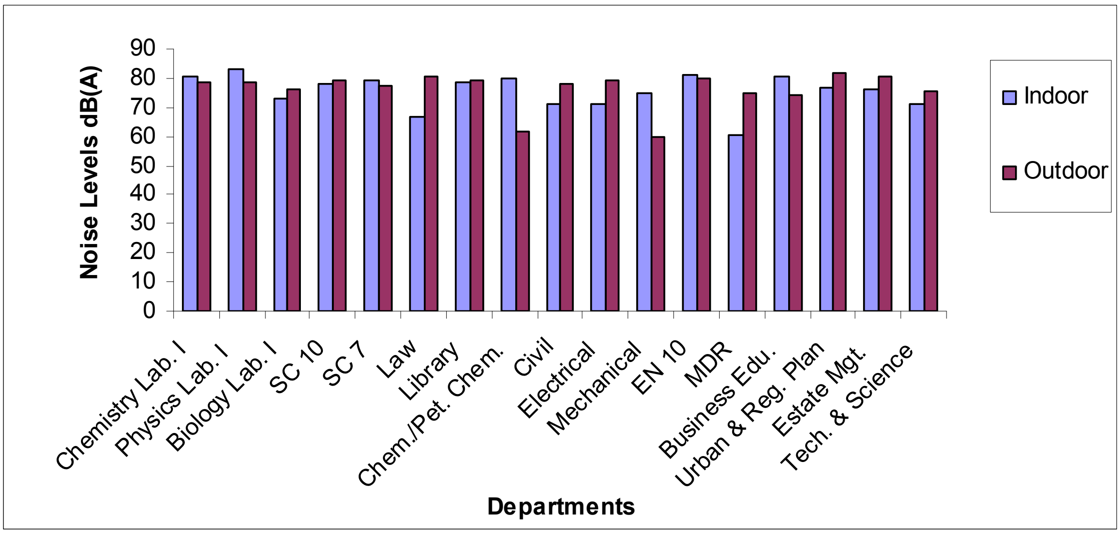


Fig. 3.3. *Comparison Between Indoor and Outdoor Noise Levels at Various Departments.*

Table 3.4 and Fig. 3.4 show the noise levels ranging from 68.2 – 81.4 dB (A) at hostel B, 64.1 – 82.8 dB (A) at Hostel C, 63.2 - 86.4 dB (A) at Hostel F and 68.1 - 86.8 dB (A) at Hostel G. In all, the results ranged from 62.7 dB (A) (between Hostels F & G) to 86.8 dB (A) (Hostel F) with a mean maximum of 81.0dB (A) (Hostel C).

Table 3.5 and Fig. 3.5 show the results of measurements at the electricity generating power plant houses. The ambient noise levels ranged from 98.2 – 103.2 dB (A) with a maximum mean of 100.4 dB (A), at 50m away, it ranged between 70.0 dB (A) and 83.6 dB (A) with a maximum mean of 76.8 dB (A), at 100m away it ranged from 58.5 –78.4 dB (A) with a maximum mean of 68.6 dB (A).

The results of noise levels obtained at International Secondary School varied from 54.5 dB (A) - 72.7 dB (A) at the gate, 69.0 dB (A) - 80.1 dB (A) at the senior block, 69.0 dB (A) - 82.8 dB (A) at the Junior block and 70.0 dB (A) – 84.6 dB (A) at the field with a maximum mean of 77.4 dB (A) (Table 3.6 and Fig. 3.6).

The noise levels results measured at the Farm site and Security village ranged from 54.0 - 67.5 dB (A) at Power Outreach Ministry, 50.1 - 73.8 dB (A) at Deeper Life Church, 53.0 - 56.8 dB (A) behind main gate car park and 54.2 - 71.2 dB (A) at the Farm site (Table 3.7 and Fig. 3.7).

Table 3.4. *Noise Levels Measured at the Hostels.*

Location	Date	Time	Noise Levels dB (A)		Mean
			Maximum	Minimum	
Hostel B (Boys)	09/04/015	08: 40am	81.4	68.4	74.9
	10/04/015	11: 00am	80.2	68.5	74.4
	28/04/015	01: 05pm	80.1	68.2	74.2
	30/04/015	02: 30pm	80.5	69.7	75.1
	05/05/015	02: 45pm	79.6	69.8	74.7
Hotel C (Girls)	03/04/015	08: 45am	81.7	65.6	73.7
	07/04/015	11: 15am	82.8	79.1	81.0
	08/04/015	01: 30pm	79.9	64.7	72.3
	10/04/015	12: 00pm	81.0	64.7	72.9
	28/04/015	12: 50pm	81.1	64.1	72.1
	30/04/015	02: 00pm	81.0	64.7	72.9
	05/05/015	02: 50pm	78.9	65.2	72.1
Outside F	01/04/015	1.50pm	86.7	63.5	75.1
Inside F		1: 55pm	85.8	62.8	74.3
Center of F & G		2: 00pm	86.2	63.2	74.7
At the Gate of F & G		2: 15pm	85.5	62.7	74.1
Center of F & G	02/04/015	01: 30pm	86.4	63.5	75.0
At the gate of F and G	03/04/015	12: 20pm	85.8	63.8	74.8
Inside F	07/04/015	01: 00pm	86.8	63.6	75.2
Inside G		01: 15pm	84.4	68.1	76.3
Inside F	09/04/015	02: 00pm	85.0	68.3	76.7
Inside G		02: 10pm	85.5	68.5	77.0
Center of F & G	28/04/015	02: 50pm	84.7	69.0	76.9
The gate of F & G	29/04/015	03: 20pm	84.9	68.4	76.7
Middle of F & G	30/04/015	11: 50am	85.5	68.7	77.1
Centre of F & G	05/05/015	08: 30am	84.9	68.9	76.9

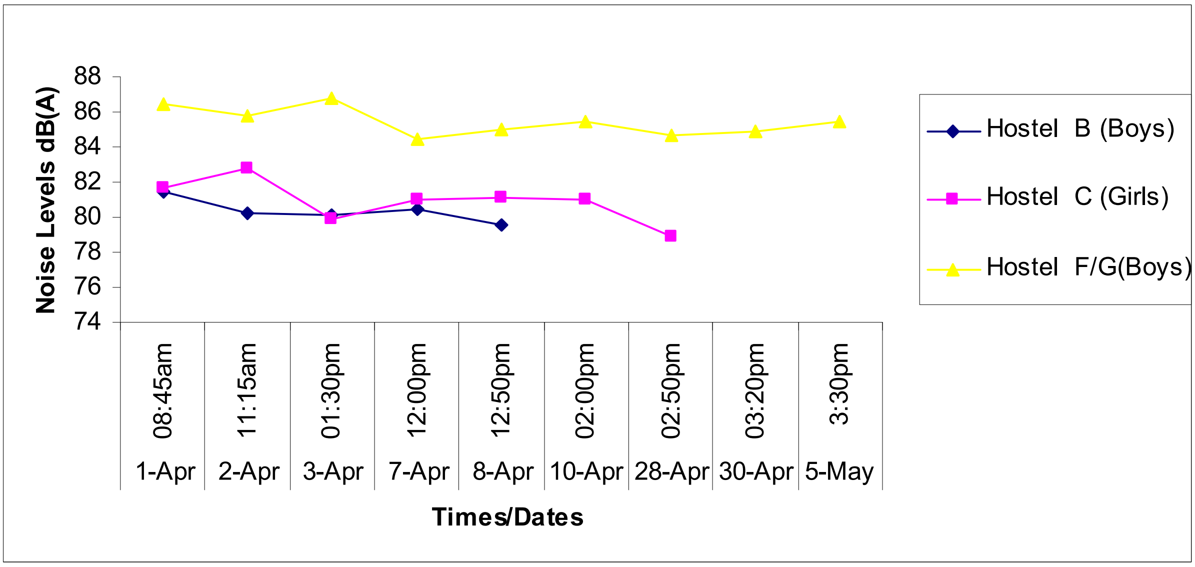


Fig. 3.4. Variations of Maximum Noise Levels with Time and Dates at Hostels.

Table 3.5. Ambient Noise Levels around University Electricity Generating Plant Houses.

Location	Date	Time	Noise Levels dB (A)				Mean
			Maximum		Minimum		
			Old site	New site	Old site	New site	
	07/04/15	08: 30am	102.8	103.0	98.4	100.0	101.1
	08/04/15	09: 00am	103.2	101.3	98.2	100.1	100.7
0m	10/04/15	09: 30am	102.6	101.0	98.5	100.3	100.6
	30/04/15	11: 00am	100.0	102.0	99.8	99.7	100.4
	05/05/15	11: 15am	101.1	101.2	99.7	99.9	100.5
	07/04/15	11: 30am	83.6	80.3	70.1	73.0	76.8
50m	08/04/15	12: 00pm	80.9	80.3	70.0	73.5	76.2
	10/04/15	12: 30pm	81.1	80.0	70.5	73 2	76.2
	05/05/15	12: 50pm	81.0	80.1	70.3	73.1	76.1
	07/04/15	12: 30pm	76.6	78.0	59.5	59.8	68.5
100m	08/04/15	01: 00pm	76.5	78.4	59.7	59.7	68.6
	10/04/15	01: 15pm	76.2	78.2	59.2	58.7	68.i
	30/04/15	01: 30pm	76.0	78.2	59.5	58.5	68.1

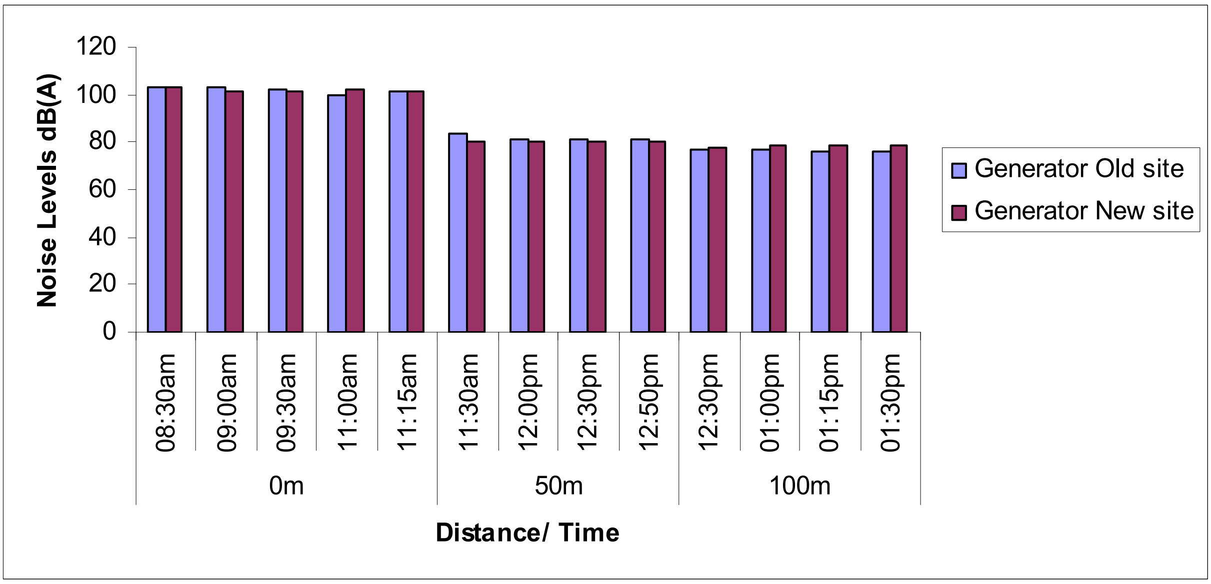


Fig. 3.5. Variations of Maximum Generator Noise Levels with Distance and Time.

Table 3.6. *Noise levels at International Secondary School (ISS).*

Location	Date	Time	Noise Levels dB (A)		
			Maximum	**Minimum**	**Mean**
Gate	06/05/015	09: 35am	71.8	54.6	63.2
		12: 05pm	72.0	54.5	63.3
		02: 41pm	71.9	54.8	63.4
	07/05/015	08: 26am	72.7	54.7	63.7
		12: 10pm	72.1	54.9	63.5
		02: 35pm	72.3	54.8	63.6
Senior block	06/05/015	09: 43am	79.7	68.9	74.3
		12: 10pm	80.1	69.0	74.6
		02: 47pm	79.4	69.3	74.4
	07/05/015	08: 34am	79.6	69.1	74.4
		12: 18pm	79.8	69.1	74.5
		02: 42pm	79.7	69.0	74.4
Junior block	06/05/015	09: 48am	82.8	69.2	76.0
		12: 15pm	82.1	69.8	76.0
		02: 52pm	82.4	69.3	75.9
	07/05/015	08: 38am	82.7	69.3	76.0
		12: 22pm	82.5	69.5	76.0
		02: 47pm	82.4	69.0	75.7
Field	06/05/015	09: 54am	84.5	70.0	77.3
		12: 22pm	84.1	70.2	77.2
		03: 00pm	84.4	70.0	77.2
	07/05/015	08: 45am	84.1	70.1	77.1
		12: 27pm	84.2	70.1	77.2
		02: 54pm	84.6	70.2	77.4

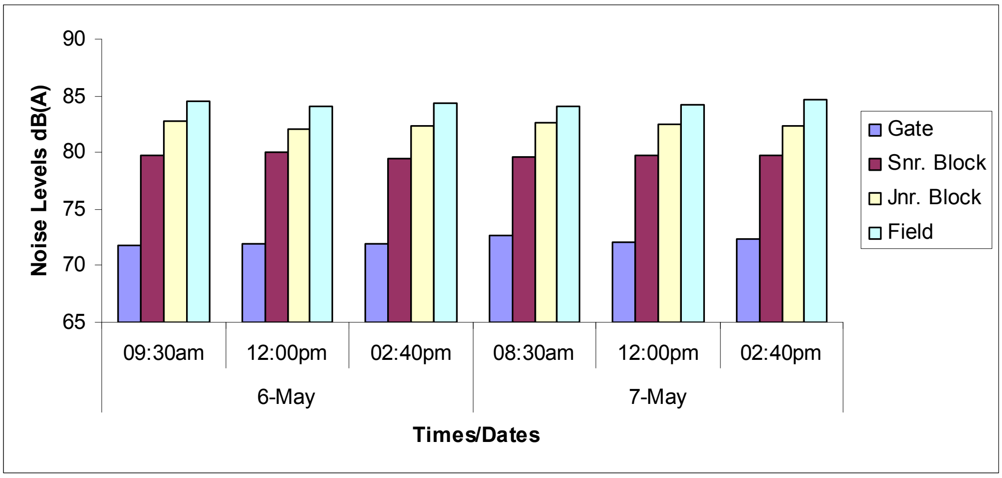


Fig. 3.6. *Variations of Maximum Noise Levels with Time and Date at ISS.*

Table 3.7. *Noise Levels Measured at Farm Site and Security village in RSUST.*

Location	Date	Time	Noise Levels dB (A)		
			Maximum	**Minimum**	**Mean**
Power outreach Ministry	06/05/015	10: 08am	67.3	54.0	60.7
		03: 11pm	67.1	54.2	60.8
	07/05/015	08: 17am	67.3	54.3	60.8
		12: 39pm	67.2	54.1	60.7
		03: 10pm	67.5	54.0	60.8
Deeper life Church	06/05/015	10: 29am	73.8	50.2	62.0
		03: 16pm	73.5	50.2	61.9
	07/05/015	08: 12am	73.6	50.1	61.9
		12: 43pm	73.3	50.4	61.9
		03: 15pm	73.5	50.5	62.0
Behind Main Gate Park	06/05/015	10: 37am	56.8	53.0	54.9
		03: 20pm	56.6	53.5	55.1
	07/05/015	08: 06am	56.3	53.2	54.8
		01: 01pm	56.2	53.3	54.8
		03: 18pm	56.1	53.0	54.6

Location	Date	Time	Noise Levels dB (A)		
			Maximum	Minimum	Mean
RSUST Farm Site	02/04/015	08: 30am	69.8	54.2	62.0
	07/04/015	12: 30pm	70.4	54.7	62.6
	10/04/015	01: 00pm	70.2	55.9	63.1
	28/04/015	03: 00pm	71.2	54.6	62.9
	01/05/015	03: 50pm	70.1	55.8	63.0

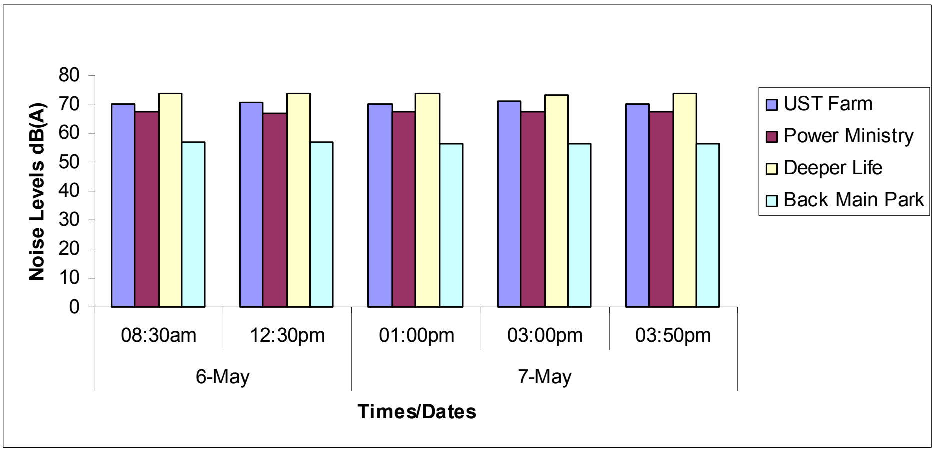


Fig. 3.7. *Variations of Maximum Noise Levels with Time and Date at Farm/Security Village.*

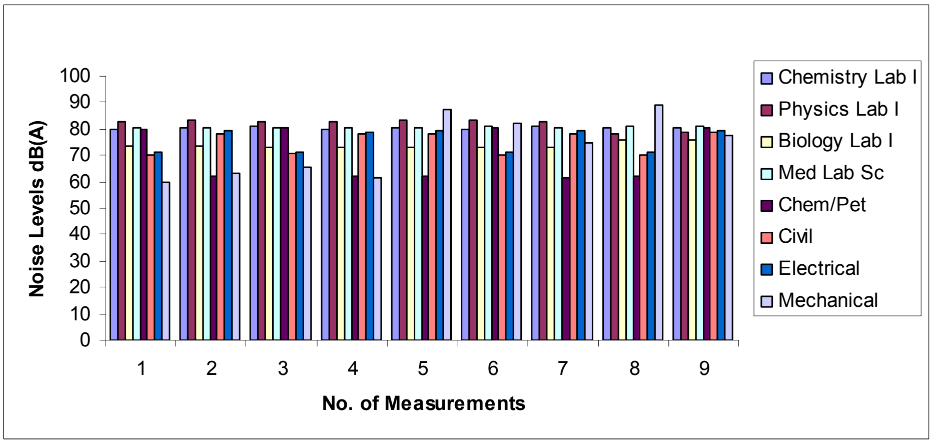


Fig. 3.8. *Comparison of Maximum Noise Levels Between Departments.*

3.2. Discussion

The noise levels at the main gate were found to be higher than that of Azikiwe gate and the main gate car park. This is due to vehicular activities and generators used by business centers outside the gate. The ANOVA between the noise levels at the gates and car park showed significant difference (P<0.05).

Along the major roads, Love Garden and RACAM were found to have high noise levels compared to other parts of the roads. This could be due to the various activities such as companies publicity and advertisements of products, vehicle traffic, landing helicopter, etc. along the major roads, the ANOVA showed significant difference (P<0.05).

At the students' hostels, the noise levels were found to be the highest at F & G followed by C while hostel B had the lowest noise levels. This observation was a result of students playing football at the field beside F & G and loud conversation/communications inside F & G. Hostel C has higher noise level than B because of noise from the business center. At the hostels, though t - test between boys and girls hostels showed no significant difference (P<0.05) but ANOVA between the hostels showed significant difference (P<0.05).

The variations of noise levels at the generator houses indicate a reducing trend away from the generator. It was found that the noise levels at the new site were higher at six of the measurement times while the old site noise levels were also higher at six of the measurement times. The t - test between the mean noise levels of the two generator sites showed no significant difference (P<0.5). There are two functional 2000KVA and 1275 KVA generators at each site of the University. The difference in noise levels at the generator houses could be due to the generator capacity in operation at the time of measurement. The alternate use of the two generators could also have influenced the variations in noise levels.

At the International Secondary School, the nose level at the field were found to be highest followed by junior block. The noise levels at the field were high because in addition to wind movement, students were playing on the field during some measurement period. The higher noise levels at junior block could be as a result of uncontrolled conversations, shouts and play by the junior students. The ANOVA showed significant difference (P<0.5). The noise measured at the farm and security village showed that deeper life church site had high noise levels. This is due to church service with enhanced sound instrument. The noise levels at UST farm site were influenced by vehicles from Agip road and Agip helicopters. ANOVA showed significant difference between farm and security village noise levels.

Comparison of noise levels between Departments showed highest at mechanical workshop. This is due to heavy machines used in the workshop. ANOVA on inter faculties noise levels showed significant difference between faculties of Science and Engineering (P<0.5) while the intra department noise level in science with date showed significant difference (P<0.05). The trend of noise levels at the various Departments followed the order:

Mechanical > Physics > Urban and Regional > Chemistry > Medical Laboratory > Estate Management > Chemical/ Petrochem Eng. > Electrical Eng. > Civil Eng. > Law > Biology > Bus Education > Technical and Science and the trend at lecture rooms followed the order: EN10 > SC10 > SC 7 > NEH > MDR.

The t - test between maximum and minimum noise levels at various departments showed significant difference (P <0.05) and positive correlation (r = 0. 5179).

Outdoor noise levels were generally higher than indoor levels, except at physics Department and SC7 which were influenced by the activity of gardens using Lawn mowers behind the physics laboratory during one of the measurement days. This observation is not in agreement with the report of Sonibare *et. al*. (2004). The indoor noise levels were higher at 7 locations while the outdoor noise levels were higher at 10 locations (Table 3.3). Generally, the outdoor levels were higher than indoor but t - test showed no significant difference (P > 0.5) between them.

The noise levels measured within the university were compared with national and international guideline values. The noise levels measured at the university main electricity generating plants exceeded both national and international guidelines.

However, the mean noise levels measured in all parts of the university exceeded the international guideline value recommended for a school (learning) environment.

WHO (1999) recommended guide line values of 35 dB (A) for school class rooms (indoors) and 55 dB (A) (school outdoors) for community noise. London Times (1968) reported 85 dB (A), while Federal Ministry of Environment (FMEnv, 1991) Nigeria recommended 90dB (A) for an 8 hour working period.

Correlation matrices (Tables 3.9 and 3.10) show positive and negative correlation coefficients. The negative correlation coefficient between indoors and outdoors locations suggest little or no impact of activities outdoors on the indoor environment's noise levels in the university while the positive correlation coefficients indicate serious impact. High positive correlation coefficients between indoors and outdoors were recorded between physics indoor and EN10 outdoor (r = 0.9820), physics outdoor and SC10 indoor (r = 0.9891), physics outdoor and EN10 indoor (r = 0.9078), physics outdoor and MDR indoor (r = 0.9959), SC10 indoor and EN10 outdoor (r = 0.9608), SC10 indoor and MDR indoor (r = 0.9707), Civil Indoor and EN10 outdoor (r = 0.9820), Electrical outdoor and MDR outdoor (r = 0.9222), Mechanical outdoor and MDR indoor (r= 0.9222), EN10 outdoor and Law outdoor (r = 0.9934). In comparing departments, high positive correlation coefficients were obtained between Chemistry Lab. and Urban & Regional planning (r = 0.9522), Civil and Electrical (r=0.9987).

Analysis of variance on noise levels between hostels, road junctions, gates and departments showed significant difference (P <0.05).

Noise levels outdoors were generally higher than indoors. t - tests on the mean noise levels between indoors and outdoors were not significant (P > 0.05) but t - tests between maximum and minimum noise levels at the departments were significant (P < 0.05).

Table 3.8. *Analysis of Variance between sections of the University.*

ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P - value**	**F crit**
Between Gates	18.64095	2	9.320476	10.92853	0.000781	3.554557
Within Gates	15.35143	18	0.852857			
Total	33.99238	20				
Between B, C, F/G	65.14667	2	32.57333	36.82915	4.64E - 05	4.256495
Within B, C, F/G	7.96	9	0.884444			
Total	73.10667	11				
Between Road Junctions	128.425	4	32.10625	36.61614	1.42E - 07	3.055568
Within Road Juncs	13.1525	15	0.876833			
Total	141.5775	19				
Between ISS Sections	423.0855	3	141.0285	2161.356	4.49E - 21	3.238872
Within Sections	1.044	16	0.06525			
Total	424.1295	19				
Between Farm/Security Village	674.0419	3	224.6806	2636.839	3.54E - 17	3.490295
Within Groups	1.0225	12	0.085208			

Table 3.9. *Correlation Matrix of Indoor and Outdoor Noise Levels.*

	Chem IN	**Chem OUT**	**Phy IN**	**Phy OUT**	**Bio IN**	**Bio OUT**	**SC 7 IN**	**SC 7 OUT**	**SC 10 IN**	**SC 10 OUT**	**C/Pet IN**	**C/Pet OUT**	**Civil IN**
Chem IN	1												
Chem OUT	0.54926	1											
Phy IN	0.150095	- 0.08112	1										
Phy OUT	0.40621	0.114468	- 0.20702	1									
Bio IN	- 0.16583	- 0.59315	- 0.11062	- 0.17175	1								
Bio OUT	- 0.13214	- 0.36212	- 0.71982	0.29036	0.534119	1							
SC 7 IN	- 0.79373	- 0.43231	0.31305	- 0.69938	- 7.5E - 15	- 0.31068	1						
SC 7 OUT	- 0.13217	- 0.86881	0.208514	0.304348	0.679608	0.472691	0.046625	1					
SC 10 IN	0.298807	- 0.08839	- 0.22097	0.98909	- 0.07202	0.426597	- 0.63246	0.423896	1				
SC 10 OUT	0.761812	0.231125	0.27735	- 0.1253	0.401762	- 0.08113	- 0.49614	0.028916	- 0.1716	1			
C/Pet IN	0.633058	0.652047	- 0.0532	0.697512	- 0.6821	- 0.24872	- 0.7151	- 0.4001	0.584178	0.059131	1		
C/Pet OUT	0.418121	- 0.03164	- 1.9E - 15	0.543324	0.38829	0.123448	- 0.89073	0.272096	0.509925	0.742891	0.412796	1	
Civil IN	- 0.16176	- 0.65043	0.101742	0.530395	0.214599	0.441201	- 0.3254	0.834441	0.836056	- 0.06727	0.085187	0.297595	1
Civil OUT	- 0.34072	- 0.0532	0.595294	- 0.21895	- 0.6027	- 0.79041	0.469776	- 0.397	- 0.25533	- 0.34597	0.213807	- 0.2786	- 0.0231
Elec IN	0.88278	0.885615	- 0.13801	0.419026	- 0.43707	- 0.6455	- 0.91816	- 0.55205	0.276026	0.547723	0.828079	0.659966	- 0.16667
Elec OUT	- 0.33103	0.551246	- 0.34816	- 0.50212	- 0.53585	- 0.30552	0.3114	- 0.88929	- 0.5693	- 0.33796	0.037113	- 0.60974	- 0.88662
Mech IN	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Mech OUT	- 0.00337	0.213293	0.740239	- 0.37011	- 0.37152	- 0.45643	0.30669	- 0.2092	- 0.42356	0.277474	0.043748	- 0.24724	0.139098
EN 10 IN	1	- 1	1	1	- 1	- 1	- 1	1	1	- 1	1	1	1
EN 10 OUT	0.211604	- 0.17066	0.981981	0.907841	- 0.59604	- 0.32733	- 0.24019	0.654654	0.960769	- 0.5	0.5	0.240192	0.981981
MDR IN	0.671932	0.344865	0.755929	0.995871	- 0.91766	- 0.75593	- 0.69338	0.188982	0.970725	4.11E - 14	0.866025	0.693375	0.755929
MDR OUT	- 0.22069	0.487088	- 0.96609	- 0.7333	- 0.18732	- 0.2582	0.196748	- 0.82808	- 0.82808	1.3E - 14	- 0.13801	- 0.37712	- 1
NEH IN	- 0.66895	- 0.84366	0.478091	0.090722	0.216295	0.447214	0.681554	0.717137	0.239046	- 0.63246	- 0.47809	- 0.4899	0.57735
NEH OUT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Law IN	0.666204	0.788263	0.517298	0.195183	- 0.77165	- 0.80341	- 0.28642	- 0.50337	0.069673	0.218625	0.756262	0.128578	- 0.14339
Law OUT	- 0.07344	0.01786	- 0.04234	0.716147	- 0.17049	- 0.15229	- 0.1705	0.302082	0.835704	- 0.65558	0.400545	0.202655	0.082135

Table 3.9. *Continued.*

	Civil OUT	**Elec IN**	**Elec OUT**	**Mech IN**	**Mech OUT**	**EN 10 IN**	**EN 10 OUT**	**MDR IN**	**MDR OUT**	**NEH IN**	**NEH OUT**	**Law IN**	**Law OUT**
Civil OUT	1												
Elec IN	- 3.4E - 14	1											
Elec OUT	0.354291	0.113228	1										
Mech IN	#DIV/0!	#DIV/0!	#DIV/0!	1									
Mech OUT	0.604077	0.766238	0.029231	#DIV/0!	1								
EN 10 IN	1	#DIV/0!	- 1	#DIV/0!	1	1							
EN 10 OUT	1	4.1E - 14	- 0.98198	#DIV/0!	0.605291	1	1						
MDR IN	0.866025	0.5	- 0.75593	#DIV/0!	0.9222	1	0.866025	1					
MDR OUT	- 4.9E - 15	0.166667	0.905822	#DIV/0!	- 0.5046	- 1	- 0.98198	- 0.75593	1				
NEH IN	0.239046	- 0.86603	- 0.39223	#DIV/0!	- 0.37225	1	0.5	0	- 0.57735	1			
NEH OUT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1		
Law IN	0.685714	0.868271	0.137219	#DIV/0!	0.711033	1	0.427121	0.821995	- 0.07893	- 0.54687	#DIV/0!	1	
Law OUT	0.174754	- 0.1063	- 0.27874	#DIV/0!	- 0.52961	1	0.993399	0.802955	- 0.63779	0.552345	#DIV/0!	0.067618	1

Table 3.10. *Correlation Matrix of Noise Levels in the Departments.*

	Chemistry Lab I	Physics Lab I	Biology Lab I	Med Lab Sc	SC 7	SC 10	Chem/Pet	Civil	Electrical
Chemistry Lab I	1								
Physics Lab I	- 0.24412	1							
Biology Lab I	- 0.04531	- 0.95164	1						
Med Lab Sc	- 0.44233	- 0.67073	0.616331	1					
SC 7	- 0.30312	0.699682	- 0.66999	- 0.8089	1				
SC 10	0.269084	- 0.66031	0.619372	0.849948	- 0.97261	1			
Chem/Pet	- 0.21765	- 0.04888	0.178047	0.150473	- 0.10788	- 0.05625	1		
Civil	- 0.17423	0.113244	- 0.16207	- 0.33654	0.271906	- 0.22723	- 0.05307	1	
Electrical	0.050535	0.144948	- 0.16371	- 0.33229	0.178855	- 0.11648	- 0.54217	0.998677	1
Mechanical	- 0.00337	- 0.45406	0.427439	0.306647	- 0.56357	0.592454	- 0.16926	- 0.05921	- 0.04584
EN 10	0.817737	0.670694	- 0.36035	- 0.92672	- 0.31469	- 0.13217	0.053484	- 0.02292	- 0.03341
MDR	- 0.90111	- 0.40962	0.323222	0.526033	0.152631	- 0.03446	0.16784	- 0.19283	- 0.1763
NEH	- 0.66895	0.478091	0.216295	0.426401	0.681554	0.239046	- 0.71289	0.683927	0.719877
Law	- 0.37465	0.085264	0.042563	0.006734	0.296408	- 0.19821	0.264153	0.014506	- 0.38179
Estate Mgt.	- 0.82163	0.271448	0.192982	0.622543	0.82922	0.038778	- 0.69451	0.664206	0.696456
Bus. Edu.	0.860073	0.239046	- 0.54074	- 0.8528	- 0.90874	0.717137	0.007749	0.027357	0
Urban & Reg Plan	0.952217	0.327327	- 0.9934	- 1	- 0.96077	0.720577	0.009464	0.033942	0
Tech. & Sci	1	1	- 1	- 1	- 1	1	- 1	1	1

Table 3.10. *Continued.*

	Mechanical	EN 10	MDR	NEH	Law	Estate Mgt.	Bus. Edu.	Urban & Reg Plan	Tech. & Sci
Mechanical	1								
EN 10	0.796709	1							
MDR	- 0.44026	- 0.9906	1						
NEH	- 0.37225	- 0.74162	0.806696	1					
Law	0.296043	- 0.04017	0.385353	0.658974	1				
Estate Mgt.	- 0.56449	- 0.87496	0.92075	0.973329	0.619024	1			
Bus. Edu.	0.95491	0.87646	- 0.82411	- 0.5	- 0.63343	- 0.64889	1		
Urban & Reg Plan	0.992005	0.928571	- 0.87512	- 0.5	- 0.84841	- 0.65465	1	1	
Tech. & Sci	1	1	- 1	1	1	1	1	1	1

4. Conclusion and Recommendations

4.1. Conclusion

Based on the findings of the study, the noise levels measured in RSUST are said to be typical of urban communities. The status of noise in RSUST does not portend significant negative occupational noise impact, since the measured noise levels were generally below Occupational Safety Health Agency and Federal Ministry of Environment guidelines for 8 hours working day and exceeded WHO guidelines for school environment. Major sources of noise within RSUST were generators, automobiles, human conversations, machineries, helicopter and wind movement.

4.2. Recommendation

University Authority should provide steady power supply by Power Holding Company of Nigeria. Alternatively, solar plant or sound proof generators should be provided. Practical actions to limit and control the exposure to environmental noise are essential.

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