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Comparative Analysis of Cell Phone Sound insulation and Its Effects on Ear System

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ABSTRACT: *The sound intensity levels emitted from five different cell phones;(SAMSUNG A100, NEC 616V, NOKIA 1100, MOTOROLA 3Vi and SONY ERICSSON K750) were measured in Port Harcourt, Nigeria and the result was analyzed to ascertain if their various sound levels fall within the permitted range of personal sound exposure levels recommended by both International and Nigeria noise regulatory bodies. The result of the study shows that to lessen the risk of hearing problems from cell phones, it is advisable to switch ears usage regularly, use an earpiece which will eliminate the risk of electromagnetic waves from the cell phones and the use of speaker phones. This paper seeks to show why it is necessary to use cell phone sound insulation to reduce the effects of noise on the ear systems. The constant exposure to sound from cell phones can over time cause damage to the hearing abilities of the cell phone users. Hence, adequate cell phone sound insulation is needed to reduce the effects of loud sound intensity levels to the ear system.*

KEYWORDS: *Cell Phone, Damping, Electromagnetic waves, Insulation, sound intensity*

I. INTRODUCTION

For years, there have been worries that cell phones can cause anything from cancer to brain tumors due to their strong vibrations. This situation became worrisome due to the increase in the number of young children carrying cell phones, using them for almost everything from gossip sessions to listening to music with the built-in MP3 players. The cell phone operator packages such as: MTN's Xtracool service in Nigeria encourages subscribers to make calls free of charge for six hours at a stretch. Also the new trend of merging the music walkman features with the cell phone will ensure most people spend more time with either the loudspeaker or earpieces of the cell phones in close proximity to their ears. The long term cell phone use particularly on one ear can cause inner ear damage [1]

The sound intensity levels emitted from five different cell phones;(SAMSUNG A100, NEC 616V, NOKIA 1100, MOTOROLA 3Vi and SONY ERICSSON K750) were measured in Rivers State university of Sciences and Technology (RSUST),. Port Harcourt, Nigeria using Eagle-Y 139A model, IEC 651 type II and NEDA 1604 IEC 6F22 sound level meter. The aim of the research is to critically analyze the sound level of the cell phones at the different measuring points within RSUST with a view to determining the sound insulation of the cell phone understudied and it effect on ear system.

Sound is subjective to humans; to some humans' high level of sound is noise while to some humans very high level of sound is pleasurable. The study conducted by the American Academy of Otolaryngology-Head, neck and surgery Foundation in Washington, D.C. which compared the hearing of hundred cell phone users and the fifty people who have never used cell phones show that there was significant different of hearing abnormalities between those who regularly use the cell phones and those who did not use the cell phones. Also, those who use the cell phones for more than sixty minutes a day for over four years had hearing losses at high frequencies.[2]. It was also observed that listening to sound at 85dB or higher over many years can cause some hearing loss [1]. It is for these reasons that the concept of sound insulation for cell phones is considered as an important step to reducing the potential risk of ear damage caused by constant exposure to cell phone sounds

II. SOUND INSULATION

Sound insulation can be defined as a means of reducing the intensity level of sound with respect to a specified source and reception. Sound insulation affects sound in two different ways such as: sound reduction and sound absorption. Sound reduction simply blocks the passage of sound waves through the use of distance and intervening objects in the path while Sound absorption operates by transforming the sound waves into heat energy which involves suppression of echoes, reverberation, resonance and reflection. The moisture level in a medium can also reflect sound waves thereby reducing and distorting the sound travelling through it and this makes moisture an important factor in sound insulation.

The prevention of transmission of sound and a reduction of sound energy transmitted into an air space can be achieved using different basic approaches such as: the use of distance, by damping, by method of room within a room and by noise cancellation

2.1 The use of distance

The energy density of sound waves decreases as they spread out, so that increasing the distance between the receiver and source results in a progressively lowering intensity of sound at the receiver. In a normal three dimensional setting, the intensity of sound waves will be attenuated according to the inverse square law of the distance from the source. By using an object to absorb sound, part of the sound energy is used to vibrate the mass of the intervening object, rather than being transmitted [3]

2.2 Damping

Damping is the process by which sonic vibrations are converted into heat over time and distance. It is achieved in several ways. One way is to add a layer of material such as lead or neoprene which is both heavy and soft. These can be used as a sound deadening layer in such areas as wall, floor and ceiling construction in sound studios where levels of air borne and mechanically produced sound are targeted for reduction or virtual elimination.

Making a sound wave transfer through different layers of material with different densities assists in noise damping. Open-celled foam is a good sound damper; the sound waves are forced to travel through multiple foam cell air pockets and their cell walls as sound travels through the foam medium. Styrofoam (XPS) and expanded polystyrene foam (EPS), commonly used for thermal insulation, are significant conductors of sound. Polystyrene's use as a sound damper should be avoided except in applications where moisture resistance and buoyancy is necessary.

2.3 A Room Within A Room (RWAR)

This is one method of isolating sound and stopping it from transmitting to the outside world where it may be undesirable. Most vibration and sound transfer from a room to the outside occurs through mechanical means. The vibration passes directly through the brick, woodwork and other solid structural elements. When it meets with an efficient sound board such as a wall, ceiling, floor or window, the vibration is amplified and heard in the second space. A mechanical transmission is much faster, more efficient and may be more readily amplified than an airborne transmission of the same initial strength.

The use of acoustic foams and other absorbent means are useless against this transmitted vibration. The user is required to beak the connection between the room that contains the noise source and the outside world. This is called acoustic de-coupling. Ideal de-coupling involves eliminating vibration transfer in both solid materials and in the air, so air-flow into the room is often controlled. This has safety implications, for example proper ventilation is assured and gas heaters cannot be used inside de-coupled space.[4]

2.4 Noise Cancellation

Noise cancellation generators for active noise control are relatively modern innovation. A microphone is used to pick up the sound that is then analyzed by a computer; then, sound waves with opposite polarity (not in phase) are output through a speaker, causing destructive interference and cancelling much of the noise [5]

III Materials and Methods

The cell phones are used as sources of sound when measurements are taken both in the anechoic chamber and in the lecture theatre. The instruments and accessories used for the data collection include.

- Eagle-Y 139A model, IEC 651 type II and NEDA 1604 IEC 6F22 sound level meter:
- A measuring tape
- Five different cell phones (Samsung A100, NEC 616v, Motorola 3vi, Nokia 1100 and Sony Ericsson K700)

3.1 Presentation of Data

Measuring tape was used to measure the distances between each cell phone and the sound level meter during each data collection. The sound level meter measures the sound pressure levels emitted from the various cell phones in both the anechoic chamber and the lecture theatre. When the cell phone is ringing the sound level of the ringing cell phone is recorded by the sound level meter. The measurements in the lecture theatre was taken when the room was empty to avoid sound interference when the theatre is full with people

TABLE 1: OUTSIDE RSUST ANECHOIC CHAMBER (LECTURE ROOM) MEASUREMENTS

	SAMSUNG	NEC 616V	NOKIA 1100	MOTOROLA 3VI4	SONY ERISSON K750	AVERAGE
INPUT SOUND (SOURCE OF SOUND)	72	72	72	72	72	72dBA
OUTSIDE SOUND (SOUND MEASURED INSIDE THE LECTURE ROOM)	70	70.5	70	70.5	70	70.5dBA

TABLE 2: INSIDE RSUST ANECHOIC CHAMBER MEASUREMENTS

	SAMSUNG	NEC 616V	NOKIA 1100	MOTOROLA 3VI4	SONY ERISSON K750	AVERAGE
OUTSIDE SOUND (SOUND MEASURED INSIDE ANECHOIC CHAMBER)	65	68	64	66	64	65dBA
INPUT SOUND (SOURCE OF SOUND)	72	72	72	72	72	72dBA

3.2 Data Analysis and Discussion

From the values obtained from tables 1 and 2 as shown in data presented above, it is necessary to verify the Inverse Square Law as pertaining to sound intensity level which states that a drop of 6.02dB is a factor of doubling the distance of the sound.

To verify the Inverse Square Law for a sound source in an ideal environment void of sound interference.

For example:
A sound source of 60 dB is measured at 10m; if the distance were doubled to 20m, the sound level expected will be;
$I_1 = 60\text{dB at } r_1 = 10\text{m}$
$\text{doubling } r_1 = 10 \times 2 = 20\text{m} = r_2$

From the formula for decibel difference, which states $\Delta D = 2\log(r_1/r_2)$

$\Delta D = I_2 - I_1 = 20\log(r_1/r_2)$
$\Delta D = I_2 - I_1 = 20\log(10/20)$
$\Delta D = I_2 - I_1 = 20\log(0.5)$
$\Delta D = I_2 - I_1 = -6.02\text{ dB}$ (1)

Equation (1) therefore proves the law that the decibel difference anytime the distance, r_1 is doubled $= 6.02\text{ dB}$. That means the sound intensity decrease by 6.02 dB, anytime the distance measured is doubled.

This law for each cell phone intensity value when the distance$r$, is doubled is shown below.

3.2.1 SAMSUNG A100

From data in table 1 in result paragraph
$\text{At } r_1 = \text{initial distance} = 0.3\text{ m}$
$I_1 = \text{initial intensity} = 69.84\text{ dB}$
$\text{Doubling } r_1 = 0.3 \times 2 = 0.6\text{ m} = r_2$
$\text{At } r_1 = 0.06\text{ m}$
$I_2 = \text{initial at } r_2 = 63.84\text{ dB}$

From the inverse square law, $I_2 - I_1$ should be approximately equal to 6.02 dB
Therefore,
$I_1 - I_2 = 69.84 - 63.84 = 6.00$ dB (2)

The obtained value in equation (2) is very close to the expected value of 6.02 dB so it can be concluded that the inverse square law is verified for this phone.

3.2.2 NEC 616 V
From data in table 1 in result paragraph
At r_1 = initial distance = 0.3 m
I_1 = initial intensity = 89.84 dB
Doubling $r_1 = 0.3 \times 2 = 0.6$ m = r_2
At $r_1 = 0.06$ m
I_2 = initial at r_2 = 83.84 dB

From the inverse square law, $I_2 - I_1$ should be approximately equal to 6.02 dB
Therefore,
$I_1 - I_2 = 69.84 = 6.00$ dB (3)

The obtained value in equation (3) is very close to the expected value of 6.02 dB so it can also concluded that the Inverse Square Law is verified for this phone.

3.3.3 NOKIA 1100
From data in table 1 in result paragraph
At r_1 = initial distance = 0.3 m
I_1 = initial intensity = 87.84 dB
Doubling $r_1 = 0.3 \times 2 = 0.6$ m = r_2
At $r_1 = 0.06$ m
I_2 = initial at r_2 = 79.84 dB

From the Inverse Square Law, $I_2 - I_1$ should be approximately equal to 6.02 dB
Therefore,
$I_1 - I_2 = 87.84 - 79.84 = 8.00$ dB (4)

The obtained value, although 2 dB more than the expected value of 6.02 dB is still acceptable if it is taken, into consideration the imperfect conditions of the Anechoic Chamber used for measurement. So we can also conclude that the Inverse Square Law is verified for this phone.

3.3.4 MOTOROLA 3VI
From data in table 1 in result paragraph
At r_1 = initial distance = 0.3 m
I_1 = initial intensity = 87.84 dB
Doubling $r_1 = 0.3 \times 2 = 0.6$ m = r_2
At $r_1 = 0.06$ m
I_2 = initial at r_2 = 79.84 dB

From the Inverse Square Law, $I_2 - I_1$ should be approximately equal to 6.02 dB
Therefore,
$I_1 - I_2 = 87.84 - 79.84 = 8.00$ dB (5)

The obtained difference is similar to that achieved for the Nokia 1100 and for the same reason stated for Nokia 1100, it can also conclude that the Inverse Square Law has once more been verified for the Motorola 3Vi phone.

3.3.5 SONY ERICSSON K750

From data in table 1 in result paragraph

At r_1 = initial distance = 0.3 m

I_1 = initial intensity = 83.84 dB

Doubling r_1 = 0.3 x 2 = 0.6 m = r_2

At r_1 = 0.06 m

I_2 = initial at r_2 = 77.84 dB

From the Inverse Square Law, $I_2 - I_1$ should be approximately equal to 6.02 dB

Therefore,

$I_1 I_2 = 83.84 - 77.84 = 6.00$ dB (6)

The obtained value in equation (6) is very close to the expected value of 6.02 dB so it can also be concluded that Sony Ericsson K750 obeys the Inverse Square Law.

The tables below confirm that when the distance is doubled the sound intensity level is 6. 00dB for all the cell phones showed below and that confirms the inverse law of sound intensity level

TABLE 3: SAMSUNG

INITIAL DISTANCE (r_1)	INITIAL INTENSITY (I_1)	DOUBLING DIATNACE (r_2)	INITIAL (I_2)	$I_2 - I_1$
0.3M	69.84dB	0.3x2=0.6m	63.84dB	63.84 – 69.84dm = 6.00dB

TABLE 4: NEC 616V

INITIAL DISTANCE (r_1)	INITIAL INTENSITY (I_1)	DOUBLING DIATNACE (r_2)	INITIAL (I_2)	$I_2 - I_1$
0.3M	89.84dB	0.3x2=0.6m	83.84dB	83.84 – 89.84dm = 6.00dB

TABLE 5: NOKIA 1100

INITIAL DISTANCE (r_1)	INITIAL INTENSITY (I_1)	DOUBLING DIATNACE (r_2)	INITIAL (I_2)	$I_2 - I_1$
0.3M	87.84dB	0.3x2=0.6m	79.84dB	87.84 – 79.84dm = 8.00dB

TABLE 6: MOTOROLA 3VI4

INITIAL DISTANCE (r_1)	INITIAL INTENSITY (I_1)	DOUBLING DIATNACE (r_2)	INITIAL (I_2)	$I_2 - I_1$
0.3M	87.84dB	0.3x2=0.6m	79.84dB	79.84 – 87.84dm = 8.00dB

TABLE 7: SONY ERISSON K750

INITIAL DISTANCE (r_1)	INITIAL INTENSITY (I_1)	DOUBLING DIATNACE (r_2)	INITIAL (I_2)	$I_2 - I_1$
0.3M	83.84dB	0.3x2=0.6m	77.84dB	77.84 – 83.84dm = 6.00dB

It has been established that measurements of the sound pressure levels of the five selected cell phones are done with sound level meter (Eagle-Y 139A model, IEC 651 type II and NEDA 1604 IEC 6F22) and from the data in tables 1 and 2, the SamsungA100 recorded the lowest sound pressure levels, out of the five selected cell phones, which shows that it has the most efficient sound insulation compared to other cell phones. While the highest sound pressure levels were recorded from the NEC 616v phone which shows that its sound insulation was the least efficient in comparison with the other five selected cell phones.

3.4 Sound Exposure Levels

Sound (Noise) exposure levels recommended by both International and Nigeria noise regulatory bodies are shown in figure 8 and figure 9 below. In Nigeria noise level standard was set by the Federal Environmental Protection Agency (FEPA), now known as federal Ministry of Environment for the protection of Nigerians Against the effect of noise as well as the environment while Intentional Noise Exposure Limit as presented by the United Kingdom(U.K) is used as the International benchmark

TABLE 8: STANDARD NOISE EXPOSURE LIMIT IN NIGERIA

Duration per day (hours)	Permissible Exposure limit dB(A)
16	85
12	87
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

TABLE 9: INTENTIONAL NOISE EXPOSURE LIMIT (UNITED KINGDOM CRITERIA)

Duration per day (hours)	Permissible Exposure limit dB(A)
8HRS	90
4HRS	93
2HRS	96
1HR	99
30 MINS	102
15 MINS	105
8 MINS	108
4 MINS	111
2 MINS	114
1MIN	117
30 SEC	120

IV. CONCLUSION

The paper shows the relevance and various methods of cell phone sound insulation. It can be seen from the values of the sound pressure levels obtained from the measurements that cell phones do emit quite a good dose of sound power which although comparable to the sound emitted during normal human conversation, is more damaging due to the close proximity of the loud speaker to the human ear. The work also shows that despite the sound insulation levels of the cell phones, the cell phone users are constantly exposed to ear damage. It is important that the cell phone users be aware of the dangers posed by constant exposure to fairly loud sound generated by cell phones so as to avoid cases of ear damage despite the degree of sound insulation of the cell phones

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