SENRA Academic Publishers, Burnaby, British Columbia
Vol. 5, No. 1, pp. 1405-1411, Feb 2011
Online ISSN: 1920-3853; Print ISSN: 1715-9997

Canadian Journal of pure&applied sciences

REVIEW OF RESIDENTIAL EXPOSURE FROM RADIO FREQUENCY (RF) OF GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM) BASE STATION (BS)

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ABSTRACT

The desire in this work is to make an attempt to answer the several questions posed on the safety level of the RF radiated from GSM Base Stations (BSs). In Nigerian some people believed that exposure to radiation from BSs for long period could cause different diseases like cancer, destroys reproductive organs, congenital anomalies, epilepsy and persistent headache and some of the BSs were installed near the home of residence. Power densities were measured in every 10s at 100m and 200m away from GSM BSs installed at Lokuwa/Barama ward Mubi Nigeria few centimeters from home of residence with the view to establish whether exposure to RF would have relationship with Human health. Average amount of power density measured at 100m were 1.48μW/m^2, 1.32μW/m^2, 1.50μW/m^2, at 200m were 1.8μW/m^2, 1.87μW/m^2 and 2.26μW/m^2 with corresponding values of specific absorption rate (SAR) as 0.005, 0.0007, 0.0005, 0.008, 0.006 and 0.0007Kg/m^2 for the major GSM Operators in Mubi that is ZAIN, MTN and GLOBALCOM respectively. The analysis shows that the SAR fall far below recommended level when compared with the general public safety guide line for limiting radiation exposure and SAR given by the world health Organization (WHO) and international Commission on non ionizing radiation protection (ICNIRP).

Keywords: Safety level, exposure, radio frequency, human health, base stations, residence and health risk.

INTRODUCTION

Due to the rise of wireless technology in Nigeria from 2001 to date, there have been several questions posed on the safety of the RF radiated from the GSM BSs in Mubi Nigeria and all over the world. In Nigeria today the health risk of the RF of GSM BSs has becomes an area of great concern since radiation from BSs use electromagnetic radiation in the microwave range as shown in Fig. 1 and many people believed to date that exposure to RF may be harmful to the health of the Human being. According to the Lennart *et al*. (2007), long term exposure or used of cellular phone for greater or equal to 10 years gives a consistent pattern of increased risk for acoustic neuroma and glioma, the risk is highest for ipsilateral exposure. Some research also highlighted much on the effects of RF on Human Brain; Radiation from 1800MHz could cause oxidative damage to the mitochondrial DNA in primary cultured neurons, oxidative damage to mitochondrial DNA may account for the neutrotoxicity of RF radiation in the brain (Shangcheng *et al*., 2009), exposure from RF is highly significant for neuronal damage in the cortex, hippocamglus and basal ganglia in the brain of exposed rats (Lief *et al*., 2003) and also expose of EA.hy926 cells to RF changes the phosphorylation status of numerous (Dariusz *et al*., 2002) some research in other areas also stated that there is risk of RF radiation to pregnant women; a pregnant woman and the foetus both are vulnerable because of the fact that these RF radiation continuously react with the developing embryo, increasing cells, because of the thermal radiation also when the pregnant women either use Mobile phone or when illuminated with RF radiation, the developing child can become affected, the developmental malformation may occur. (Loque *et al*., 2004; Thomas, 2007; Persson, 1997) and also according to Hyland (2000) exposure to RF have effect on two areas of the body like eyes and testes, are particularly vulnerable to RF heating because of the relative lack of available blood flow to dissipate the excessive heat load.

Although some group like the International Commission on non ionizing radiation protection (ICNIRP) and mobile manufacturer forum (MMF) that manufactures mobile equipments and GSM operators across the world insists that radiation from base station has no discernible effects on human health.

Therefore to confirm these positions whether there is scientific evidence or not to suggest that the low power emission levels are inimical to human or animal health; this now prompted the demand for this work.

Secondly the study was carried out to assess the RF exposure level from GSM BSs at unguwar Lokuwa/ Barama ward Mubi Nigeria and its effects on Human health. There are others GSM BSs installed in Mubi town

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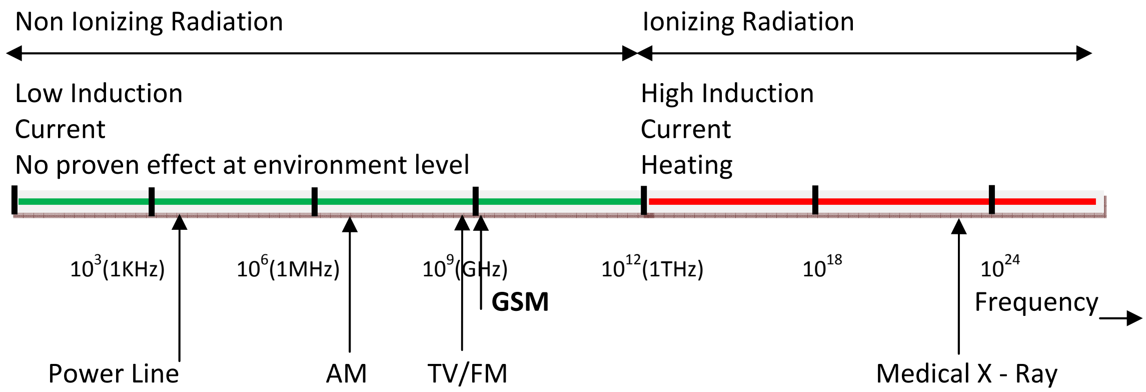

Fig. 1. Non Ionizing and Ionizing radiation spectrum (V – Mobile, 2004).

at different locations but this area was chosen because of the population density around the area, accessibilities of the area by general public especially students from Adamawa State University, Federal polytechnic and College of Health, also student hostel are located there and some students spend most of their time within the area.

MATERIALS AND METHODS

The materials used in this research are stop watch, measuring tape, electromagnetic meter and BSs.

Method of Data Collection

The data (power density) were collected from the major three (3) GSM operator BSs in Nigeria; all the BSs were located at unguwar Lokowa/Barama Mubi North Adamawa State of Nigeria. For each of these BSs the measurements were taken at 100m and 200m in every 10 minute for an hour in front, back and sides of the BSs. All the BSs are dual band antennas; the antennas have an in build features which enable them radiate at 900/1800MHz. the antenna are sectored 120^0 and the antenna were installed at the height of 30m, 30m and 35m above the sea level for ZAIN, MTN and GLOBACOM respectively the electromagnetic meter was place at approximately 1.5m to detect the power density at a given point as shown in figure 2, the electromagnetic detector was made mobile which permit us to take reading at the desired point while the BSs are fixed. The summary of the standard parameters for BSs installed in Mubi town are shown in table 1.

Method of Data Analysis

The power density measured is express as

$$P_D = \frac{E^2}{Z_0} \tag{1}$$

Where E is the electric field, Z_0 is the free space impedence equivalent to 120π or 3777Ω. The electric field assumed all the components of the electric field in x, y, z plane which may be further express as

$$E^2 = E_x^2 + E_y^2 + E_z^2 \tag{2}$$

to determine the SAR we have to know the values of the electric field, from equation (1), we have

$$E^2 = 3777 P_D \tag{3}$$

then the SAR is usually define in terms of electric field or in respect to change in temperature given by

$$SAR = \sigma \frac{E^2}{\rho} = c \frac{dT}{dt} \Big| \; t \to 0 \tag{4}$$

Table 1. Summary of the standard parameters for BSs installed in Mubi town.

Parameter	Standard conditions		
Transmitter Power (dBm)	45		
Height of the Base Stations (m)	30	30	35
Height of the power density detector (m)	1.5		
Reference distances (m)	100	200	
Carrier Frequency (MHz)	900/1800		

neglecting the temperature effects and the specific heat capacity (c), then the required SAR becomes

$$SAR = \sigma \frac{E^2}{\rho} \quad (5)$$

where σ is the conductivity measured in ($\Omega^{-1}m^{-1}$) and ρ is the mass density in (Kgm^{-3}), substituting equation (3) into (5) it yield

$$SAR = \sigma \frac{3777 P_D}{\rho} \quad (6)$$

Equation (6) defines average the SAR of the whole body and SAR of localized part of the body (head).

While table 2 and 3 give the summary of the Human brain tissue dielectric parameter and the ICNIPR's general public safety guide lines for limiting radiation exposure and SAR.

Table 2. Summary of the Human brain tissue dielectric parameter.

Frequency (MHz)	Conductivity ($\Omega^{-1}m^{-1}$)	Mass density (Kgm^{-1})
900	0.7665	1030
1800	1.1531	1030

Table 3. Summary of the ICNIPR's general public safety guide lines for limiting radiation exposure and SAR.

Frequency (MHz)	Power Density (wm^{-1})	Whole body (Average SAR)	Localized SAR (head)
900	4.50	0.08	2.00
1800	9.00	0.08	2.00

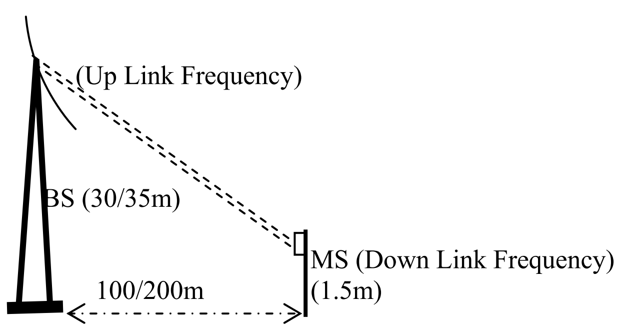

Fig. 2. The Measurement Set Up.

RESULTS

All the power densities measured from each GSM BSs at 100m and 200m are presented in tables 4-9 as follows:

DISCUSSION

Point – to – Point microwaves antenna transmit and receive microwave signals across relatively short distance from a few tenth of kilometers to 48Km or more (Kelly, 2005). These antennas are usually circular in shape and are normally found mounted on a supporting tower, they are always place at a considerable height say from 30 – 200m to provide clear and unobstructed line of sight (LOS) path between both ends of a transmission path or link. These antennas have a variety of uses, such as transmitting voice and data message and serving as link between broadcast or cable TV studios and transmitting antennas. The RF signal from these antennas travel in a directed beam from a transmitting antenna to a receiving antenna, and dispersion of microwave energy outside of the relatively narrow beam is minimal and this antenna transmit usually very low power levels, usually on the order of a few watts or less. The measurement were taken at 1.5m above the sea level and the average amounts of power densities measured in this study were 1.48μW/m^2, 1.32μW/m^2, 1.50μW/m^2, at 200m were 1.8μW/m^2, 1.87μW/m^2 and 2.26μW/m^2 at 100m for the major GSM Operators in Mubi that is ZAIN, MTN and GLOBALCOM respectively and it seems the power density increases as the distance of measurement increases. These measurements show that ground level power densities due to microwave directional antenna are far less than the minimum recommended safety level which is in the range of 4.5 to 10.5W/m (Aiman, 2010) while the SAR obtained were compared with the ICNIPR's general public safety guide lines for limiting radiation exposure and SAR and was also found to be far below the minimum recommended level (ICNIPR, 2009). Moreover as added margin of safety, microwave towers are in accessible to the general public because of its considerable height. Significant exposure from these antennas could only occur in the unlikely event that an individual has to stand directly in front of the antenna and very close to the antenna for a long period of time.

Since the power density measured was taken in four directions that is in the front, back and two sides of the GSM BSs the enclosed area is about 10,000m^2 and 40,000m^2 for the reference distances 100m and 200m respectively shows that the smaller the area the higher the power density detected and vice – versa as depicted in figure 3.

At 100m the power density measured for GLOBALCOM was the highest (1.50μW/m^2) followed by that of ZAIN (1.48μW/m^2) then MTN is lowest (1.32μW/m^2) while at 200m MTN is the highest (2.26μW/m^2) in this case GLOBACOM and ZAIN have the same power density (1.87μW/m^2) as shown in figure 4.

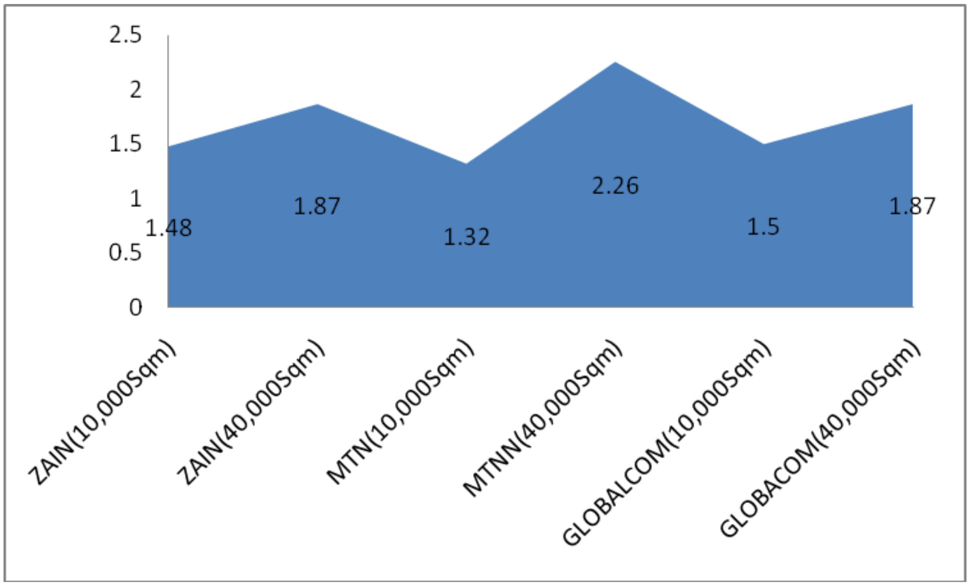

Fig. 3. Power density in enclosed area.

Table 4. Radiation from GLO masts at 100m.

Y(min)	X_1	X_2	X_3	X_4	X
10	0.45	0.41	0.30	0.27	0.36
20	0.40	0.40	0.25	0.21	0.32
30	0.21	0.40	0.20	0.21	0.26
40	0.40	0.45	0.40	0.20	0.26
50	0.45	0.40	0.40	0.20	0.36
60	0.40	0.30	0.30	0.25	0.31
3.5h	2.31µW/m^2	2.36 µW/m^2	1.87 µW/m^2	1.34 µW/m^2	1.87 µW/m^2

(Field Survey, 2009)

Y = Time taken during the measurement in minutes

X_1 = Amount of radiation measured in front of the Antenna

X_2 = Amount of radiation measured at the back of the Antenna

X_3 = Amount of radiation measured at side 1 of the Antenna

X_4 = Amount of radiation measured at side 2 of the Antenna.

X = Average

Table 5. Radiation from GLO masts at 200m.

Y (min)	X_1	X_2	X_3	X_4	X
10	0.25	0.20	0.20	0.40	0.26
20	0.20	0.10	0.20	0.20	0.18
30	0.20	0.10	0.30	0.32	0.23
40	0.40	0.20	0.31	0.31	0.31
50	0.30	0.40	0.32	0.27	0.32
60	0.20	0.10	0.21	0.28	0.20
3.5h	1.55 µW/m^2	1.10 µW/m^2	1.51 µW/m^2	1.78 µW/m^2	1.50 µW/m^2

(Field Survey, 2009)

Figure 5 present combined average power density at 100m and 200m; MTN is the highest (3.58µW/m^2) followed by GLOBACOM (3.37µW/m^2) and ZAIN (3.35µW/m^2) is the least.

The measurements were carried out to assess the RF radiation level from the three major GSM BSs at unguwar Lukuwa/Barama in Mubi town Nigeria, the power density and SAR were compared with that of WHO and ICNIRP guides; the results show that all power densities and SAR are far below the recommended safety guide lines.

Table 6. Radiation from MTN masts at 100m.

Y (min)	X_1	X_2	X_3	X_4	X
10	0.60	0.40	0.40	0.40	0.45
20	0.20	0.40	0.30	0.40	0.33
30	0.40	0.30	0.30	0.30	0.33
40	0.50	0.35	0.40	0.20	0.36
50	0.40	030	0.30	0.60	0.40
60	0.45	0.30	0.40	0.40	0.39
3.5h	2.55 µW/m^2	2.05 µW/m^2	2.10 µW/m^2	2.30 µW/m^2	2.26 µW/m^2

(Field Survey, 2009)

Table 7. Radiation from MTN masts at 200m.

Y (min)	X_1	X_2	X_3	X_4	X
10	0.25	0.19	0.19	0.20	0.21
20	0.21	0.25	0.25	0.30	0.25
30	0.30	0.25	0.25	0.20	0.25
40	0.30	0.15	0.20	0.20	0.21
50	0.27	0.10	0.19	0.21	0.19
60	0.25	0.15	0.18	0.24	0.21
3.5h	1.60 µW/m^2	1.09 µW/m^2	1.26 µW/m^2	1.35 µW/m^2	1.32 µW/m^2

(Field Survey, 2009)

Table 8. Radiation from ZAIN masts at 100m.

Y (min)	X_1	X_2	X_3	X_4	X
10	0.20	0.20	0.20	0.40	0.25
20	0.30	0.30	0.20	0.20	0.28
30	0.40	0.20	0.20	0.30	0.28
40	0.40	0.30	0.40	0.38	0.35
50	0.50	0.30	0.40	0.38	0.38
60	0.40	0.20	0.40	0.32	0.33
3.5h	2.20 µW/m^2	1.50 µW/m^2	1.80 µW/m^2	2.00 µW/m^2	1.87 µW/m^2

(Field Survey, 2009)

Table 9. Radiation from ZAIN masts at 200m.

Y (min)	X_1	X_2	X_3	X_4	X
10	0.25	0.11	0.20	0.26	0.21
20	0.27	0.20	0.25	0.21	0.23
30	0.25	0.25	0.30	0.20	0.25
40	0.20	0.20	0.25	0.22	0.22
50	0.49	0.20	0.30	0.22	0.30
60	0.30	0.25	0.28	0.25	0.27
3.5h	1.76 µW/m^2	1.21 µW/m^2	1.58 µW/m^2	1.36 µW/m^2	1.48 µW/m^2

(Field Survey, 2009)

CONCLUSION

The purposed of this research is to study the amount of RF radiation in the Residential areas at Lokuwa/Bamara ward with view to establish that exposure from RF would have discernable effect on Human health. The results obtained from this work were compared with that of WHO and ICNIRP safety guide lines and was found to be far below recommended level. However this research does not take into consideration the Laboratory experimental effects on any part of the human body. I believed that this work has made attempt to answer some of the several questions posed on the safety level of the RF radiated from GSM BSs in Lokuwa/Barama ward in Mubi town of Nigeria.

Table 10. Summary of average values of the power density and the SAR measured.

GSM Operators	ZAIN		MTN		GLOBACOM	
Distance (m)	100	200	100	200	100	200
X ($\mu W/m^2$)	1.48	1.87	1.32	2.26	1.50	1.87
SAR (Kg/m^2)	0.005	0.007	0.005	0.008	0.006	0.007

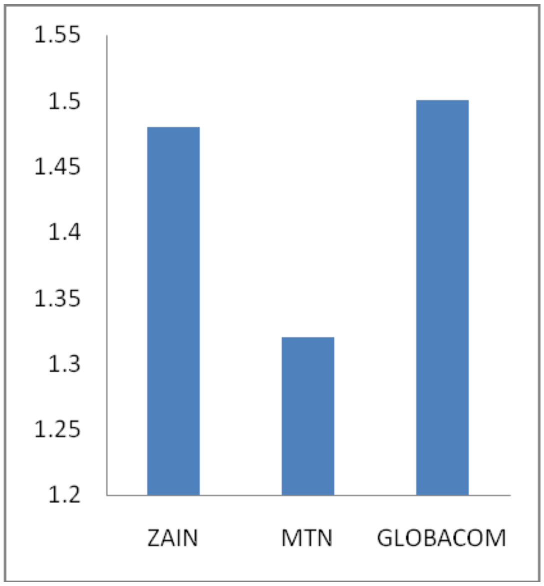

Fig. 4(a). Average power density at 100m.

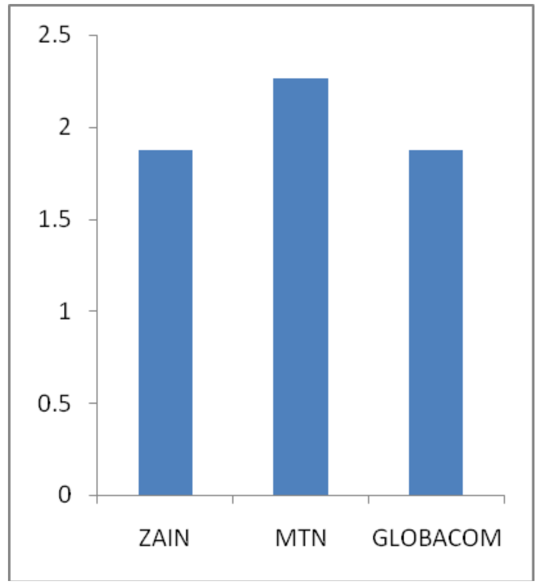

Fig. 4(b). Average power density at 200m.

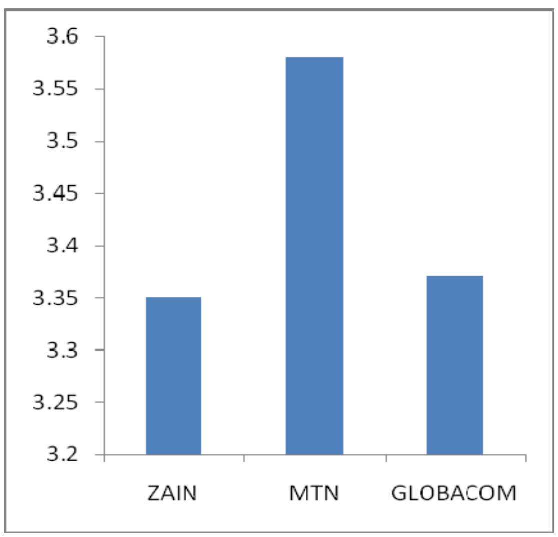

Fig. 5. Combine Average power density at 100m and 200m.

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Received: May 18, 2010; Revised and Accepted: Dec 13, 2010