ASSESSMENT OF RADIO FREQUENCY RADIATION IN THE FAR FIELD OF SELECTED MOBILE BASE STATIONS IN IJEBU-ODE, OGUN STATE, NIGERIA.

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ABSTRACT

With the advancement of generations of 4^{th} and 5^{th} mobile technologies, more mobile base stations may be erected close to the public domains. There is a need to alleviate if possible, the perceived danger of exposure to non-ionizing radiation. Hence, the assessment of Radio-Frequency (RF) radiation in the far-field from the selected mobile base station in Ijebu-Ode, Ogun State, Nigeria has been carried out. Measurements were carried out using a handheld three-axis RF meter placed at one meter above the ground level and pointing towards the mast at arm's length. The values of the power density and the specific absorption rate for the sixteen (16) base stations selected for the study are within the range of 0.228 μW/m^2 −20860 μW/m^2 and 0.20 μW/kg - 175 μW/kg respectively. These values are quite lower than the permissible limits (0.08 W/kg) for the whole-body average specific absorption rate and 4.5 W/m^2 for 900 MHz and 9.0 W/m^2 for 1800 MHz.respectively. This shows that there is no significant health risk for the general public within the far-field vicinity of the selected base stations.

Keywords: Assessment, RF Radiation, Far-Field, and Mobile Base Station.

INTRODUCTION

There has been an exponential growth in the use of mobile communication services over the years and this growth is expected to continue in the future with the introduction of the 4th (4G) and 5th (5G) generation mobile technologies. Accompanying this growth is the unavoidable increase in the number of base stations which generates fears in the minds of the public because of the possibly perceived health implications. The area of study (Ijebu Ode) is densely populated with a population of 222,653 from the 2007 population census and is the second-largest city in Ogun State after Abeokuta. There are lots of schools and tertiary institutions located in the area. All the base stations selected for the research study are located close to schools, residential areas, banks, shops where on daily basis has an appreciable influx of people in the vicinity of the masts for various service providers. The study area has the highest number of tertiary institutions located in the state. This suggests that many of the students may be subscribing to any of the service providers which will result in more mast being sited close to where the students are staying for extended coverage by the service providers.

The area very close to an RF antenna is referred to as the **"**near field.**"** The area farther away from the antenna is referred to as the "far-field". Determining exposure in the near field zone is more challenging and special methods or measurements over a long period can be adopted for such measurements. The far-field is the field of interest to the public since the probability of the populace being in the vicinity of the field as they go about their daily activities is significant. International Commission on Non-Ionizing Radiation Protection (ICNIRP) restrictions on the effects of electromagnetic (EM). Exposure is based on established health effects and is termed basic restrictions. Depending on the frequency, the physical quantities used to specify basic restrictions on EM exposure are current density, Specific absorption rate (SAR), and power density. In the frequency range of 10 MHz to a few GHz (including 900MHz and 1800MHz cellular phone frequencies), SAR is the main physical parameter (Ozyalcin *et al.,* 2002). The SAR measurements are calculated averagely either for the whole body, measured as a small volume of tissue for instance between 1 and 10 g of tissue. Infants and children are more susceptible to radiation absorption than adults. Their bodies are under development and are prone to damage from radiation from cell phones. For instance, radiation from a cell phone is absorbed faster into the head of children (Gandhi *et al.*, 1996; Wiart *et al.*, 2008) and tissues of children such as the bone marrow and the eyeballs are prone to energy absorption more than adult head (Christ *et al.*, 2010). Available experimental evidence indicates that the human body cannot regulate itself under a permanent temperature increase of more than 1^{o}C, which corresponds to a whole-body SAR value between 1-4 W/kg under 30 minutes EM exposure for resting humans. From this 4 W/kg value, a general public continuous exposure limit of 0.08 W/kg is derived with a safety factor of 5 (Ozyalcin *et al.*, 2002). This research is aimed at estimating the power densities and specific absorption rates (SAR) for the general public in the far-field of the masts for the various service provider viz: MTN, GLOBACOM, ETISALAT, AIRTEL, and MULTILINK.

MATERIALS AND METHOD

A handheld isotropic RF meter was used for the measurement of the electric field, magnetic field, and power density of radiofrequency radiation from mobile base stations. The meter is a broadband device for monitoring high-frequency radiation in the range of 50 MHz to 3.5 GHz. It is used in three-axis(isotropic) measurement mode and five digits LCD offers mV/m, V/m, µA/m, mA/m, A/m, µW/m2, mW/m2, and µW/cm2. Display revolution of 0.1V/m, 0.1µW/m2, 0.001µW/cm2 and 0.001µW/m2. The meter measures the electric field (E) and convertes it into magnetic field (H) and power density (Pd). Most of the base stations have at least three beacons. Measurements were taken at an interval of 25 m – 150 m from the base station. The meter was set to measure the average maximum electric field, magnetic field, and power density at each spot. Measurements were taken by pointing the EMF meter to the antenna at arm's length and 1.5 m away from the sea level (Ismail *et al.*, 2010). The maximum average value of the measured electric field, magnetic field, and power density were taken when the meter was steady for five (5) minutes to reduce interference from field strength emanating from electrostatic charges present. The specific absorption rates (SAR) for the general public were calculated. Figure 2 presents the location map for the study area.

Figure 1: Radiofrequency 3- axis field strength EMF meter.

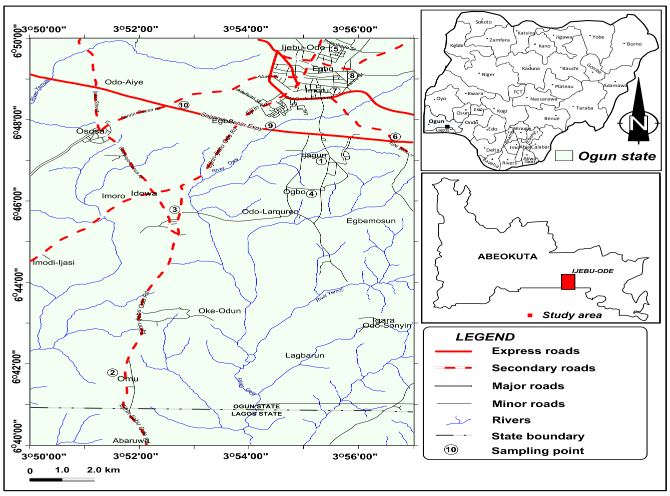

Figure 2: Location Maps of the area of study.

Geoeleclectric Field Strength

Variation in voltage or current in the transmission of RF results in electric (E) and magnetic field variation (H). The electric field strength denotes the force (F) on an infinitesimal unit positive test charge (q) at a point divided by the charge q and is given by:

$$E = \frac{F}{q} \quad \text{(unit is volt/ meter (V}^{-1}\text{))} \qquad (1)$$

Magnetic Field Strength

The magnetic field strength (H) is equivalent to magnetic flux density (Ø) divided by the permeability of the medium (µ). Its unit is ampere per meter (Am^{-1}).

$$H = \frac{\emptyset}{\mu} \qquad (2)$$

Power density

The power density (Pd) is the power (P) per unit area in the direction of propagation of the RF radiation. Its unit is watts per square meters (Wm^{-2})

$$P_d = \frac{P}{A} \qquad (3)$$

Specific Absorption rate (SAR)

This is the amount of RF energy absorbed by a body in the field of radiation (eg using a wireless device). Its unit is μWkg^{-1}. The SAR considers the power absorbed per unit of tissue mass and is mostly used for high-frequency radiation, such as the radiation resulting from telephone systems.

$$SAR = \frac{P_d \times B_s}{W} \qquad (4)$$

B_s is the body surface area (a function of the human weight, ~60kg (Enyinna, and Avwir, 2010).

RESULTS AND DISCUSSION

The results are presented on Tables 1 to 5 and Figures 2 to 7. The range of power density measured for the base station is (594.0– 4976.0) µW/m2 with a mean of 3013.95 µW/kg (Table 1). The highest value of power density recorded is at the second base station for MTN and is 20860.0 µW/m2 and the estimation for the highest value of SAR is 731.108 µW/kg. The general public in the vicinity of the (far-field) of the base station has no significant health risk due to exposure radiofrequency radiation from the base stations since the measured power densities are far below the standard limit set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998) which is 4.5W/m2 for 900 MHz and 9.0W/m^2 for 1800 MHz.

The range of the specific absorption rate (SAR) estimated is (20.0– 175.0) µW/kg with a mean of 105.64 µW/kg. The permissible limit for the general public for SAR is 1.6 W/kg for 1gram and 2.0W/Kg for 10gram and the mean value estimated is lower than the permissible limit. The value of SAR for the study was compared with the study of Ajiboye *et al.*, 2014, (31–40) µW/kg and is higher than that of their study. The study was also compared with the work of Isabona and Ojuh, 2015 (100 µWkg–1200 µWkg) and is again lower than their study. The power density range for MTN base stations for the study is less than the study by Enyinna (2010), with the range of 150 µWm^2 - 3130 µWm^2.

TABLE.1: Measured and estimated parameters for MTN base station.

	1st BS		2nd BS		3rd BS		4th BS	
Distance (m)	P_d (µW/m^2)	SAR (µW/kg)	P_d (µW/m^2)	SAR (µW/kg)	P_d (µW/m^2)	SAR (µW/kg)	P_d (µW/m^2)	SAR (µW/kg)
25	1425.3	49.965	2779	97.399	718.2	25.172	2835	99.362
50	1982.7	69.490	1658.8	58.138	76.87	2.694	1501.2	52.615
75	617.0	21.625	882.4	30.927	1800.5	63.104	1187.9	41.634

100	1286.2	45.079	1480.8	51.900	949.0	33.261	423.4	14.839
125	2853.0	99.993	2189.0	76.721	8.645	0.303	2967.0	103.988
150	2648.0	92.808	20860.0	731.108	12.61	0.442	19192.0	672.647
Mean	1802.03	63.16	4975.0	174.366	594.30	20.829	4684.42	164.180

BS: Base Station

Table 2: Measured and estimated parameters for Airtel base stations

	1st BS		2nd BS		3rd BS		4th BS	
Distance (m)	P_d (μW/m^2)	SAR (μW/kg)	P_d (μW/m^2)	SAR (μW/kg)	P_d (μW/m^2)	SAR (μW/kg)	P_d (μW/m^2)	SAR (μW/kg)
25	5.547	0.194	701.0	24.569	3122.0	109.421	1107.6	38.820
50	0.285	0.009	1115.9	39.110	2188.0	76.686	2741.0	96.067
75	0.228	0.007	1670.7	58.555	1369.2	47.988	707.7	24.804
100	0.634	0.022	1478.3	51.812	1580.0	55.376	863.8	30.275
125	0.329	0.015	532.6	18.667	2932.0	102.762	1333.3	46.730
150	561.5	19.680	391.4	13.718	2573.0	90.179	2324.0	81.452
Mean	94.75	3.321	981.65	34.405	2294.03	80.402	1512.90	53.025

BS: Base Station

The range of power densities {(0.2−3200) μW/m^2} measured at AIRTEL base stations is far below the recommended standard limit by (ICNIRP, 1998) and (IEEE, 1991) which are of the values of 4.5 W/m^2 and 9.0 W/m^2 for 900 MHz to 1800 MHz respectively. The value of the power density for the base station is lower than the work of Briggs *et al.*, 2018 with a range of 60 − 43900) μW/m^2 and lower the study by Felix *et al*, 2017 with a range of (121− 10847) μW/m^2 The SAR {(0.01− 110.00) μW/kg} estimated is lower than Felix *et al,* 2017 and Iortile and Agba, 2014 with the highest value of 3639.7 μW/kg and range of (0.18 − 1.03) W/kg for Airtel and MTN base station respectively. The value of SAR was found to be below the minimum acceptable limit by all the international agencies permissible limits for exposure to radiofrequency radiation from base stations.

Table 3: Measures and estimated parameters for Globacom base stations

	1st BS		2nd BS		3rd BS		4th BS	
Distance (m)	P_d (μW/m^2)	SAR (μW/kg)	P_d (μW/m^2)	SAR (μW/kg)	P_d (μW/m^2)	SAR (μW/kg)	P_d (μW/m^2)	SAR (μW/kg)
25	184.31	6.460	243.4	8.531	1239.6	43.446	506.9	17.766
50	168.52	5.906	459.0	16.087	319.3	11.191	363.9	12.754
75	9.06	0.318	59.71	2.093	74.42	2.608	244.8	8.580
100	1.04	0.036	1675.5	58.723	113.99	3.995	442.8	15.519
125	1560.0	54.675	1995.0	69.921	86.29	3.024	2215.0	77.632
150	1861.2	65.232	2639.0	92.493	45.35	1.589	246.4	8.636
Mean	630.68	22.105	1178.60	41.308	313.15	10.976	669.96	23.481

BS: Base Station

The range of the power densities measured for the Globacom base stations is between (1.0–2700.0) μW/m² and is below the set standard by all the International agencies. The power density values were compared with a research by the European health risk assessment network on electromagnetic fields exposure (EHFRAN, 2010) in which the power density ranged from (0.000081W/m² – 0.0118) W/m² and is higher than that of the GLOBACOM base station.

The power densities measured for the base station were compared with the work of Victor *et. al*, (2011) and the highest value of power density measured for their study was 1730 μW/m² which is lower than the upper limit value for the Globacom base station. The range {(0.03–93.00) μW/kg} of the estimated SARs for the study was compared with the work of Iortile and Agba, 2014 with a range of (103, 0000–1800000) μW/kg and is lower than that of their study. The range for SAR for the study is les than the standard by ICNIRP, 1998.

Table 5: Measures and estimated parameters for Multilink base station

Distance (m)	P_d (μW/m²)	SAR (μw/kg)
25	727.4	25.494
50	388.6	13.620
75	611.7	21.439
100	401.8	14.082
125	1263.5	44.284
150	192.47	6.746
Mean	597.57	20.944

The range {(380–1264) μW/m² with a mean of 597.57 μW/m²} of power density from the multilink base station was found to be below the permissible limit. The value was also compared with the work of Victor *et al.*, *(*2011*)* with power density ranging from 1.0 mW/m^2 –1740 mW/m^2 and is lower than that of their study but higher than that of Enver et al. 2016 and Sadiya, 2010 with reported power density of the range (110–730) μW/m² and (9.29 – 58.08) nW/m² respectively. Again, comparing the SAR (6–45) μW/kg for the study (Multilink base station) with the study by Felix *et al*, 2017 with a reported SAR in the range of (10.847– 3639.17) μW/kg, and reported SAR by Isobona *et al., 2015* (100-1200) μW/kg, the SAR value is lower than that for the two studies.

CONCLUSION

The values of the power densities and the SAR for the sixteen base stations selected for the study are within the ranges of 0.228 μW/m² –20860 μW/m² and 0.20 μW/kg - 175 μW/kg respectively and are below the set standard by International Commission on Non-Ionizing Radiation Protection (ICNIRP), a value of 1.6 W/kg for 1 gram spatial volume and 2.0W/Kg for 10 gram spatial volume. The SAR was also compared with the standard of the Federal Communication Commission (FCC) with a value of 1.6 W/kg for 1 gram and 2.0 W/kg for 10 gram and other agencies. The values of these depict that there is no health risk for the general public as a result of exposure to non-ionization radiation from the base stations.

REFERENCES

Ajiboye Y., Farai I.P., Ayinbode B.O and Alao O.A., 2014: Hazard estimation from Radiofrequency Radiation in a Nigerian Teaching Hospital from nearby GSM Base-Stations. IOSR Journal of Applied Physics, 6(5): 40-45

Brigg M.A., Funsho, B.I and Tamunobereton A.I., 2018: Assessment of radiofrequency exposure from base stations in some Tertiary institutions in Rivers State, Nigeria. Dutse Journal of Pure and Applied Sciences.

Christ, A., Gosselin M.C, Christopoulou M, Kühn, S, Kuster. N., 2010: Age-dependent tissue-specific exposure of cell phone users. Phys Med Biol, 55(7): 1767-1783.

Enyinna, P. I *and* Avwir, G.O., 2010: Characterization of the radiofrequency radiation potential of Alakahia and Choba communities, Nigeria. Facta UniversitatisSeries: Working and living environmental Protection Vol. 7, No 1, 2010, Pp. 25 – 3.

Ehfran, 2010: European Health Risk Assessment Network on Electromagnetic Fields Exposure Annex 7. (Retrieved on 20/03/19) https://webgate.ec.europa.eu/chafea_pdb/assets

Felix, U.N., Avwiri, O.G., Oghenevovwero, E. E. *and* Akpata. C., 2017: Risks associated with radio-frequency radiation exposure at close proximities to mobile phone base stations in Port Harcourt, Rivers State, Nigeria. Current Journal of Applied Science and Technology, 24(3):1-8.

Gandhi, O. P., Lazzi, G., Furse, C. M., 1996: Electromagnetic absorption in the human head and neck for mobile telephones at 835 and 1900 MHz. IEEE Trans. Microwave Theor. Techniq. 44(10).

Isabona, J. *and* Ojuh, O. D., 2015: Experimental Assessment of Specific Absorption Rate Using Measured Electric Field Strength in Benson Idahosa University and Environs. American Journal of Modern Physics,4(2): 92-96.

Ismail A, Norashidah M. Din, MD Z Jamaluddin and Nagaletchum, I. B., 2010: Mobile Phone Base Station Radiation Study for Addressing Public Concern" American journal of engineering and applied science.

IEEE, 1991. IEEE C95.1-1991, IEEE standard for safety levels concerning human exposure to radiofrequency electromagnetic fields. 3 kHz to 100 GHz (Replaces ANSI C95.1-1982). The Institute of Electrical and Electronics Engineers, Inc. New York, NY, USA.

ICNIRP, 1998: "Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300GHz)."*Health Physics*, vol. 74 No. 4, April 1998, 494-522.

Iortile, J.T. and Agba, E.H. 2014.Assessment of radiofrequency radiation distribution around mobile base stations in Makurdi, Benue State. International Journal of Natural Sciences Research, 2(1): 2-4.

Lester, E. P., 2005: Radiation Hazards RadHaz Issues for Telecommunication Facility Professionals. Comsearch · 19700 Janelia Farm Blvd., Ashburn, VA US 21047 Page 1 of 13 Bulletin TP-100320-EN (03/05) ©2005 Andrew Corporation.

Ozyalcin, M.O., Akleman. F. and Sevgi, L., 2002: SAR Simulation in Wireless Communication and Safety Discussion in the Society. Turk J.Elec Engn, 10:.2 2002.

Sadiya U., 2010: Assessment of radio-frequency radiation exposure from selected mobile base stations in Zaria and environs, Nigeria. A dissertation, Ahmadu Bello University, Zaria. (Unpublished).