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Assessment of Radio-Frequency Radiation from Selected Mobile Base Stations within Kaduna Metropolis, Kaduna State, Nigeria

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Abstract

In this paper, radio-frequency radiation levels from some selected Base Transceiver Stations of different network providers (MTN, 9mobile, Airtel and Globacom) within Kaduna metropolis, Kaduna State, Nigeria were measured using a portable hand-held spectrum analyzer model 2658A, within radial distance intervals of 20 m to 100 m from the foot of each Base Transceiver Station. The measured values range between 0.24 μWm^{-2} to 30.42 μWm^{-2} with an average value of between 0.298 μWm^{-2} to 14.578 μWm^{-2} respectively. The measured radiation levels were found to be less than the acceptable standard value of 4.5 Wm^{-2} recommended by International Commission on Non-ionizing Radiation Protection for Global System for Mobile communication with frequency 900 MHz. Results obtained show exposure to RF emissions from the sampled Base Transceiver Stations will not impose health risk to humans living within that area.

Keywords: Radio frequency radiation; health risk; mobile phones; base transceiver stations; power density.

I. Introduction

Mobile phones were introduced in the 1990s through Global System for Mobile Communication (GSM) with frequency transmission capacity of 900 MHz/ 1800 MHz, with an improved communication service following the introduction of Universal Mobile Telecommunications System (UMTS) called third generation (3G) system, which transmits data rates above 2 megabits per second (Mbps) providing steady communication services to portable computers and telephones irrespective of their locations. Then came the introduction of data optimized 4G and Long-Term Evolution (LTE) systems, with 4G providing data speeds of up to 1 gigabits per second (1Gbps), and lately the 5G systems that allow data speeds up to 20 gigabits per second (20 Gbps) which is still at its evolution stage [1, 2].

The growth and development of the telecommunication industry in Nigeria had led to an increase in the number of installations of BTS. In 2009, it was estimated that more than 120 base stations were built monthly on the average by each of these network operators, and each of these network operators were estimated to have about 3,000 BTS, mostly found in the cities [3]. These BTS or towers are free standing or mounted on existing structure which is usually from 50-200 feet high, and equipped with electronic equipments and antennas that receive and transmit RF signals. All communications via cell phones are associated with the near BTS through RF waves. The Installation of these BTS near schools, residential and public buildings, companies/ industries and organizations has raised a lot of concerns with regards to its health effects and the well-being of people living within the area, as it is now believed that we are literally living in a microwave oven [4]. Although RF radiations from antennas are non-ionizing, as the energy is insufficient to cause direct ionization which can break chemical bonds in biological systems, nonetheless exposure from these radiations over a long period of time is unsafe as it could lead to burns and body tissue damage [5].

Several studies have been carried out on the assessment of RF radiation exposure levels from Base Transceiver Stations within Nigeria. In a study carried out within Giwa and Zaria local government areas of Kaduna State [4], the measured mean power density values obtained range between 9.29 $nW\mathrm{m}^{-2}$ and 58.08 $nW\mathrm{m}^{-2}$. Likewise in an investigation carried out by [6] within Zaria local government, the mean power density values obtained range between $3229.82\ m\mathrm{Wm}^{-2}$ and $1027.73\ m\mathrm{Wm}^{-2}$, while [7] recorded a mean maximum power density value of $718.6\ \mu\mathrm{Wm}^{-2}$ in a study carried out within Ogbomosho. Similarly, in a study carried out by [8] within Kaduna-North local Government area, measured mean power densities values obtained ranged between $108.27\ \mu\mathrm{Wm}^{-2} - 94.74\ \mu\mathrm{Wm}^{-2}$, whereas [9] recorded mean power densities values between $0.03\ \mu\mathrm{Wm}^{-2}$ and $4.204\ \mu\mathrm{Wm}^{-2}$ in a study carried out in Rivers state. In all these alongside other related studies carried out outside Nigeria [10, 11, 12, 13 and 14], the results obtained were seen to be lower than the maximum permitted exposure value of 4.5 Wm^{-2} for GSM 900 and 9.0 Wm^{-2} for GSM 1800, as set by ICNIRP. However there's always a concern about the cumulative effect of RF radiation on living organisms as a result of continuous exposure.

This study is aimed at assessing RF radiation exposure level from selected BTS of the four major network providers (MTN, 9mobile, Airtel and Globacom) within Kaduna Metropolis, Kaduna State, Nigeria and to ascertain if they pose any health hazard to the people residing within that area.

A. Study Area

The study area which lies between latitude $10°53^{I}0^{II}N$ and longitude $7°43^{I}0^{II}E$ (see Fig. 1) comprises of Chikun, Kaduna North, Kaduna South and Igabi Local Government Areas of Kaduna State, Nigeria.

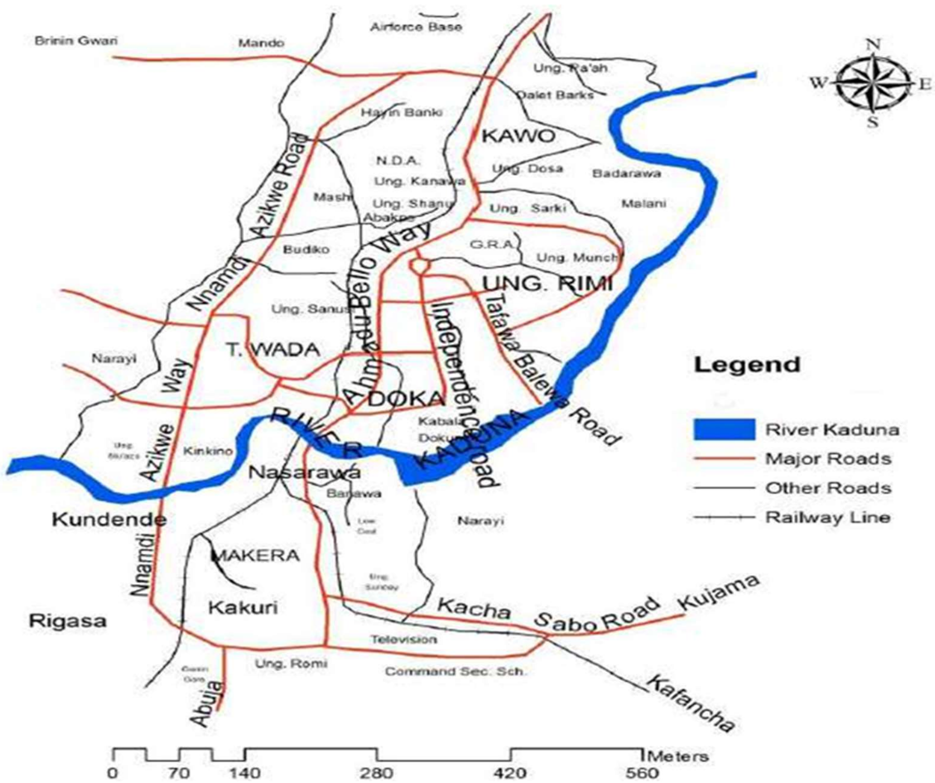

Fig. 1 Map of Kaduna metropolis [15].

II. Materials and Methods

A. Materials

Materials used in this study include a portable hand-held spectrum analyser model 2658A, linen tape, Global Positioning System (GPS) receiver and an aluminium pointer stick (13 inches).

B. Methods

1) Data collection

Data were collected near BTS of the four major network operators namely MTN, 9mobile, Globacom and Airtel within Kaduna metropolis. Forty-two (42) BTS were chosen at random base on their proximity to residential and public buildings, schools, companies/ Industries and organizations. The Forty-two (42) BTS were tagged $M1 - M42$. The received power radiation (dBm) and exposure limit (μWm^{-2}) were taken at distance were taken at intervals of $20\ m$ distance for consecutive radii around the mast. Five (5) signal readings from each of the 42 masts were measured which amounted to a total of 210 measurements. Each of the sample mast had three (3) or more sectoral antennas for radiation of the signal radially around the mast. The GPS meter was used to obtain the longitude and the latitude of each BTS.

2) Data Analysis

A simple random sampling was employed for this quantitative research in choosing the BTS. The data utilized for the research are of two types: main and supplementary data. The main data were collected as a result of measurement from the field quantification by physical analysis using the spectrum analyser and linen tape while the secondary data were obtained from exposure guideline regulations bodies like ICNIRP.

The level of radiations emanating from sample base stations were obtained from computation of primary data using (1) [16].

$$S = \frac{P_{in} \times G}{4\pi r^2} \quad (1)$$

Where S is the power density, P_{in} is the input power of antenna, G, is the gain of antenna, while r is the distance of received radiation from antenna.

The actual power radiated from the transmitting antenna in the base station is given by

$$Power\ radiated = power\ density \times Area \quad (2)$$

$$P_{rad.} = \frac{P_{in} \times G}{4\pi r^2} \times Area \quad (3)$$

The power obtained was in decibel relative milli-watts but the acceptable universal standard is in watt/meter-square (Wm^{-2}).

Thus, (4) was use to convert the power from decibel (dBm) to watt.

$$P(in\ watt) = \frac{10^{\frac{P(dBm)}{10}}}{1000} \quad (4)$$

III. Results and Discussion

The results of power density measurements in μWm^{-2} is presented in Table I. The BTS that radiated the highest radiation was MTN coded M13 at distance of $20\ m$ with maximum power density of $30.42\ \mu Wm^{-2}$ while the BTS that radiated the lowest radiation was 9mobile coded M9 at distance of $100\ m$ with minimum power density of $0.24\ \mu Wm^{-2}$. The maximum power density of 30.42 μWm^{-2} is less than the International Guidelines Exposure levels of $4.5\ Wm^{-2}$ for GSM 900 set by ICNIRP [17]. BTS M1, M3, M4, M8, M12, M21, M26 and M28 were also observed to have low RF signals.

Similarly, a maximum value of average power density of $14.578\ \mu Wm^{-2}$ was recorded at M13 while a minimum average power of $0.298\ \mu Wm^{-2}$ was recorded at M9. Largely, a significant fluctuation in data during measurement was observed. It is expected that measured power density values should decrease as you move farther away from reference base station base on the inverse square law. However, the radiation intensity obtained show little deviation from inverse square law at some point and these could be attributed to the topography (or elevation) of the area, obstacles constituted by immobile structures placed or erected within the line of sight of measurement, wave interference from other sources of electromagnetic radiation and wave interference from other mobile base stations clustered around a reference base station. It was also observed that most of the BTS were closely installed usually about 100 m or even less and had 6 sectoral antennas in densely populated areas. Fig. 2 shows the result of power density radiated at difference distances from BTS M1 to M42.

Fig. 3 depicts the percentage contribution of each BTS. The highest percentage contribution of 8.88% was recorded for M13, MTN, while the least percentage contribution of 1.18% was recorded for M9, 9Mobile.

Table I. Measured power density ($\mu W m^{-2}$) of surveyed BTS at 20 m distance interval alongside their mean, average and percentage (%) contribution.

BTS	Network	Power density ($\boldsymbol{\mu W m^{-2}}$)							
		20 m	40 m	60 m	80 m	100 m	Sum	Average	Percentage Contribution (%)
M1	9Mobile	00.38	00.39	00.38	00.38	00.37	01.90	00.380	0.23%
M2	MTN	06.64	05.51	03.02	01.98	00.95	18.10	03.620	2.21%
M3	MTN	03.79	02.14	01.42	01.17	00.96	09.48	01.896	1.16%
M4	GLO	00.48	00.46	00.47	00.48	00.46	02.35	00.470	0.29%
M5	9Mobile	00.39	00.38	00.39	00.38	00.37	01.91	00.382	0.23%
M6	Airtel	07.67	07.61	06.04	03.06	01.94	26.32	05.264	3.21%
M7	MTN	15.59	09.60	07.63	09.60	09.75	52.17	10.434	6.36%
M8	9Mobile	00.39	00.37	00.38	00.37	00.39	01.90	00.380	0.23%
M9	9Mobile	00.31	00.30	00.29	00.24	00.35	01.49	00.298	0.18%
M10	GLO	01.95	02.46	03.06	00.97	01.26	09.70	01.940	1.18%
M11	GLO	04.87	02.41	01.24	01.26	01.54	11.32	02.264	1.38%
M12	9Mobile	00.96	00.97	00.95	00.96	00.97	04.81	00.962	0.59%
M13	MTN	30.42	19.19	09.67	07.57	06.04	72.89	14.578	8.88%
M14	Airtel	24.20	01.97	01.96	00.95	01.26	30.34	06.068	3.70%
M15	MTN	04.82	01.57	01.53	00.96	00.96	09.84	01.968	1.20%
M16	Airtel	19.24	14.25	13.45	12.10	13.87	72.91	14.582	8.88%
M17	MTN	01.52	01.57	00.96	01.26	00.96	06.27	01.254	0.76%
M18	GLO	07.61	02.02	01.93	01.23	01.21	14.00	02.800	1.71%
M19	MTN	11.35	05.26	03.76	01.43	01.51	23.31	04.662	2.84%
M20	MTN	07.63	03.83	03.02	01.50	01.26	17.24	03.448	2.10%
M21	9Mobile	00.74	00.76	00.75	00.76	00.75	30.76	00.752	0.46%
M22	Airtel	06.17	04.43	04.73	03.45	02.64	21.42	04.284	2.61%
M23	MTN	02.29	01.50	00.86	00.71	00.78	06.14	01.228	0.75%
M24	GLO	03.72	02.34	01.50	01.08	00.61	09.25	01.850	1.13%
M25	MTN	18.26	09.40	07.61	03.44	01.87	40.58	08.116	4.95%
M26	9Mobile	00.61	00.60	00.55	00.52	00.58	02.86	00.572	0.35%
M27	GLO	05.42	04.39	02.74	01.44	01.22	15.21	03.042	1.85%
M28	9Mobile	00.49	00.48	00.47	00.48	00.46	02.38	00.476	0.29%
M29	Airtel	12.10	09.60	12.03	07.61	03.22	44.56	08.912	5.43%
M30	MTN	01.86	01.40	00.81	00.69	00.60	05.36	01.072	0.65%
M31	9Mobile	01.30	01.27	01.21	01.25	01.19	06.22	01.244	0.76%
M32	MTN	07.52	03.72	02.63	01.74	01.39	17.00	03.400	2.07%
M33	GLO	03.01	01.98	01.49	01.15	00.71	08.34	01.668	1.02%
M34	MTN	01.83	01.49	00.95	00.70	01.18	06.15	01.230	0.75%
M35	GLO	18.28	11.56	05.54	04.20	02.21	41.79	08.358	5.09%
M36	Airtel	03.01	01.96	01.57	00.92	00.61	08.07	01.614	0.98%
M37	MTN	27.41	22.10	12.10	10.40	07.63	79.64	15.928	9.70%
M38	MTN	09.42	06.15	03.60	01.92	00.91	22.00	04.400	2.68%
M39	MTN	24.11	07.52	04.55	03.77	01.58	41.53	08.306	5.06%
M40	Airtel	15.23	07.57	04.69	02.38	01.18	31.05	06.210	3.78%
M41	MTN	02.38	01.77	01.22	00.59	00.44	06.40	01.280	0.78%
M42	GLO	04.74	03.38	01.91	01.21	01.42	12.66	02.532	1.54%
								03.908	100.00%

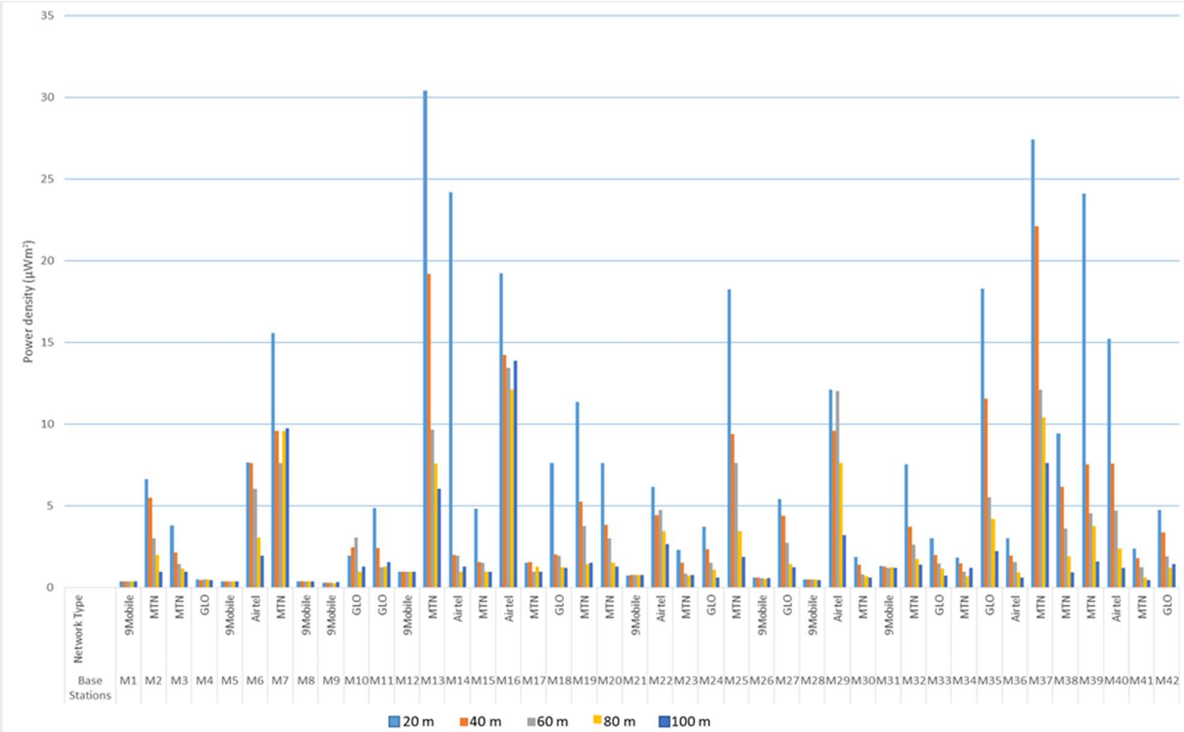

Fig. 2 Power density of each BTS.

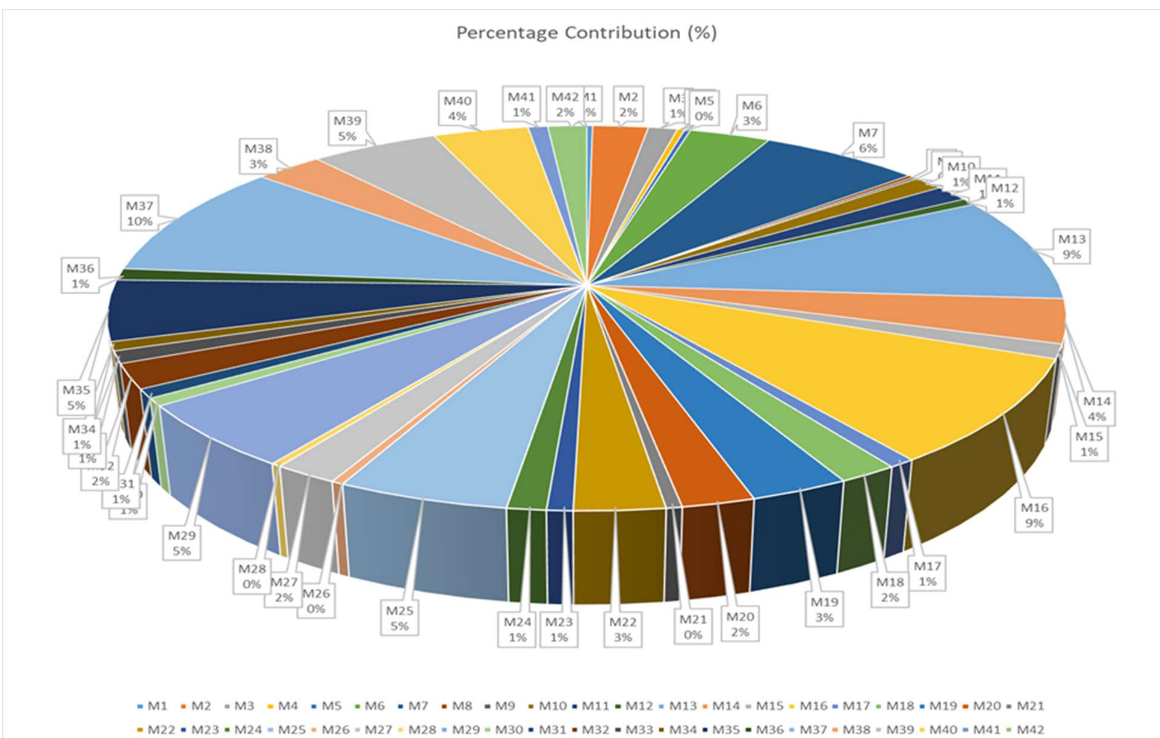

Fig. 3 Percentage contribution of each BTS.

IV. Conclusion

Assessment of RF radiations from some selected mobile BTS within Kaduna metropolis was carried out using a spectrum analyser modelled 2658A. The highest power density level of 30.42 μWm^{-2} was obtained at a distance of 20 m from the BTS M13, which is much lower than the maximum permitted exposure value of 4.5 Wm^{-2} for GSM 900 and 9.0 Wm^{-2} for GSM 1800, as set by ICNIRP. The results obtained from this assessment shows that exposure to RF emissions from the sampled BTS within Kaduna metropolis does not pose health risk to people living within these areas.

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