Investigation of Radio-frequency Power Density Distribution around GSM Mast in Keffi Town, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors UI and MM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author IMM managed the analyses of the study. Authors AAM and IY managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

In this study, an investigation of radiofrequency power density distribution around GSM mast in Keffi town, Nigeria was determined. Radiofrequency meter (Electrosmog ED- 155A) was used to measure the EM radiation at 50, 70, 90,110, 130, 150, 170, and 190 m away from mobile base stations. A total of fifteen mobile base stations were randomly selected in Keffi town covering about four network providers (MTN, Globacom, Etisalat, and Airtel), according to their proximity to buildings, number of antennas mounted on their masts, how close they are to other base stations and the population density around them.The result reveal that MBS5 was found to have the highest value of average power density compared to that of the remainder, with a contribution of about 16% (2908.38 µW/m^2). The least contribution was recorded in MBS3 with only about 1% (173.71 µW/m^2). The other MBS with significant contribution are MBS6 (15%), MBS11 (15%), MBS10 (13%), MBS8 (13%) and MBS13 (11%) with average power densities of 2878.72µW/m^2, 2767.28µW/m^2, 2385.43 µW/m^2, 2382.70 µW/m^2, and 1996.36 µW/m^2 respectively. The findings reveal that the measured values of power densities across all the sites are well below the RF radiation exposure safety limit set by International Commission on Non-ionizing Radiation

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Protection (ICNIRP) when compared with the findings in this study. Therefore, RF radiation exposure from mobile base stations in Keffi town may pose no health risk to the people living within the area.

1. INTRODUCTION

Mobile communications technology are now common in Nasarawa State particularly Keffi town. The introduction of communication systems in the year 2002 in Nigeria has increased radiofrequency radiation exposure of the general public to telecommunications and mobile base stations [1].

There is widespread public concern about the potential adverse health effects of mobile phones and especially their associated base stations alongside with hundreds of apparently conflicting reports in the media about the health effects of mobile phones and base stations as reported by Zenon [2]. Studies have shown that exposure levels of about 3 kHz-5 MHz generates painful nerves impulses while 100 kHz-3 GHz leads to temperature rise of the body and frequencies of 300GHz can change the cellular DNA and initiate a carcinogenic transformation [3]. In medicine, it is used for the treatment of liver cancer, cosmetic surgery, sleep Apnea, Snoring, rapid heartbeat syndrome etc, [4].

The increased use of mobile phone has led to increased deployment of base stations. There are two sources of radiofrequency radiation exposure from the mobile telephone system: base station antenna and mobile phone. Exposure from base station antennas is continuous and it irradiates the whole body and expose an entire community in different ways according to position and separation distance. The mobile phone system works as a network containing base stations within each cell. These base stations can link with a number of handsets. The mobile phone and base stations communication with each other, sharing a number of operation frequencies [5,6].

A cellular phone transmits 1 to 2 Watt of power in the frequency range of 824-849 MHz (CDMA), 890-915 MHz (GSM900), 1710-1780 MHz and 1805-1880 MHz (GSM 1800). In Nigeria, the Specific Absorption Rate (SAR) limit for cell phones is 1.6W/kg, which is actually for 6minutes per day usage [7]. It has a safety margin of 3 to 4, so a person should not use a cell phone for more than 18 to 24 minutes per day. This information is not commonly known to most people in Nigeria, so people use cell phones for more than an hour per day without realising the related health hazards [8,9].

2. MATERIALS AND METHODS

Measurement of Electromagnetic radiation was carried using RF Meter (Electrosmog ED- 155A). The RF meter is a frequency weighted broadband device for monitoring high frequency radiation in the specific ranges of 900 MHz, 1800 MHz, and 2.7 GHz. Measurements of power density were made by simply pointing the RF meter to the source of the RF radiation. A maximum of 190m radial distance from the foot of the base station was considered and measurement were taken at 20 m interval from each base station starting with 50 m. The proximity of residential buildings, office buildings and schools to base stations forms the bases for choosing this range of distance. A total of fifteen (15) mobile base stations were randomly selected in Keffi town covering about four (4) network providers –MTN, Globacom, Etisalat, and Airtel, according to their proximity to buildings, number of antennas mounted on their masts, how close they are to other base stations and the population density around them.

The meter was set to the tri-axial measurement mode and also to the maximum instantaneous measurement mode, to measure the maximum instantaneous power density at each point. Each measurement was made by holding the meter away from the body, at arm's length and at about 1.5m above the ground level pointing towards the mast as suggested by Victor et al. [10]. The values of the measured Electric field taken after the meter is stable (about 2 min) were recorded. We ensured that the measured values were not influenced by unwanted sources and disturbances. Such precautions taken were to avoid the movement of the meter during measurements and excessive field strength values due to electrostatic charges. We also ensured (where possible) that phone calls and movement of cars were reduced before taking measurements. Global positioning system (GPS) was used to take the geographical location of the MBS investigated as shown in Table 1.

Table 1. Geographical locations of the mobile base stations investigated

Base Stations	Geopoints	
	Latitude	Longitude
MBS1	N8°51'10.5408''	E7°52'59.34''
MBS2	N8°49'40.662''	E7°52'35.262''
MBS3	N8°50'2.25''	E7°52'32.448''
MBS4	N8°50'47.766''	E7°51'55.416''
MBS5	N8°50'49.674''	E7°51'59.91''
MBS6	N8°50'41.274''	E7°52'30.744''
MBS7	N8°50'48.096''	E7°52'41.526''
MBS8	N8°50'52.866''	E7°52'44.298''
MBS9	N8°50'17.34''	E7°53'3.474''
MBS10	N8°51'25.788''	E7°52'1.83''
MBS11	N8°51'32.268''	E7°51'57.528''
MBS12	N8°51'20.592''	E7°52'55.644''
MBS13	N8°51'19.176''	E7°53'21.636''
MBS14	N8°51'34.002''	E7°53'48.042''
MBS15	N8°51'14.436''	E7°53'56.388''

The meter measures the value the electric field E and converts it into the magnetic field H and the power density S using equation (1) [ICNIRP, 1998]. The RF meter was set to display the value of power density S. The power density values were converted to $\mu W/m^2$ from mW/m^2 taken from the RF meter display. The conversion formula is given as:

$$S = EH = \frac{E^2}{377} = 377\Omega H^2 \qquad (1)$$

The meter can also measure electric field E along a different axis, but readings can also be taken in all Es at the same time (Tri axial) using:

$$E^2 = E_x^2 + E_y^2 + E_z^2 \qquad (2)$$

Where,

E_x, E_y and E_z are the electric field in *x, y* and *z* coordinate directions.

3. RESULTS AND DISCUSSION

The results of the measured power density S for all the mobile base station investigated is shown in Table 2.We observed that MBS5 was found to have the highest value of average power density compared to that of the remainder, with a contribution of about 16% (2908.38 $\mu W/m^2$) as shown in Table 3 and Fig. 1. The least contribution was recorded in MBS3 with only about 1% (173.71 µW/m2). The other MBS with

Table 2. Measured power density of surveyed MBS at 20 m distance interval

Base station	Distance from the antenna (m)							
	50	70	90	110	130	150	170	190
MBS1	399.08	200.40	370.50	178.60	215.30	330.90	209.81	303.40
MBS2	663.70	694.23	937.12	303.30	491.99	619.51	390.79	205.00
MBS3	246.50	120.70	224.54	191.00	105.89	195.80	176.60	128.61
MBS4	1180.02	332.23	208.29	325.90	711.55	679.00	797.98	341.83
MBS5	4803.70	3294.41	3999.90	3564.43	1827.59	1592.72	2919.45	1264.87
MBS6	3403.11	3235.54	4540.18	3450.30	2835.54	1914.24	1294.43	2356.40
MBS7	510.12	304.32	448.68	178.61	163.71	235.32	304.00	299.13
MBS8	3524.43	3100.70	2324.21	2766.33	1827.23	1826.90	1294.65	2397.18
MBS9	247.31	102.70	125.80	192.45	132.71	294.44	277.21	178.60
MBS10	3400.10	2235.51	3600.72	3500.33	2935.62	1814.11	1340.65	256.40
MBS11	3490.70	3294.12	3990.12	3540.66	1923.81	1814.87	2809.11	1274.85
MBS12	399.23	210.40	180.31	180.57	117.12	250.56	309.43	358.40
MBS13	3440.44	1240.50	1550.24	2330.33	1826.32	1920.23	1300.71	2362.12
MBS14	236.65	130.23	234.13	320.32	200.43	110.39	196.12	180.09
MBS15	987.12	912.22	450.22	380.39	216.50	430.98	430.98	310.44
Mean	**1795.48**	**1293.88**	**1545.66**	**1426.90**	**1035.42**	**935.33**	**936.79**	**814.49**

Table 3. Mean power density of each mobile base station and their percentage (%) contribution

| Base station	Average power density ($\mu W/m^2$)	Percentage contribution (%)
MBS1	276.00	2.0
MBS2	538.21	3.0
MBS3	173.71	1.0
MBS4	572.10	3.0
MBS5	2908.38	16.0
MBS6	2878.72	15.0
MBS7	305.49	2.0
MBS8	2382.70	13.0
MBS9	193.90	1.0
MBS10	2385.43	13.0
MBS11	2767.28	15.0
MBS12	250.75	1.0
MBS13	1996.36	11.0
MBS14	201.05	1.0
MBS15	514.86	3.0
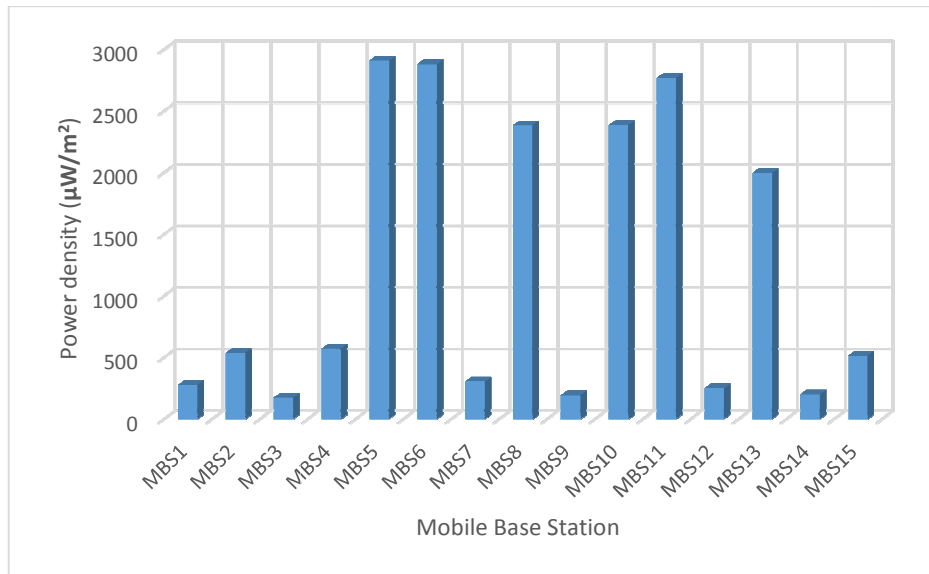
Fig. 1. Mean power density of each MBS

significant contribution are MBS6 (15%), MBS11 (15%), MBS10 (13%), MBS8 (13%) and MBS13 (11%) with average power densities of $2878.72 \mu W/m^2$, $2767.28 \mu W/m^2$, $2385.43 \mu W/m^2$, $2382.70 \mu W/m^2$, and $1996.36 \mu W/m^2$ respectively.

Significant fluctuation in data collection during measurement was observed. It is expected that the variation of the power flux density should obeys inverse–square-law ($P_t /4\pi R^2$) as you move farther away from the reference mobile base station. The measured power flux densities however deviated as shown in Fig. 2. This deviation could result from either of the following: obstruction constituted by immobile structures placed or erected within the line of sight of measurement; wave interference from other sources of electromagnetic radiation around reference base station such as radio and TV antennas, receivers etc; interference from radiation and/or noise from moving objects such as vehicles, motorcycles etc; topography (or elevation) of the land area around reference base station with respect to radial distance away from base station; and wave interference from other mobile base stations clustered around a reference base station.
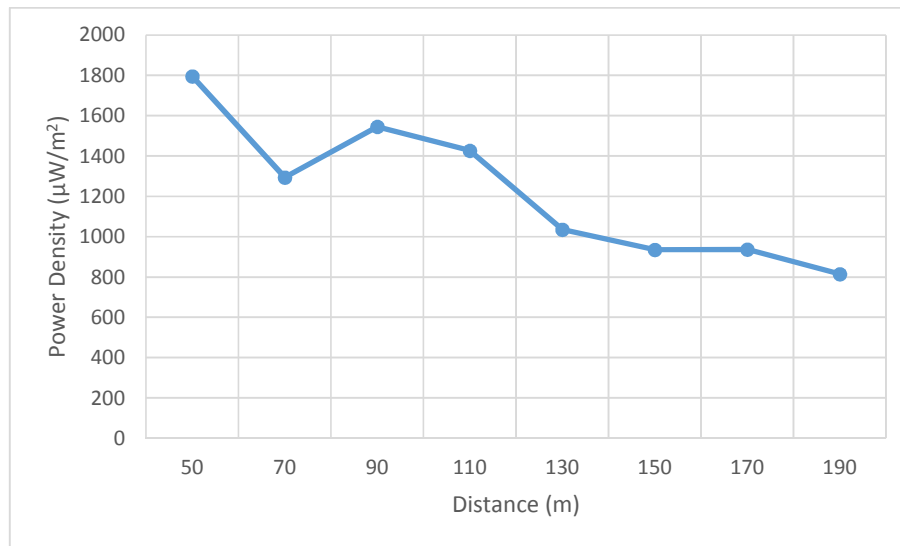
Fig. 2. Mean power flux density vs distance plot for all mobile base station

The graph in Fig. 2 shows that power flux density decreases exponentially with distance. That is at distance, d= 0, the power density S is maximum and ford> 0, the power density decreases exponentially.

The effects from excessive power density can lead to headaches, concentration difficulties and behavioral problems in children and adolescents; and sleep disturbance headaches and concentration problems in adults. Other long term effect of Power density can cause loss of memory and cancer that will be experienced after severe years of exposure. 900 mHz emission has the effect of thermal heating of body tissue.

4. CONCLUSION

Over the years, a lot of work has been done to understand how radiofrequency (RF) radiation interacts with matter. Different instruments have been use to study the health impact of non-ionizing radiation which includes environmental health assessment and epidemiological surveys to assess the level of RF exposure in the environment. The present study was carried out to determine the RF radiation exposure from mobile base stations (MBS) in Keffi town, Nasarawa State, Nigeria. It has been observed from the findings that the measured values of power densities across all the sites are well below the RF radiation exposure safety limit set by ICNIRP for the general public and occupational exposure when compared with the findings in this study. Therefore, RF radiation

exposure from mobile base stations in Keffi town may pose no health risk to the people living within the area. It is recommended that mobile network providers should site mobile base stations at least 50 m distance away from residential building areas, school buildings, office buildings and so on.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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