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Evaluation of Radiofrequency Radiation Emissions from Mobile Telephony Base Stations In Geidam Town, Yobe State.

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Abstract
Concerns associated with the delivery of electric and magnetic field (EMF) emissions through mobile communication cellular services from most cellular base transceiver stations (BTSs) prompted this work, as it is supposedly linked to health hazards. This research article assesses and analyses the Radio Frequency ElectroMagnetic Radiation (RF EMR) emitted by mobile cellular BTS antennas within Geidam town. With the3-axis RF field strength meter, measurements of the RF electric field intensity,and RF EMF power density were carried out from the BTSs at distances of 10, 20, 30, ..., 100 metres within a frequency range 900 MHz to 8 GHz. Results obtained shows that the RF electric field intensity and RF EMF power density ranges from 0.2913 to 0.9014 V/m and 0.3017 to 1.265 mW/m^{2}respectively. In comparison with RF EMFs safety exposure levels for general public as stipulated by International Commission on Non-ionized Radiation Protection (ICNIRP) and IEEE International Committee on Electromagnetic Safety (SCC39) for up to 300 GHz, the results obtained signifies that radiation levels from the BTS antenna are within the regulatory standards as such have no adverse effects to the members of the town. These work recommends routine assessment checks of these exposure limits as the technology is fast growing and BTSs are subject to regularly upgrades.

Keywords: Mobile communication cellular services, BTSs Antenna, RF EMR, safety exposure levels, RF power density.

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I. Introduction

Cellular BTS antenna commonly called GSM masts continuously radiate RF electromagnetic signals with mobile handsets during calls, while during idle times specific control signals are exchanged to ensure an active connection is maintained. Because wireless communication services rely on RF waves to operate, its presence everywhere increases the level of RF EMFs to which the public in the immediate environment is exposed. As such, public concerns are continuously growing about possible health risks associated with electromagnetic radiation emissions from GSM masts sited close to residential houses, schools, offices, and hospitals especially in densely populated areas (Vincent, Kassim, & Ibrahim, 2019; Iortile & Agba, 2014; Osahon, Okungbowa, & Ogboghodo, 2013; Olorunfemi, Ojo, Aboyeji, Akeju, & and Okezie, 2016; Raimondas, et al., 2017).

Geidam Town, a local Government headquarter in Yobe State have many BTSs located at different locations within the town which has over 157,000 as at the 2006 census, is not left out of the possible health hazard posed by these BTS masts. This research accesses the level of RF electric field intensity, RF magnetic field intensity and RF EMR power density surrounding the BTSs mast within the town, with the sole aim of assessing the level of compliance with Electromagnetic Compatibility (EMC) standards as well as safety guidelines relating to exposure of non-ionizing radiation as stipulated in Nigeria Communication Commission (NCC) guidelines(Ozovehe, Usman, & Hamdallah, 2015). In order to achieve this, appropriate measurements were carried out and results obtained therein were analyzed. From this,necessary information and recommendations were made available for concerned authorities on appropriate measures of the BTSs management.

II. Review of Related Literature

Global System for Mobile Communications (GSM) and other telecommunication technologies are now ubiquitous worldwide. The radiofrequency (RF) Electromagnetic Radiation (EMR) exposure to the public from GSM cellular phones and telecommunication transmitting and receiving antennas from BTSs has been considerable increased over the years. If the RF radiation emanating from these devices exceeds internationally recommended limits it may poses a considerable health risk to the public. Hence, there are dire needs for database of RF distribution levels in Nigeria for safety assessment, this is one of the focus of this research.

The Institute of Electrical and Electronic Engineers (IEEE), American National Standard Institute (ANSI), International Commission on Non – Ionizing Radiation and Protection ICNIRP) and National Radiological Protection Board (NRPB) has developed guidelines on the exposure limits to RF radiation due to the awareness of the potential health hazards associated with these radiations. People perceive the radiation risks from RF exposure as likely or even possibly severe, these has risen several reasons for public fear including media announcements of new unconfirmed scientific findings leading to a feeling of uncertainty (Osahon, Okungbowa, & Ogboghodo, 2013; Olorunfemi, Ojo, Aboyeji, Akeju, & and Okezie, 2016).

Several researches have focused on determining the RF EMRs exposure levels associated with GSM mast/towers (BTS) in various cities all over Nigeria. In their work (Olorunfemi, Ojo, Aboyeji, Akeju, & and Okezie, 2016), provided a GIS-based mapping of the levels of microwave radiation in Ile Ife metropolis, which they use to establish the levels of radiation from some popular brands of cell phones, as well as some factors presumed to be capable of influencing these levels. They believe these will enable realistic assessments of exposure of people to microwave radiation, and consequently contribute to overall risk assessment of adverse health impacts associated with electromagnetic radiation in the GSM telecommunication industry.

In a similar study (Ojuh & Isabona, 2015), evaluated the radio frequency radiation levels near several mobile phone BTSs in GRA, Benin City, Nigeria. They carry out measurements in terms of power density, which were made to check the exposure level at public locations. Data (power density) were collected from three (3) major GSM operators (GLO, MTN and Airtel) BTSs within the area at 5 m intervals to 100 m from the BTSs. In same city (Benin City), an extensive study involving total of forty (40) mobile phone base station masts was conducted by (Osahon, Okungbowa, & Ogboghodo, 2013), the power density (mW/m^2), magnetic field strength (A/m) and electric field strength (V/m) were determined by means of a digital Electrosmogmeter (model MECO 9810 RF) covering the frequency range of 10 MHz – 8 GHz. The measurements were made at the base of the masts and at distances 25, 50, 75 and 100 m respectively from the base of the masts.

In Makurdi, Benue State, (Iortile & Agba, 2014) conducted a research to measure the radiofrequency field levels of selected MTN and ZAIN base stations using electromagnetic field tester (EMF 827, Lutron). The measurements were done at distances of approximately 5.00, 10.00, 15.00 and 20.00 metres for each base station at the North, South, West, and East directions. Results shows that the average magnetic field levels of MTN and ZAIN base station ranged between 0.09 µT to 0.15 µT and the mean electric field values for eye, brain and muscles ranged between 18.81 V/m to 31.55 V/m, while the specific absorption rate (SAR) for MTN and ZAIN networks were found to range between 0.18 W/Kg to 1.03 W/Kg. They concluded from the results obtained that the radiation emitted by the mobile base stations are within the regulatory standards and have no adverse effects to the members of the public.

Similarly, (Vincent, Kassim, & Ibrahim, 2019) in their work assessed the intensity of EMFs radiated from GSM masts located near Mundra School in Mubi, Adamawa State. They carry out Measurements of power density and electric field intensity at four different locationsusing 3-axis radiofrequency field strength meter. Their findings shows that the power density and electric field intensity varied between 263.5 – 2658.4 μW/m^2 and 239.9 – 902.2 mV/m, and the average levels were 917.3 μW/m^2 and 510.1 mV/m respectively. Their results reveals that the measured values in comparison with maximum permissible exposure limits set by the ICNIRP was well below permissible limits. Hence, the EMF radiation from the GSM mast does not pose any potential threat to health. And recommends regularly check on these as the BTSs are ungraded. This results also agrees with that carried by (Verloock, et al., 2014) in Belgium for RF exposure in schools, homes, and public places.

From the reviewed literatures, this research targeted the assessment (through measurement, in terms of power density (mW/m^2), and electric field strength (V/m)), and analysis of the RF EMFs generated by thethree active (3) mobile phone operator (Airtel, MTN and Glo) base transceiver stations (BTSs) antennas found within the general populace inthe town. This was achieved through broadband and frequency-selective measurements of the RF electric field strength and RF EMF power density which werecarried outat different directions from BTSs at ground distances within thedistance of 10 m up to 100 m. The results obtained were compared with international exposure (health hazard) guidelines stipulated by ICNIRP as adopted by NCC and that by IEEE International Committeeon Electromagnetic Safety (SCC39) for generalization and CENELEC, (Ulf, et al., 2000).

Table 1 (a): ICNIRP reference levels for the general public exposures for GSM frequencies

Exposure Setting	**Frequency Range**	**Power Density (W/m^2)**	**E-Field Strength (V/m)**
General Public	GSM 900 MHz	4.5	41.25
	GSM 1800 MHz	9.0	58.33
	TETRA 1400 MHz	2.0	51.45
	WCDMA 2100 MHz	10.0	61

Source:(Cansiz, Abbasov, Kurt, & Celik, 2016)

Table 1(b): Reference level for the General Public at 900 MHz and 1800 MHz

Document	900 MHz Limits		1800 MHz limits	
International health based Guidelines	Electric field (V/m)	Power Density (W/m^2)	Electric field (V/m)	Power Density (W/m^2)
ICNIRP, 1998	41.25	4.5	58.3	9.0
IEEE, 1999	47.6	6.0	67.3	12
CENELEC, 1995	41.4	4.5	58.1	9.0

Source: (Ulf, et al., 2000)

III. Materials And Method

For the research, the materials used include Garmin GPS Receiver, fibre measuring tape, a 3-axis Radiofrequency field strength meter (Model: TENMARS, TM-196), and information from BTSs maintenance Engineers and operators. The research was conducted on the Seven (7) accessible and active BTSs within the town consisting of five (5) Airtel, one each for GLO and MTN. The GPS Receiver was used to get the exact location (coordinates) of the BTSs for ease of referencing, see table 2.

Table 2: Coordinates of the BTSs in Geidam Town

Mobile Network BSTs		Coordinates
Airtel	A-1	12.888846, 11.925746 (12°53'19.9"N 11°55'32.7"E)
	A-2	12.887912, 11.923575 (12°53'16.5"N 11°55'24.9"E)
	A-3	12.889772, 11.928885 (12°53'23.2"N 11°55'44.0"E)
	A-4	12.893502, 11.925001 (12°53'36.6"N 11°55'30.0"E)
	A-5	12.893823, 11.925714 (12°53'37.8"N 11°55'32.6"E)
Glo		12.883199, 11.922377 (12°52'59.5"N 11°55'20.6"E)
MTN		12.884413, 11.923437 (12°53'03.9"N 11°55'24.4"E)

Source: (Field work, 2021)

The 3-axis RF field strength meter used is a broadband device has a non-directional (isotropic) electric probe with three channels measurement sensor (3-axis) that can be used to measure and monitor high frequency radiation within the range of 10 MHz to 8 GHz, details of its specification is given in table 3.

Table 3: 3 - Axis RF Field Strength Meter (TENMARS,TM-196) Technical and Operating Details

1.	Type	Broadband
2.	Frequency range	10 MHz – 8 GHz
3.	Measurement units	mV/m , V/m , μA/m , mA/m , μW/m2 , mW/m^2, $\mu W/cm^2$
4.	Sensor	Triple Axis (X, Y, Z)
5.	Display resolution	0.1 mV/m, 0.1 μV/m, 0.001 $\mu W/m^2$, 0.001 $\mu W/m^2$
6.	Sample Rate	2.5 times per second
7.	Operating Voltage	9 V
8.	Power source	Battery Powered

Source: (TENMARS, 2001)

The BTSs are dual band-three sectored antennas; with some of the antennas having inbuilt features which enable them radiate at 900 - 1800MHz (Airtel: A-1, A-4 and A -5), while the others (Airtel A-2, A-3, MTN and GLO) radiating at 900 MHz – 8GHz. This is due to the upgrade from 2G/3G to 4G functional capability. The antennas were installed at different heights ranging from 20m to 35m above the sea level, measurement with RF field strength meter was taken at about 1.2 m above ground level at different desirable and convenient direction from the BTSs (which are fixed). With the RF field strength meter and measuring tape, microwave radiation parameters at each measured points (distances: 10, 20, 30, …, 100 metres) were measured. The parameters measured for each data point are: electric field intensity and power density.

IV. Results And Discussion

The measured electric field intensity radiated from the seven (7) Mobile network BTSs at the specified distances as shown in table 4 and the corresponding bar chart in figure 1varies from 0.2913 to 0.9014 V/m. With the maximum (0.9014 V/m) radiation measure from Airtel BSTs A-2 while the minimum (0.2913 V/m) from Airtel BSTs A-3.

Table 4: Measured Electric Field Intensity from BTSs

Electric Field Intensity (V/m)											
Mobile Network BSTs		Distance (m)									
		10	20	30	40	50	60	70	80	90	100
Airtel	A-1	0.8152	0.7802	0.7275	0.7313	0.6812	0.5697	0.4713	0.5256	0.4105	0.3896
	A-2	0.9014	0.8257	0.7132	0.6817	0.7004	0.6592	0.525	0.5989	0.4842	0.3791
	A-3	0.8735	0.7645	0.7356	0.6982	0.5765	0.6183	0.4301	0.4005	0.3146	0.2913
	A-4	0.8451	0.8237	0.7114	0.6819	0.69.6	0.5582	0.5634	0.4798	0.4357	0.4297
	A-5	0.8684	0.7509	0.7743	0.6426	0.6045	0.5868	0.5592	0.5108	0.4784	0.3471
Glo		0.8371	0.8542	0.6994	0.6672	0.5371	0.6048	0.5115	0.4879	0.4315	0.3988
MTN		0.8764	0.7467	0.7047	0.6784	0.6240	0.5893	0.4674	0.3497	0.3105	0.3114

Source: (Field work, 2021)

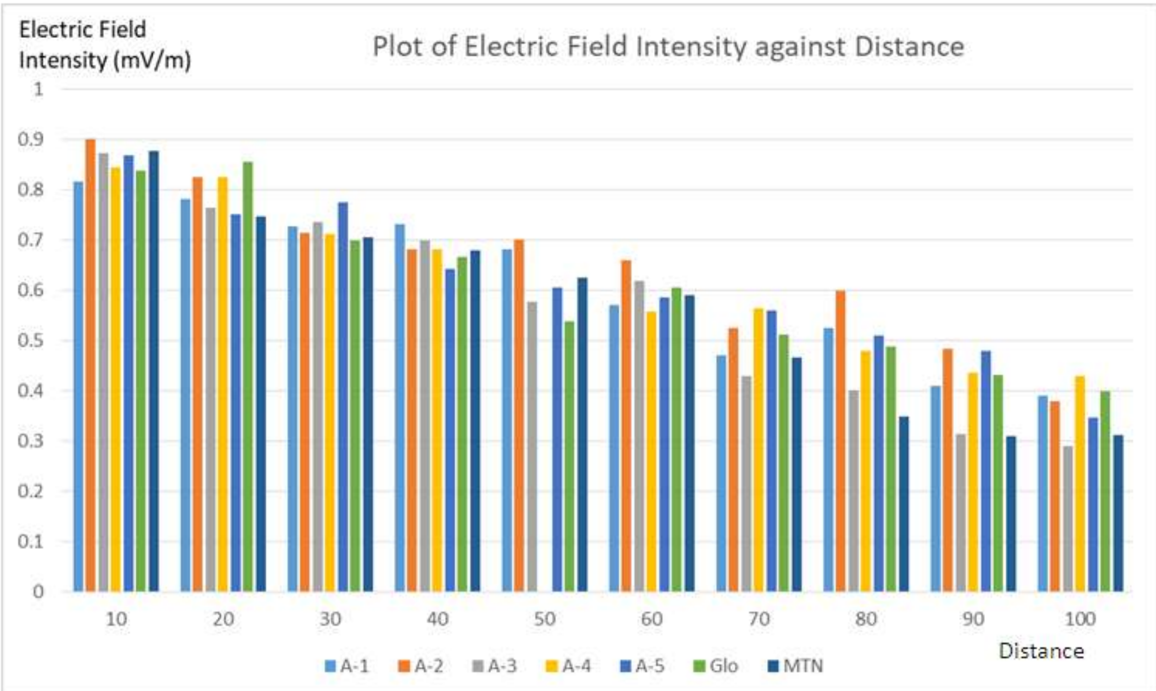

Figure 1: Plot of Electric Field Intensity against Distance

Source: (Field work, 2021)

From table 5 and the corresponding bar chart in figure 2, the measured Power Density from the seven (7) Mobile network BTSs antenna at the specified distances varies from 0.3017 to 1.265 mW/m^2. With the maximum (1.265 mW/m^2) radiation measure from Glo BSTs antenna while the minimum (0.3017mW/m^2) from MTN BSTs antenna.

Table 5: Measured Power Density from BTSs

Mobile Network BSTs		Power Density (mW/m^2) Distance (m)									
		10	20	30	40	50	60	70	80	90	100
Airtel	A-1	0.9123	1.009	0.9756	0.8945	0.8812	0.8032	0.9123	0.7895	0.7773	0.6051
	A-2	1.132	1.007	0.9942	0.9125	0.9856	0.8973	0.8018	0.7982	0.6325	0.5894
	A-3	1.095	1.123	0.9963	0.8917	0.8674	0.7954	0.7116	0.6974	0.6812	0.6132
	A-4	0.9527	0.9025	0.8859	0.8127	0.7945	0.7127	0.7245	0.7008	0.6785	0.5174
	A-5	0.9817	0.9128	0.8916	0.7856	0.8003	0.7029	0.6871	0.6238	0.5971	0.4361
Glo		1.265	1.102	0.9873	0.8973	0.7458	0.7159	0.5287	0.6126	0.4582	0.3125
MTN		1.023	1.187	0.9457	0.9005	0.8754	0.7916	0.7426	0.6673	0.5412	0.3017

Source: (Field work, 2021)

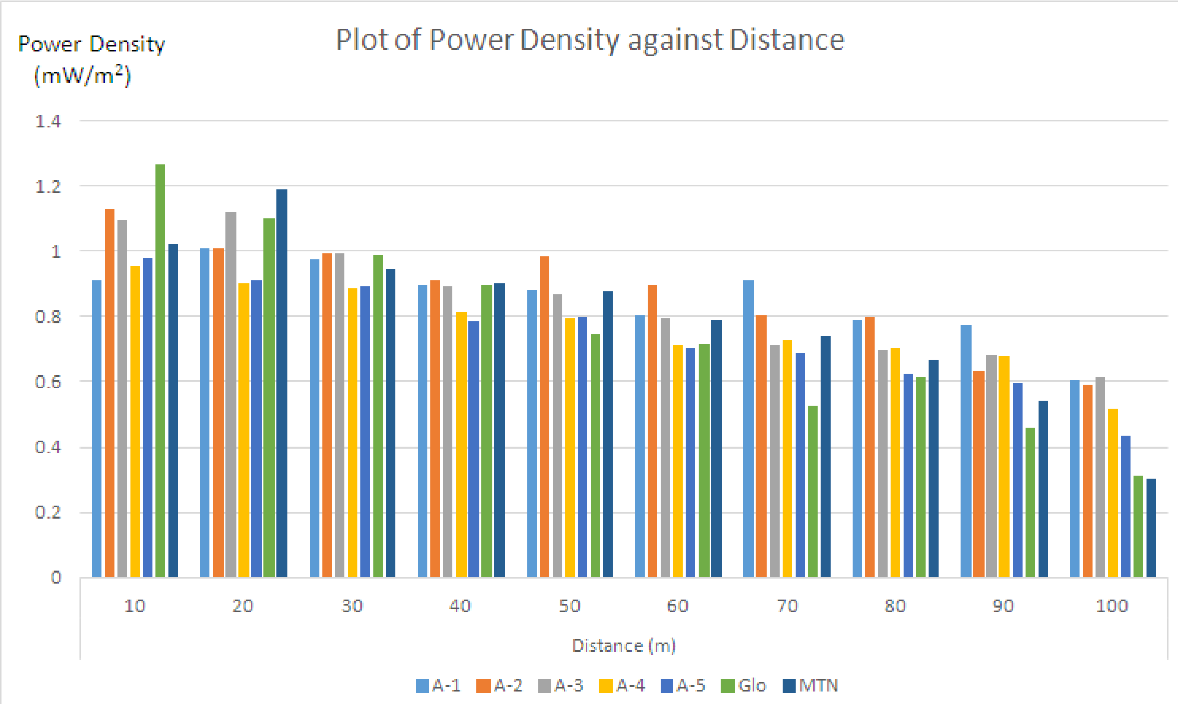

Figure 2: Plot of Power Density against Distance

Source: (Field work, 2021)

These values (tables 4 & 5) in comparison to table 1 (a) as adopted by Nigerian Communication Commission (NCC) and Table 1 (b) relating to international standard limits for exposure for general public are quite small as they are all far below the minimum value of 41.25 V/m for electric field intensity and 12 W/m^2 for power density.

V. Conclusions

In this research, Radio-Frequency (RF) radiation emissions from mobile telephony base stations in Geidam town, Yobe state was assessed from seven (7) different Base Transceiver Stations antenna situated within the town. In situ evaluation and assessment on the extent of exposure to RF radiation was conducted by measuring the electric field strength and power density from the BTSs antenna. All measured field levels in terms of the electric field strength (highest was 0.9014 V/m) and power density (highest was 1.265 mW/m^2) of the BTSs are significantly very low and below the threshold level of the guidelines for International exposure limits as stipulated by International Commission on Non-Ionizing Radiation Protection (ICNIRP) which was adopted by NCC for regulating RF electromagnetic radiation emissions from GSM BTSs. This was also compared to other international standards, and was comfortable below their minimum exposure levels.

From results obtained (see tables 4 and 5), it is obvious that the RF electric field intensity and RF power density varies with distances. They in most cases decreases with increase in distance, this is inconsonance with the work of (Renke & Chavan, 2015), that concludes that at any given time, the number of voice calls made, distance from the mast and height of the antenna will affect the power density and electric field strength of the EMF.

The great number of the BTSs are mostly installed in populated areas, same applied to the study area. Most of the BTSs operating in the town are in the GSM 900, 1800 and UMTS 2100 MHz frequency bands, with few recently upgraded with 4G facility through the replacement of classic antennas with new high-gain antennas and other few circuitry operating not above 8 GHz, hence increasing the RF radiation. In future, there will be need to limit the number of such BTSs situated within the populace in order to prevent excessive exposure to the general public. Hence, with emerging technologies (advanced 4G, 5G and possible 6G), there will be need for regular exposure assessment in the future to evaluate their contribution to RF radiation exposures. Similarly, their consequent penetration limits as it concerns nature of building as studied by (Elechi & Otasowie, 2015), will equally be essential. For consistency, future research should adopt similar measurement techniques for evaluation of the RF radiations with consideration of increasing the number of microenvironments that occurs on daily basis.

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