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Assessing Electromagnetic Field Exposure Levels from Selected Base Transceiver Stations in Uromi Metropolis of Nigeria

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Abstract— *Concerns have been raised regarding potential health risks associated with exposure to electromagnetic fields (EMF) emitted by BTS installations. Despite regulatory standards set by organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and national regulatory bodies like the Nigeria Communications Commission (NCC) and the National Environmental Standards and Regulations Enforcement Agency (NESREA), empirical research on actual EMF exposure levels in specific locations remains scarce. This study aimed to assess electromagnetic field (EMF) exposure levels from selected base transceiver stations (BTSs) in Uromi metropolis of Nigeria. Using a combination of precise geolocation techniques and EMF meters, EMF exposure levels were measured at predetermined distances around ten selected BTS sites in the Uromi Metropolis. Data collection involved radial measurements around each BTS, extending from 20 meters to 100 meters in distance, along three distinct directions. The results revealed varying levels of EMF exposure across the selected BTS sites, with the highest average power density and specific absorption rate (SAR) recorded at BTS 9, with an average power density of 0.02571 W/m² and an average SAR value of 0.000862 W/kg at a distance of 80m.Despite localized areas of elevated radiation levels, the overall average power density remained below the ICNIRP standards for GSM 900 and GSM 1800 frequencies, indicating minimal risk of EMF exposure to residents in the vicinity of the BTS sites. The study findings suggest that EMF radiation emitted by mobile BTS installations in the Uromi Metropolis of Nigeria falls within permissible limits, as defined by international and national regulatory standards.*

Keywords— *Electromagnetic Field Exposure, Base Transceiver Stations, Uromi Metropolis, Radiofrequency Radiation.*

I. INTRODUCTION

The last few decades have witnessed an unprecedented surge in mobile communication networks globally. The market for mobile telecommunication is very large and it is a major economic driver in many countries including Nigeria [1 & 2]. These networks, encompassing various technologies such as 2G, 3G, 4G, and now 5G, have revolutionized the way people communicate, work, and interact with each other. Base Transceiver Stations (BTS), also known as cell towers or masts, serve as the fundamental infrastructure for these networks, facilitating the transmission and reception of wireless signals. As urban centers expand and demand for mobile connectivity grows, the proliferation of BTS installations has become increasingly prevalent, with these structures dotting the landscapes of cities and towns worldwide. According to [3 & 4] more than 120 base stations are built monthly on the average by each of the major network operators in Nigeria (MTN, 9mobile, Airtel and Globacom), with each of these network operators estimated to have approximately 3,000 BTS in cities within Nigeria. BTS installations play a crucial role in enabling wireless communication by connecting mobile devices to the broader telecommunications network. These stations receive signals from mobile devices and relay them to the core network infrastructure, allowing users to make calls, send text messages, and access the internet. Conversely, BTS stations also transmit signals to mobile devices, ensuring seamless connectivity and network coverage within their operational range. Given their pivotal role in wireless communication, BTS installations are strategically located in urban areas, commercial centers, and along transportation routes to provide comprehensive coverage to users.

Despite the undeniable benefits of mobile communication networks, concerns have been raised regarding potential health risks associated with exposure to electromagnetic fields (EMF) emitted by BTS installations. Electromagnetic fields are a form of radiation generated by the transmission and reception of wireless signals, encompassing a broad spectrum of frequencies. Electromagnetic wave radiation emanating from MBTS antennas can be reflected, refracted, scattered or absorbed by human tissues [5 & 6]. Some groups had and still believe that non-ionizing radiation from GSM masts is harmful to health; i.e. living near a pole for a long time can cause several diseases such as cancer, constant headaches, destroy the reproductive organs and damage the brain [7 - 10]. Recognizing the potential health risks posed by EMF exposure, regulatory bodies and health organizations have established guidelines and standards to limit human exposure to electromagnetic radiation. Organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and national regulatory agencies set limits on permissible levels of EMF exposure based on scientific research and risk assessment. These standards aim to protect public health and ensure that BTS installations comply with safe exposure limits. In Nigeria, regulatory bodies such as the Nigeria Communications Commission (NCC) and the National Environmental Standards and Regulations Enforcement Agency (NESREA) enforce compliance with EMF exposure standards to safeguard the well-being of citizens.

Despite the existence of regulatory standards, there remains a need for empirical research to assess actual EMF exposure

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levels from BTS installations in specific geographical locations. While studies have been conducted in various parts of the world to evaluate EMF exposure, research specific to the Uromi Metropolis of Nigeria is scarce. Given the rapid urbanization and increasing deployment of mobile communication infrastructure in Uromi, there is a pressing need to understand the extent of EMF exposure and its potential implications for public health. This study aims to bridge this gap by systematically assessing EMF exposure levels from selected BTS sites within the Uromi Metropolis, providing valuable insights into the safety and compliance of telecommunications infrastructure in the region.

II. Materials and Methods

A. Materials

For the research, a Global Positioning System (GPS) device, specifically the Etrex 10 GPS Handheld Navigator manufactured by Garmin, was employed for precise geolocation and mapping of selected Base Transceiver Station (BTS) sites within Uromi Metropolis. Additionally, an Erickhill EMF Meter was utilized to quantify the intensity of electromagnetic fields emitted by the BTS installations. The Erickhill EMF Meter operates within a frequency range of 50 Hz to 3.5 GHz, measuring EMF levels in units of milliwatts per square meter (mW/m²). With its high accuracy of ±2 dB, the Erickhill EMF Meter provided reliable measurements of EMF exposure levels at predetermined distances from the base of each selected BTS, contributing essential data for assessing compliance with regulatory standards and identifying potential "hotspots" of elevated EMF exposure.

B. Methods

a. Study Area/Site Selection

Uromi Metropolis, located in the Esan North-East Local Government Area of Edo State, Nigeria, was chosen as the study area due to its urban setting and significant presence of Base Transceiver Stations (BTS). Uromi lies at approximately 6º 42’ North latitude and 6º 19’ East longitude. It shares its borders with Ewu to the North, Irrua to the Northwest, Ugboha and Ubiaja to the South, and Ugbegun and Igueben to the Southeast.

Systematic random sampling approach was utilized to select BTS locations to ensure representativeness. Criteria for selection include diversity in network providers (e.g., MTN, Airtel, Glo), proximity to residential and public buildings, and geographical distribution within the metropolis. After careful selection, ten (10) BTS (name BTS 1, BTS 2, BTS 3, ……. BTS 10) were chosen for the study.

b. Data Collection

Measurements of radiation power density were made using Erickhill EMF Meter by holding the meter away from the body at arm’s length and at about 1.5m above the ground level to the source of the RF radiation. Also, a GPS device was used to know the location of each of the BTS. Data were collected from a total number of ten (10) BTS sites at GSM 900/GSM 1800. Radial Measurements were taken around each Base Transceiver Station (BTS), extending from 20 meters to 100 meters in distance. Data collection occurred along three distinct directions, with measurements recorded at 20-meter intervals.

c. Data Analysis

The field measurement approach was selected to analyze radiation emissions from Base Transceiver Stations across different sites. The EMF meter was used to measure the power density around each BTS, extending from 20 meters to 100 meters in distance at an angle of 120º around.

The general expression for power density is

Power Density $Pd = \frac{Pt \ x \ Gt}{4\pi r^2}$ …………………………….. (1)

Where

Pd= Power density in W/m^2

Pt =Transmitter power in W

Gt = Gain of transmitting antenna

r = Distance from the antenna in meters

The Specific absorption rate (SAR) was computed using the formula in equation (2) [11]:

$SAR = \frac{Pd \ x \ Hsa}{Wa}$ …………………………… (2)

Where

Pd = power density ($W \ m^{-2}$),

Hsa = human surface area (2.012899 m^2),

WA = Weight of Average human (60 kg).

III. Results and Discussion

A. Results

The average EMF power density measurements and corresponding average Specific Absorption Rates (SARs) are presented in Tables 1 to 10. Note that the average power density for each BTS was calculated by adding the three (3) values gotten from each distance around a BTS and divided by three (3). The corresponding average Specific Absorption Rate (SAR) was computed from the average power density.

TABLE 1: Average power density and Average Specific Absorption Rate (SAR) for BTS 1

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m^2)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00343	0.0001151
6º 19’ 11”E	6º 42’ 23”N	40	0.00462	0.000155
		60	0.00315	0.000105
		80	0.00302	0.000101
		100	0.00286	0.000096

TABLE 2: Average power density and Average Specific Absorption Rate (SAR) for BTS 2

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m^2)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00053	0.000018
6º 19’ 16”E	6º 42’ 44”N	40	0.00052	0.000017
		60	0.00041	0.000014
		80	0.00042	0.000014
		100	0.00041	0.000014

TABLE 3: Average power density and Average Specific Absorption Rate (SAR) for BTS 3

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m²)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00027	0.000009
6º 19' 34"E	6º 42' 59"N	40	0.00036	0.000012
		60	0.00093	0.000031
		80	0.00024	0.000008
		100	0.00253	0.000085

TABLE 4: Average power density and Average Specific Absorption Rate (SAR) for BTS 4

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m²)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00315	0.000105
6º 19' 24"E	6º 42' 09"N	40	0.02099	0.000704
		60	0.00631	0.000212
		80	0.00533	0.000179
		100	0.00401	0.000134

TABLE 5: Average power density and Average Specific Absorption Rate (SAR) for BTS 5

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m²)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00673	0.000226
6º 19' 32"E	7º 0' 08"N	40	0.00662	0.000222
		60	0.00514	0.000172
		80	0.00502	0.000168
		100	0.00476	0.000160

TABLE 6: Average power density and Average Specific Absorption Rate (SAR) for BTS 6

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m²)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00012	0.000004
6º 19' 17"E	7º 0' 24"N	40	0.00386	0.000130
		60	0.00321	0.000108
		80	0.00075	0.000025
		100	0.00048	0.000016

TABLE 7: Average power density and Average Specific Absorption Rate (SAR) for BTS 7

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m²)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00043	0.000014
6º 19' 33"E	6º 42' 55"N	40	0.00347	0.000116
		60	0.00701	0.000235
		80	0.00585	0.000196
		100	0.00066	0.000022

TABLE 8: Average power density and Average Specific Absorption Rate (SAR) for BTS 8

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m²)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00443	0.000148
7º 05' 19"E	6º 42' 28"N	40	0.00402	0.000135
		60	0.00385	0.000129
		80	0.00342	0.000115
		100	0.00289	0.000097

TABLE 9: Average power density and Average Specific Absorption Rate (SAR) for BTS 9

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m²)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00241	0.000080
7º 22' 11"E	6º 42' 25"N	40	0.00387	0.00013
		60	0.00392	0.000131
		80	0.02571	0.000862
		100	0.01185	0.000398

TABLE 10: Average power density and Average Specific Absorption Rate (SAR) for BTS 10

GSM Location Site(900/1800MHz)		Distance from BTS (m)	Avg power density (W/m²)	Avg SAR (W/kg)
LONGITUDE	LATITUDE	20	0.00089	0.000030
6º 19' 55"E	6º 42' 44"N	40	0.00204	0.000068
		60	0.00502	0.000168
		80	0.00285	0.000096
		100	0.00218	0.000073

Tables 11 and 12 present the average power density and the corresponding average specific absorption rates (SAR) with distance for all ten (10) BTSs. Also, Figures 1 is a scatter plot of average power density against distance for all ten (10) BTSs and Figure 2 is a bar chart of average SAR against distance for all ten (10) BTSs.

TABLE 11: Average power density for all ten (10) BTSs

S/N	Distance (m)	Avg power density for all ten BTSs (W/m²)
1	20	0.00198
2	40	0.00293
3	60	0.00375
4	80	0.00483
5	100	0.00338

TABLE 12: Average Specific Absorption Rate (SAR) for all ten (10) BTSs

S/N	Distance (m)	Avg SAR for all ten BTSs (W/Kg)
1	20	0.000065
2	40	0.000099
3	60	0.000135
4	80	0.000263
5	100	0.000110

B. Discussion

In the research findings, the highest average power density recorded among the BTS sites and the calculated average specific absorption rate (SAR) were recorded at BTS 9, with an average power density of 0.02571 W/m² and an average SAR value of 0.000862 W/kg at a distance of 80m. This indicates a localized area with elevated levels of electromagnetic radiation, which could potentially pose health risks to individuals in close proximity to the BTS installation. Conversely, the lowest average power density recorded among the BTS sites and the calculated average specific absorption rate (SAR) were recorded at BTS 6, with an average power density of 0.00012 W/m² and an average SAR value of 0.000004 W/kg at a distance of 20m. This suggests minimal electromagnetic radiation exposure in the vicinity of this particular BTS site, indicating a lower risk to individuals in the surrounding area.

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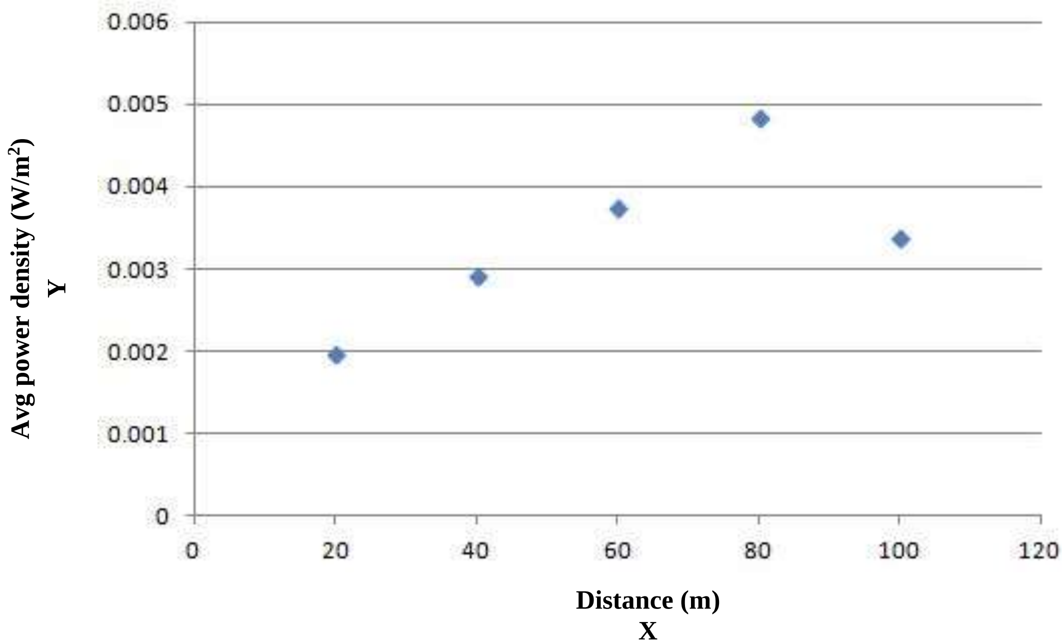

Figure 1: Scatter plot of average power density against distance for all ten (10) BTSs

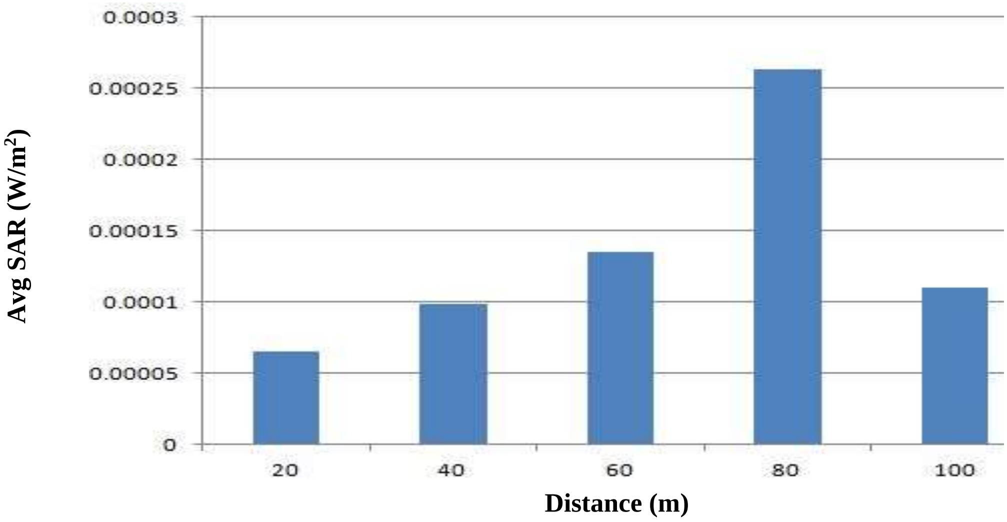

Figure 2: Bar Chart of average SAR against distance for all ten (10) BTSs

Also, the average power density for each point of measurement for all ten (10) BTSs was plotted on a scattered matrix as depicted in Figure 1, and the corresponding average SAR for each point of measurement for all ten (10) BTSs was plotted on a bar chart as depicted in Figure 2. It shows the distribution of the average power density at different distance from the BTS antenna. The maximum average value for power density and the corresponding SAR value are 0.00483 W/m^2 and 0.000263 W/kg respectively, which occur at 80m away from the BTS antenna. Again, the minimum average value for power density and the corresponding SAR value are 0.00198 W/m^2 and 0.000065 W/kg respectively, which occur at 20m away from the BTS antenna.

In all, the average power density measured ranged between 0.00012 W/m^2 and 0.02571 W/m^2 indicating that the RF radiations emitted by Mobile BTS in Uromi metropolis were below the ICNIRP standards which are 4.5 W/m^2 for GSM 900 and 9.0W/m^2 for GSM 1800 or 0.08 W/kg (SAR). The ICNRP standards are also adopted by the Nigeria Communications Commission and National Environmental Standards and Regulations Enforcement Agency (NESRAE) [2]. The results have shown that despite some localized area with elevated levels of electromagnetic radiation, the emitted RF radiation was still far below the permissible standards.

IV. Conclusion

The results from the study show that the EMF radiations emitted by mobile BTS located in Uromi metropolis were below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) standards which are 4.5 W/m^2 for GSM 900 and 9.0W/m^2 for GSM 1800 or 0.08 W/kg (SAR). Therefore, there is no significant risk of electromagnetic field

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exposure to humans residing close to the BTS sites in the locations investigated in Uromi, Edo State, Nigeria. The study underscores the importance of continuous monitoring and adherence to safety guidelines to mitigate potential health risks associated with EMF exposure, despite the presence of localized "hotspots" of elevated radiation levels.

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