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QUANTITATIVE EVALUATION OF HUMAN EXPOSURE TO RF-EMF FROM SELECTED MOBILE TRANSCEIVER STATIONS IN OKENE, KOGI STATE, NIGERIA

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ABSTRACT
The rapid deployment of mobile transceiver stations (MTS) has raised concerns regarding human exposure to radiofrequency electromagnetic fields (RF-EMF). This study presents a quantitative assessment of RF-EMF exposure levels from selected MTS in Okene, Nigeria. Electric field strength measurements were conducted at radial distances ranging from 1.5 m to 15 m using a calibrated Extech RF-EMF meter. The measured values ranged from 0.083 V/m to 0.127 V/m, which are significantly below the public exposure limit of 61 V/m recommended by the International Commission on Non-Ionizing Radiation Protection. The results indicate compliance with international safety standards. However, limitations such as near-field effects and environmental variability are acknowledged. Continuous monitoring is recommended.

Keywords: RF-EMF, Electric Field Strength, Mobile Transceiver Station (MTS), Power Density, Exposure Assessment, Okene

INTRODUCTION
Mobile phone technology has significantly transformed the telecommunication landscape in Nigeria, resulting in improved connectivity and socio-economic development. Over the past decade, the expansion of mobile network infrastructure by major operators such as MTN, Airtel, Globacom, and 9mobile has led to increased deployment of base transceiver stations (BTS) across urban and rural areas. This rapid growth has enhanced communication services but has also raised concerns regarding public exposure to electromagnetic fields (EMFs).
Radiofrequency (RF) radiation emitted by mobile phones and BTS is classified as non-ionizing radiation, lacking sufficient energy to ionize atoms or molecules. According to the World Health Organization, the primary established biological effect of RF exposure is tissue heating, which occurs only at exposure levels significantly above recommended safety limits (WHO, 2010). Similarly, the International Commission on Non-Ionising Radiation Protection provides guidelines indicating that typical environmental exposure levels from BTS are far below thresholds known to cause adverse health effects (ICNIRP, 2020).
Although ongoing research examines potential non-thermal effects of RF radiation, current scientific evidence has not established consistent or causal relationships between low-level exposure and adverse health outcomes. As such, earlier claims suggesting that non-thermal effects are significantly more harmful than thermal effects are not supported by established literature and are therefore not considered reliable.
Empirical studies conducted in Nigeria have shown that RF exposure levels around BTS installations remain within internationally accepted safety limits. For instance, measurements in Kaduna State using spectrum analyzers indicated that radiation levels from mobile base stations operated by major network providers were within safe limits for public exposure (Aminu *et al*., 2014). Similarly, a study conducted in Lagos reported that power flux density values measured around BTS sites were below the recommended thresholds and unlikely to pose health risks to residents located at reasonable distances (Asiegbu & Ogulaja, 2010). Akinyemi *et al.* (2014) carried out power density measurements within 100m of the MBS. This was done to determine the potential effects of EMF radiation from the MBSs on human health in the Ikeja environs of Lagos State. The highest power density value recorded was 0.28W/m^{2}, which is quite higher than the ICNIRP exposure limit. In 2011, the National Environmental Standards and Regulations Enforcement Agency (NESREA) stipulated that all new facilities shall have a minimum setback of 10 m from the perimeter wall of any premises to the transceiver/mast (NESREA, 2011). International safety standards recommend exposure limits with significant safety margins. For example, ICNIRP guidelines specify a reference level of approximately 61 V/m for public exposure at relevant frequencies. These limits are designed to protect all individuals, including vulnerable populations. While no strict duration limits have been established for mobile phone use, precautionary measures such as using hands-free devices or reducing call duration are often recommended to minimize unnecessary exposure. The Nigerian Communications Commission (NCC, 2009) provided a guideline stating that the distance for transceivers' set-back shall be 5 m from any demised property, excluding the fence.
In addition to electromagnetic radiation, other environmental concerns associated with BTS installations, such as noise and emissions from power generators, may affect nearby residents and should be addressed through proper regulatory compliance. Overall, while mobile communication technology continues to drive development in Nigeria, adherence to international safety standards and continuous monitoring are essential to ensure public health and safety.

Theoretical Framework and Equations
Maxwell's equations govern the interaction of electromagnetic waves with the environment. For far-field conditions, the

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relationship between electric field strength, magnetic field strength, and power density is well established.
The power density (S) of an electromagnetic wave is given by:
$S = E \times H$ (1)
For plane waves in free space, the ratio of electric to magnetic field is constant and equal to the intrinsic impedance of free space:
$\eta = \frac{E}{H} = 3.77\Omega$ (2)
Substituting equation (2) into the power density expression equation (2):
$S = \frac{E^2}{\eta}$ (3)
Thus,
$S = \frac{E^2}{3.77}$ (4)

This shows that power density is directly proportional to the square of the electric field strength.
For isotropic radiation, power density varies with distance according to:
$S = \frac{P_t G}{4\pi r^2}$ (5)
where:
P_t = transmitted power, G = antenna gain, and r = distance from the source
The triaxial electric field E measured by the meter is given by:
$E^2 = E_x^2 + E_y^2 + E_z^2$ (6)
Where: E_x, E_y and E_z are orthogonal components of the electric field.

MATERIALS AND METHODS

The research work was carried out in Okene (lat. 7 ° 33' 4.39" N and long. 6 ° 14' 9.20" E), Kogi State. According to the 2007 population census, Okene has a total population of 279,178. The teledensity in Okene is high due to the communication needs of its growing population. Highly populated residential areas were selected for this research, as depicted in Figure 1.

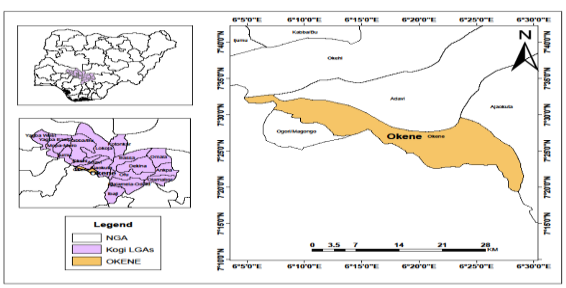

Figure 1: Map of Okene, Kogi State

Electromagnetic field data measurements were conducted using a calibrated Extech RF-EMF strength meter operating within the frequency range of 50 MHz to 3.5 GHz, as shown in Figure 2. Prior to measurements, the instrument was factory-calibrated, and verification checks were performed according to manufacturer specifications.

Figure 2: Extech RF EMF Strength Meter

Radiation power flux density was measured by simply pointing the meter at the RF radiation source. A maximum of about 15 m distance from the base was considered, and measurements were taken at 1.5 m intervals from each base station. Each measurement was made by holding the meter at arm's length, 1.5 m above ground level, away from the body to approximate human exposure, as suggested by Ismail et al. (2010) and Isabona and Odesanya (2015). At each location, measurements were recorded over a 3-minute averaging period to reduce temporal fluctuations. Three repeated readings were taken and averaged. The probe was oriented toward the source, and care was taken to minimize body interference.

RESULTS AND DISCUSSION

The electric field strength of the radio-frequency radiation from selected mobile transceiver stations was measured using an Extech RF Meter in different areas, with their proximity to residential buildings, as shown in Table 1 below.

Table 1: Measured Power Flux Density Level at Different Distances for Mobile Transceiver Stations (Okene)

Power Flux Density Exposure (mW/m²)										
MTS1	38.60	33.56	28.81	26.40	24.62	20.34.	18.70	15.98	12.27	10.56
MTS 2	45.82	40.41	36.23	32.96	30.80	27.56	21.60	22.57	16.80	12.72
MTS 3	28.92	26.65	24.38	20.23	24.83	15.96	18.27	14.67	12.90	10.62
MTS 4	65.76	60.46	54.40	39.12	36.71	30.33	27.19	22.38	24.67	20.19
MTS 5	30.80	25.54	25.59	27.95	22.30	19.22	18.98	18.08	14.27	12.65
MTS 6	27.08	17.53	16.34	15.01	14.46	13.30	18.45	12.32	11.43	10.41
MTS 7	27.96	24.54	24.07	22.15	20.61	19.31	15.09	12.86	11.12	10.04
MTS 8	26.44	23.43	21.55	18.26	34.67	26.83	16.90	16.34	14.31	12.50
MTS 9	60.58	51.87	40.51	35.96	34.74	38.86	33.29	27.92	27.80	17.64
MTS10	27.20	19.45	16.07	13.95	11.74	10.55	13.97	13.81	11.42	9.34
MTS11	44.27	40.89	36.46	33.11	28.87	23.30	20.85	19.83	16.48	14.77
	1.5	**3.0**	**4.5**	**6.0**	**7.5**	**9.0**	**10.5**	**12.0**	**13.5**	**15.0**
Distance (m)										

The measured mean power flux densities for each MTS and their percentage contributions at different locations are shown in Figure 3, with the corresponding percentages in Figure 4.

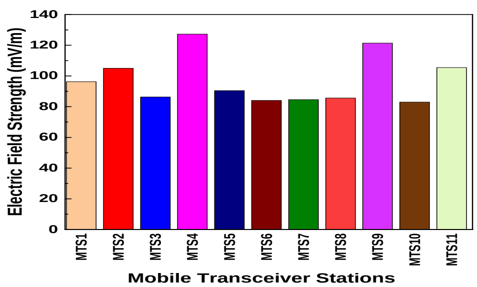

Figure 2: Average electric field Strength Vs MTSs in Okene

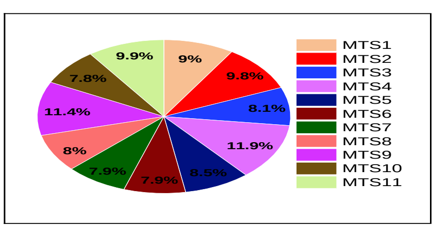

Figure 3: Percentage Contribution of each MTS in Okene

The study observed that the average electric field strength of MTS4 was considerably high, with a contribution of 127.25 mV/m (0.127 V/m) and a percentage contribution of 11.90% compared with others. MTS10 has the lowest contribution value of about 82.97 mV/m (0.083 V/m), with a percentage contribution of 7.8%, which is in agreement with Ushie *et al.* (2013).

Figure 4 shows the plot of mean power flux density against distance for MTS in Okene. An increase in distance results in a decrease in power flux density. The graph shows that the mobile transceiver stations have minimal interference from external sources.

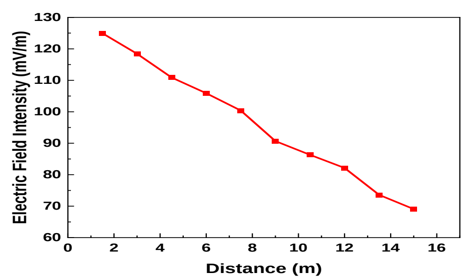

Figure 4: Mean Electric Field Strength Vs Distance Plot in Okene

The measured electric field strength values (0.083 – 0.127 V/m) are significantly lower than the public exposure limit of 61 V/m recommended by the International Commission on Non-Ionizing Radiation Protection. These findings are consistent with similar studies conducted in Nigeria by Ojo *et al. (2025) and* Arekumo and Marere (2024). These consistent findings across different regions in Nigeria strengthen the reliability of the present study and confirm that RF-EMF exposure from mobile transceiver stations generally remains within internationally accepted safety limits.

Conclusion

This study quantitatively evaluated RF-EMF exposure levels around selected mobile transceiver stations in Okene, Nigeria, and found that the measured electric field strength values were well below the limits recommended by international guidelines, particularly those established by the International Commission on Non-Ionizing Radiation Protection. Rather than asserting absolute safety, the findings indicate that current exposure levels comply with established public exposure standards; however, the study is subject to certain limitations, including the restriction of measurements to short radial distances, incomplete characterization of near-field effects, and potential influence of environmental and temporal variations on the readings. Future research should therefore consider extending measurements over larger distance ranges, incorporating long-term monitoring, and applying advanced modeling techniques. In contrast, continuous monitoring and strict adherence to regulatory standards remain essential to ensure public safety as telecommunication

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infrastructure continues to expand.

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