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REVIEW ARTICLE

THE EFFECTS OF RADIO FREQUENCY RADIATIONS FROM TELECOMMUNICATION TOWERS ON OSOGBO RESIDENTS

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ABSTRACT

High frequency electromagnetic radiations affect various biological mediums in a variety of ways. Studies are still being conducted to determine how radio frequency radiation affects people, particularly in light of the abundance of communication masts in urban areas. This study on radio frequency radiation from telecommunication masts was conducted to compare the radiation found in this research with the safe limit established by the International Commission for Non-Ionizing Radiation Protection and to evaluate the continuous electro-sensitivity (ES) conditions associated with exposure to radio frequency radiation emitted from the telecommunication mast on the environment in Osogbo. Power density measurements at six different base stations are covered in this work. Four days' worth of readings were taken at various masts, using the electric strength field. A range of 0 to 500 meters was taken into account. According to the results, Base Station 1 at the base of the GLO mast had the highest power density of 4.271mW/m2, while Base Station 2 at the MTN mast had the lowest power density of 0.048mW/m2. High power density measurements at both base stations were made at distances of less than 100 meters. Additionally, all but one (base station 4) show that power density diminishes with distance exceeding 200 meters. The ICNIRP set a limit for power density of 4.50W/m2 for public exposure, which is well below this maximum number. This research provides an analysis of power density measurements for radio frequency radiation emitted by telecommunication masts. The findings indicate that the levels of public exposure in the vicinity of Okebaale Osogbo and Osun State University are well below the established safety threshold. Consequently, this study offers significant contributions to the understanding of the safety implications associated with urban communication mast radiation.

KEYWORDS

Radio frequency, radiation, emitted telecommunication mast, electromagnetic fields.

1. INTRODUCTION

Our contemporary generation is heavily reliant on technology. Radio-frequency radiation (RFR) exposure is widespread, especially in public places where wireless devices such as mobile phones are routinely used for personal or industrial reasons (Patel, 2018; Pearce, 2020). This research covers the most recent scientific data about health problems related with non-ionizing radiofrequency radiation (RFR) exposure. While there is evidence indicating the possible physiological and/or morphological changes generated by Radio Frequency Radiation (RFR) on bees, plants, and trees, this article will largely focus on its influence on human health.

There are differing viewpoints on the possible risks connected with exposure to radiofrequency radiation (RFR) generated by mobile phones and other wireless transmitting devices (WTDs), such as cordless phones and Wi-Fi (Foster, 2013). In the study of cancer epidemiology, the paradigmatic method is used to investigate causation and includes a thorough review of several types of evidence, such as epidemiological, toxicological, and mechanistic/cellular data (Yunus, 2011).

The need for effective communication and mobile phone use has increased significantly over the last decade, necessitating the increased use of functioning telecommunications networks. Millions of Nigerians were relieved when the Global System for Mobile (GSM) Communications was launched in 2001, granting them access to a variety of services such as mobile TV, electronic payments, mobile tracking, more cost-effective international calls, online banking, and mobile TV. The Global System for Mobile Communications (GSM), according to Bello (2010), has evolved as an important and critical tool for the transmission and exchange of information in modern society. The growing use of mobile phones inside the microwave spectrum has spurred a survey aimed at determining the impact of mobile phone radiation on wireless technology masts, gaining substantial attention and scientific interest. Mobile phone communication methods might result in the production of pulsing carrier signals with low frequency (Onwuka et al., 2018). The biological importance of modulations has been a source of contention, as addressed by (Foster and Repacholi, 2004).

The purpose of this study is to assess the electro-sensitivity (ES) conditions associated with exposure to radio frequency radiation emitted by telecommunication towers. An electric strength field metre will be used

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to measure the amount of radiation emitted by six different telecommunication towers in Osogbo. The goal is to determine if the radiation released by these telecommunication towers is below the safe limit defined by the International Commission on Non-Ionizing Radiation.

According to studies, people who live near telecommunication poles are more likely to develop cancer, lung disease, sleep disturbances, memory loss, poor sperm count, and even physical disability (Hu et al., 2022). According to research by the World Health Organization (WHO), there are now no scientific proofs of health risks linked with telecommunication masts. Living in an environment populated by students and young people necessitates a study of the level of radio frequency radiation emitted by telecommunication masts to determine whether it is high enough to have a significant impact on humans, as some researchers claim, and to make any necessary recommendations. The population density in the three study locations is significant, and growing concerns about the possible detrimental effects of telecommunication mast radiation underscore the necessity for this research. The findings of this study will inform the public about the nature and extent of radiation emitted by telecommunication towers. The Okebaale Osogbo, Osun State University Road Osogbo, and Oja Oba market area Osogbo, all of which had one, two, and four telecommunication masts respectively, were selected. MTN, GLO, ETISALAT, and AIRTEL, the four major network providers, have several base stations consisting of cell towers located across the Osogbo metropolis. However, due to time and budgetary constraints, this work is limited to only the three zones mentioned above, where population density is high and the population is primarily composed of young people. Also, the difficulty to simultaneously quantify the quantities of radiation released by those six telecommunication masts.

2. Measurements of Human Exposure to Nir from Cell Tower

The results of Bolaji et al. (2013) show that, as assessed by RF dosimetry, the human body absorbs and distributes external radio frequency (RF) electromagnetic fields (EMF) in several organs. As reference levels for occupational or population exposure in the far field regions of the sources, international exposure standards for the radio frequency (RF) region of the electromagnetic (EM) spectrum establish maximum acceptable values for the root mean square (RMS) electric field strength (E) or power density (S).

Analysing the distribution of the specific absorption rate (SAR), also known as the temporal derivative of the absorbed energy per unit mass, allows one to estimate how much electromagnetic radiation is being exposed to humans (Bejenaru et al., 2018; Bejenaru et al., 2020). The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has established reference criteria for the general population for frequencies of 900MHz and 1800MHz, which are shown in Table 1.

Table 1: ICNIRP reference levels for public exposure to E.M\ field (Osuagwe and Emmanuel, 2013).

Frequency	Limit for electric field (V/m)		Limit for power density W/m²	
	Public	Occupation	Public	Occupation
900MHz	41.25	90.00	4.50	22.50
1800MHz	58.3	127.28	9.00	45.00

2.2 Parameters Used To Quantify Human Exposure Levels Are

2.2.1 The Electric Field Strength (E)

The size of an electric field at a given place is represented numerically by the electric field strength. The volt per metre (V/m) is considered the standard unit by (Bolaji et al., 2013). Instruments used to measure an electric field (E-field) typically consist of two primary components: a small antenna that detects the presence of an E-field and a detector that converts the resulting signal into a format suitable for registration on a readout device, such as a metre (Kazemipour et al., 2007). The aggregate electric field, according to Bolaji et al. (2013), may be described as a superposition of incident and reflected field elements.

$$E_{tot} = E_{inc} + E_{ref} \tag{1}$$

Where the corresponding incident and reflected electric field components:

$$E_{inc} = \frac{E_0(\phi,\theta)}{R} e^{-j\beta R} \tag{2}$$

And

$$E_{inc} = \rho(\phi,\theta)\frac{E_0(\phi,\theta)}{R} e^{-j\beta R} \tag{3}$$

Where ρ is the appropriate reflection coefficient, and E_0 is the magnitude of the incident wave defined as, (Sabah et al., 2008).

2.2.2 The Magnetic Field Strength

The magnitude of the magnetic field is one of two ways for determining the strength of a magnetic field. There is a technical distinction between magnetic field strength H, which is measured in amperes per metre (A/m), and magnetic flux density B, which is measured in Newton-meters per ampere (Nm/A), commonly known as teslas (T). Magnetic field strength is generally measured in amperes per metre (A/m) (Saha, 2017). This metric is typically examined under air circumstances and may be used to directly estimate an organism's amount of exposure to radio frequency (RF) radiation. Because it is dependent on parameters such as the frequency of the RF field, as well as the size and alignment of the body, the presented measurement does not provide an accurate estimate of the absorbed radio frequency (RF) energy within the human body. Instruments used to measure magnetic field strength are generally made up of two main components: the pickup and the detector. According to Bolaji et al. (2013), the pickup utilised to measure the B-field is usually a loop.

2.2.3 The Specific Absorption Rate

The measure used to calculate the amount of radio frequency electromagnetic radiation (RF EMR) absorbed by the human body. In the metric system, the specific absorption rate (SAR) is generally expressed as Watts per kilogramme (W/kg) (El Amrani et al., 2017). Because of the inherent complexity and requirement for specialist equipment and controlled settings, SAR measurements are often performed by research laboratories. According to Bolaji et al. (2013), the use of Specific Absorption Rate (SAR) as a component of RF dosimetry has been in use since 1974. As seen in equation 4, the relationship under study is the electric field strength, abbreviated as E.

$$S = \frac{\sigma}{\rho|E|^2} \tag{4}$$

Where S is Specific absorption rate in W/Kg, σ is Conductivity, ρ is Density and E is Electric field strength in V/m.

Power Density

The quantity of power dispersed throughout a certain area, measured perpendicular to the direction of gearbox, is referred to as power density. It is frequently measured in Watts per square metre (W/m²). According to the findings of (Akpolile et al., 2014). The power density is the amount of electromagnetic energy per unit area that is used to calculate the amount of radiation radiated from a transmitting antenna at a specific place (Sabah, 2008). Sabah (2008) found these sources of electromagnetic radiation. The sources of electromagnetic interference range from artificial sources like commercial broadcast stations and car ignition systems to natural sources like cosmic noise and lightning discharges. Equation 5 may be used to calculate the power density at the antenna's aperture.

$$S = \frac{PG}{4\pi R^2} \tag{5}$$

The variable S in this equation denotes power density, P the power input to the antenna, G the power gain of the antenna in the specific direction of interest relative to an isotropic radiator, and R the distance to the antenna's centre of radiating. In the case of aperture antennas, Equation 6 offers a more accurate theoretical estimate of power density.

$$S_{surface} = \frac{4P}{A} \tag{6}$$

Where $S_{surface}$ is maximum power density at the antenna surface P is power fed to the antenna A is π*(D/2)² physical area of the aperture antenna and D is the antenna diameter (Sabah, 2008). The equivalent plane wave's power density (P_d) is often represented by Equation 7.

$$P_d = \frac{1}{2} R_e E \times \bar{H} \tag{7}$$

$$P_d = \frac{|E_{rms}|^2}{Z_0} = Z_0 . |H_{rms}|^2 \tag{8}$$

Where $\bar{E} and \bar{H}$ are the electric and magnetic fields intensity of the electromagnetic waves. Z_0 is the impedance of the free space given as;

$$Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} \tag{9}$$

$\mu_0 = 4\pi \times 10^{-7}$ H/m is the permeability of free space

$\mathcal{E}_0 = \frac{10^{-9}}{36\pi}$ F/m is the permittivity of free space

Hence $Z_0 = 377\Omega$

The use of cornet Electrosmog metres is used in this investigation. Because of its low cost, the power density method was chosen as a measuring methodology for radio frequency radiation.

3. METHODOLOGY

3.1 Material

A variety of materials and instruments were used throughout the measurement technique to get accurate and necessary data, which was specifically developed to explore the influence of radio frequency radiations from telecommunication towers on the population of Osogbo. A tape measure, a wristwatch, and the Cornet Electromog RF metre are all part of this comprehensive strategy. The latter is especially noteworthy due to its distinct and specialised qualities (Osuagwu & Emmanuel, 2013).

The Cornet Electromog RF metre used in this investigation displayed great adaptability and dependability, making it an excellent fit for the research goals. The digital interface, electric field sensing capabilities, wide sensitivity and dynamic range, and capacity to measure in multiple units make it an ideal instrument for precisely recording and monitoring radiofrequency emissions, efficiently achieving the study's objectives. Furthermore, the ability to quantify measurements using various units improves data interpretation and ensures that the collected data is not only important but also simply comprehensible. This, in turn, allows for further research and analysis into the impacts of radiofrequency radiation on the Osogbo populace.

3.2 Methods

Over the course of four days, measurements were taken at numerous telecommunication towers in the morning, afternoon, and nighttime. On the first day, the aforementioned steps were documented at the Glo telecommunication tower at Okebaale Osogbo, along the Osun State University Road in Osogbo. On the second day, measurements were taken at Airtel and MTN telecommunications poles located along Okebaale Osogbo Road. On day three, readings were taken at MTN communications towers in the Oja Oba market area. On the fourth day, measurements were performed at Etisalat and MTN cellular towers near Osun State University.

The power density of each telecommunication tower was measured at various distances ranging from 0 to 500 m. Measurements were taken at 10 m intervals for lengths less than 100 m and at 50 me intervals for distances more than 100 m. The electric field strength metre was given enough time to stabilise before taking an accurate measurement. Distances were measured using a tape measure at various intervals, and power density measurements of antennas from each telecommunication mast were recorded at specific time intervals using a smart watch. The data gathered for each telecommunication tower was arranged by time and distance.

4. RESULTS AND DISCUSSION

The findings obtained from studies carried out at the telecommunication masts of Glo, Etisalat, and MTN located near Osun State University, Osogbo are presented in Table 2. The obtained results play a crucial role in evaluating the electromagnetic conditions within the given geographical area.

Table 2: Power density measurement result for three (3) base stations (BS)

Distance (m)	Base station 1(Glo)		Base station 2 (MTN)		Base station 3 (Etisalat)	
	Time (pm)	Power density (S)mW/m²	Time (pm)	Power density (S)mW/m²	Time (am)	Power density (S)mW/m²
0.0	12:45	4.271	5;57	1.827	10:47	0.816
10.0	12:52	4.171	6:01	1.667	10:59	0.761
20.0	12:55	1.276	6:10	1.355	11:01	0.895
30.0	12:59	3.340	6:12	1.235	11:03	0.648
40.0	1:01	3.438	6:16	1.153	11:06	0.564
50.0	1:03	0.711	6:18	0.854	11:08	0.424
60.0	1:05	3.104	6:20	0.527	11:10	0.418
70.0	1:06	2.465	6:21	0.480	11:20	0.428
80.0	1:09	1.355	6:22	0.439	11:23	0.348
90.0	1:11	1.413	6:24	0.381	11:25	0.364
100.0	1:12	1.028	6:25	0.240	11:29	0.332
150.0	1:16	0.515	6:29	0.235	11:32	0.230
200.0	1:19	1.006	6:32	0.141	11:43	0.283
250.0	1:24	0.438	6:38	0.195	11:46	0.200
300.0	1:26	0.648	6:40	0.132	11:50	0.182
350.0	1:31	0.503	6:44	0.120	11:53	0.135
400.0	1:34	0.141	6:47	0.162	11:55	0.115
450.0	1:39	0.105	6:52	0.120	11:56	0.091
500.0	1:42	0.126	6:54	0.095	11:58	0.056

Figure 1 depicts data acquired from three important telecommunications masts: Glo's Base Station 1, MTN's Base Station 2, and Etisalat's Base Station 3. These masts are strategically placed close to Osun State University. The graph above serves as a visual tool to represent electromagnetic field readings within the university's proximity. Its goal is to make it easier to compare and analyse signal strengths and variations across multiple base stations. The aforementioned resource is critical in assessing and comprehending the electromagnetic environment surrounding the institution.

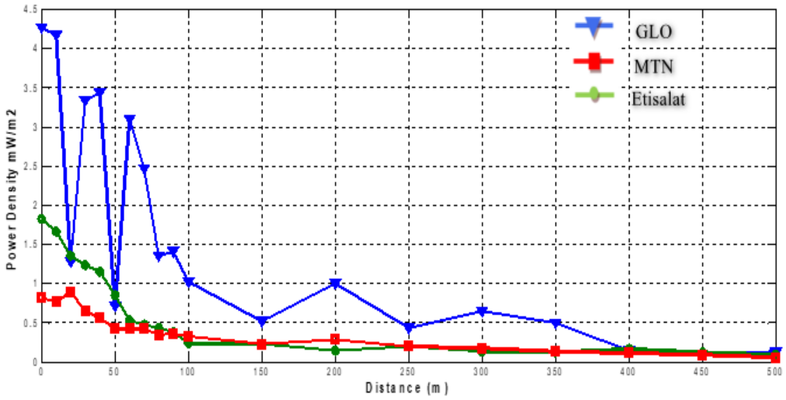

Figure 1: Distribution of power density with distance for three (3) BS

Table 3 presents a thorough summary of the data obtained from three separate telecommunication masts. The initial set of findings can be ascribed to the presence of the MTN telecommunication mast located along the road of Osun State University. The second piece of data relates to the Airtel telecommunication tower situated on Hospital road in Osogbo. The third dataset pertains to the MTN communications tower, specifically identified as the 6th Base Station, ideally located in the vibrant Oja Oba Market vicinity of Osogbo. The findings presented in this study encompass a wide variety of measures pertaining to electromagnetic fields, enabling a comprehensive evaluation of the electromagnetic environment in these particular regions.

Table 3: Power density measurement result three (3) base stations (mast)

Distance (m)	Base station 4 (Airtel)		Base station 5 (MTN)		6th Base station (MTN)	
	Time (am)	Power density(S) mW/m²	Time (am)	Power density(S) mW/m²	Time (am)	Power density (S) mW/m²
0.0	8:45	1.310	10:45	0.711	6:57	0.797
10.0	8:56	1.258	10:48	2.465	7:01	1.235
20.0	9:30	1.195	10:59	1.355	7:06	1.153
30.0	9:33	0.811	11:00	1.413	7:10	0.816
40.0	9:35	0.648	11:01	1.028	7:12	1.027
50.0	9:37	0.356	11:02	1.006	7:16	0.648
60.0	9:38	0.356	11:03	0.767	7:19	0.648
70.0	9:39	0.340	11:04	0.672	7:22	0.564
80.0	9:41	0.767	11:05	0.515	7:25	0.854
90.0	9:45	0.672	11:07	0.439	7:29	0.480
100.0	9:52	0.410	11:09	0.381	7:32	0.439
150.0	9:58	0.079	11:15	0.148	7:35	0.381
200.0	10:03	0.252	11:20	0.132	7:37	0.246
250.0	10:06	0.205	11:23	0.166	7:40	0.240
300.0	10:11	0.159	11:27	0.303	7:44	0.219
350.0	10:15	0.303	11:31	0.155	7:48	0.200
400.0	10:20	0.166	11:35	0.126	7:51	0.148
450.0	10:24	1.027	11:40	0.105	7:54	0.132
500.0	10:30	0.155	11:46	0.141	7:57	0.048

Figure 2 shows a graphical depiction of data collected from three different telecommunications masts, providing significant insights into the electromagnetic environment. The graph displays data from three separate base stations: Airtel's Base Station 4, MTN's Base Station 5 on Osogbo's Hospital Road, and MTN's Base Station 6 in the bustling Wednesday market area. This visual format aids signal intensity comparison and analysis, allowing for the detection of changes and trends within discrete geographical locations.

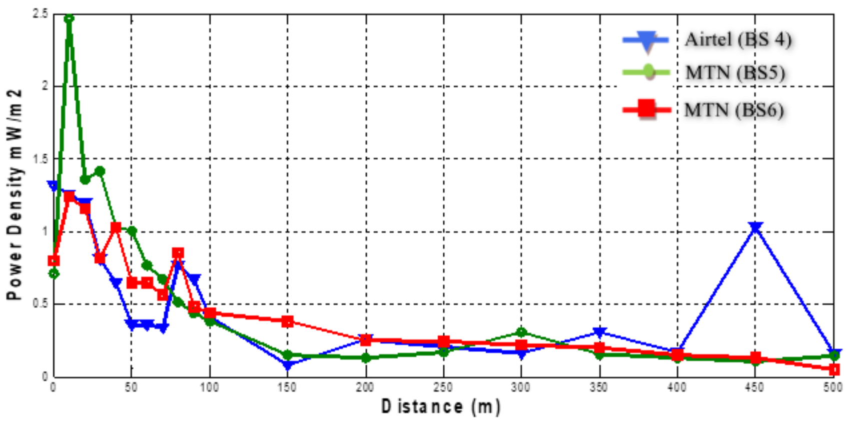

Figure 2: Distribution of power density with distance for three (3) BS

The highest power density values of 4.271 mW/m² and 1.827 mW/m² were recorded at the foot of the mast (0.0m) of the Glo telecommunication mast (Base station 1) and MTN telecommunication mast (Base station 2), respectively, which dropped dramatically to 0.105 mWm² and 0.095 mWm² at the radius of 450m and 500m. While the highest power density of 0.895mW/m² was measured at 20 meters from an Etisalat telecommunication mast (Base station 3), it fell to 0.056mW/m² at 500 m. The highest value of power density 1.310 mW/m² and 2.465 mW/m² were recorded at the foot of the mast (0.0m) of the Airtel telecommunication mast (Base station 4) and at 10m radius of the MTN telecommunication mast (Base station 5) respectively, which decreased to 0.079 mWm² and 0.105 mWm² at 150m and 450m distances, respectively. The greatest power density of 1.235mW/m² was measured at a distance of 10m from the MTN telecommunication mast (6th Base station), dropping to 0.048mW/m² at a distance of 500m. The results show that near the base of the GLO mast, the maximum power density of 4.271mW/m² was measured among the six base stations (Base station 1). Within 100 m of the base states, high power density values were obtained at all sites. On the other side, the lowest power density of 0.048mW/m² was found in the vicinity of an MTN mast (6th Base station). In majority of the charts at distances less than 200m, the connection between power density and distance did not follow a specific trend. However, all but one (base station 4) show that power density declines as distance increases above 200m. The highest power density (4.271 mW/m²) was observed in the afternoon (between 12.00noon and 1.00pm), when the majority of people are outside. However, the greatest power densities of 4.271mW/m², 2.465mW/m², and 1.235mW/m² obtained at Osun State University area, Oke baale road, and Oja Oba market are well below the ICNIRP power density limits of 4.50W/m² and 9.00W/m² for 900MHz and 1800MHz, respectively. According to the aforesaid findings, residents in the Osun State University area, Oke Baale road Osogbo, and Oja Oba market Osogbo are not at risk from radio frequency radiation released by telecommunication masts placed inside those areas.

5. Conclusion

The detailed study was out in the municipality of Osogbo to examine the radio frequency radiation emissions from six telecommunication towers yielded interesting results. The power density readings were found to be significantly lower than the criteria specified by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), easing immediate concerns about potential health effects.

However, the research findings did reveal distinct abnormalities within a 200-meter radius of these antenna towers, underscoring the importance of exercising caution while locating base stations in urban areas. Regulation of the proximity of cell towers to schools and residential structures is required to address the potential concerns connected with cumulative radiation absorption and the hazards of mast collapse.

Given the aforementioned findings, it is critical for the government to develop a consistent system of surveillance relative to the location of network provider masts. This is required to ensure compliance with a minimum distance limit of 500 m from both private houses and public spaces. Implementing this preemptive measure would successfully protect the local community's welfare and eliminate any risks associated with communications infrastructure. Through the execution of these standards and the frequent performance of audits, governing bodies may promote the responsible implementation of communications infrastructure, therefore nurturing a safe and well-being-promoting urban environment.

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