TIMBOU-AFRICA PUBLICATION INTERNATIONAL JOURNAL FEBRUARY, 2026 EDITIONS.

INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH AND TECHNOLOGY
VOL. 11 NO. 5 E-ISSN 3027-1770 P-ISSN 3026-8095

ASSESSMENT OF POWER-FLUX-DENSITY OF MOBILE TRANSCEIVER STATIONS IN GIDAN-KWANO, BOSSO LGA, NIGER STATE

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DOI: https://doi.org/10.70382/tijert.v11i5.023

ABSTRACT

The benefits of electromagnetic fields of mobile transceiver stations (MTS) to society are numerous. However, there are disagreements on whether or not emissions from different mobile cell towers are harmful for human health. Therefore, the assessment of the power flux density of the electromagnetic radiation coming from mobile transceiver stations (cell towers) close to residential areas are the main focus of this study. The signal levels of all the mobile telecommunication networks in Gidan-

Introduction

The modern telecommunication networks are fundamentally dependent on mobile transceiver stations, which are integral to the functionality of cellular networks globally. These stations, commonly referred to as cell towers, are responsible for the transmission and reception of radio frequency (RF) radiation, enabling the seamless wireless communication that underpins contemporary society. The deployment of these stations has escalated with the increasing demand for mobile data and voice services, leading to a widespread presence in both urban and rural environments (Harris, 2021). RF radiation, a form of non-ionizing electromagnetic energy, occupies a specific portion of the electromagnetic spectrum. It is characterized by frequencies that are insufficient to cause ionization of atoms or molecules, which differentiates it from high-energy radiation such as X-rays or gamma rays (Smith & Jones, 2020).

The rapid and extensive rollout of mobile infrastructure has inadvertently placed significant populations in close proximity to these sources of RF radiation, which has become a focal point of public and scientific inquiry. Public discourse is often characterized by concerns regarding the

Kwano, Bosso Local Government Area, Niger State were measured with RF Strength Meter Level (480836 Meter) along all the possible accessible routes and the corresponding distances and locations (coordinates) were also measured using Global Positioning System (GPS). The analysis revealed that power flux density varied significantly across different locations, largely due to environmental factors such as topography, building, and vegetation. Despite these fluctuations, the maximum measured signal strength was 6.172 V/m and the maximum power flux density was 101.7 mW/m^2, which are well below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommended safety limit of 61 V/m and 4,500 mW/m^2 (for 900 MHz) for signal strength and power flux density respectively, signifying that public exposure levels remain within safe limits.

Keywords: power flux density, electromagnetic radiation, mobile transceiver, signal level.

potential long-term health consequences of continuous exposure to low-level RF fields. These concerns have spurred a considerable body of research aimed at understanding the intricate interactions between RF radiation and biological systems. While regulatory bodies and international organizations have established safety guidelines primarily based on the prevention of thermal effects, which are well-understood, the investigation into potential non-thermal biological effects remains a complex and active area of study (Roberts, 2021). The lack of absolute consensus in the scientific community, combined with the continuous evolution of mobile technology, necessitates the assessment of human exposure to RF radiation from these transceiver stations.

Despite the widespread deployment of mobile transceiver stations and their integral role in modern society, a significant gap exists in the comprehensive understanding of the direct health impacts of low-level RF radiation exposure on the human population. Existing international and national safety guidelines, such as those from the International Commission on Non-Ionizing Radiation Protection (ICNIRP), are primarily based on preventing acute thermal effects, which are well-documented and occur at high power densities (Roberts, 2021). However, a growing body of research suggests the possibility of non-thermal biological effects at exposure levels far below these established thresholds. The conflicting results from various studies, which range from no observed effects to reported associations with symptoms like headaches, fatigue, and sleep disturbances, create a high degree of ambiguity and public concern. This lack of a definitive scientific consensus challenges the adequacy of current regulatory frameworks and highlights the necessity for a more thorough assessment of actual human exposure levels. Therefore, a clear understanding of the RF radiation levels in residential areas and a critical evaluation of their potential biological implications are essential to address public anxiety and inform future policy decisions. Therefore, this work aimed to assess the power flux density of the electromagnetic radiation from mobile transceiver stations in Gidan-Kwano, Bosso Local Government Area of Niger State.

THEORETICAL FRAMEWORK

The theoretical foundation for understanding the interaction between radio frequency (RF) radiation and biological systems is rooted in electromagnetic theory. Mobile transceiver stations emit non-ionizing electromagnetic waves, characterized by their frequency and power density, which can be absorbed by biological tissues (Cioni *et al.,* 2012). The primary mechanism of interaction at the power levels typically encountered is the induction of electric currents and the subsequent heating of tissue, a phenomenon known as the thermal effect (Annida *et al.,* 2021). This thermal effect is the basis for most international safety guidelines, which set limits on the Specific Absorption Rate (SAR) to prevent tissue damage. However, a significant body of research has also investigated non-thermal effects, which are defined as biological changes that occur without a significant increase in temperature (Ghanem *et al.,* 2017). These studies explore a range of potential effects, including impacts on gene expression, cellular signaling, and oxidative stress, at exposure levels below the thermal thresholds. The ongoing scientific debate between these two schools of thought (thermal versus non-thermal effects) highlights the complexity of this field and the need for a comprehensive assessment that considers all potential mechanisms of interaction.

MATERIALS AND METHODS

Measurement of the electric field strength and power flux density of the electromagnetic radiation from mobile transceiver stations in Gidan-Kwano, Bosso Local Government Area of Niger State were carried out with Extech RF EMF Strength Meter Level (480836 Meter) while Global Positioning System (GPS 72 – Personal Navigator) was used to measure line-of-sight distances and coordinates (Longitude and Latitude) as shown in Figure 1 and 2

Figure 1: Extech RF EMF Strength Meter Level (480836 Meter)

Figure 2: Global Positioning System (GPS 72 – Personal Navigator)

E-ISSN 3027-1770
P-ISSN 3026-8095

Study Area and Site Selection

The research was conducted in Gidan-Kwano (Figure 3), a growing community that hosts the main campus of Federal University of Technology, Minna in Niger State and the community has a significant residential population. The area is served by three mobile network operators, which are MTN, Airtel, and Glo, making it a suitable location for this study. There are only four active Base Transceiver Stations (BTS) within Gidan Kwano community.

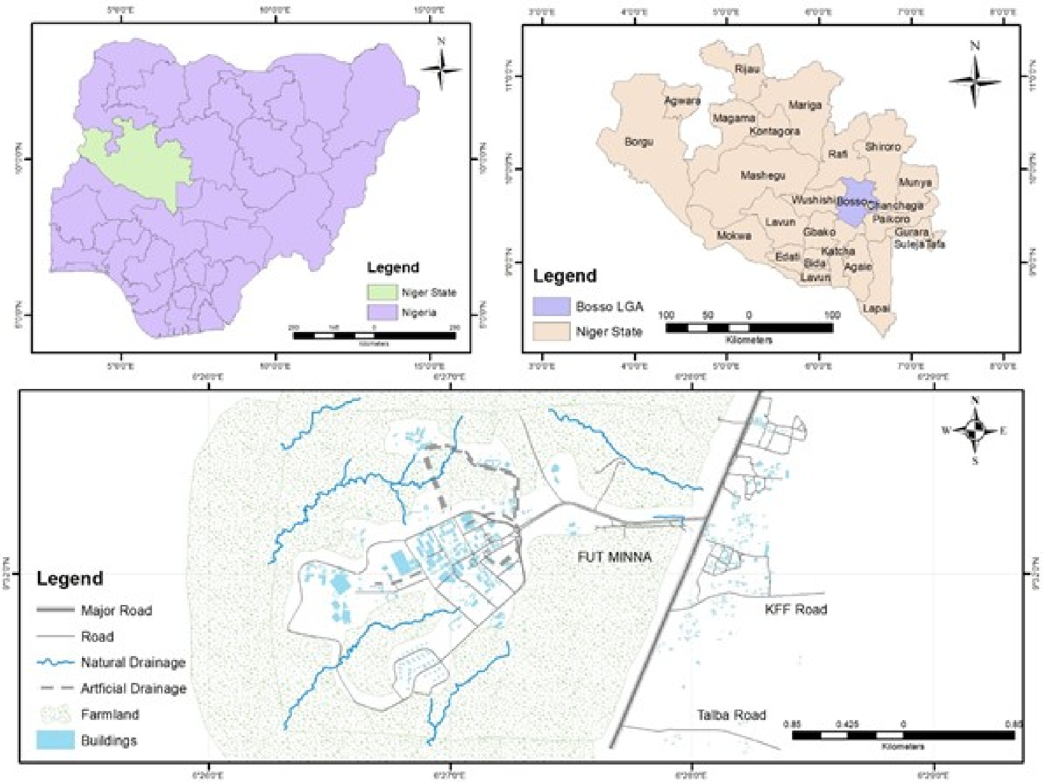

Figure 3: Map of Gidan Kwano

Data Collection and Analysis

A selected BTS site was used as the point of reference for measurement. The measurement of the power flux density was made by pointing the meter (Extech RF EMF Strength Meter Level, 480836 Meter) to the source of RF radiation and measurements were taken at 100 m interval from each base station. Also, Global Positioning System (GPS 72 – Personal Navigator) was used to measure the corresponding distances away from the base of the transmitting antenna and the coordinate (Longitude and Latitude) of each location.

Data processing and computation were carried out using a computer spreadsheet program (Microsoft Excel) running on a personal computer and Suffer 16 software application was used for the coverage area of the mobile network.

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To reduce the possibility of body interference during readings, the RF meter was held at arm's length while taking measurements as suggested by Ismael *et al.* (2010). Each reading was allowed to stabilize for about two minutes before it was recorded to ensure accuracy. In addition, precautions were taken to avoid interference from external sources such as active mobile phones, moving vehicles, and nearby electronic equipment, which could have distorted the readings.

Estimation of Power and Energy Exposure to Human Body

The potential power exposure to human body from the BTS was estimated by modeling a human body as a cylinder with an average height of 1.71 m (NBRRI Report 10) and waist circumference of 0.951 m (Peters *et al.*, 2018; Australian Bureau of Statistics, 2022).

The curved surface area (CSA) of human body was computed as:

$$CSA = waist\ circumference \times height = 1.62621\ m^2 \quad (1)$$

The power exposure was calculated as:

$$P_{exposure} = P_d \times CSA \quad (2)$$

$$P_{exposure} = 1.62621 P_d \quad (3)$$

where P_d is the power flux density in W/m^2. This gave an estimate of potential radiation exposure on the human body in the studied environments.

To estimate the cumulative energy exposure in joules, the power was multiplied by the time of exposure, t, in seconds

$$Energy_{exposure} = P_{exposure} \times t \quad (4)$$

RESULTS AND DISCUSSION

The results showed that the measured RF power flux density and the electric field strength values were well below the standard limits set by international bodies, such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines for public exposure as shown in Figure 4 to 7 and Table 1. The signal strength generally tends to decrease with increasing distance from the base station, consequently, decreasing power flux density with distance. This observation aligned with the principle of electromagnetic wave propagation, where signal strength attenuates as it spreads out from its source. However, this attenuation was not uniform, the graphs showed significant fluctuations, characterised by sharp peaks and troughs at various distances as a result of environmental factors such as buildings, trees, and other obstructions. Also, the signals started to increase as it was getting closer to another mobile base station. Figure 8 showed the power flux density distribution across the signal coverage area of the study area.

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P-ISSN 3026-8095

Comparing the results with the safety limits set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2020), the maximum measured signal strength was 6.172 V/m and the maximum power density was 101.7 mW/m² which are significantly below the ICNIRP's recommended safety limit of 61 V/m and 4,500 mW/m² (for 900 MHz) for signal strength and power flux density respectively. The measured peak value of the power density is approximately 44 times lower than the safety limits for general public exposure. This result demonstrates that even at the points of highest measured intensity or power, the RF radiation levels in Gidan Kwano, the study area, remain well within the bounds of international safety standards. The energy exposure from the mobile base stations for an adult of average size per hour and per day are 553.94 kJ/h and 13,294.55 kJ/day respectively. Therefore, based on these findings, the cumulative RF emissions from the mobile base stations in the area do not pose a health risk to the general public. This conclusion aligns with findings from similar studies conducted in other urban and semi-urban areas in Nigeria (Jokela, 1998; Asiegbu & Ogulaja, 2010; Aminu *et al*., 2014).

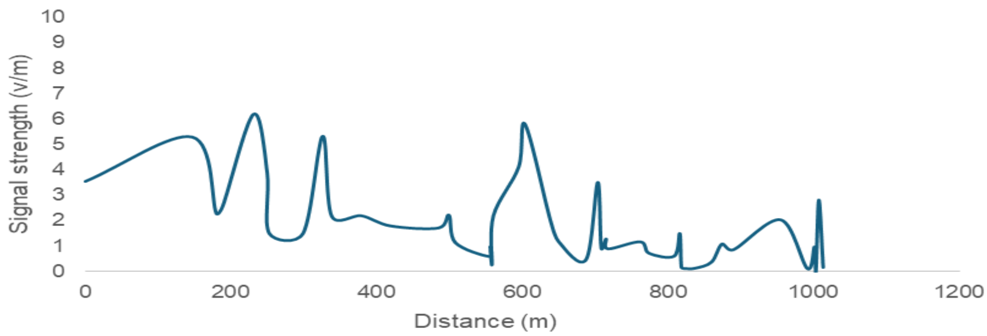

Figure 4: Electric Field Strength

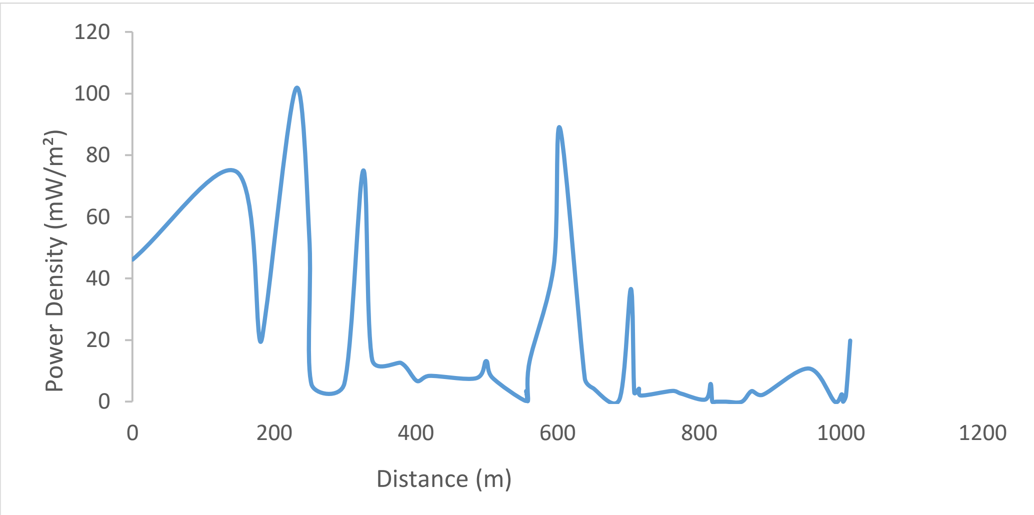

Figure 5: Power Flux Density

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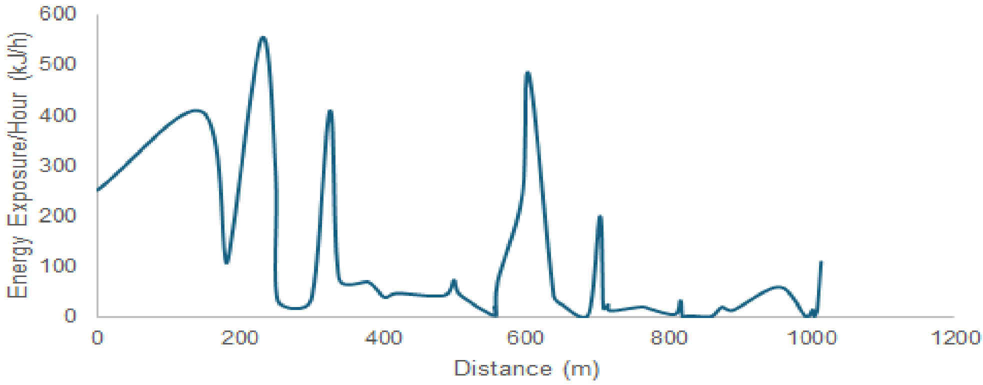

Figure 6: Energy Exposure/Hour

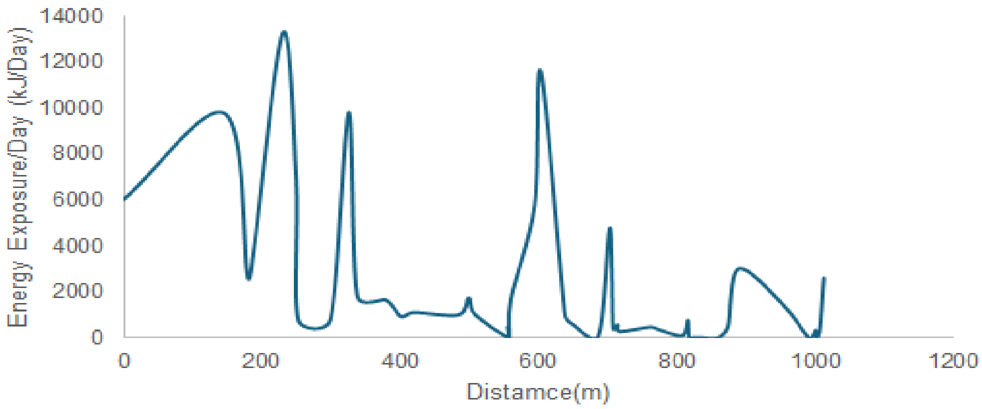

Figure 7: Energy Exposure/Day

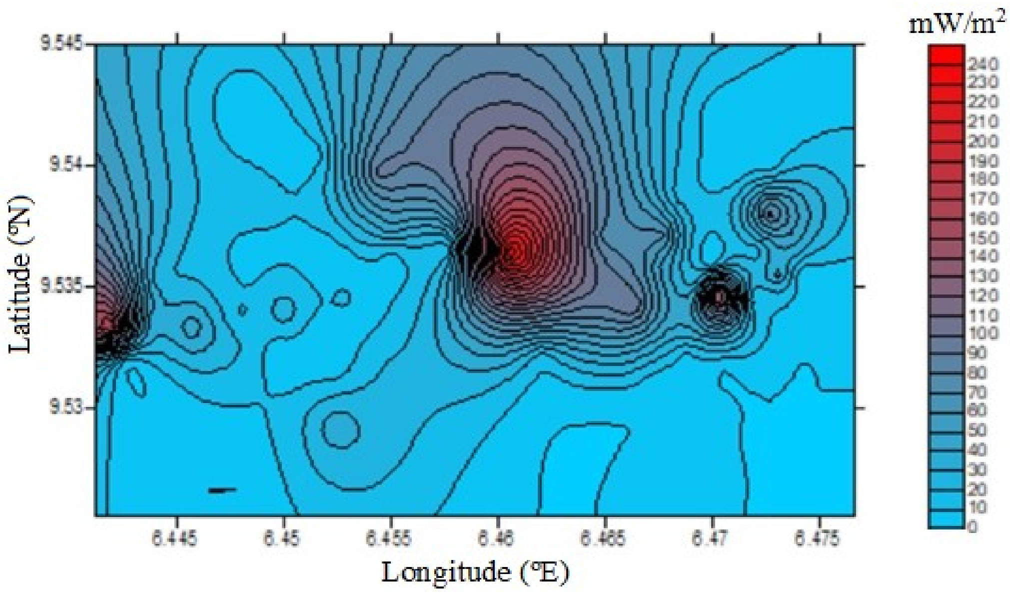

Figure 8: Power Flux Density Distribution across the Signal Coverage Area

E-ISSN 3027-1770
P-ISSN 3026-8095

Table 1: Comparison of maximum measured RF signals with ICNIRP safety limits parameters

Parameters	Frequency band/range	ICNIRP Limits	Maximum measured value	Compliance status
Electric Field Strength	10 - 300 MHz	61 V/m	6.172 V/m	Within safe limits
Power flux density	900 MHz	4500 mW/m²	101.7 mW/m²	Within safe limits
	1800 MHz	9000 mW/m²		
	2100 MHz	10000 mW/m²		

CONCLUSION

Based on the empirical measurements and subsequent analysis, this study concludes that human exposure to radio frequency (RF) radiation from mobile transceiver stations within the study area is well within the recommended safety limits as adopted by many countries, including Nigeria. The measured maximum power density value is 101.7 mW/m² and the measured maximum level for electric field strength value is 6.172 V/m which are consistently far below the maximum permissible exposure levels set by international bodies like the ICNIRP.

The research, therefore, concludes that the public is not exposed to RF radiation at levels that would cause acute thermal effects and, based on current scientific consensus on thermal effects, may pose no immediate health risk to the populace living within these regions. However, it is imperative to acknowledge that the general public should be made aware of the potential for low-level radiation to accumulate over a long period, a subject that remains a focus of ongoing scientific investigation.

REFERENCES

Aminu, A, Danladi, A.T., Yahaya, H.A., & Zakariyya, H.A. (2014). Measurement of Electromagnetic Waves Radiated from Base Transceiver Stations (BTS) for Assessing Exposure Limit in Kaduna State. *International Journal of Engineering and science*. 3, 28-34.

Annida, A., Supriyanto, T., & Nugroho, H. (2021). Review of Radio Frequency Radiation Effects from Cell Phone Towers on Human Health. Journal of Physics: Conference Series, 2034(1), 012014.

Asiegbu, A.D. & Ogulaja O.O. (2010). Preliminary investigation of R.F. Exposure Levels from Mobile. Telephone Base Stations in Abia, South east Nigeria, *International Journal of Current Research.* 11, 47-53

Cioni, R., D'Inzeo, G., & Fara, G. M. (2012). A brief review of the biological effects of radio frequency radiation on the human body. *The Journal of the Egyptian Public Health Association*, 87(2), 79-84.

Ghanem, G. A., Ghamrawy, M. E., El-Shami, S. M. & Hassan, S. M. (2017). Biological Effects of Electromagnetic Radiation Emitted by Cell Tower Base Stations and Other Wireless Antenna Arrays. *International Journal of Scientific and Research Publications*, 7(3), 619.

Harris, T. (2021). The global rise of mobile communication technology. *Journal of Telecommunications Policy*, 45(3), 201-215.

ICNIRP (2025, November 10). Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). *Health Phys* 118(00):000–000; 2020. Pre-print. DOI: 10.1097/HP.0000000000001210.

Jokela, K (1998), Theoretical and Measured Power Density in Front of VHF/UHF Broadcasting Antennas. *Journal of Health Physics*, 54(5), 533-543.

Roberts, E. (2021). Non-ionizing radiation and human health: A review of current research and safety standards. *Public Health Journal*, 15(1), 45-58.

Smith, J. & Jones, A. (2020). Fundamentals of electromagnetic radiation. *Science Publishing*, 101-115.

E-ISSN 3027-1770
P-ISSN 3026-8095