

## Evaluation of Radiofrequency Power Flux Density from Mobile Base Transceiver Stations in Gidan-Mangoro, Bosso Local Government Area, Niger State, Nigeria

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### ABSTRACT

Radiofrequency (RF) radiation emitted from Global System for Mobile Communication (GSM) Base Transceiver Stations (BTS) is classified as non-ionizing radiation. Nevertheless, concerns have been expressed worldwide regarding the possible health effects associated with prolonged exposure, particularly for individuals residing close to BTS installations. The International Agency for Research on Cancer has categorized RF electromagnetic fields as possibly carcinogenic to humans (Group 2B), highlighting the need for continued scientific investigation. This study evaluated the power flux density of RF radiation emitted from mobile transceiver stations located near residential areas of Gidan-Mangoro in Bosso Local Government Area of Niger State in order to determine compliance with safety standards recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Measurements of signal levels from three mobile network operators (MTN, GLO and Airtel) available within the study area were carried out using an RF Strength Meter (Model 480836). Several measurements were taken along all the accessible routes to cover the study area, while the corresponding distances and geographic coordinates were recorded using a Global Positioning System (GPS) device. The results indicated that power flux density varied across different locations, largely influenced by environmental conditions such as terrain, buildings, and vegetation. Despite these variations, the highest recorded value was 109.4 mW/m<sup>2</sup>, which is below the ICNIRP recommended public exposure limits of 4,500 mW/m<sup>2</sup> (900 MHz), 9,000 mW/m<sup>2</sup> (1,800 MHz) and 10,000 mW/m<sup>2</sup> (2,700 MHz). These findings suggest that RF exposure levels within the study area remain within internationally accepted safety limits.

### Keywords:

Electromagnetic Radiation,  
Power Flux Density,  
Radiofrequency,  
Mobile Transceiver.

### INTRODUCTION

The rapid expansion of the Global System for Mobile Communication (GSM) has significantly transformed the telecommunications sector in Nigeria and has become an essential component of modern communication and economic activities (Akanji *et al.*, 2023). As mobile network usage continues to grow, the number of Base Transceiver Stations (BTS), which serve as the primary infrastructure for wireless communication, has also increased substantially. These installations comprise antennas, transmitters, amplifiers, and other electronic equipment that continuously emit radiofrequency (RF) radiation to facilitate network connectivity (Umar *et al.*, 2017). Although RF radiation belongs to the category of non-ionizing radiation and therefore lacks sufficient energy to break chemical bonds within biological tissues,

global concern persists regarding the potential health consequences of prolonged exposure. This concern is particularly relevant for individuals living in close proximity to BTS facilities (Ali *et al.*, 2021).

The International Agency for Research on Cancer (IARC) has classified RF electromagnetic fields as possibly carcinogenic to humans (Group 2B), indicating that further research is required to better understand the associated risks (IARC/WHO, 2011). In Nigeria and many other developing countries, BTS installations are often located within densely populated residential areas, including near homes, markets, and schools. In some instances, such installations may occur without strict enforcement of international safety guidelines. As a result, public concern has increased regarding the potential health implications of RF exposure. Possible

effects associated with RF radiation exposure include thermal effects such as localized tissue heating, as well as other reported symptoms including headaches, fatigue, and sleep disturbances (Gasmelseed, 2026). Although the long-term health implications of RF exposure remain a subject of ongoing scientific debate, the issue warrants systematic investigation, particularly in areas with high population density. Previous studies have suggested that individuals residing closer to cellular base stations may experience a higher occurrence of certain health complaints (Maduka *et al.*, 2019).

International regulatory organizations have established exposure guidelines to ensure public safety. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) provides limits that are widely adopted across many countries, including Nigeria. For instance, the recommended reference level for power density is 4.5 W/m<sup>2</sup> for GSM frequencies around 900 MHz and 9.0 W/m<sup>2</sup> for frequencies near 1800 MHz. Additionally, the whole-body Specific Absorption Rate (SAR) limit for the general public is set at 0.08 W/kg (Elechi *et al.*, 2019). Similarly, the Institute of Electrical and Electronics Engineers (IEEE) has established standards for human exposure to RF fields that are largely consistent with those of ICNIRP. These guidelines are derived from extensive scientific research and incorporate significant safety margins to protect public health. The general consensus among regulatory bodies is that exposure levels below these recommended limits are unlikely to produce adverse health effects (Geidam & Kassim, 2021).

In view of the increasing deployment of telecommunications infrastructure, this study measured the power flux density of RF radiation emitted from mobile transceiver stations in Gidan-Mangoro, Bosso Local Government Area of Niger State. The research provides empirical data on RF radiation levels within the area, thereby contributing to the limited scientific information currently available for the region.

Numerous investigations have been undertaken to quantify and evaluate radio-frequency (RF) radiation levels in different environments in order to assess the extent of public exposure. A common observation reported in many of these studies is that RF radiation

levels measured in public spaces, including residential areas, are typically far below the safety limits recommended by international and national regulatory authorities (Annida *et al.*, 2021). For instance, research carried out across several urban locations reported that the recorded power density values consistently remained within the prescribed regulatory thresholds, indicating that public exposure is unlikely to pose a significant risk in terms of thermal effects (Gajšek *et al.*, 2021).

Nevertheless, some studies have identified localized areas with relatively higher exposure levels. Such instances are often observed in locations situated very close to transmitting antennas or in environments with a high concentration of transceiver stations. Differences in reported findings can largely be attributed to variations in measurement procedures, the characteristics and transmission power of the base stations, and environmental conditions such as terrain, building structures, and population density (Annida *et al.*, 2021). In addition, fluctuations in network traffic contribute to temporal changes in RF radiation levels, implying that studies based on single or limited measurements may not adequately represent the full range of possible exposure. The variation in methodologies and outcomes across existing studies underscores the importance of adopting more standardized measurement procedures, as well as conducting comprehensive analyses of the factors influencing RF exposure levels. Such improvements are essential for generating accurate and dependable data that can support informed public discussions and guide regulatory policy decisions.

## MATERIALS AND METHODS

The electric field strength and power flux density of electromagnetic radiation emitted by mobile transceiver stations in Gidan-Magoro, Bosso Local Government Area of Niger State were measured using an Extech RF EMF Strength Meter (Model 480836). A Global Positioning System device (GPS 72 – Personal Navigator) was also used to determine the line-of-sight distances and geographic coordinates (longitude and latitude), as illustrated in Figures 1 and 2.



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



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

**Study Area and Site Selection**

The study area, Gidan-Mangoro (Figure 3), is a significant and growing community, with students and the indigenous people, because of its proximity to a university campus (Federal University of Technology, Minna). The area is served by three mobile network

operators and they have one mobile transceiver station each to serve the population, making it a suitable location for assessing human exposure levels to RF radiation and ensuring they fall within safe limits as stipulated by regulatory bodies.

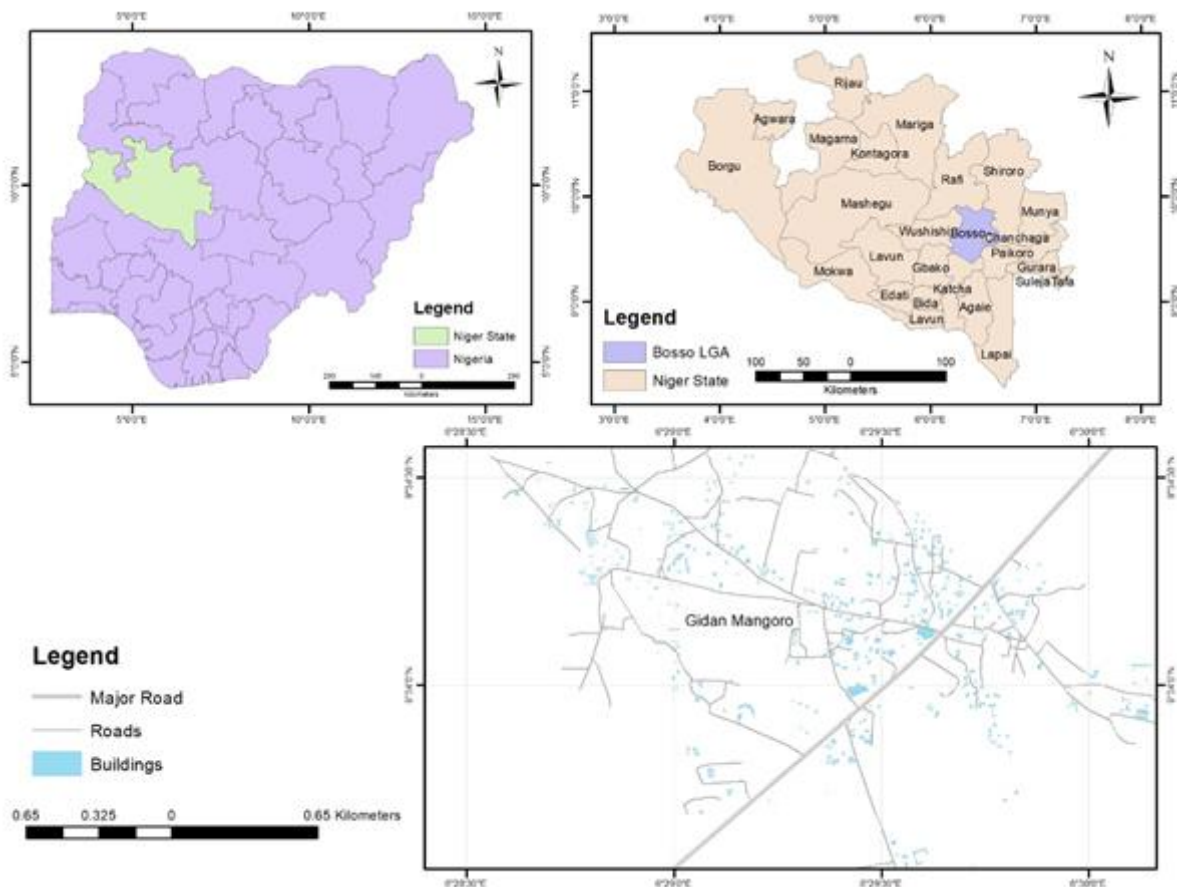


Figure 3: Study Area Map of Gidan-Mangoro

### Data Collection and Analysis

One of the Base Transceiver Station (BTS) sites was selected as the reference point for the measurements. The power flux density measurements were obtained by directing the Extech RF EMF Strength Meter (Model 480836) toward the radio-frequency (RF) radiation source. Measurements were taken at intervals of 100 m from each base station. A Global Positioning System device (GPS 72 – Personal Navigator) was also employed to determine the corresponding distances from the base of the transmitting antenna, as well as the geographical coordinates (longitude and latitude) of each measurement point. Each measurement was allowed to stabilize for approximately two minutes before being recorded to improve accuracy. Furthermore, precautions were taken to prevent interference from external sources, such as active mobile phones, passing vehicles, and nearby electronic devices, which could otherwise influence the readings.

The collected data were processed and analyzed using a computer spreadsheet program, Microsoft Excel, while Surfer 16 software was utilized to generate the coverage map of the mobile network.

### 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 (NBRRRI Report 10) and waist circumference of 0.951 m (Australian Bureau of Statistics, 2022).

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

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

The power exposure was calculated as:

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

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

Where  $P_d$  is the power flux density in  $\text{W}/\text{m}^2$ . 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

$$\text{Energy}_{\text{exposure}} = P_{\text{exposure}} \times t \quad (4)$$

### RESULTS AND DISCUSSION

The findings revealed that the measured radio-frequency (RF) power flux density and electric field strength were significantly below the standard exposure limits recommended by international regulatory bodies, particularly the guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for public exposure, as shown in Figures 4 to 6. The results further indicated that signal strength generally decreased with increasing distance from the base transceiver station, resulting in a corresponding reduction in power flux density. This trend is consistent with the theoretical principles of electromagnetic wave propagation, whereby signal intensity diminishes as it spreads away from the source. However, the observed attenuation was not uniform. The graphical results displayed noticeable fluctuations, including pronounced peaks and troughs at different distances. These variations can be attributed to environmental influences such as buildings, vegetation, and other physical obstructions. Additionally, an increase in signal strength was observed as the measurement points approached another mobile base station. Figure 7 presents the spatial distribution of power flux density within the signal coverage area of the study region.

When the measured values were compared with the safety limits established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2020), the maximum recorded power density was  $109.4 \text{ mW}/\text{m}^2$ , which is substantially lower than the recommended limit of  $4,500 \text{ mW}/\text{m}^2$  for frequencies around 900 MHz. This indicates that the peak measured value is approximately forty-one times lower than the threshold specified for public exposure. The results therefore suggest that, even at locations where the highest radiation levels were detected, RF emissions within Gidan-Mangoro, the study area, remain well within internationally accepted safety standards.

Furthermore, the estimated energy exposure from the mobile base stations for an average adult was calculated to be 640.47 J per hour and 15.37 kJ per day. Based on these observations, it can be inferred that the cumulative RF emissions from the base stations in the study area do not constitute a significant health risk to the general population based on thermal effects. This conclusion aligns with findings from similar studies conducted in other urban and semi-urban areas in Nigeria (Jokela, 1988; Asiegbu & Ogulaja, 2010; Aminu *et al.*, 2014).

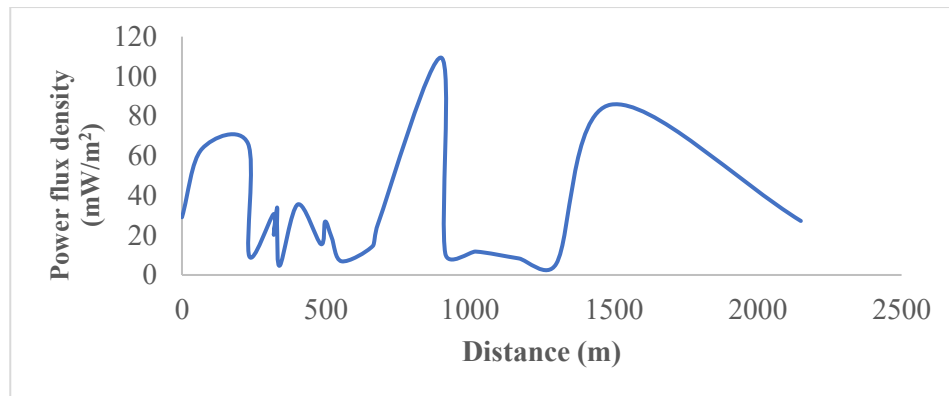


Figure 4: Power Flux Density

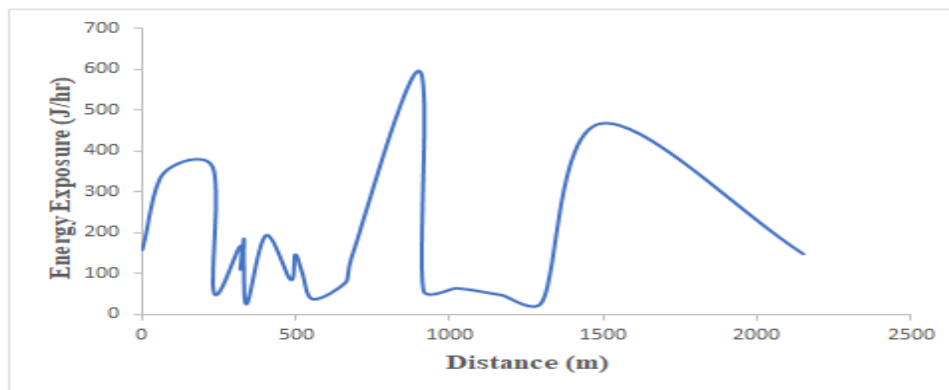


Figure 5: Energy Exposure/Hour



Figure 6: Energy Exposure/Day

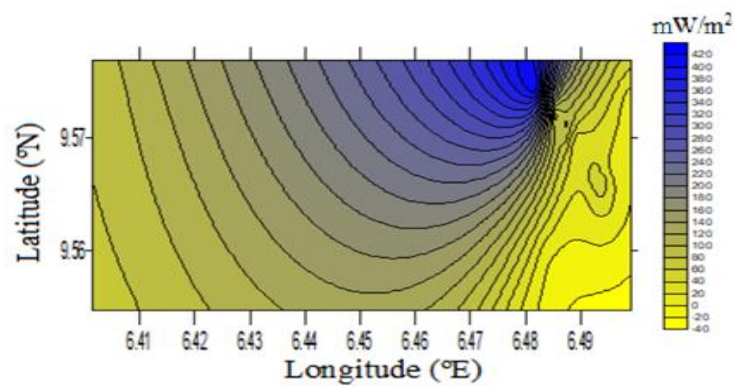


Figure 7: Power Flux Density Distribution across the Signal Coverage Area

## CONCLUSION

This study assessed the levels of radio-frequency (RF) radiation emitted from the mobile transceiver stations within the study area through empirical field measurements and analytical evaluation. The results obtained indicate that the power flux density recorded during the investigation are significantly below the exposure limits recommended for the general public by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). In particular, the maximum measured power density of 109.4 mW/m<sup>2</sup> is substantially lower than the ICNIRP guideline limit of 4,500 mW/m<sup>2</sup> for frequencies around 900 MHz. This substantial safety margin indicates that RF emissions from the studied base transceiver stations fall well within internationally accepted regulatory standards.

The findings therefore suggest that residents within the study area are not exposed to RF radiation levels capable of producing adverse thermal effects. Despite the reassuring results obtained in this study, it is important to recognize that public concern regarding long-term exposure to low-level RF radiation still persists. While current international guidelines are primarily based on established thermal effects, continuous monitoring and further research remain necessary to better understand possible long-term biological impacts of prolonged exposure.

Consequently, regulatory authorities and relevant stakeholders should continue to enforce compliance with established exposure standards and maintain routine environmental monitoring of telecommunications infrastructure. In addition, further studies involving longer observation periods, a larger number of base stations, and advanced measurement techniques are recommended in order to provide more comprehensive data on RF radiation exposure in rapidly expanding urban and semi-urban environments.

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