International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 9 Issue 5 May - 2025, Pages: 104-108

Assessment of Radio Frequency Radiation Emitted by Mobile Phones during Call and Text Modes at Varying Distances

[1*]Matudi Peter Basho, [2]Joel Aliya and [2]Department of Physics

[1*]Department of Pure and Applied Physics, Federal University, Wukari Taraba State
2Modibbo Adama University, Yola, Adamawa State
Correspondent: matudipeter@gmail.com

Abstract: *This study aimed to measure the intensity of RF radiation emitted from a mobile phone during call and text modes at varying distances (2 cm, 5 cm, and 15 cm) from six sides of the device—front, back, top, bottom, left, and right. Using an Electromagnetic Radiation (EMR) meter, magnetic flux densities were recorded and converted into power densities (µW/m²). Results indicated that the highest radiation was emitted from the front of the phone in call mode at 2 cm (1.92 µW/m²), followed by text mode (1.17 µW/m²), with radiation levels decreasing substantially at greater distances. All recorded values were significantly below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) safety limits of 4.5 W/m² and 9.0 W/m² for GSM 900 and 1800 MHz respectively. Although the findings suggest minimal risk of immediate biological harm, the potential for long-term thermal effects from frequent close-range usage underscores the need for precautionary measures. The study concludes by recommending increased public awareness, safe phone usage practices, and clearer consumer information on device-specific absorption rates to mitigate possible health implications.*

Keywords: Radiofrequency Radiation, Mobile Phone Emissions, Electromagnetic Field (EMF), Specific Absorption Rate (SAR), Thermal Effects

1. Introduction

The rapid expansion of mobile telecommunications has revolutionized global communication, enabling instant connectivity across continents. According to the International Telecommunication Union (ITU), as of 2022, there were over 8.6 billion mobile cellular subscriptions worldwide, surpassing the global population and reflecting the ubiquity of mobile phone usage (ITU, 2022). With increasing dependence on mobile phones for both personal and professional purposes, concerns have emerged regarding the potential health risks associated with prolonged exposure to radiofrequency (RF) radiation emitted by these devices (Hardell & Carlberg, 2019).

Globally, the discussion surrounding mobile phone radiation primarily centers on the non-ionizing electromagnetic fields (EMFs) within the RF range. Although these do not have sufficient energy to ionize atoms or molecules, research suggests they can cause thermal effects, such as tissue heating, which may have biological implications if exposure is intense or prolonged (Foster & Repacholi, 2004). The Specific Absorption Rate (SAR) — a measure of the rate at which the body absorbs RF energy — has become a key regulatory benchmark, with guidelines provided by organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the World Health Organization (WHO).

In Africa, the exponential growth in mobile phone penetration has similarly transformed communication infrastructures. By 2021, the GSM Association (GSMA) estimated over 615 million unique mobile subscribers across Sub-Saharan Africa, making it one of the fastest-growing mobile markets globally (GSMA, 2021). Countries such as South Africa, Kenya, and Ghana have led the continent in mobile technology adoption, yet concerns have also arisen regarding radiation exposure, particularly in urban centers with dense mobile traffic and proximity to base transceiver stations (Afolayan et al., 2019).

In Nigeria, mobile phone usage has surged dramatically since the early 2000s. According to the Nigerian Communications Commission (NCC), active mobile subscriptions exceeded 222 million by late 2022, representing a substantial portion of the population (NCC, 2022). With this growth, Nigerians — particularly youth and urban dwellers — are increasingly exposed to RF radiation from handheld devices, often at very close range. While regulatory frameworks exist, including SAR compliance requirements, public awareness and scientific monitoring of RF exposure remain limited. Several Nigerian studies have highlighted the lack of localized data on the extent and health implications of mobile phone radiation (Ayinmode & Farai, 2013; Felix et al., 2014), emphasizing the need for empirical assessments based on real usage conditions.

Consequently, this study aims to address this gap by measuring the radiofrequency radiation emitted from a mobile phone during call and text modes at varying distances, providing baseline data on exposure levels and comparing these with international safety standards. This is especially relevant in a country like Nigeria, where mobile phones are often held close to the body for extended durations, potentially amplifying the thermal effects of RF radiation.

2. Materials and Methods

This study employed an experimental design to measure the intensity of radiofrequency (RF) radiation emitted from a mobile phone during both call and text operations. The key instrument used was an Electromagnetic Radiation (EMR) Meter, specifically calibrated to measure magnetic flux density in microtesla (µT). The EMR meter had a measurement range of 0–19.99 µT with an accuracy of ±(4% + 3 digits) and a bandwidth of 30 to 300 Hz. Other materials included a standard mobile phone and a meter rule used to maintain consistent distances during the experiment.

The mobile phone was tested in two functional modes — call mode and text mode — and measurements were taken from six sides of the device: front, back, left, right, top, and bottom. For each side, the EMR meter was placed at three distances (2 cm, 5 cm, and 15 cm), simulating common user proximity. In the call mode, a phone call was initiated without being answered, and the magnetic flux density was measured during the ringing phase to capture peak radiation. In text mode, a text message was sent repeatedly while measurements were recorded. Each reading was taken three times, and the average value was used for analysis to ensure consistency and accuracy.

The measurements were conducted under controlled environmental conditions, and data were subsequently converted from magnetic flux density (µT) to power density (µW/m²) to compare results against international safety standards such as those set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The resulting data provided a quantitative assessment of mobile phone radiation emission patterns, offering insight into the safety of phone usage at close proximity.

3. Results

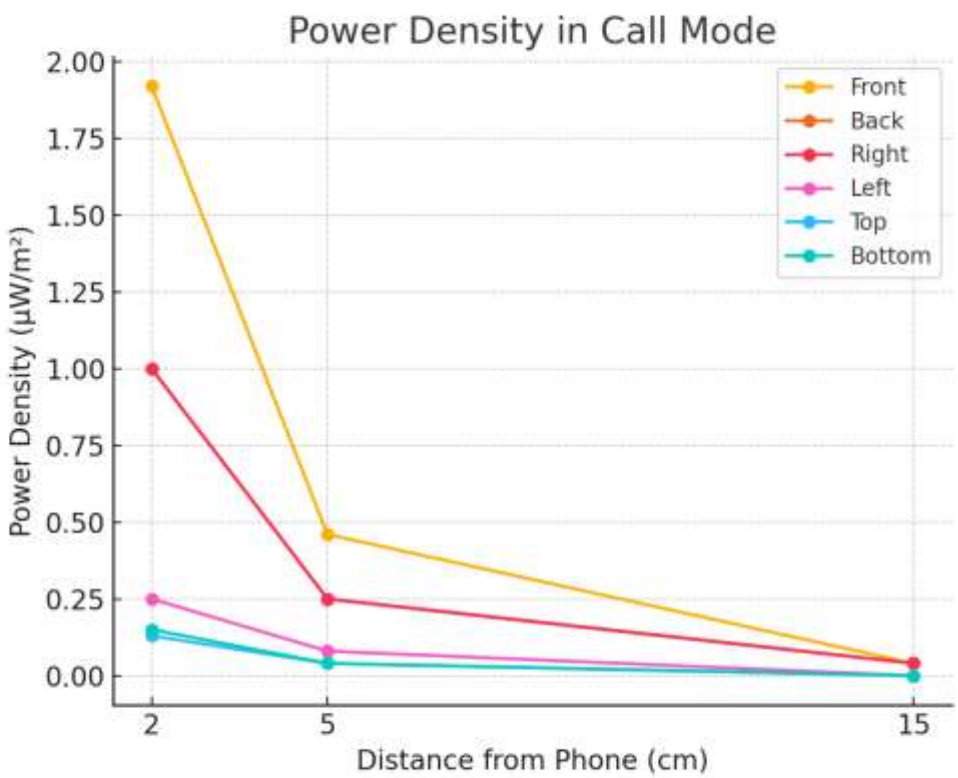
The results below show the average magnetic density (in microtesla, µT) and converted power density (in microwatts per square meter, µW/m²) emitted from a mobile phone at different distances (2 cm, 5 cm, 15 cm) and sides (front, back, right, left, top, bottom) in both call and text modes.

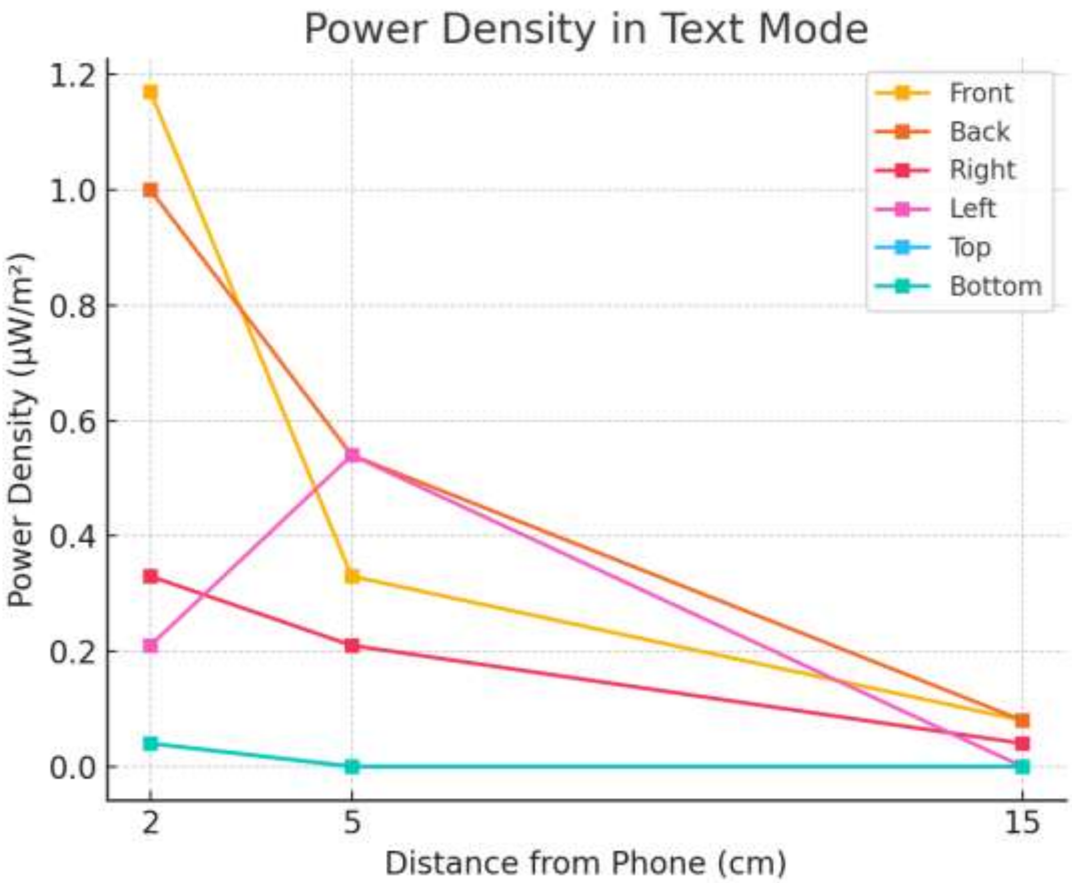
Table 1: Average Magnetic and Power Density in Call Mode

Side of Phone	Distance (cm)	Magnetic Density (µT)	Power Density (µW/m²)
Front	2	0.46	1.92
	5	0.11	0.46
	15	0.01	0.04
Back	2	0.24	1.00
	5	0.06	0.25
	15	0.01	0.04
Right	2	0.24	1.00
	5	0.06	0.25
	15	0.01	0.04
Left	2	0.06	0.25
	5	0.03	0.08
	15	0.00	0.00
Top	2	0.03	0.13
	5	0.01	0.04
	15	0.00	0.00
Bottom	2	0.03	0.15
	5	0.01	0.04
	15	0.00	0.00

Table 2: Average Magnetic and Power Density in Text Mode

Side of Phone	Distance (cm)	Magnetic Density (μT)	Power Density (μW/m²)
Front	2	0.28	1.17
	5	0.08	0.33
	15	0.02	0.08
Back	2	0.24	1.00
	5	0.13	0.54
	15	0.02	0.08
Right	2	0.08	0.33
	5	0.05	0.21
	15	0.01	0.04
Left	2	0.05	0.21
	5	0.13	0.54
	15	0.00	0.00
Top	2	0.01	0.04
	5	0.00	0.00
	15	0.00	0.00
Bottom	2	0.01	0.04
	5	0.00	0.00
	15	0.00	0.00





4. Discussion of Findings

The findings of this study reveal that radiofrequency (RF) radiation emitted from mobile phones varies significantly with both distance from the device and the mode of operation. In both call and text modes, the highest levels of radiation were recorded at a distance of 2 cm, particularly on the front and back sides of the mobile phone. This is consistent with existing literature, which emphasizes that RF exposure diminishes rapidly with distance due to the inverse square law of electromagnetic radiation propagation (Foster & Repacholi, 2004). The observed sharp drop in power density at 5 cm and almost negligible levels at 15 cm reaffirms this principle and highlights the importance of maintaining physical distance from the mobile device during use.

Furthermore, this study found that call mode generated higher RF emissions than text mode, with maximum power density values of 1.92 $\mu W/m^2$ and 1.17 $\mu W/m^2$ respectively. This aligns with previous studies which indicate that voice communication requires sustained connection with the nearest cell tower, thereby increasing signal strength and RF output (Ayinmode & Farai, 2013). The front side consistently produced the highest emissions, likely due to the proximity of internal antennas to this area — a pattern also documented in the work of Felix, Gabriel, and Emmanuel (2014), who found similar directional intensity patterns in emission profiles.

When compared against international safety standards, the RF levels recorded in this study remain well below the ICNIRP limits of 4.5 W/m^2 for GSM 900 MHz and 9.0 W/m^2 for GSM 1800 MHz (ICNIRP, 1998). This supports the conclusion by Heynick et al. (2003) that environmental and near-field exposure from mobile phones under normal use is not sufficient to cause direct thermal or tissue damage. Nevertheless, our findings also resonate with concerns raised by Hardell et al. (2012) and Leszczynski (2002), who noted that frequent, close-range exposure to mobile phone radiation may have cumulative thermal effects, particularly when held close to the head or body for extended durations.

Moreover, this study's observations support public health guidance promoting precautionary measures, such as the use of speaker mode or hands-free devices, to minimize direct contact during calls. This aligns with WHO recommendations on RF exposure reduction strategies (WHO, 2014), particularly for high-usage demographics such as adolescents and young adults. Although nonthermal biological effects remain inconclusive across literature (Hamblin & Wood, 2004; ICNIRP, 2020), the measurable thermal emissions highlighted in this work confirm the need for cautious, informed usage of mobile devices.

The study validates earlier claims that radiation from mobile phones is directional, distance-sensitive, and mode-dependent, and while the emission levels observed fall within international safety thresholds, the potential for long-term thermal effects — especially from prolonged close-range usage — underscores the importance of public education and further research into mobile phone radiation exposure in Nigeria and similar developing contexts.

5. Conclusion

This study investigated the levels of radiofrequency (RF) radiation emitted by a mobile phone during call and text modes at varying distances and orientations. The results show that RF radiation is highest when the phone is operated in call mode, particularly on the front and back sides, and at close proximity (2 cm). The emission levels declined sharply with increased distance, becoming minimal at 15 cm. While all recorded values were significantly below the ICNIRP exposure limits, the proximity-based increase in radiation suggests a potential for thermal effects with habitual close-range use.

These findings reaffirm the established understanding that mobile phones emit non-ionizing radiation capable of generating heat in nearby biological tissues. Though the measured RF levels do not pose immediate biological harm according to international standards, the cumulative thermal exposure over time could raise public health concerns, particularly with extended and frequent use. Therefore, public awareness and precautionary behavior are essential in mitigating potential long-term risks associated with RF exposure from mobile phones.

5.1 Recommendations

1. Encourage Use of Hands-Free Devices: Users should be encouraged to use speaker mode, wired earphones, or Bluetooth headsets during calls to reduce direct contact between the phone and the body, especially the head.

2. Maintain Safe Distance During Use: Mobile phone users should be advised to hold their phones at least 5 cm away from their body, particularly during call initiation, when RF radiation levels are typically highest.

3. Limit Call Duration and Frequency: Reducing the number and length of voice calls can significantly lower cumulative RF exposure. Texting or using messaging apps may serve as safer alternatives for communication.

4. Promote Public Awareness Campaigns: Government health agencies and mobile service providers should collaborate to disseminate information about safe phone use practices and the importance of reducing RF exposure.

5. Incorporate SAR Ratings in Consumer Guidance: Regulatory agencies should ensure that mobile phones sold in Nigeria are clearly labeled with their Specific Absorption Rate (SAR) values and that consumers are informed of the safest models to purchase based on SAR limits.

References (APA Style)

- Afolayan, M. O., Okafor, F. C., & Onibokun, O. R. (2019). Assessment of RF radiation exposure from GSM base stations in Lagos, Nigeria. *International Journal of Environmental Health Research*, 29(2), 205–215.
- Ayinmode, B. O., & Farai, I. P. (2013). Measurement and method in radiofrequency radiation exposure assessments. *The Pacific Journal of Science and Technology*, 14(2), 342–350.
- Felix, O. K., Gabriel, A. U., & Emmanuel, A. C. (2014). Investigation and analysis on electromagnetic radiation from cellular base station transmitters and the implications to the human body. *Journal of Environment and Ecology*, 5(1), 1–15.
- Foster, K. R., & Repacholi, M. H. (2004). Biological effects of radiofrequency fields: Does modulation matter? *Radiation Research*, 162(2), 219–225.
- GSMA. (2021). *The Mobile Economy: Sub-Saharan Africa 2021*. Retrieved from https://www.gsma.com
- Hardell, L., & Carlberg, M. (2019). Health risks from radiofrequency radiation, including 5G, should be assessed by experts with no conflicts of interest. *Oncology Letters*, 17(6), 5587–5593.
- ITU. (2022). *Measuring digital development: Facts and figures 2022*. Retrieved from https://www.itu.int
- NCC. (2022). *Industry statistics*. Nigerian Communications Commission. Retrieved from https://www.ncc.gov.ng