



## Measurement and Evaluation of Radiation Power Density Emitted from Mobile Cellular Base Stations in Abuja and its Environ, Nigeria

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### Authors' contributions

This work was carried out in collaboration among all authors. Authors IA and JTZ designed the study, wrote the first draft of the manuscript, set up the experiment, compelled the results and discussed them. Authors DA and RSI managed the literature searches and effect all the necessary corrections. Authors MZM and DDM managed the measurement and analyses of the study. All authors read and approved the final manuscript.

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### ABSTRACT

This paper presents measurement and evaluation of radiation power density emitted from mobile cellular base stations in Abuja and its environ. Forty (40) mobile base stations with ten (10) each from AIRTEL, ETISALAT, GLO and MTN located in areas with high population were randomly examined across Abuja. Broadband analysis method was employed in the measurement of the radiation power density. The results obtained shows that most of the base stations recorded lower radiation power density below the safety standard value of  $4.5\text{watt/m}^2$ ,  $22.5\text{ watt/m}^2$  for 900MHz frequency though few base stations recorded above standard value: GLO-BS02, GLO-BS03 and MTN-BS02 recorded  $59.02\text{ mW/m}^2$ ,  $39.76\text{ mW/m}^2$  and  $46.70\text{ mW/m}^2$  respectively. The result also revealed that as distance increases, the mean power density reduces. This is to said that human exposure to radio frequency radiation have less or no health hazard at distance far away from the mobile cellular base station.

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## 1. INTRODUCTION

Mobile cellular base stations are connected via microwave links in order to broadcast large quantities of information because of their high frequencies. The transmitting end of the antenna emits the microwave signal from the transmission line into free space and at the receiving end; the antenna pointed toward the transmitting station picks the signal energy and feeds it into the transmission line for processing by the receiver. An antenna is a transducer that transmits or receives electromagnetic waves. It converts electromagnetic radiation into electric current and vice versa [1]. Mobile broadband networks are becoming insufficient as operators offer widespread broadband multimedia access to meet the increased demand. Fortunately, mobile cellular network known as the fourth generation wireless communication system, promises to meet the requirements of real time applications, advanced games and video downloading, and other ultrafast broadband services for mobile phones and data terminals. To meet the demand for mobile communication with extended coverage, high cell capacity, and high data rates, the number of mobile base stations will also increase sharply. With the increased number of mobile base stations, the possible health hazards are a matter of concern for people within the study area due to exposure to electromagnetic (EM) radiation [2].

The radiofrequency proliferation of towers and the resultant effect hazards on human health cannot be over emphasized. The towers using antennas are one of the main sources of producing Electromagnetic Energy including radio waves. Electromagnetic waves are generated and travel through free space at the speed of light. Radio waves emitted by transmitting antennas are one form of electromagnetic energy. This electromagnetic energy is characterized by its frequency (in Hz) and wavelength as shown in figure 1. This electromagnetic spectrum includes ionizing and non-ionizing radiations. The Figure 1 also shows electromagnetic spectrum signifying frequency range of Ionizing & Non-Ionizing radiations. Radio frequency waves occupy the frequency range 3 kHz to 300 GHz [3]. Microwaves are a specific category of radio waves that cover the frequency range between 1 GHz to approximately 100 GHz. According to Mahmoud M.D [4] Radio frequency spectrum spans the

range of 3 kHz to several hundred GHz. The most utilized range is the microwave range. Most of modern point to point, wireless, and satellite communications occupy this range.

The possible effects of microwave radiations on humans are of public concern near the locations of radio and television transmitters, mobile base stations, wireless networks among others. It has been the utmost concern to investigate the non-ionizing radiation levels that result from these sources and their effects on humans. Several studies have been initiated all over the world to determine the safe levels of exposure to radio frequency radiation (RFR) for occupational workers and general public. Several guidelines and standards have been issued by international commission for ionizing radiation (ICNIRP), National communication commission (NCC) and other national and international regulatory agencies.

Electromagnetic radiation is among the type of pollution we have in our society today and it called the fourth pollution source besides air, water and noise by the environmentalist (Saheel Aqeel et al.). The European Commission recommendation adopted on 12 July 1999 requires that a maximum field strength of RF EMR (0–300 GHz) be established and that information about the population's exposure to RF electromagnetic fields (EMFs) and the measures taken to reduce them be provided [5,6].

Ekata and Kostanic [7] reported factors affecting human exposure to radiation as follows:

- i. Distance from source
- ii. Tissue type
- iii. Frequency
- iv. Body resonance
- v. Volume and duration of exposure
- vi. Power density: the power density (pd) of an equivalent plane wave is generally express a

$$p_d = \frac{1}{2} \times R_e (E \times H) \quad (1)$$

$$p_d \times \frac{(E_{rms})^2}{z_0} = z_0 \times (H_{rms})^2 \quad (2)$$

Where H and E are the electric and magnetic fields intensity of the electromagnetic waves and  $z_0$  is the impedance of the free space

$$z_o = \sqrt{\frac{\mu_o}{\epsilon_o}} \tag{3}$$

where  $\mu_o$  is permeability and  $\epsilon_o$  permittivity

According international commission for ionizing radiation [8] most acceptable guideline for non – ionizing radiation recommend 4.5watt/m<sup>2</sup>, 22.5 watt/m<sup>2</sup> for GSM 900MHz and 9 watt/m<sup>2</sup>, 45 watt/m<sup>2</sup> for GSM 1800MHz as reference level for both public and occupational exposure.

Although exposure from the base station antennas is far less than that from handled devices: the public appears to be more concerned about the safety of the base stations. For this reasons the world health organization (WHO) has recommended to undertake research on this subject area [9]. In some part of Nigeria, there is little or no information about electromagnetic radiation from the base station antennas and their effects on human health. This research is intended to provide solution to vacuum created. However, measurement of EM

radiation from base station antennas of various mobile network operators will be compared with the recommended EMF levels from the international commission on Non – Ionizing radiation protection and other organizations.

## 2. MATERIALS AND METHODS

The study was conducted in Abuja, (9.0765° N, 7.3986°E) North Central, Nigeria. Forty (40) mobile base stations with ten (10) each from AIRTEL, ETISALAT, GLO and MTN were randomly examined across Abuja, Nigeria. The base stations examined are located within high population densities areas.

Instruments used to carry out this experiment include the following: electromagnetic field meter, global positioning system and measuring tape. However, in this work, broadband analysis method was employed in the measurement. The electromagnetic field meter is capable of monitoring high frequency radiation in the range of 50 MHz to 3.5 GHz.

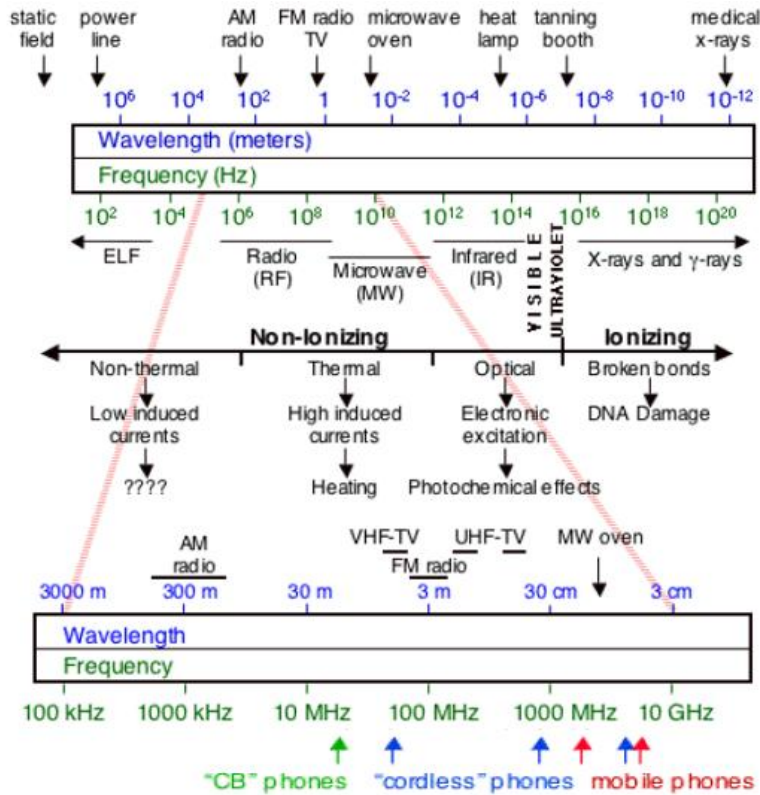


Fig. 1. Electromagnetic spectrum representing non-ionizing and ionizing radiation along with frequencies and wavelength1

Source: Moulder J.E [12]

Radiation power density measurement was achieved by pointing the meter to the source of the RF radiation. Maximal radial distance at about 300m was considered from the foot of the base station and 30m interval from each base station was considered. The meter was set to trivial measurement mode (X, Y, Z) and also to the maximum instantaneous measurement mode as suggested by [10] and [11].

### 3. RESULTS

Results of this study were obtained base on standards issued by international commission for ionizing radiation (ICNIRP), National

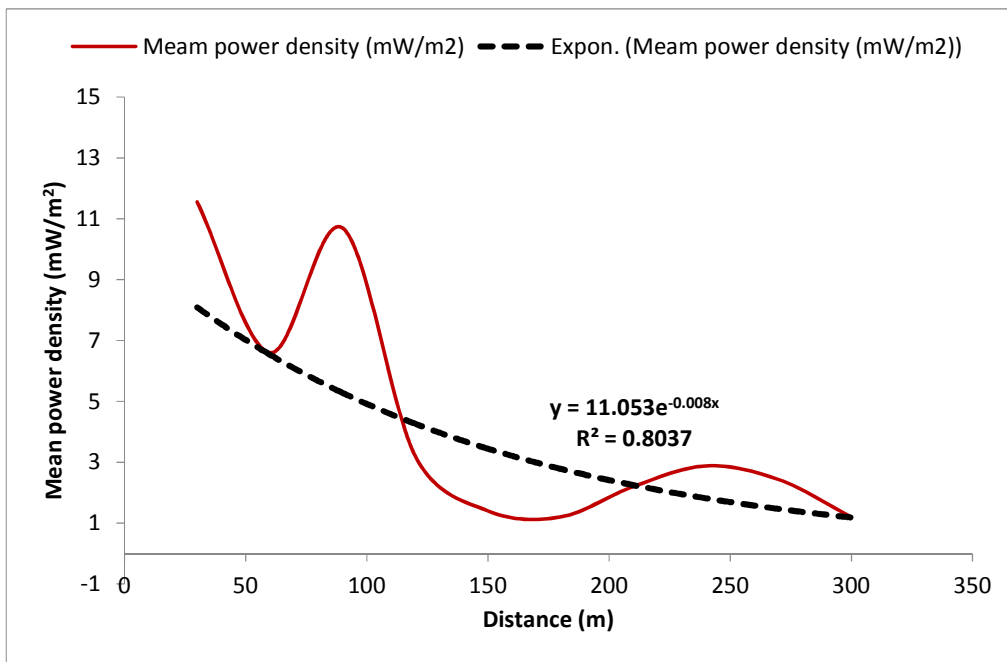
communication commission (NCC) and other nation and international regulatory agencies.

### 4. DISCUSSIONS

Table 1 presents the results of mean radiation power density of all the mobile cellular base stations under review. The result shows that most of the examined base stations recorded lower radiation power density below the safety standard value of 4.5watt/m<sup>2</sup>, 22.5 watt/m<sup>2</sup> for 900MHz frequency. Also, the result shows that GLO-BS02 and BS03 recorded 59.02 mW/m<sup>2</sup> and 39.76 mW/m<sup>2</sup> respectively higher than the safety standard value and MTN-BS02 recorded 46.70 mW/m<sup>2</sup> higher than the safety standard value.

**Table 1. Mean radiation power density of base stations under study**

Base station	Mean power density (mW/m <sup>2</sup> )			
	AIRTEL	ETISALAT	GLO	MTN
BS01	1.98	6.20	3.20	1.52
BS02	18.95	1.67	59.00	46.70
BS03	2.05	4.15	39.76	0.89
BS04	2.39	0.58	1.47	0.63
BS05	3.22	1.20	6.51	1.33
BS06	1.07	3.64	0.96	14.50
BS07	1.14	20.70	0.40	3.30
BS08	1.63	1.30	6.97	4.18
BS09	0.63	0.75	0.50	0.80
BS10	1.38	0.37	0.65	0.60



**Fig. 2. Mean Power Density of ETISALAT base station against distance**

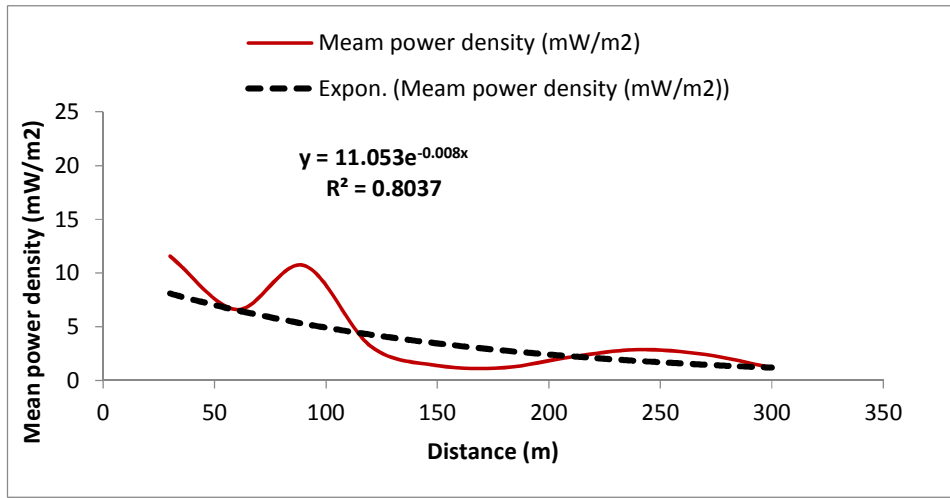


Fig. 3 Mean Power density of GLO base station against distance

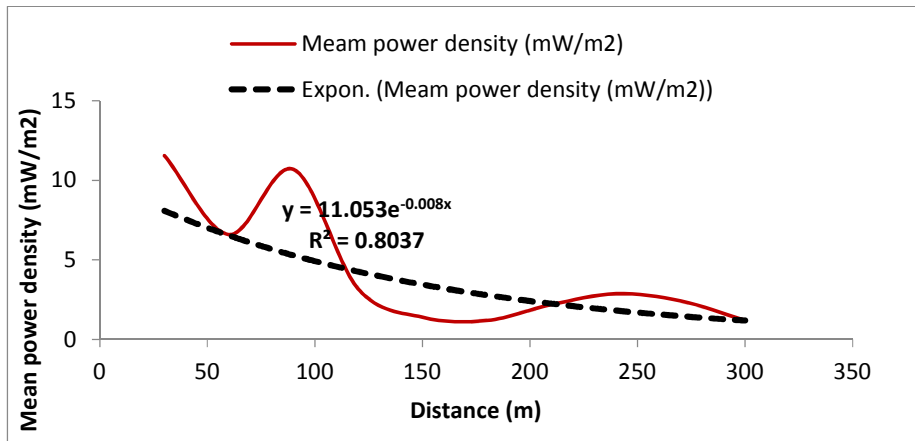


Fig. 4. Mean Power density of AIRTEL base station against distance

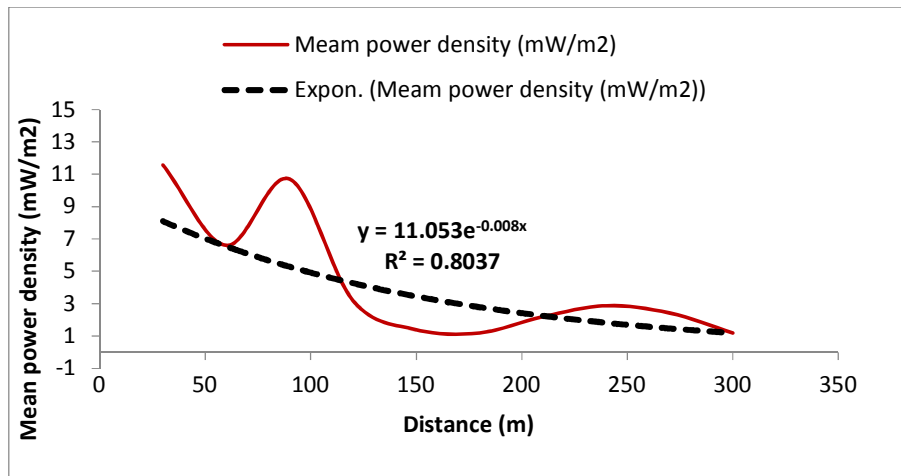


Fig. 5. Mean power density of MTN base station against distance

Figs. 2, 3, 4 and 5 presents the results of mean power densities against distance of ETISALAT, GLO, AIRTEL, and MTN base Station respectively. The results clearly revealed that as distance increases, the mean power density reduces. This is to said that human exposure to radio frequency radiation have less or no health hazard at distance far away from the mobile cellular base station.

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## 5. CONCLUSION

Measurement and evaluation of radiation power density emitted from mobile cellular base stations in Abuja and it's environ was carried out. The results obtained revealed that only few base stations recorded radiation power density higher than the safety standard value. The results also revealed that power density of all the mobile cellular base stations under review reduces with increase in distance.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Mughele ES, Adegbola T, Ilonge O, Boateng R. Factor analysis for GSM services congestion – The case of MTN Nigeria. *Computing and Information Systems Journal*. 2015;15(1):4-15.
2. Frieden R. *Telecommunication: Technical report by redmond, Microsoft Corporation*; 2009.
3. Kwan-Hoong Ng. Non-Ionizing radiations sources, biological effects, emissions and exposures. *Proceedings of the International Conference on Non-Ionizing Radiation at UNITEN (ICNIR 2003) Electromagnetic Fields and Our Health*; 2003.
4. Mahmoud MD. High frequency radiation and human exposure. *Proceedings of the International Conference on Non-Ionizing Radiation at UNITEN (ICNIR 2003) Electromagnetic Fields and Our Health*; 2003.
5. World Health Organization. *Electromagnetic fields and public health: Electromagnetic hypersensitivity*. Available:<http://www.who.int/peh-emf/publications/facts/fs296/en/> (Accessed on 6 December, 2019).
6. Raimondas B, Birute S, Juozas R, Rimantas S, Aurelija S, Rimante C. A Technical approach to the evaluation of radiofrequency radiation emissions from mobile telephony base stations. *International Journal of Environmental Research and Public Health*. 2017; 14(244):1-18.
7. Ekata G, Kostanic I. Model for monitoring GSM base station radiation safety in Nigeria. *International Journal of Engineering Research and Application*. 2014;4(10):97–104.
8. ICNIRP. Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic field (up to 300GHz), *Health Physics*. 1998;74(4):494–522.
9. Kitchen R. *RF and microwave radiation safety*. Second Edition. Newness; 2001.
10. Ismail A, Norashida M, Tamaludin M, Balasubramaniam N. Mobile phone base station radiation study for addressing public concern. *American journal of engineering and applied sciences*. 2010;3(1):117–120.
11. Bolaji A, Idowu F. Risks associated with low level radio frequency exposure at close proximities to mobile phone base stations. *Pacific Journal of Science and Science and Technology*. 2012;13(2):330–335.
12. Moulder JE. *Power Frequency Fields and Cancer*. *Critical Reviews in Biomedical Engineering*. 2004.
13. Bergqvist U, Friedrich G, Hamnerius Y, Martens L, Neubauer G, Thuroczy G. Mobile telecommunication base stations—Exposure to electromagnetic fields. *Rep. Short Term Mission COST*. 2001;244: 1–77.
14. Bortkiewicz A, Gadzicka E, Szykowska A, Poltanski P, Mamrot P, Szymczak W. Subjective complaints of people living near mobile telecommunication base stations in

- poland. Int. J. Occup. Med. Environ. Health. 2012;25:31–40.
15. Breckenkamp J, Neitzke HP, Bornkessel C, Berg-Beckhoff G. Applicability of exposure model for the determination of emissions from mobile telecommunication base stations. Radiat. Prot. Dosim. 2008;131:474–481.
  16. Briggs V, Beale L, Bennett J, Toledano MB, De Hoogh KA. Geographical model of radio-frequency power density around mobile telecommunication masts. Sci. Total Environ. 2012;426:233–243.
  17. Bürgi A, Frei P, Theis G, Mohler E, Braun-Fahrlander C, Frohlich J.. Model for radiofrequency electromagnetic field predictions at outdoor and indoor locations in the context of epidemiological conduct field measurements. Bio-electromagnetics. 2010;31:226–236.
  18. Gajsek P, Simunic D. Occupational exposure to base stations-compliance with EU directive 2004/40/EC. Int. J. Occup. Saf. Ergonom. 2006;12:187–194. Health,”
  19. Moulder JE. Cellular phone antennas (mobile phone base stations) and Human.
  20. Moulder JE. Power frequency fields and cancer. Critical Reviews in Biomedical Engineering. 1998;26:1-116.
  21. Roosli M, Huss A. Mobile telecommunication base station exposure and symptoms. Environ. Health Perspect. 2008;116:62–63.
  22. Rowley JT, Joyner KH. Comparative international analysis of radiofrequency exposure surveys of mobile communication radio base stations. J. Expo. Sci. Environ. Epidemiol. 2012;22:304–315.
  23. Wojcik D, Topa T, Szczepanski K. Absorption of EM energy by human body in the vicinity of GSM base station antenna. J. Telecommun. Inf. Technol. 2005;32:34–38.

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