Assessment of radiofrequency radiation exposure level from selected base transceiver stations in Ogbomoso, Oyo State, Nigeria.

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Abstract. With the growth of mobile phone technology globally, which has also influenced the number of mobile phone masts, the effects of radiofrequency radiation (RFR) have been a major concern of scientist globally. Many literatures have described the effects on the human health and his environment. We embarked on this study to assess the power densities of RFR from base transceiver stations (BTS) in Ogbomoso, Oyo State. Electrosmog meter was used, the power densities of RFR were taken from 12 BTS across 4 Local Governments in Ogbomoso at different distances. The power densities were measured to evaluate the mean power densities across Ogbomoso and its environment with the standard values provided by International Commission on Non-Ionizing Radiation Protection (ICNIRP). The maximum average 718.6 μW/m² was observed at 25 m away from the mast, which is below the ICNIRP guidelines. The results showed that the radiation level in the Local Governments is below the ICNIRP limit. Hence, we recommend that individuals should keep their exposure as low as reasonably achievable.

Keywords: Radiofrequency Radiation, Base Transceiver Station, Power Density, Electrosmog meter, International Commission on Non-Ionizing Radiation Protection.

1.0 INTRODUCTION
In the modern age, technology plays a vital role in human’s lifestyles. Man is a social being; therefore, communication is very important. Mobile phones are one of the most important innovations which turned huge number of smartphone users to develop interest on the impact of the electromagnetic fields (EMF) on living organisms [1]. The use of mobile phone has been made susceptible to electromagnetic field radiation (EMR) globally which is ubiquitous in modern society [2]. Presently, more than 6.9 billion mobile subscribers exist globally [3].

The recent subject of interest and study which result in tremendous increment in the use of mobile phone globally is the effect of cell phone radiation on human health. Part of the radio waves given off through a mobile telephone handset is absorbed by the body [4]. In the microwave range cell phones make use of electromagnetic radiation. As a result of heavy installations of public mobile base transceiver stations (BTS) in the residential environment it was observed that additional electromagnetic radiation occurs [5]. Radiations from cell phone mast or BTS and from mobile phones cause detrimental effects to all mammals. It is the solution to avoid excess exposure and its detrimental health effects, if used for limited amount of time daily [6].
1.1 Electromagnetic radiation (EMR)

The traveling of electric and magnetic wave by space at the speed of light is called electromagnetic radiation (EMR). It does not contain mass or charge but travels in packets of radiant energy known as photons. EMR comprises of radio waves, microwaves infrared, ultraviolet, gamma and x-rays. They travel in a waveform at constant speed. EMR wave characteristics is expressed in equation 1:

\[ c = \lambda f \]  

(1)

where \( c \) = velocity (m/s), \( \lambda \) = wavelength (m), and \( f \) = frequency (Hz). All forms of EMR are grouped according to their wavelengths in an electromagnetic spectrum [7].

Electromagnetic spectrum is made of electromagnetic waves of the wavelength ranges from 1000 m and longer to less than \( 10^{-12} \) m, which also include the frequency ranges from \( 10^5 \) to \( 10^{20} \) Hz [8].

1.2 Radio Frequency Radiation (RFR)

The term “Radio Frequency (RF) energy” ranges in frequencies between 30 kHz and 300 GHz. When bio-systems are exposed to RF radiation, burns, cancer, reproductive diseases and neurological effects are noticed [9]. Due to the ability of RF energy to heat biological tissue, exposure to very high levels of radiofrequency radiation is harmful [10].

2.0. Materials and Methods

2.1. Materials

Broadband analysis methods were used in this work. A handheld Electrosmog meter (50 MHz to 3.5 GHz) was used in the RF survey for monitoring high frequency radiation.

2.2. Study Area

This research was done in Ogbomoso, Oyo state, Nigeria, which covers four (4) Local Government Areas namely: Ogbomoso South, Ogbomoso North, Ogo-Oluwa and Sulurele Local Government Area. The areas lie between Latitude 8° 08’ N and Longitude 4° 15’ E. Map of the locations showing the selected Local Government was shown in Figure 1.
Figure 1. Map showing the study areas [11].

2.3. Methods
Twelve (12) base transceiver stations (BTS) were selected at random, covering 3 network providers: Globacom, MTN and Airtel. They were selected based on their proximity to residential areas, hospitals, offices etc. Group 11 (G11) was selected based on the fact that it was powered by solar, to observe the difference between the power density from a solar powered BTS and a diesel powered BTS. Measurements were taken using an Electrosmog meter which measures between 50 MHz - 3.5 GHz. The Electrosmog meter was used to measure the power density (µW/m²) for the 12 locations at different radius in meters between 25 m - 400 m respectively. The average power density was taken at 25 m, 50 m, 100 m, 200 m, 300 m and 400 m. Altogether, 72 measurements were made, 6 samples from each 12 BTS.

3.0. RESULTS AND DISCUSSION

The selected base transceiver station (BTS) in the twelve (12) locations of Ogbomoso was shown in Table 1. The accepted radiation norms were revealed in Table 2. The results of power densities (µWm²) obtained at different distances for 12 BTS are presented in Table 3. The value of the maximum power density was found to be 1227.1 µWm² observed at 25 m from a GLO BTS (location G10) while the minimum power density was found to be 10.8 µWm² observed at 400 m from a BTS (location G2). The maximum power density of 1227.1 µWm² obtained was below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) maximum permissible limit for GSM 900. In order to have a clearer picture of the power density distribution over all the locations, the average of the power density over the entire locations at an interval of 25 m from the foot of each base transceiver station up to 400 m was obtained as presented in Table 4. The average power densities in all the locations (G1 to G12) and the maximum value of all distance intervals from the BTS was found to be 718.6 µWm² which is below the ICNIRP maximum permissible limit.
Table 1. Selected base transceiver station in Ogbomoso.

| BTS  | Location (Ogbomoso)          | Position/Location         |
|------|-----------------------------|---------------------------|
| G1   | Soun palace area            | Lat. 8.1252°N, Long 4.2474°E |
| G2   | Adenike area                | Lat. 8.1270°N, Long 4.2396°E |
| G3   | Iwagba area                 | Lat. 8.1550°N, Long 4.2311°E |
| G4   | High court area             | Lat. 8.1477°N, Long 4.2526°E |
| G5   | Under G area                | Lat. 8.162916°N, Long. 4.2639°E |
| G6   | Kuye area                   | Lat. 8.1476°N, Long. 4.2538°E |
| G7   | LAUTECH Teaching Hospital   | Lat. 8.1528°N, Long. 4.2536°E |
| G8   | Ayegun area                 | Lat. 8.1211°N, Long. 4.2374°E |
| G9   | Iwagba area                 | Lat. 8.1502°N, Long. 4.2443°E |
| G10  | Gambari area                | Lat. 8.2760°N, Long. 4.3246°E |
| G11  | Ladanu village, Ajaawa area | Lat. 7.5516°N, Long. 4.0948°E |
| G12  | Prison area                 | Lat. 8.1162°N, Long 4.2452°E |

Table 2. Accepted Radiation Norms [12]

| Frequency (MHz) | ICNIRP Radiation Norms in W/m² | Revised DoT Norms Effective from 01/09/2012 in W/m² |
|----------------|-------------------------------|--------------------------------------------------|
| 900            | 4.5                           | 0.45                                             |
| 1800           | 9.0                           | 0.90                                             |
| 2100           | 10.5                          | 1.05                                             |

Table 3. Measured power density (µW/m²) of the BTS at different distances.

| Power Density (µW/m²) | BTS |
|-----------------------|-----|
| 447.1                 | 25 m |
| 388.0                 | 50 m |
| 229.8                 | 100 m|
| 96.9                  | 200 m|
| 81.0                  | 300 m|
| 70.0                  | 400 m|
At G11 base transceiver station (BTS), little or no energy was observed. While other BTS were powered by diesel generators, G11 was the only location powered by Solar panels in Ogo-Oluwa Local Government Area of Ogbomoso.

Also, a significant fluctuation in data was observed during measurement. There was a decrease in power density by the square of radial distance as we move farther from referenced BTS; this was right in all cases except G11 where the power density was constant from 100 m to 400 m. At 100 m, mean power density in Oyo State (410.20 µW/m$^2$) is lower than Kogi State (421.06 µW/m$^2$) [13], but significantly higher than Kaduna State (0.03 µW/m$^2$) [14]. Hence, we recommend that individuals should keep their exposure as low as reasonably achievable. The aggregate mean power density of the selected BTS was shown in Table 5.

### Table 4. Mean power density of individual group and percentage contribution (%)

| BTS Code | Mean power density (µW/m$^2$) | Percentage contribution (%) |
|----------|-------------------------------|-------------------------------|
| G1       | 218.8                         | 5.0                           |
| G2       | 148.7                         | 3.0                           |
| G3       | 461.3                         | 10.0                          |
| G4       | 394.8                         | 9.0                           |
| G5       | 332.7                         | 8.0                           |
| G6       | 468.4                         | 10.0                          |
The bar chart of the power densities of individual base transceiver stations was shown in Figure 2.

| G7 | 511.7 | 11.0 |
| G8 | 345.3 | 8.0  |
| G9 | 519.4 | 12.0 |
| G10| 566.4 | 13.0 |
| G11| 0.4  | 0.0  |
| G12| 497.3 | 11.0 |
| TOTAL| 4464.2 | 100.0 |

**Figure 2.** Average power density of individual BTS
Table 5. Aggregate mean power density of the selected BTS

| Base Transceiver Station (BTS) | Distance (m) | Mean power density (µW/m²) |
|-------------------------------|--------------|---------------------------|
| G1-G12                        | 25           | 718.6                     |
|                               | 50           | 576.2                     |
|                               | 100          | 410.2                     |
|                               | 200          | 250.4                     |
|                               | 300          | 169.9                     |
|                               | 400          | 105.0                     |

Plot of the mean power density of selected BTS with radial distances was shown in Figure 3. Also, Figure 4 shows the pie chart representing the percentage contribution of individual BTS.

Figure 3. Mean power density plot of all BTS with radial distances.
4.0 CONCLUSION
The base transceiver station average power density decreases as the radial distance (away from the BTS) increase, although, there is variation in radiation intensity from one base transceiver station to the other. It was noticed that base transceiver stations with little or no fluctuation in power density including distance have little interference from external sources, while those with evident data fluctuations have significant interference from external sources. The minimum average power density value from each base transceiver station in the four Local Government of Ogbomoso was about 105.0 μW/m² while the mean maximum value was about 718.6 μW/m². Thus, the radiofrequency radiation exposure hazard index in Ogbomoso and its environment was below the recommended limit specified by ICNIRP. However, network providers should site base transceiver stations away from the residential area. More research should be carried out at Gambari area of Ogbomoso, Oyo State as the radiation level was reported to be the highest. Government should also organize seminars in orientating the people living near the base transceiver station on the harm that radiation does to the human health.

REFERENCES
[1] Bortkiewicz A 2001 A study on the biological effects of exposure mobile-phone frequency EMF, Medycyna prac, chapter 52 pp 101-106
[2] Feychting M Ahlbom A and Kheifets L 2005 EMF and health Annual Rev Public Health chapter 26 pp 165-189
[3] World Health Organization 2014 Electromagnetic Fields and Public Health: mobile phones https://www.who.int/news-room/fact-sheets/detail/electromagnetic-fields-and-public-health-mobile-phones
[4] Wiki 2014 Mobile Phone Radiation and Health [Online] Available: http://en.wikipedia.org/wiki/Mobile_phone_radiation_and_health (January 5, 2013)
[5] Koprivica M Neskovic N Neskovic A Paunovic G 2014 Statistical analysis of electromagnetic radiation measurements in the vicinity of GSM/UMTS base station antenna masts (Radiation Protection Dosimetry, Vol 158) Issue 3, pp 263-275 https://doi.org/10.1093/rpd/nct230
[6] Kovach S 2017 The Hidden Dangers of Cell Phone Radiation. Life extension magazine.

[7] Robert Percuoco 2014 Plain Radiographic Imaging Editor(s): Dennis M Marchiori Clinical Imaging (Third Edition) Mosby, chapter 1 pp 1-43, ISBN 9780323084956, https://doi.org/10.1016/B978-0-323-08495-6.00001-4. (https://www.sciencedirect.com/science/article/pii/B9780323084956000014)

[8] Wolfgang B and Garry D 2011 University Physics with Modern Physics McGraw Hill Companies, Inc. U.S.A. pp. 1000-1002.

[9] Occupational Safety and Health Administration (OSHA) 2015 Communication Tower Safety https://www.federalregister.gov/documents/2015/04/15/2015-08633/communication-tower-safety

[10] FCC 2016 Policy on Human Exposure to Radiofrequency Electromagnetic Fields https://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety#Q5

[11] Amuda D B 2016 Assessment of Radiofrequency Radiation exposure level from Base Transceiver Stations and its Radiological implications on Tomatoes and Mice (Unpublished Doctoral Dissertation) Ladoke Akintola University of Technology, Ogbomoso, Oyo State Nigeria.

[12] Rakesh K B 2013 Electro Magnetic Field (EMF) Radiation from Mobile Towers & Handsets. http://www.itu.int/en/ITUT/climatechange/emf1305/Documents/Presentations/s2part2p3-RKBhatnagar.pdf (January 2, 2014)

[13] Nwankwo Victor U J Norbert N Jibiri Silas S Dada Abraham A Onugba and Patrick Ushie 2013 Assessment of Radio-Frequency Radiation Exposure Level from Selected Mobile Base Stations (MBS) in Lokoja, Kogi State, Nigeria. IOSR Journal of Applied Physics (IOSR-JAP). Vol 3, Issue 2 pp 48-55

[14] Sadiya Umar 2017 Assessment of Radio-Frequency Radiation Exposure from Selected Mobile Base Stations in Zaria and Environs, Nigeria. Nigerian Journal of Scientific Research, 16(2)