Effects of Base Transceiver Station (BTS) on Humans in Ikeja Area of Lagos State.

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ABSTRACT

This paper presents the effects of base transceiver stations on humans in Ikeja Area of Lagos State and ways of mitigating the risk posed by BTS. This was achieved using the measured and calculated values of some electromagnetic parameters such as power density and pathloss. The ICNIRP exposure limit for BTS antennas is 0.1 W/m2 (100mw/m2). For values of radiating power of the base station antenna ranging from 33Watts to 100Watts, the power density experienced in the vicinity of the antenna ranges from 0.7 mW/m2 to 280 mW/m2. The health effect of the antennas is at its peak when the base station antenna is transmitting at 100 Watts. At radiating power of 100 Watts, the mean power density was found to be 39 mW/m2, and the Root Mean Square Error (RMSE) value was 73 mW/m2. The distance away from the base station that is safe for residential purposes was found to be 16m. Also, the health risks associated with the inhabitants in the vicinity of BTS are discussed and the public are advised on possible solutions.

(Keywords: base transceiver station, BTS, antenna, electromagnetic radiation, power density, distance, radiating power, electric field)

INTRODUCTION

There is an enormous increase in the use of wireless mobile telephony throughout the world. As a result of this, the need for telephone base stations is massive. There are over 1200 base stations in Lagos. This is so due to the desire of network providers to meet the demands of the increasing number of telephone users.

Adverse effects of these important communication tools are being reported [4]. Sensations of burning or warmth around the ear, headache, and disturbance of sleep, memory loss, and sudden movement of body parts are some of the effects being reported as resulting from living in the vicinity of Base Transceiver Station (BTS) [5]. The most widely accepted standard for the control of electromagnetic radiation was developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The measured values obtained were compared to the ICNIRP standard to determine the distance away from residential or commercial building that is safe for siting of BTS [1,7].

MEASUREMENT PROCEDURE

Power density measurements were made within 100m of the base station, with each measurement positions 10m away from each another.

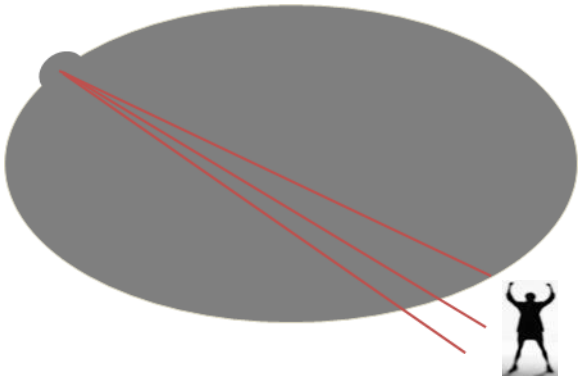

Figure 1: An Individual Exposed to Radiation from BTS Antenna.

Theoretical calculations of the power density experienced in the vicinity of BTS antennas were made.

Power Density Calculation

The power density of an antenna can be mathematically expressed as:

$$P_d = \frac{1}{2} Re\left[\overline{E} \times \overline{H}\right] \quad \textbf{(1)}$$

$$P_d = \frac{|E_{rms}|^2}{Z_O} = Z_O . |H_{rms}|^2 \quad \textbf{(2)}$$

Where, $\overline{E}$ and $\overline{H}$ are the electric and magnetic field intensity of the electromagnetic waves.

$$Z_O = \sqrt{\frac{\mu_0}{\epsilon_0}} \quad \textbf{(3)}$$

$$\mu_0 = 4\pi \times 10^{-7} \frac{H}{m} \quad \textbf{(4)}$$

$$\epsilon_0 = \frac{10^{-9}}{36\pi} \quad F/m \quad \textbf{(5)}$$

Then, $Z_O = 120\pi \approx 377\Omega$ **(6)**

The total electric field intensity due to the base station antenna is:

$$E_{rms} = \frac{\sqrt{30 N P_{rad} G}}{R} \quad \textbf{(7)}$$

Where:

N is the number of carriers (antennas),

P_{rad} is the radiated power,

G is the radiation gain for a pattern antenna,

R is the distance from the base station.

Then substituting Equation (7) in Equation (2) we get :

$$P_d = \frac{30 N P_{rad} G}{R^2 Z_O} \quad \textbf{(8)}$$

The following formula enables the calculation of equivalent power density (P_d) to be made and assumes field impedance:

$$P_d = 0.0796 N \frac{P_{rad}}{R^2} \times 10^{\frac{G}{10}} \quad \textbf{(9)}$$

$$P_d = \frac{|E_{rms}|^2}{Z_O} =$$

Where.

G in Equation (9) is the gain of base station antenna in dB. The simplest case of application is the one when human is exposed to a single base station antenna, (N=1).

Then: $P_d = 0.0796 \frac{P_{rad}}{R^2} \times 10^{\frac{G}{10}}$ **(10)**

Where,

P_{rad} is the radiated power (in Watts) emitted by the base station antenna,

G is the antenna gain (in dB) in the direction where the person is placed relative to the antenna.

INVESTIGATED ENVIRONMENT

The investigated area is Ikeja. Ikeja is a suburb of the city of Lagos and the capital of Lagos State, Nigeria. It has a population of 313,196 people, and its geographical coordinates are 6.59° North, and 3.34° East. The test base station is located along Ajibade Oladipo Drive, Ikeja, Lagos State [1,2].

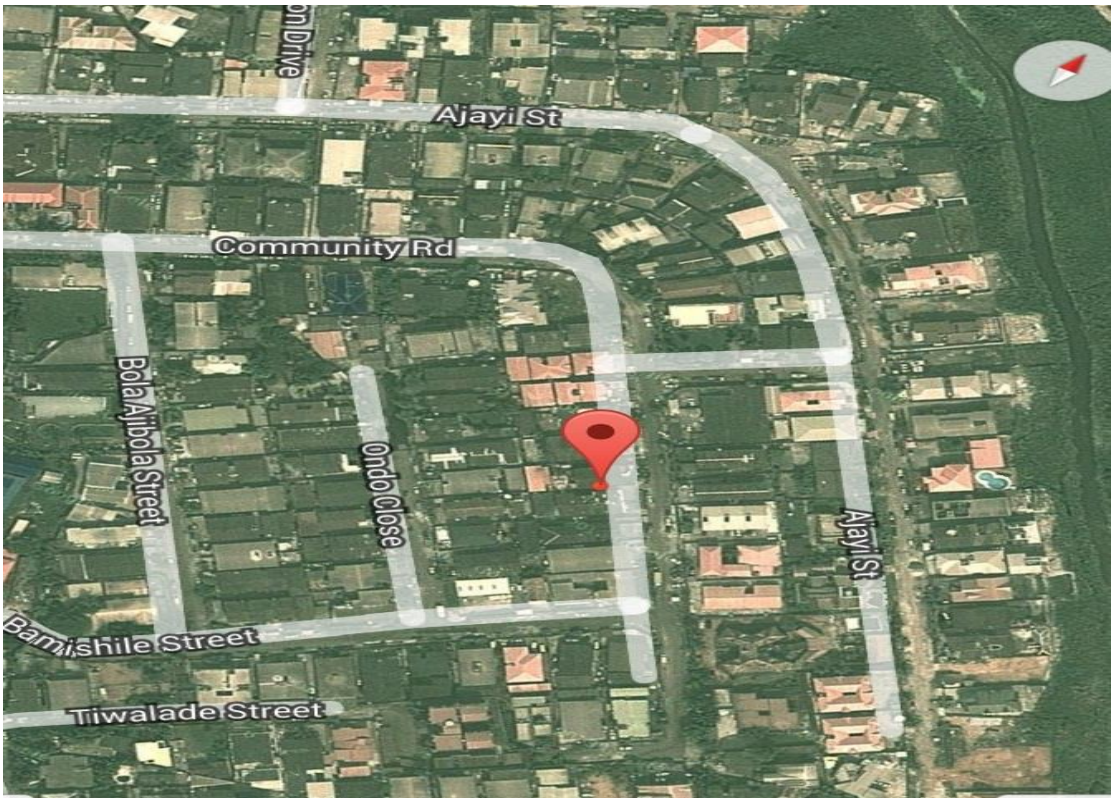

Figure 2: Google Map View of Ikeja, Lagos State.

ANALYSIS OF RESULTS

Table 1 shows the results of the measured and calculated power density experienced at distances ranging from 10 to100m with 10m intervals from the base station in Ikeja area of Lagos State.

MATLAB software was used for the graphical analysis of the data obtained. The radiation power (P) of base station antennas is within the range of 33watts and 100watts, at a gain (G) of 5dB. Table II shows the statistical analysis of the data obtained. The results obtained are also tabulated. Arithmetic Mean is defined by:

$$\bar{x} = \frac{\sum(x)}{n} \qquad \textbf{(11)}$$

Mean Deviation is defined by:

$$\text{M.D} = \frac{\sum(x - \bar{x})}{n} \qquad \textbf{(12)}$$

Root Mean Square Error is defined by

$$\text{RMSE} = \sqrt{\frac{\sum(x - \bar{x})^2}{n}} \qquad \textbf{(13)}$$

Variance is the square of R.M.S.E, and is defined by:

$$\frac{\sum(x - \bar{x})^2}{n} \qquad \textbf{(14)}$$

Table 1 shows the measured power density with respect to distance from the base station antennas located at Ikeja, while Table 2, shows the statistical analysis of the calculated power density,

Table 1: Power Density with Respect to the Distance from Base Station Antennas Located at Ikeja Lagos State.

Distance From Base Station Antenna (Metres)	P=33W G=5dB Power Density ($P.D_1$) (W/m^2)		P=66.7W G=5dB Power Density ($P.D_2$) (W/m^2)		P=100W G=5dB Power Density ($P.D_3$) (W/m^2)	
	Measured	Calculated	Measured	Calculated	Measured	Calculated
10	0.074	0.0831	0.18	0.168	0.28	0.252
20	0.018	0.0207	0.035	0.042	0.054	0.0629
30	0.0078	0.0092	0.017	0.0186	0.023	0.028
40	0.0041	0.0052	0.009	0.0105	0.016	0.0157
50	0.0028	0.0033	0.0054	0.0067	0.0091	0.0101
60	0.0026	0.0023	0.0040	0.0047	0.0066	0.0070
70	0.0014	0.0017	0.0037	0.0034	0.0055	0.0051
80	0.0012	0.0013	0.0029	0.0026	0.0031	0.0039
90	0.0011	0.0010	0.0018	0.0021	0.0028	0.0031
100	0.00071	0.00083	0.0015	0.0017	0.0022	0.0025

Table 2: Statistical Analysis of Calculated Power Density.

Statistical Parameters	P=33W G=5dB (W/m^2)	P=66.7W G=5dB (W/m^2)	P=100W G=5dB (W/m^2)
Mean	0.0129	0.026	0.039
Mean Deviation	0.0156	0.0316	0.047
R.M.S.E	0.0241	0.0487	0.073
Variance	0.00058	0.00237	0.0053

Statistical Parameters	P=33W, G=5dB (W/m^2)	P=66.7W, G=5dB (W/m^2)	P=100W G=5dB (W/m^2)
Mean	0.01137	0.02596	0.04023
Mean Deviation	0.0139	0.0326	0.050711
R.M.S.E	0.0207	0.05226	0.0813
Variance	0.0004	0.00273	0.00661

GRAPHICAL ANALYSIS OF RESULTS

MATLAB simulation software was used for the graphical analysis of the data tabulated above. The resulting graphs from the simulation are shown in Figures 3, 4, 5, 6 and 7, respectively.

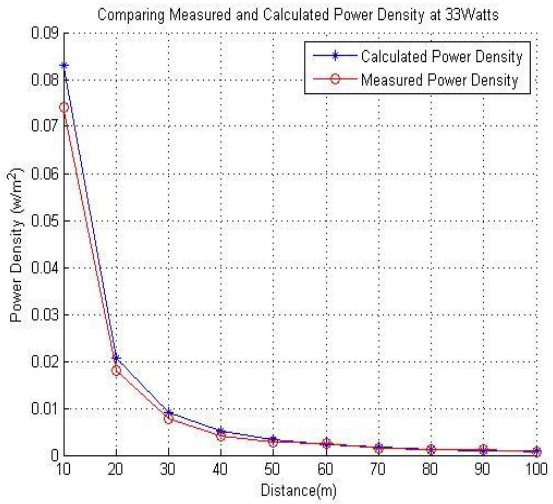

Figure 3: Comparison of Calculated and Measured Power Density at 33Watts against Distance.

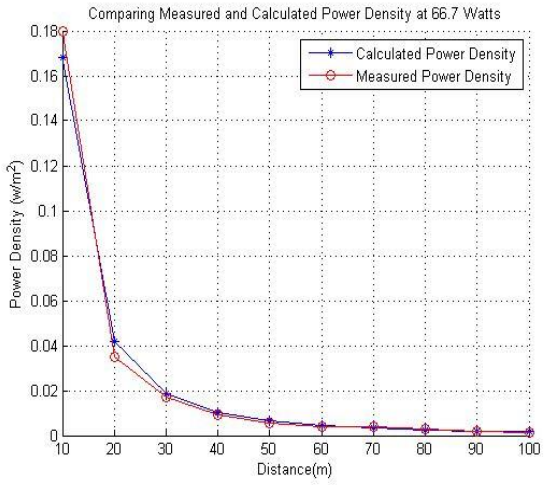

Figure 4: Comparison of Calculated and Measured Power Density at 66.7Watts against Distance.

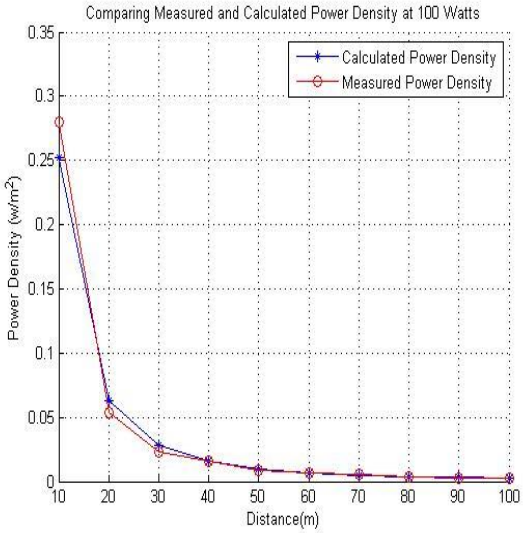

Figure 5: Comparison of calculated and measured Power Density at 100Watts against Distance.

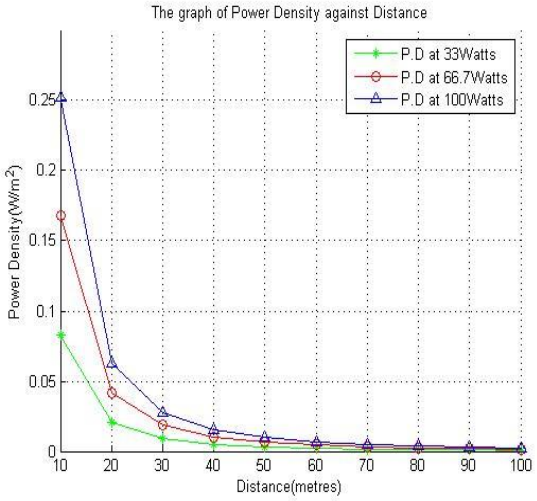

Figure 6: Comparison of Calculated Power Density at 33W, 66.7W, and 100W against Distance.

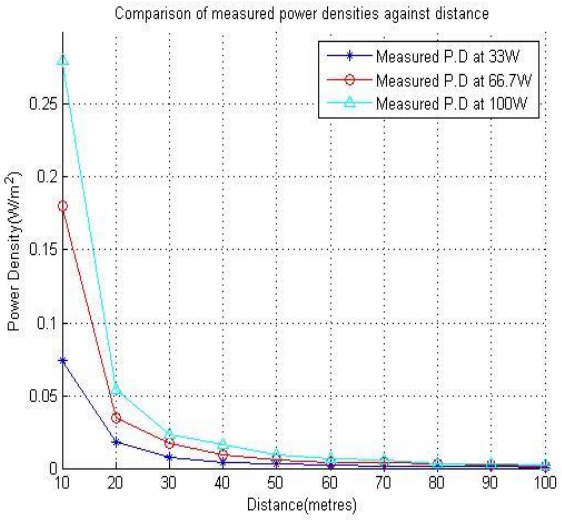

Figure 7: Comparison of Measured Power Density at 33W, 66.7W, and 100W against Distance.

DISCUSSION OF RESULTS

The maximum radiating power of base station antennas in Lagos is in the region of 100Watts, and power density at the immediate vicinity of the antenna exceeds ICNIRP exposure guideline of 0.1 w/m^2.Most BTS antennas in Lagos environs operates at radiation power (P) of 100Watts and Antenna gain (G) of 5dB. The highest value of power density measured is 0.28w/m^2. This far exceeds the ICNIRP exposure limit (280% of ICNIRP limit), and being exposed to such a value of power density (P.D) is totally not safe. The distance at which a power density of 0.1 w/m^2 will be experienced from a BTS antenna with P=100W and G=5dB is 15.9m. This implies that it is not safe to live within 15.9m (approximately 16m) of a BTS.

Figures 3 and 4 are in the form of an exponentially decaying graph. It shows that the power density decreases exponentially as the distance from the base station increases. A distance of 100m from the BTS gives a power density of 0.022w/m^2, which is just 2.2% of the ICNIRP exposure limit. The farther the exposed person is from the BTS, the safer. The measured value of the power density is lower than the calculated value because of some interference caused by environmental factors.

CONCLUSION

The power density in the vicinity of BTS antenna with radiation power 33Watts, 66.7Watts and 100Watts were also analyzed. The analyses obtained from these cases were compared to the ICINRP exposure guidelines.

The 10m distance from residential homes law given to network operators as regards siting of BTS is still violated by some operators. Some houses even have BTS sited in their compounds. Short term effects associated with the exposure to electromagnetic radiation include headaches, fatigue, insomnia, rashes and body pain [6]. Medical reports have shown that radiations from BTS are carcinogenic; they are capable of generating cancer cells in the human body. Some research reports also suggest that they are also capable of causing genetic mutation in human cells, which can result in having children with some form of physical deformity. Long term exposure to electromagnetic radiation from BTS can affect reproduction, these accumulated radiations is capable of damaging genital cells [3].

REFERENCES

1. Akintonwa, A., A.A. Busari, O. Awodele, and S.O. Olayemi. 2009. “The Hazards of Non-Ionizing Radiation of Telecommunication Mast in an Urban Area of Lagos, Nigeria”. *African Journal of Biomedical Research*. January 2009.

2. Sabah, H. and A. Saeid. 2008. “Theoretical Estimation of Power Density Levels around Mobile Telephone Base Stations”. *Journal of Science & Technology*.

3. Boniface, O.A. and B.A. Udochukwu. 2012. “Electromagnetic Wave Effect on Human Health: Challenges for Developing Countries”. CEPA.

4. Victor, U.J., N. Norbert, S. Silas, A. Abraham, and U. Patrick. 2012. “Assessment of Radio-Frequency Radiation Exposure Level from Selected Mobile Base Stations (MBS) in Lokoja”. Kogi State, Nigeria. October 2012.

5. Santini, R., P. Santini, P. Le Ruz, J.M. Danze, and M. Seigne. 2003. “Survey Study of People Living in the Vicinity of Cellular Phone Base Stations”. *Journal of Electromagnetic Biology and Medicine*.

6. Enyinna, P.I. and G.O. Avwir. 2010. “Characterization of the Radiofrequency

Radiation Potential of Alakahia and Choba Communities, Nigeria, Working and Living". *Environmental Protection*. June 2010.

7. Akinyemi,L.A., N.T. Makanjuola, O. Shoewu, and F.O. Edeko. 2014. "Comparative Analysis of Base Transceiver Station (BTS) and Power Transmission Lines Effects on Human Body in the Lagos Environs, Lagos State, Nigeria." *African Journal of Computing & ICT*. 7(2):33-42.

SUGGESTED CITATION

Akinyemi, L.A., O. Shoewu, O.A. Pinponsu, J.O. Emagbetere, and F.O. Edeko. 2014. "Effects of Base Transceiver Station (BTS) on Humans in Ikeja Area of Lagos State". *Pacific Journal of Science and Technology*. 15(2):173-179.