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Analytical Study of Radio Frequency Radiation Exposure Level from Different Mobile Base Transceiver Stations in Urban area

*[1]Aremu, O. A., [2]Makinde, O. S., [3]Oyinkanola L. O. A., [4]Akande Ademola
[1-4]Physics Department, The Polytechnic, Ibadan. P.M.B 22, UI Post Office, Ibadan, Nigeria

ABSTRACT

Several base stations have been installed due to large economy demand for advancement in technologies. In this work, measurements of radiation level emitted from the base stations were made using a hand held GQ-380 EMF RF meter, the distance was measured at the interval of 20 m from the foot of the base station using a digital distance wheel meter. The electric field of the base station was measured using a GM 3120 electromagnetic radiation tester. The experimental results from this study shows that generally, for all base stations considered, the power density increases between (0 – 40 m) from the base stations and it decreases as the distance increases from 40 – 300 m. The maximum radiated value obtained was 13.35% of the Non-ionizing radiation protection standards (ICNIRP) recommended limit and the average power density for the multiple network was found to be 0.021 mW/m^2 while that of single network was found to be 0.006 mW/m^2, this is far below the recommended safety level standard for public exposure. Going by the low level of radiations obtained from the various locations in this study, it is discovered that all the operators comply with the ICNIRP recommended level which is 0.45 W/m^2. It is therefore concluded that the electromagnetic emission from GSM base stations in the selected areas pose no threat to members of the public within this area.

Keywords : Base Stations, Electric Field, Electromagnetic Radiation, Power Density, Radiation Level.

I. INTRODUCTION

Due to increase number of mobile phone users, the number of base stations, which enable mobile phones to connect to other mobile phones are to be increased so as to provide a well communication opportunity [1]. Furthermore, the prevalent use of 3G and 4G communication system needs new and more base stations than 2G system [2]. Thus, base stations can be shown every region we live and electromagnetic waves always exposes us everywhere in modern society. Since the introduction of mobile communication base stations in Nigeria the health implication of electromagnetic field (EMF) radiofrequency (RF) radiation from the mobile communication base stations has been of great concern to the Nigerian citizens. Many researches and studies [3, 4, 5, 6] about the effect of EM radiation towards to the human organism, especially to the brain, indicate the importance of the issue. Some interested groups believed that radiation from mobile communication base station (GSM) Masts are dangerous to health, others do not believed that RF radiation have effect on human health when exposures to RF field [3]. They also believed that exposure to radiation from base station for long period could cause different diseases like cancer, destroys reproductive organs, congenital anomalies, epilepsy and persistent headache. It is generally agreed that further research is needed to determine the effects and their possible relevance, if any, to human health [4, 5].However, in spite of the continuous research that has be carried out by many researchers in order to determine a safety limit for RF

radiation exposure, biological effects as relate to human exposure standards throughout Nigeria need to be harmonized. The recommended level have being revised many times recently and not all scientific bodies have being able to reach an agreement on this issue. In Nigeria the International Commission on ICNRP for maximum limits of exposure is adopted by the Nigeria Communications Commission (NCC) as the standard limit of exposure [10] [11]. Human exposure is quantified by the distribution of the time derivative of the absorbed electromagnetic energy per unit mass, i.e., specific absorption rate (SAR). The standards give the accepted maximum values for this quantity, in the form of basic restrictions, which are the starting point in the computation of the reference levels given in the standards (Nicholas and Bechet, 2006). There are few regulatory bodies providing recommendations or precautionary limit to prevent any possible health effect that may be associated with GSM radiation exposure. The Nigerian Communication Commission (NCC) adopted the International Commission on Non Ionization Radiation Protection (ICNIRP) guideline which is 4.5 $\mu W/m^2$ for GSM 900 and 9.00 $\mu W/m^2$ for GSM1800, and this guideline is based on the thermal effects of radiofrequency (RF) radiation exposure(NCC, 2014).
In this work, evaluation of the exposure level of electromagnetic radiation (EMR) from mobile communication base stations in The Polytechnic, Ibadan main campus has been explored so as to determine the level of EMR emitted from the base stations within the campus

II. MATERIALS AND METHOD

In this study, the materials and instrumentation system used are hand held GQ EMF-360 EF RF meter, Digital distance wheel meter and GM3120 electromagnetic radiation tester. GQ EMF-360 EF RF meter has a high sensitivity sensors installed with radio frequency up to 10 GHz and EMF up to 400 KHz with built in RF spectrum analyzer and GQ RF browser for real time RF monitoring. It has a built in flash memory for data logging.

Four mobile phone base stations were selected as a sample from the base stations which are constructed in The Polytechnic Ibadan. These sites selected for radiation assessment are distributed in different regions within the campus. The sites are; DPP Office, North campus Library, VSESC road and Odejayi, Apete, Ibadan.

The electromagnetic radiation emitted from mobile phone base stations was measured at an interval of 20 m starting from the 20 m from the foot of the base station up to a distance of 300 m. The measurements were accomplished using a GQ360 EMF RF meter alongside the digital distance wheel meter which was used to measure the distance from the base stations. The power density which is the power per unit area normal to the direction of propagation was estimated using equation (1) while the electric field was computed using equation (2). The experimental measurement of electric field was carried out using GM3120 Electromagnetic radiation tester.

$$S = \frac{P_t G_t}{4\pi R^2} \quad (1)$$

$$S = \frac{E}{120\pi} \quad (2)$$

III. MEASUREMENT CAMPAIGN

Base station A, located at DPP Office supplies MTN and 9-MOBILE which is a single network and double operator, it has antenna gain of 17 dB, antenna height of 50 m and transmission frequency of 935 MHz. Base station B, located at North Library supplies MTN which is a single network and single operator, it has antenna gain of 8 dB, antenna height of 35 m and transmission frequency of 954 MHz. Base station C, located along VSESC Office supplies SPECTRANET

SMILE which is a single network and multiple operators, it has antenna gain of 17 dB, antenna height of 50 m and transmission frequency of 957 MHz. The SPECTRNET SMILE is basically used for data connection. Base station D, located at Apete, Odejayi supplies MTN, GLO & AIRTEL which is a single network and multiple operator, it has antenna gain of 17 dB, antenna height of 50 m and transmission frequency of 947 MHz. hence, all the base stations considered operates at GSM900.

IV. RESULTS AND DISCUSSION

Figures 1 depict electromagnetic radiation power densities with distance in the study area. Generally, for all the base stations considered, the power density increases as the distance increases from 0 to 40 m and decreases as the distance increases from 40 m up till 300 m. It was also noted that the power densities of each base station differ, this may be due to the rate of subscribers using the network supplied by each base stations. The results also shows that, the radiation level was dominant at base station A which supplies MTN and 9-MOBILE (around DPP office) when compared with other locations as shown in figure 1. Power density was also varied depending on the varieties of prevailing factors at the base station as a result frequency band of transmission. Amplitude fluctuations were also noticed during the measurement and this may be attributed to the rate at which the particular base station was being assessed by subscribers, nevertheless, the power densities for the four selected base stations comply with the ICNIRP standard for GSM900MHz which is 0.45 mW/m^2.

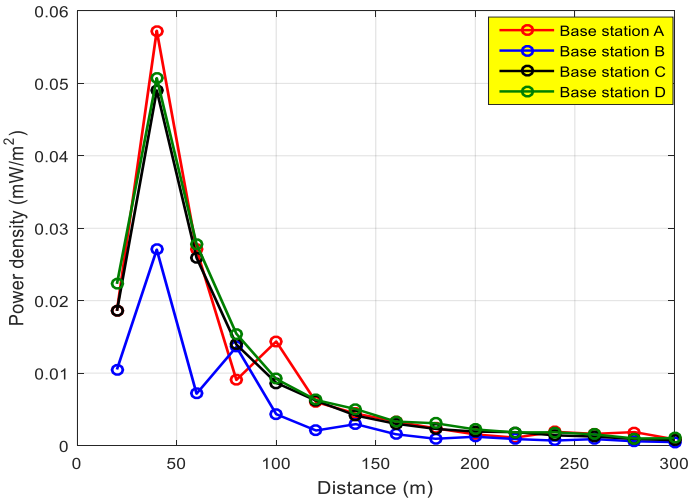

Figure 1 : Graphical representation of power density against distance for all the base station

Table 1: Correlation coefficient between the distance from the base station and the power density measured

Base stations	Correlation coefficient (r)
A	1.0000 −0.7001 −0.7001 1.0000
B	1.0000 −0.7146 −0.7146 1.0000
C	1.0000 −0.7435 −0.7435 1.0000
D	1.0000 −0.7632 −0.7632 1.0000

Figure 2 depicts the variation of electric field with distance for all the base stations considered. It was observed that the maximum electric field level for base station A obtained was 40.60 V/m which almost reaches the International limit, this is due to the high rate of the user of the provided network from this base station which is MTN and 9-MOBILE. These two networks have high demand in the economy for call making and data connection in this study area and this could influence the rate of the electric field from the base station and cause congestion or overloading on such station. For the other base stations understudy B, C and D. the maximum Electric field noted were 15.12, 35.60 and 34.50 V/m

respectively. The peak value was also observed around 40 m which implies that the compliance distance of all the base stations in this area is 40 m. The IEEE standard for electric field from a base station is 41 V/m for GSM 900.

Figure 3 shows the bar graph of the mean variation of electric field emitted by each base stations. Base station around DPP office radiate high amount of electric field with the mean value 14.95 V/m while the base station located around the North library of the institution shows lowest mean radiation value (5.74 V/m)

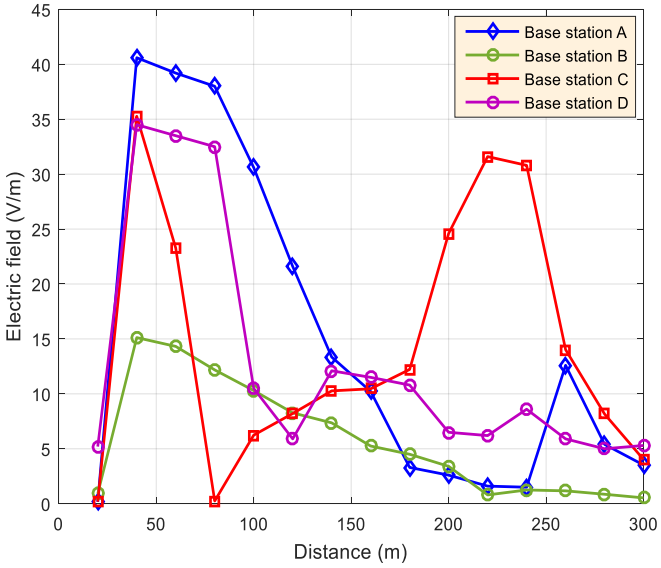

Figure 2 : Graphical representation of electric field against distance for all the base station

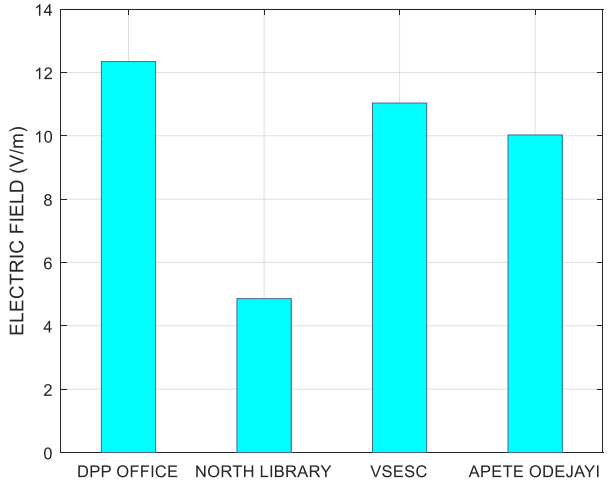

Figure 3 : Average electric field for all the base stations considered

Table 1 : percentage comparison of measured power densities with ICNIRP limit

D (m)	Base station A	Base station B	Base station C	Base station D
20	0.01859 (4.1%)	0.01050 (2.3%)	0.01860 (4.13%)	0.02232 (4.96%)
40	0.02705 (6.01%)	0.02705 (6.0%)	0.04903 (10.89%)	0.05072 (11.27%)
60	0.05326 (11.8%)	0.00716 (1.59%)	0.02593 (5.76%)	0.02780 (6.18%)
80	0.00906 (2.01%)	0.01362 (3.02%)	0.01395 (3.1%)	0.01543 (3.43%)
100	0.01437 (3.19%)	0.00433 (0.96%)	0.00866 (1.92%)	0.00920 (2.04%)
120	0.00601 (13.35%)	0.00208 (0.46%)	0.00620 (1.38%)	0.00629 (1.40%)
140	0.00442 (9.82%)	0.00296 (0.66%)	0.00414 (0.92%)	0.00503 (1.12%)
160	0.00333 (0.74%)	0.00157 (0.35%)	0.00301 (0.67%)	0.00332 (0.74%)
180	0.00238 (0.53%)	0.00094 (0.21%)	0.00230 (0.5%)	0.00308(0.68%)
200	0.00154 (0.34%)	0.00122 (0.27%)	0.00193 (0.43%)	0.00223 (0.50%)
220	0.00110 (0.24%)	0.00090 (0.2%)	0.00185 (0.41%)	0.00182 (0.40%)
240	0.00190 (0.42%)	0.00069 (0.15%)	0.00141 (0.31%)	0.00183 (0.41%)
260	0.00162 (0.36%)	0.00089 (0.19%)	0.00124 (0.28%)	0.00154 (0.34%)
280	0.00186 (0.41%)	0.00059 (0.13%)	0.00091 (0.20%)	0.00098 (0.22%)
300	0.00087 (0.19%)	0.00048 (0.11%)	0.00074 (0.16%)	0.00102 (0.23%)

Table 1 shows the percentage comparison of measured power densities with ICNIRP limit, it was discovered that all the operators comply with the

ICNIRP recommended level. For base station A, the maximum radiated value is 13.35% of the ICNIRP Limit, for base station B, the maximum radiated value is 6% of the ICNIRP, for base station C, the maximum radiated value is 10.89% of the ICNIRP and for base station D, the maximum radiated value is 11.27% of the ICNIRP.

V. CONCLUSION

The average RF EMF power density declined with increasing distance from the base stations and radiation intensity varies from one mobile telecommunication base station to another. The highest total power density in The Polytechnic, Ibadan campus was obtained in DPP office and VSESC office respectively. Hence, the work has revealed that the radio frequency exposure hazard index in The Polytechnic Ibadan campus was below the permitted RF exposure limit to the general public has recommended by ICRNIP and WHO. However, as much as possible, mobile network providers should site mobile base stations at least 300 m away from residential areas and other sources of electromagnetic radiation. The coefficient of correlation values are of negative correlations which are insignificant to exposure of human health.

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