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Evaluation of GSM Radiation Power Density in Three Major Cities in Nigeria

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***Abstract*—**The levels of maximum power density of GSM signals in the cities of Lagos, Ibadan and Abuja were studied. Measurements were made with a calibrated hand held spectrum analyzer 200m away from 271 base stations, at 1.2m to the ground level. The maximum GSM 900 signal power density was 139.63μW/m^2 in Lagos, 162.49μW/m^2 in Ibadan and 5411.26μW/m^2 in Abuja. Also, the maximum GSM 1800 signal power density was 296.82μW/m^2 in Lagos, 116.82μW/m^2 in Ibadan and 1263.00μW/m^2 in Abuja. The level of power density of GSM 900 and GSM 1800 signals in the cities of Lagos, Ibadan and Abuja are far less than the recommended value of 4.5W/m^2 for GSM 900 and 9.0 W/m^2 for GSM 1800 by the ICNRP guideline. It can be concluded that exposure to GSM signals in these cities cannot contribute to the health detriments caused by thermal effects of radiofrequency radiation.

***Keywords*—**Radiofrequency, power density, radiation exposure, base stations (BTS).

I. Introduction

THE Global System of Mobile Communication (GSM) has dominated the telecommunication market in the world [1]. In Nigeria, thousands of base stations have been installed between 2001 and 2013, and a larger part of them are found in her major cities. There is no doubt that the current rate of increase in the number of these base stations are of great concern to the public [2], [3]. There have been speculations that there will be an increase in the numbers of phone users in the nearest future [1]-[4]. This increment in the numbers of phone users will in return increase the numbers of base station sites, leading more agitations and public concerns for the possible negative effects on health and other hazards associated with living in close proximity to these base stations [5].

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) [6] guideline, and this guideline is based on the thermal effects of radiofrequency (RF) radiation exposure.

Mobile communication antennas are designed to radiate in an omnidirectional or a directional pattern [7]. Directional antennas are mostly employed in highly populated areas where communication sectors or cell are created to target specific set people using mobile phones [8]. In this kind of environment the maximum radiation power density from a GSM antenna is usually found at some distances away from the foot of the mast, due to the height of the antenna and its radiation beam pattern [9].

In Nigeria GSM mobile communication makes use of GSM 900 and GSM 1800 communication band [10]. Although 3G systems have introduced, the existing GSM facilities are still much in existence. Communication antennas in Nigeria are commonly mounted at 30m to 45m on tall masts and the coverage of these antennas are mostly tri-sectorial in configuration. Base stations can at times be as close as 5m to residential buildings and can also be found on tall office buildings [11]. Also, the distance between two base stations in an area can be as close as 500m [12], [13].

The public are ignorant about the level of RF power density around GSM base stations [14], the mechanism of interaction of RF radiation with biological units and the effect of RF radiation from GSM antennas on the human body. This has been a major concern to the public and it will take a lot of research publications and enlightenment to prove that there are no or limited health risks associated with these bas stations. It is very important to assess the level of exposure to RF radiation from the numerous base stations antennas in our cities, to test their compliance with set standards and to provide information on exposure scenarios to the public. Therefore, this study aims at assessing the level of maximum power density around GSM base stations in three major cities in Nigeria.

II. Materials and Methods

This study was conducted in the cities of Lagos, Ibadan and Abuja, Nigeria. Lagos is a mega city and it is also regarded a state with 20 local government areas, about 2.2 million households and a human population of about 9.1 million. The city of Ibadan is located in Oyo state and it is one of the largest cities in Africa. Ibadan's core region consists of about 6 local government areas, a household population of about 0.4 million and a human population of about 3 million. The whole of the federal capital territory is commonly regarded as Abuja. It has about 6 local governments with a household population of 0.3 million and a human population 1.4 million [15].

There are many areas in Lagos, Ibadan and Abuja that have similar social, economic and environmental characteristics. Such similarities include the types and arrangement of houses, road networks and transport system, commercial centre with

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tall buildings, markets and the presence of different educational institutions. These cities due to their large population will definitely have their fare share of the Nigeria's 93.4% teledensity and about 27,000 base stations. GSM base station sites are usually located near a target population. They can sometimes be as close as 5m to residential building in highly populated area in the study areas. Base station antennas are usually mounted at 30m to 45m on tall masts in tri-sectorial configuration, and these masts are observed to be averagely 500m apart in many areas.

From the previous study of the variation power with distance from some GSM base stations in Nigeria [9], the maximum power density from a single BTS signal frequency can be observed averagely around 200m radius of the BTS. Based on the results of this study, measurement of maximum power density (worst case scenario of exposure) from some GSM base stations in the cities of Lagos, Ibadan and Abuja was done at about 200m from the feet these base stations. Measurements of GSM 900 and GSM 1800 signal radiations were made at 96 base stations in the city of Ibadan, 95 in the city of Lagos and 80 in the city of Abuja. Measurements were made between 9.00 am and 3.00 pm each day and all necessary precautions were taken to reduce external influences on the integrity of the results.

Measurements were made with a calibrated SPECTRAN HF - 60105V4 hand held spectrum analyzer coupled with a calibrated OmniLOG 90200 isotropic antenna both made by Aaronia AG. The spectrum analyzer can measure signals from 1 MHz to 9.4 GHz and it is also sensitive to signals between – 170 dB to +20 dB power levels. The antenna can receive signals from 700 MHz up to 2.5 GHz and being isotropic can receive signals from all directions. All Measurements were taken at line of sight to the base station antennas at each spot. The spectrum analyzer was set to maximum hold function, where the peak values of each signal were recorded over each sweep. This was done to estimate the worst case scenario of exposure at each location. When the spectrum analyzer's receiving antenna captures the radiofrequency signal into the RF meter, the meter measures the received power density S at the receiving end using:

$$S = \frac{10^{\left(\frac{P-G}{10}\right)}}{1000} \times \frac{4\pi}{\lambda^2} \quad (1)$$

where P is the received power in dBm, G is the receiver's antenna gain in dBi and λ is wavelength of the transmitted signal. Measurements were taken at 1.2m to the ground level for period of 6 minute average time.

III. Results and Discussions

The results of the measurement of maximum Radiofrequency (RF) radiation power density of GSM 900 and GSM 1800 signals, at about 200m from 271 base stations in Lagos, Ibadan and Abuja are presented in the graphs in Fig. 1 to 6. The results show that 78% of the measurements of GSM 900 signal and 72% of that GSM 1800 signal are less than 10μW/m^2 in Lagos. There is an indication in Fig. 2 that there is a close spread of exposure to GSM 1800 in the city of Lagos. About 70% of the measurements of GSM 900 signal and 80% of that of GSM 1800 signal are less than 10μW/m^2 in the city of Ibadan. The city of Abuja presents a different level of exposure, where 19% of the measurements of both GSM 900 and GSM 1800 signals are less than 10μW/m^2. Also in Abuja, 25% of the measurements of GSM 900 signal and 38% of that of GSM 1800 signal are between 10 - 100μW/m^2, while 35% of the measurements of both signal bands are between 100 - 500μW/m^2.

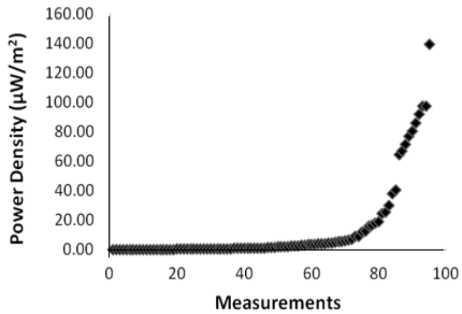

Fig. 1 GSM 900 signal maximum power density measurements in Lagos

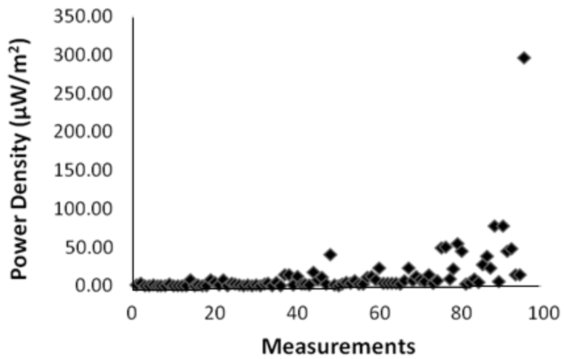

Fig. 2 GSM 1800 signal maximum power density measurements in Lagos

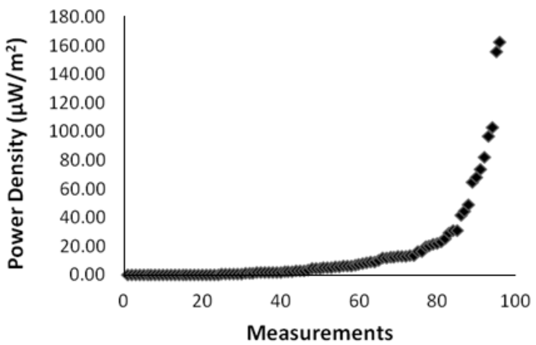

Fig. 3 GSM 900 signal maximum power density measurements in Ibadan

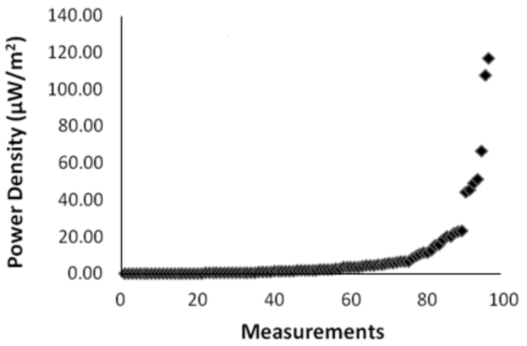

Fig. 4 GSM 1800 signal maximum power density measurements in Ibadan

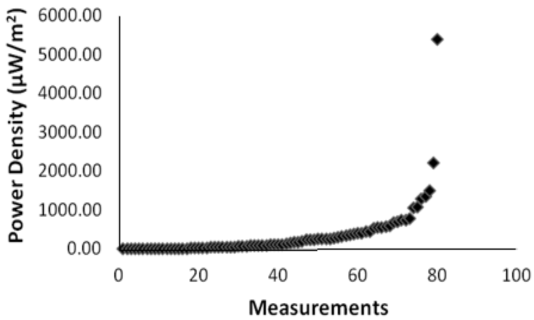

Fig. 5 GSM 900 signal maximum power density measurements in Abuja

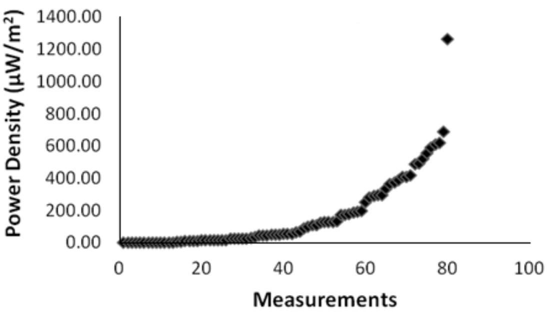

Fig. 6 GSM 1800 signal maximum power density measurements in Abuja

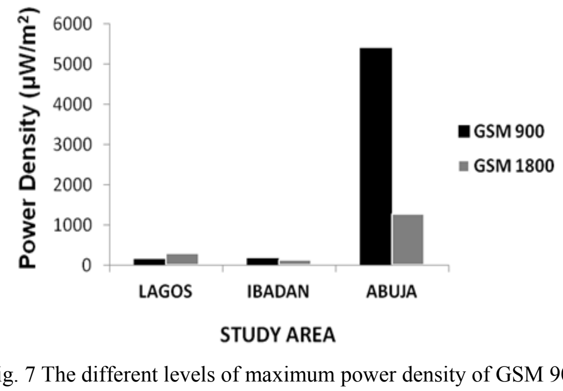

Fig. 7 The different levels of maximum power density of GSM 900 and GSM 1800 in the study areas

The highest value of the measurements of the maximum GSM 900 signal power density is 139.63μW/m^2 in Lagos, 162.49μW/m^2 in Ibadan and 5411.26μW/m^2 in Abuja. Also the highest value of the measurements of the maximum GSM 1800 signal power density is 296.82μW/m^2 in Lagos, 116.82μW/m^2 in Ibadan and 1263.00μW/m^2 in Abuja. This result is presented in the graph in Fig. 7. The level of RF exposure to GSM signals in the city of Lagos and Ibadan appears to be similar. The only factor that might have contributed to the little difference in the level of exposure in these cities is that in Lagos, the limited land space encourages the cluster of base stations and the presence of more GSM 1800 signals.

The level of RF exposure due to GSM signals in the city of Abuja is about 5 times higher than that of Lagos and Ibadan. The land space in the central Abuja district is small and this has encouraged the installation of many base station collocations and the presence of so many radiating antennas in the city. In other areas of the city where longer range of mobile communication is needed, GSM 900 signal band is employed. Since GSM 900 signals are associated with a higher level of transmitting power, GSM 900 signals power density is higher in Abuja. All the values of the measured power density of GSM 900 and GSM 1800 signals in the cities of Lagos, Ibadan and Abuja are far less than the recommended value of 4.5W/m^2 for GSM 900 and 9.0 W/m^2 GSM 1800 by the ICNRP guidelines [6].

IV. Conclusion

From the study of the level of maximum radiofrequency radiation power density at about 200m away GSM base stations in the cities of Lagos, Ibadan and Abuja, it can be observed that the level of maximum or worst case scenario of exposure in the city of Abuja is significantly higher than the other cities. This can be attributed to higher demand for communication base stations relative to the availability of space in the city. Although the level of exposure in these cities are far less than the recommended reference levels, precautions should be taken on how close a base station is installed to residential buildings and on the rapid increase in the number base stations in the country. To alleviate the fear that people have concerning the exposure to GSM radiation signals in Nigeria, it can be concluded based on results of this study that the level of worst case scenario of RF exposure due to GSM signals cannot contribute to health detriments caused by thermal effects of radiofrequency radiation.

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