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ANALYSIS OF MEASURED RADIOFREQUENCY ELECTROMAGNETIC FIELD LEVELS FROM SOME SELECTED 4G LTE BASE STATIONS IN THE ASHANTI AND WESTERN REGIONS OF GHANA

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Abstract

Radiofrequency electromagnetic power density levels were measured and analyzed for 100 4G LTE Mobile Base Stations in the Ashanti and Western regions of Ghana. Measurements were made at varying distances in the vicinity of each base station using a spectrum analyzer coupled to a log-periodic antenna. The results varied from as low as 3.42E-08 mWm^{-2} to as high as 1.52E-01 mWm^{-2}. The results however, complied with the ICNIRP reference level of 4 W/m^2 for the frequency of 800 MHz and also found to be lower than previous works conducted in Ghana and elsewhere.

Introduction

In the telecommunication industry, RF can be used for the purposes of both voice and data communication. 4G LTE wireless technology in Ghana is driving data usage in the application of multimedia Anibrika et al. (2017)
Simply put, 4G is the shortened name for the fourth generation of the wireless data transmission networks set-up by the mobile phone industry in order to offer more bandwidth and greater speeds for everyday mobile device operations, such as messaging and video calling whilst LTE, an abbreviation for Long-Term Evolution, commonly marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements (Rappaport, 2002). The standard is developed by the 3GPP (Third Generation Partnership Project).
Most of the antennas that carry the signals to and fro the 4G LTE gadgets are located near schools, hospitals and highly populated residential areas (Amoako et al., 2009) and this has brought about a lot of agitations from the public with regards to health and safety issues as far as the radiofrequency (RF) radiation which is emitted from these antennaes is concern (Freudenstein et al., 2014, 2015).
The objective of this research work was to determine the contribution of exposure due to LTE technology and to compare the measured eld levels to International Commission on Non-Ionising Radiation Protection (ICNIRP) reference level.

Materials and Methods

Study areas

Ashanti Region

It is the third-largest of the ten administrative regions, occupying a total land surface of 24,389 km^2 (9,417 sq miles) or 10.2 per cent of the total land area of Ghana (Ghana Statistical Service, 2022). The Ashanti Region lies between longitudes 0.15W and 2.25W, and latitudes 5.50N and 7.46N. However, it is the second most populated region in the country with a population of 5,432,485 according to the 2022 census, (Ghana Statistical Service, 2022). The Ashanti Region is famous for its major gold bar and cocoa production. The regional capital is Kumasi and its the largest city in the region. Figure 1 is a map that shows the location where the measurements were taken in the region.

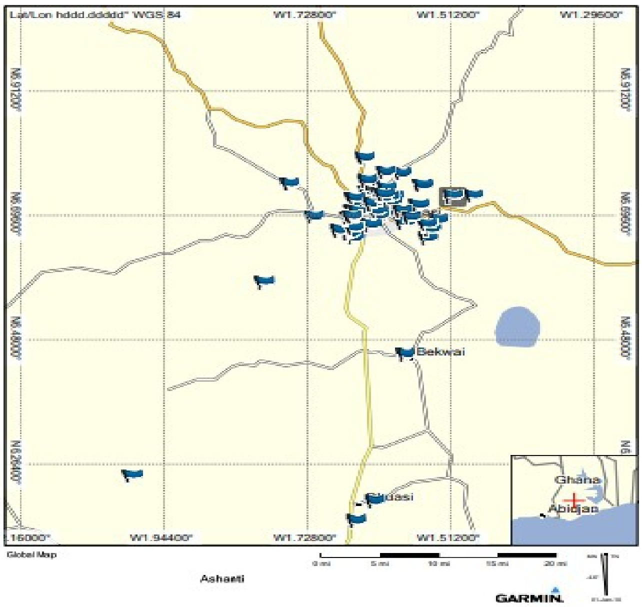

Figure 1. Locations of sites where measurements were taken in the Ashanti region indicated by the tower symbol

Western Region

The Western Region spreads from the Ivory Coast border in the west to the Central Region in the east, and located at 5.499998 N latitude and -2.499998 W longitude (Ghana Statistical Service, 2022). The region experiences the highest rainfall in Ghana and has fertile soils. There are a number of small and large-scale gold mines and offshore oil platforms which dominate the Western Regions economy. Figure 2 is a map that shows the location where measurements were taken in the region.

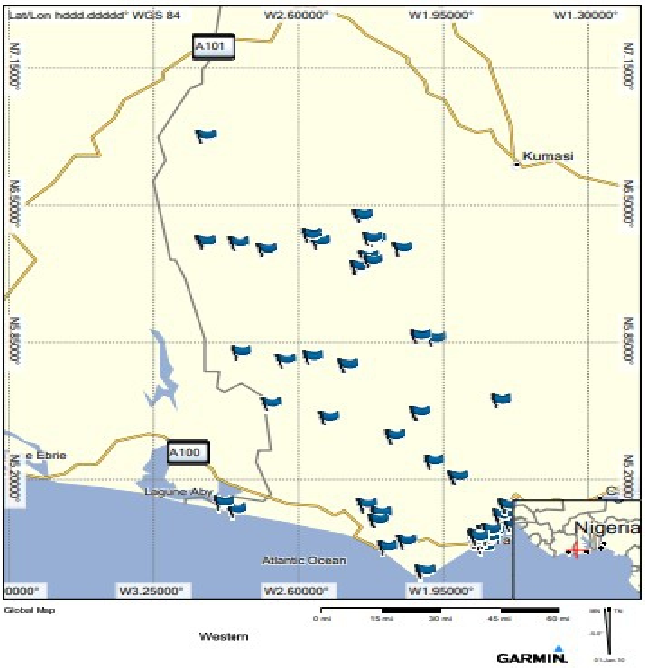

Figure 2. Locations of sites where measurements were taken in the Western region, indicated by the tower symbol

Measurement Procedure

The measurements covered fty (50) location of Fourth Generation Long Term Evolution (4G LTE) base stations, distributed within the two regions. Five measurements were made at distances of 10, 30, 50, 70 and 100 m from each mast. Measurements were between 08:00 and 17:00 Greenwich mean time (GMT) each day.

The procedures for EM eld measurements have been dened and standardised (European Committee for Electrotechnical Standardization, 2002, 2006, 2008a,b; The Institute of Electrical and Electronics Engineers, 2003; The Standards Association of Australia, 1998). Electronic Communications Committee (2007), protocol was used for the eld measurements. A calibrated spectrum analyzer (Anritsu Spectrum Master MS2720T) with a frequency range of 9 kHz to 43 GHz was connected to a hand-held Log-periodic antenna (Transformational Security TS-6021) of frequency range of 80 MHz to 3 GHz, with the aid of an RF cable for electric eld measurement.

All the measurements were made at public access points and the points were chosen to represent the highest levels of exposure to which a person might be subjected to, at an average height of 1.5 m from the ground according to the ECC protocol. In addition, the measurement was made using root-mean-square (RMS) and maximum hold spot measurement methodology. The measured spectrum data recorded, was stored and used to perform Electric eld strength analysis as indicated in equation 1.

$$E_{dB(\mu\frac{V}{m})} = V_{0\ db(mV)} + A_{c\ (dB)} \tag{1}$$

where; E is the electric eld strength in dB (mV/m), V_o is the output voltage of the antenna in dB (mV), K is the antenna factor in dB (m^{-1}) and A_c is the attenuation of the antenna signal path in decibel.

The corrected Electric eld strength was then converted into V/m taking into consideration polarization according to the following equation 2:

$$E\left(\frac{V}{m}\right) = 10\left\{\frac{\left(E\left(dB\mu\frac{V}{m}\right)\right)}{20} - 120\right\} \tag{2}$$

An average of ve identied measurement location of potential exposure in the vicinity of the base station at each site was then calculated using equation 3:

$$Mean, x = \Sigma_{j=1}^{n}\frac{x_j}{n} \tag{3}$$

The power density (in Wm^{-2}) which is the amount of power (time rate of energy transfer) per unit volume was calculated using the relations as shown equation 4:

$$S = \frac{E^2}{Z_0} \tag{4}$$

Where: E is the electric eld strength in V/m, S is the power density in W/m^2 and Z_0 is the impedance in Ω. For free space, impedance is 377Ω. In determining compliance with ICNIRP, the relation below was used:

$$\Sigma_1^n\frac{S_i^{meas}}{S_i^{guid}} = \frac{S_1^{meas}}{S_1^{guid}} + \frac{S_2^{meas}}{S_2^{guid}} + \ldots + \frac{S_N^{meas}}{S_N^{guid}} < 1 \tag{5}$$

Where S^{meas} is the measured (calculated) power density and S^{guid} is the guidance or reference power density and checked with the public exposure limits of 4 W/m^2 as recommended by the International Commission on Non-ionising Radiation Protection (ICNIRP, 2010).

Results and Discussion

The results indicated by gures 3 and 4, generally showed a variation of the power density levels recorded at various location in both Ashanti and Western regions of Ghana. The results varied from a minimum to a maximum with comparable mean levels. The levels in the Ashanti Region was found to be relatively higher than that of the Western Region.

The power densities levels in the Ashanti region ranged from a minimum of 5.74E-08 mW/m^2 at site 23 which recorded a mean value of 5.86E-08 mW/m^2 and a maximum value 1.79E-06 mW/m^2 to a maximum level of 1.52E-01 mW/m^2 at site 11

Table 1. Comparison of results to works in Sweden and the United Kingdom

Country	Frequency (MHz)	ICNIRP Reference (Wm^{-2})	Power Density (mWm^{-2})		Compliance(%)
			Maximum	Mean	
Ghana	800	4.0	0.15	0.05	0.004
Kosovo	1810 - 1825	9.0	1.26	0.19	0.014
Sweden	2600	10	1.52	0.10	0.015
UK	2600	10	0.59	0.10	0.006

which also recorded a mean value of 4.93E-02 mW/m^2 and minimum value of 1.54E-03 mW/m^2. Site 23 was however located in a community along the Kumasi-Mampong road while that of site 11 was very close to the main Kumasi Township and the area had an undulating terrain. The relatively high level recorded at location 11 could be as a result of a convergence of the greater part of the beam at that spot during measurement.

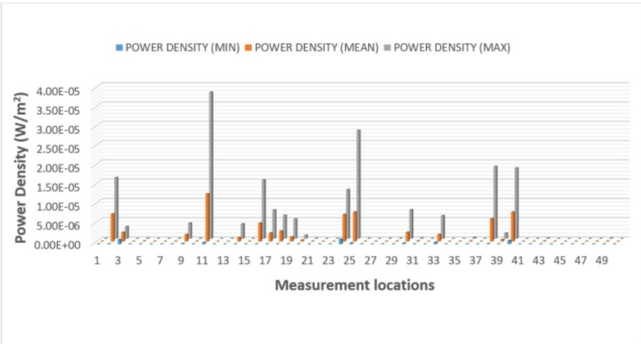

Figure 3. Variation of power density levels with measurement locations in the Ashanti Region

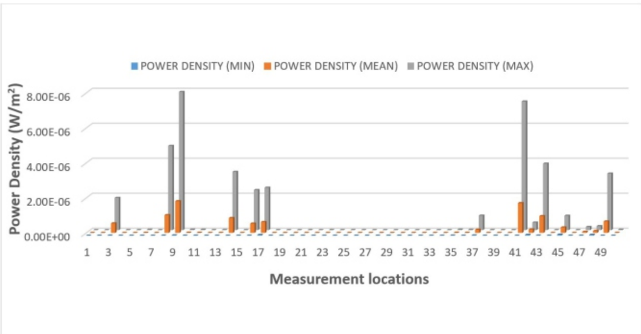

Figure 4. Variation of power density levels with measurement locations in the Western Region

Similarly, the power density levels in the Western Region varied from as low as 3.42E-08 mW/m^2 at site 19 with 3.63E-11 mW/m^2 and 3.96E-08 mW/m^2 as mean and maximum values respectively to as high as 7.79E-03 mW/m^2 at site 9 with a minimum value of 1.59E-05 mW/m^2 and 1.81E-03 mW/m^2 as mean.

Figure 5 shows the variation of mean power density levels in both Ashanti and Western Regions. Comparatively, the results varied with 4.29E-10 and 7.45E-11 mW/m^2 at the 10% percentile for Ashanti and Western Regions respectively. This result increased in power density level at the 90% percentile with 6.84E-06 and 8.30E-07 mW/m^2 respectively. The median levels recorded, however, were 2.34E-08 and 1.69E-09 mW/m^2. To evaluate the spread of the results with respect to the levels and locations, variation from the mean values were estimated for both regions. The variation from the mean values was found to be 197.4 and 216.2% respectively for Ashanti and Western Regions. This result is shown in gure 6.

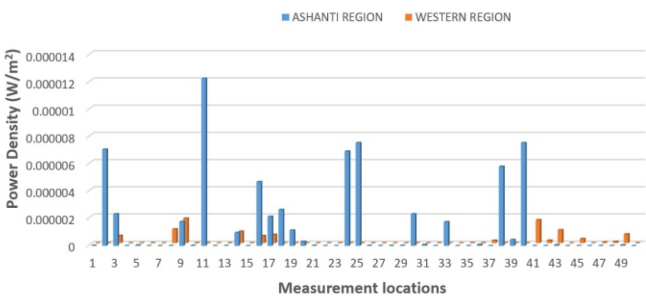

Figure 5. Variation of mean power density levels

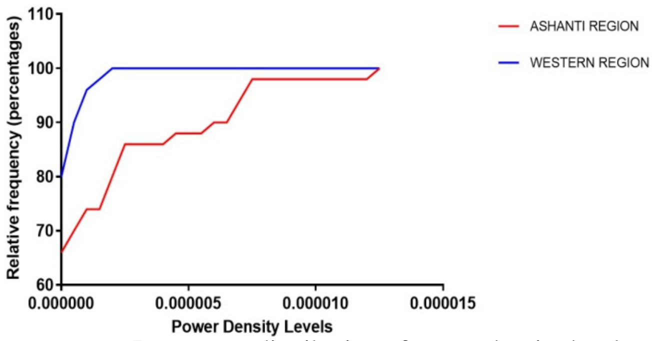

Figure 6. Percentage distribution of power density levels

The mean and their respective standard across the entire locations were also estimated to be (1.37E-06 – 3.82E-07) mW/m^2 and (1.93E-07 – 5.91E-08) mW/m^2 respectively for Ashanti and Western Regions. Comparing the results to works carried out in Ghana in the frequency range of 900 MHz, 1800 MHz and 2100 MHz showed a relatively low level (Amoako et al., 2009; Deatanyah et al., 2018, 2012). Comparing the results to similar research work of 138 locations with 20 LTE mobile base stations as recorded by Mimoza et al. (2017). The results from Mimoza et al. (2017) was found to be relatively high compared to this current work. The maximum from this work was 0.004% of the ICNIRP reference level of 4 W/m^2 compared to 0.014% reported by Mimoza et al. (2017). Further comparison to other works in Sweden and the United Kingdom (Joseph et al., 2012a,b) revealed relatively higher values for both the mean and maximum values respectively recorded by this work as indicated in table 1.

Conclusion

The analysis of radiofrequency eld measurement of 4G LTE base stations in the Ashanti and Western regions of Ghana to determine the level of exposure was carried out at varying distances from the mast. The results compared to works done within and out of the country revealed a low contribution of radiofrequency exposure to the general public. The results were also found to comply with the ICNIRP reference levels for the general public.

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