ANALYSIS OF ELECTRIC FIELD STRENGTHS AND POWER DENSITIES OF 4G LTE BASE STATIONS IN THE GREATER ACCRA REGION OF GHANA[1]

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ABSTRACT

The analysis of electric field strengths and power densities at Fifty (50) Fourth Generation Long Time Evolution (4G LTE) telecommunication base stations in the Greater Accra region, which is an urban and densely populated area was carried out using an Anritsu Spectrum Master coupled to a handheld log-periodic antenna. Measurements were made at five different locations at a height of between 1.5 m above ground level around each of the base stations at a transmission peak period during the day. The measurements were however made at public access points around sites near schools, hospitals and highly populated residential areas. The results of the compliance electric field measurement for the various base stations in the Greater Accra region used for this work varied from as low as 3.85E-08 mV/m at site 46 to as high as 1.17E-02 mV/m at site 40 with corresponding power densities of 1.54E-07 mW/m^2 and 4.71E-02 mW/m^2 respectively. The results however comply with the ICNIRP recommended values of 38.89 V/m and 4 W/m^2 for electric field strength and power density for 800 MHz frequency band respectively.

INTRODUCTION

Mobile communication technology has dominated the telecommunication industry in the world (Olatinwo et. al, 2014). In Ghana most of the telephone mast are installed near hospitals, schools and in densely populated residential areas. There is evidence that the high number of these base stations are of significant concern to the general public (Chitranshi et. al, 2014). It is envisaged that there will be an increase in the number of usage of moibe phones in the near future (Singh, 2012). This will bring about an increase in the number of base stations and will lead to more agitations with regards to the health and safety concerns associated with these base stations (Bello, 2010). There have been reports of dizziness, sleeping problems and nausea, due to RF radiations associated with these base stations (Eger et. al, 2009).

Ghana has adopted the ICNIRP reference limits as it does not currently have its own national guidelines. Therefore the results of this work were compared to that of the ICNIRP safety limits on electromagnetic field.

STUDY AREA

This region has the smallest area of Ghana's 10 administrative regions, occupying a total land mass of 3,245 square kilometres or 1.4 per cent of the total land area of Ghana (https://www.stasghana.gov.gh). It is located at 5.8143° N latitude and 0.0747° E longitude and bordered on the north by the Eastern Region, on the east by the Volta

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Region, on the south by the Gulf of Guinea, and on the west by the Central Region (https://www.ghana.gov.gh). This is the second most populated region, after the Ashanti Region, with a population of 4,010,054 in 2010, accounting for 16.3 per cent of Ghana's total population. Below is a map that shows the sites where measurements were taken in the region (https://www.stasghana.gov.gh).

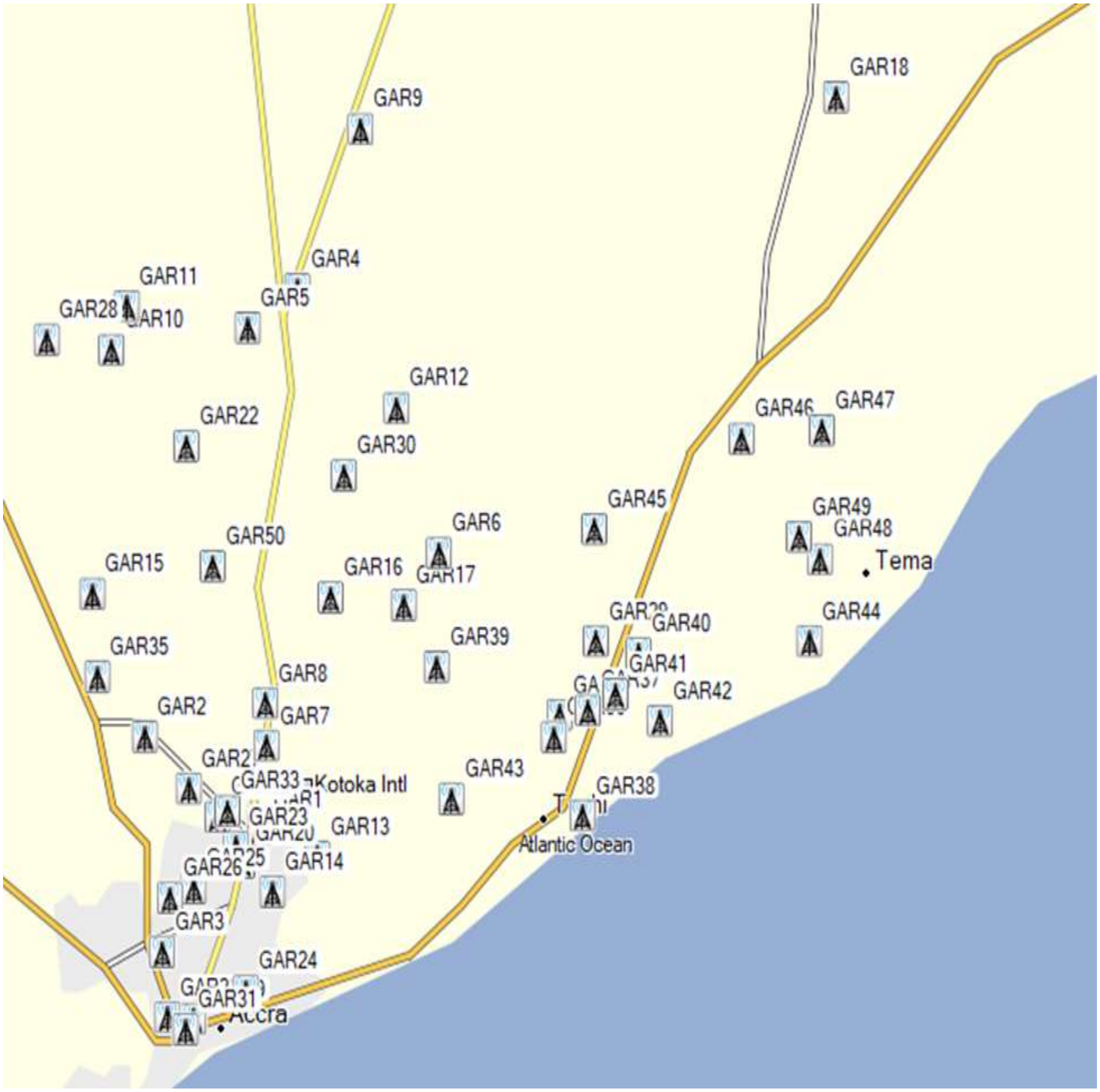

Figure 1: Map that showing sites where measurements were taken in Greater Accra region

MATERIALS AND METHODS

Radiofrequency (RF) signals were measured around fifty (50) Fourth Generation Long Term Evolution (4G LTE) base stations in the Greater Accra region of Ghana, which is an urban and densely populated areas.

The measurements were carried out at five (5) different locations around each mast using an Anritsu Spectrum Master, model MS2720T which was coupled to a handheld Log Periodic Antenna (LPA) model TS-6021.

The spectrum master had an in-built antenna factors and associated cable factors that were able to correct the measured electric field strength. The points at which the measurement were taken around the base stations were chosen based on the direction of the antennae (sector). Also, 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, considering the positions of antennas and also to make sure that there were little or no reflecting objects and as few overhead conductors like power lines and buildings with metal roofs much as possible. These locations were however found by a quick sweep of the area using the measuring equipment. The selected sites were chosen to cover schools, hospitals and highly populated residential areas.

The antenna was connected to the spectrum master with the aid of a RF cable which had a load impedance of 50Ω. The data was then downloaded after each day's measurement onto a lap-top computer. The spectrum master software that had been installed on the lap top was then used to determine the corresponding electric field strength in dB (mV/m) which is a quantitative expression of the intensity of an electric field at a particular location.

$$E = V_o + K + A_c \quad [1]$$

Where; E is the electric field strength in dB (mV/m), Vo is the output voltage of the antenna in dB (mV), K is the antenna factor in dB (m^{-1}) and Ac is the attenuation of the antenna signal path in dB.

An average of all the 5 points at which the measurements were taken at each site was then calculated using the formula:

$$\text{Mean, } \bar{x} = \sum_{j=1}^{n} \frac{x_j}{n} \quad [2]$$

The intention of the measurements was to determine if the RF EME over the frequency bands of 800 MHz of the cell sites comply with the public exposure limits of 38.89 V/m recommended by the International Commission on Non-ionising Radiation Protection (ICNIRP) (ICNIRP, 2010).

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:

$$S = \frac{E}{Z_o}^2 \quad [3]$$

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

$$\sum_1^N \frac{S_i^{meas}}{S_i^{guid}} = \frac{S_1^{meas}}{S_1^{guid}} + \frac{S_2^{meas}}{S_2^{guid}} + \cdots + \frac{S_N^{meas}}{S_N^{guid}} < 1$$
[4]

Where Smeas is the measured (calculated) power density and Sguid 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), (ICNIRP, 2010).

RESULTS AND DISCUSSIONS

The results of the compliance electric field strength measurement for the various base stations in the region varied from as low as 3.85E-08 mV/m at site 46 which had a mean value of 1.42E-07 mV/m and a maximum value of 3.14E-07 mV/m to as high as 1.17E-02 mV/m at site 40 which had a mean value of 8.30E-03 mV/m and a minimum value of 5.65E-03 mV/m. The corresponding power densities of site 46 were; a minimum of 1.54E-07 mW/m^2, a mean of 5.68E-07 mW/m^2 and a maximum of 6.39E-07 the area is mainly a residential area with few factories.

Whereas the corresponding power densities of site 40 were 3.33E-02 mW/m^2 as the mean and 2.27E-02 mW/m^2 and mW/m^2. The site is located along the Tema-Aflao highway and

4.71E-02 mW/m^2 as the minimum and maximum respectively. The mast is located in a sect of estate buildings and it's close to a beach and a lagoon. It's originally a fishing village.

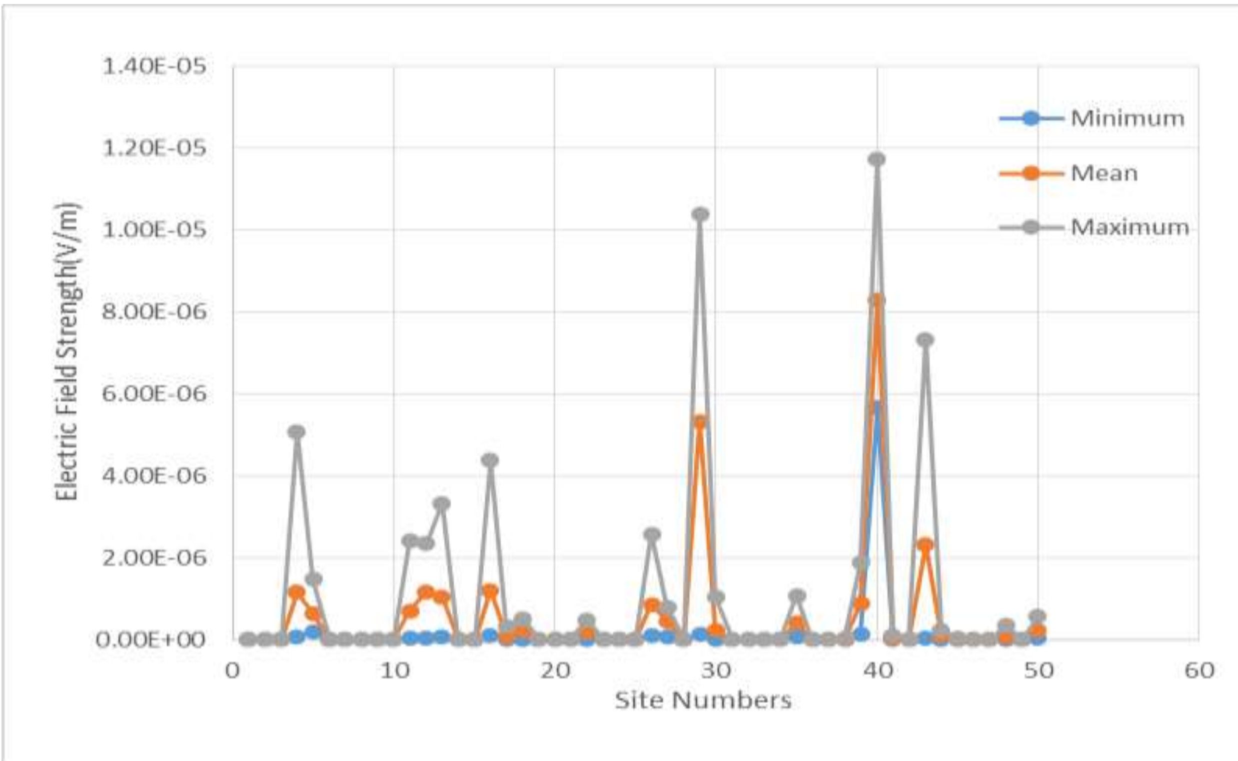

Figure 1: Graph of electric field strength variation with site numbers

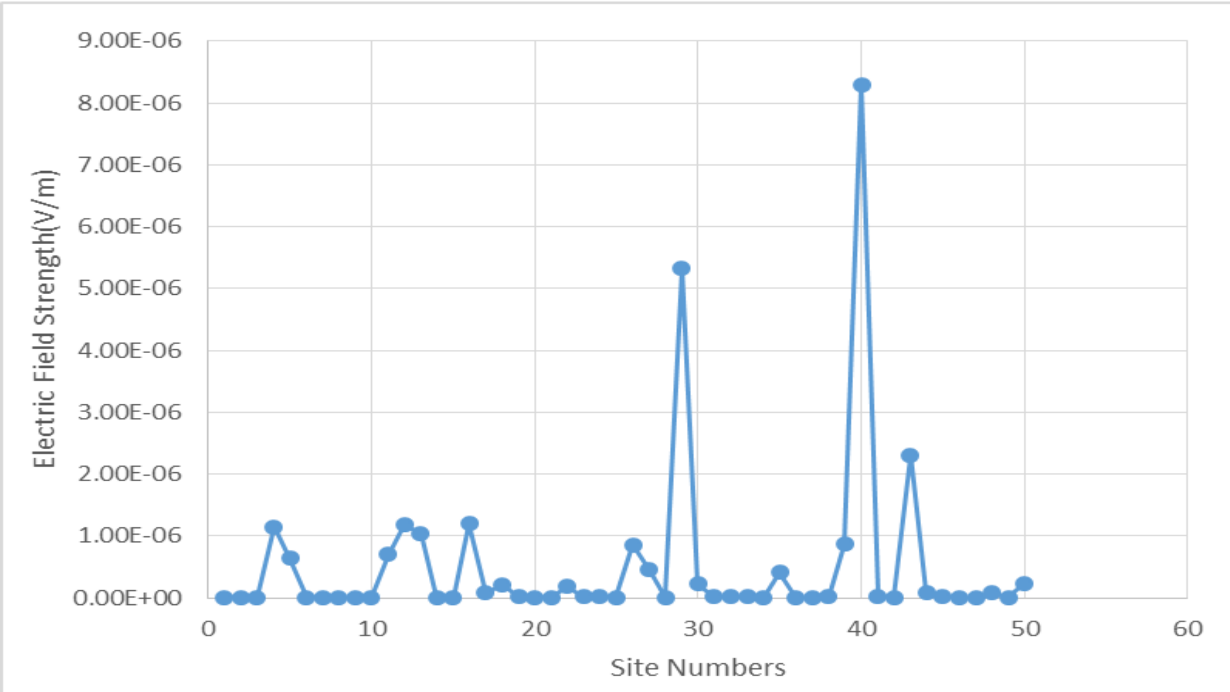

Figure 2: Graph of mean electric field strength variation with site numbers

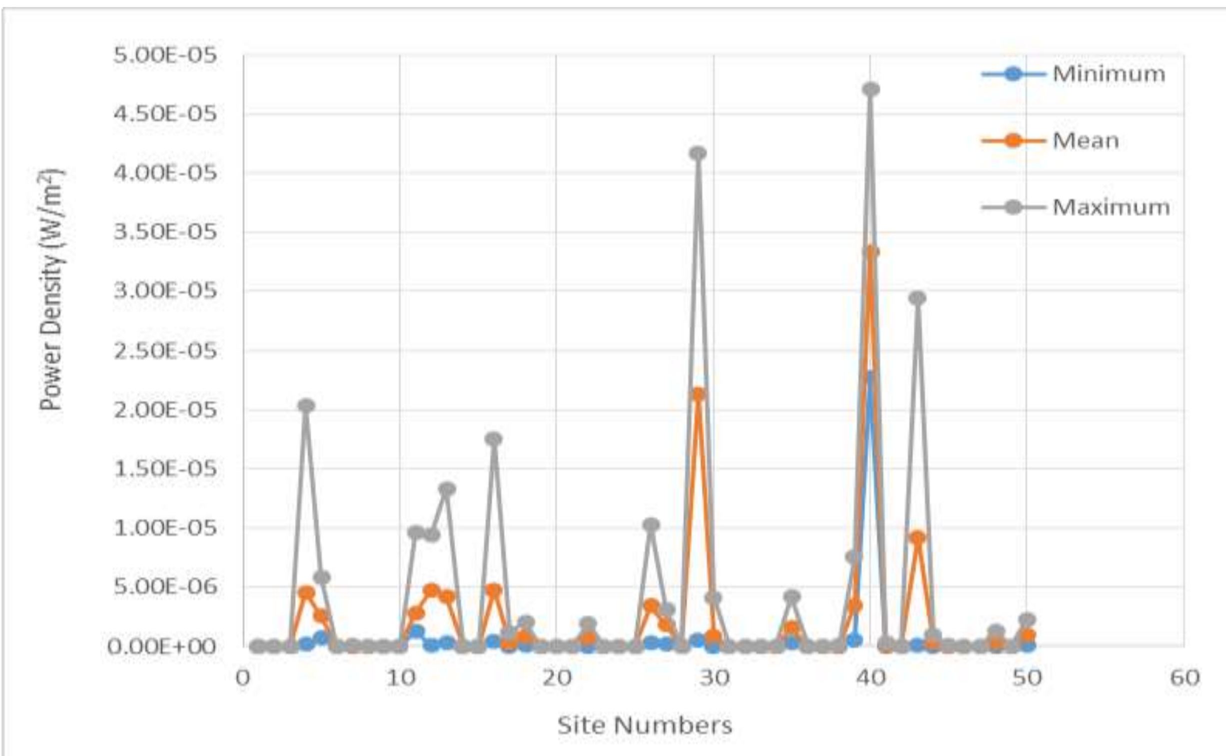

Figure 3: Graph of power density variation with site numbers

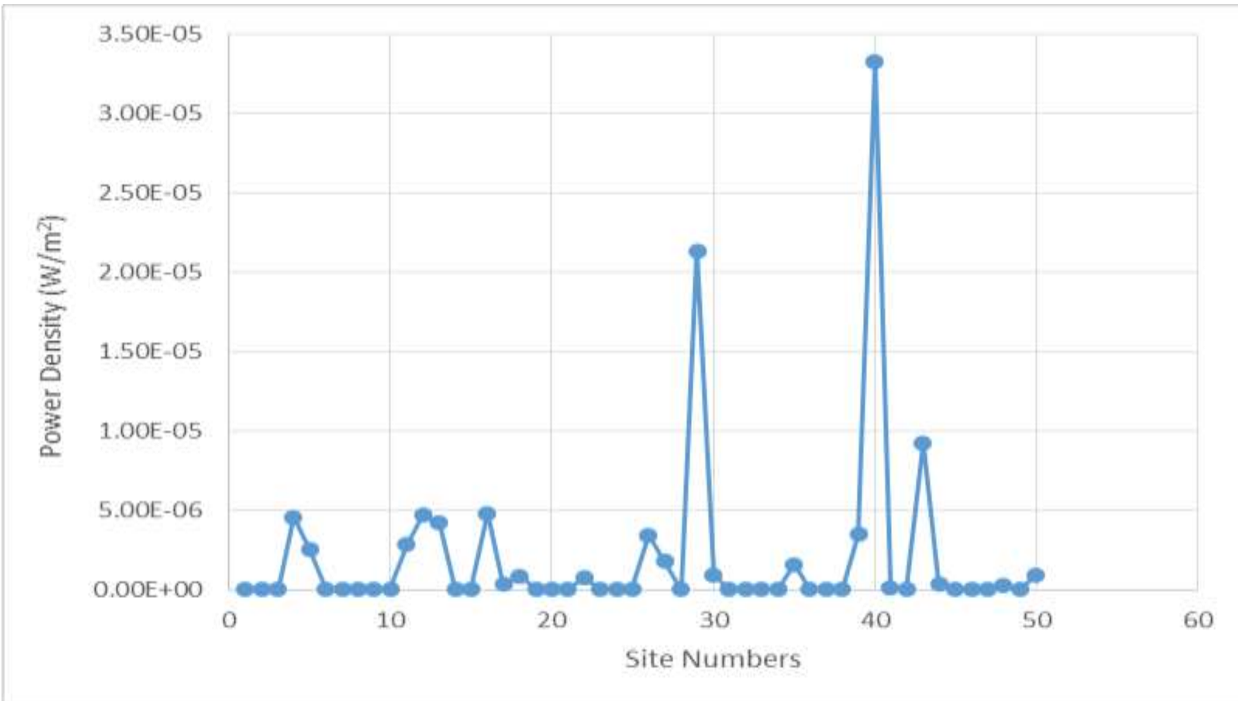

Figure 4: Graph of mean power density variation with site numbers

Specifically, the highest electric field strength is 0.001% of the recommended limit of 38.89 V/m and the highest power density measured within the vicinity of the masts was 4.71E-02 mW/m^2 of the recommended limit of 4 W/m^2.

The results of this work were compared to Deatanyah et.al, (2018) who also measured and analyzed radiofrequency radiations from selected base station in Ghana. Their average electric field strength for GSM 900 was 266.13 mV/m, GSM 1800 was 414.43 mV/m and UMTS 2100 was 366.54 mV/m. The average power densities from Deatanyah et.al, (2018) were GSM 900 was 0.1879mW/m^2, GSM 1800 was 0.4556 mW/m^2 and UMTS 2100 was 0.3564 mW/m^2. This indicates that the results from this work were relatively lower than theirs and could be attributed to the fact that the technology used in the 4 G LTE is much better than that in the 1G, 2G and 3G and also had a lower operating frequency than their work.

The results of the power density were also compared to Chen and Lin, (2014). They also measured Electric fields emitted from a LTE Base Station in an Urban Area in Taiwan and their maximum power density was 1.853 mW/m2 and so appeared higher than this work.

Also, there is generally a higher level of compliance of the results with the ICNIRP limits. But this does not mean that there is no possibility of a biological effect from these sites when one is exposed to them for long.

CONCLUSION

From the study, there will surely be an increase in the number of base stations and also an introduction of new and sophisticated technologies into the telecommunication industry as far as Ghana is concern. And so the levels of public exposures to radiofrequency radiations is expected to increase.

This work should be replicated in the other regions that were not studied. This will therefore be a base point as far as the study of 4G LTE base stations are concern in Ghana.

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Conflict of interest: None

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