Assessment of Radiofrequency Exposure from Telecommunication Masts in the Central Part of Delta State, Nigeria

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Orogodo Godstime[1*], Okpaidi Oluwaseun Sunday[2], Mokobia Chukwuka Emmanuel [3], Agbajor Godwin Kparobo [4]

[1, 2, 3,4]Department of Physics, Delta State University, Abraka, Nigeria.

*Corresponding author email: orogodo.godstime@delsu.edu.ng, orogodogodstimeo@gmail.com

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Abstract: As more network providers emerge, radiation exposure from Base Transceiver Stations (BTS) has become an issue of concern for public health. In this study, a Trifield EMF meter was used to measure power density (PD) at heights of 1.5 and 1.7 m above the ground level for distances ranging from 0 – 100 m from 40 masts distributed throughout the study area. The results obtained range from 0. 0.299 to 20.000 mWm^{-2} at 1.5 m and 1.7 m above ground level. The results indicate that the measured values are low compared to the International Commission of Non-Ionising Radiation Protection (ICNIRP) recommended values of 4500 mWm^{-2} for GSM900 and 9000mWm^{-2} for GSM1800. According to these results, there are no radiological threats associated with non-ionizing radiation (NIR) exposure in the area of the study. The study further revealed that about 87.5% of the masts in the study area may have violated the safety regulations set by the Nigerian Communication Commission (NCC) and the National Environmental Standard and Regulation Enforcement Agency (NESREA).

Keywords: Radiation exposure, Power Density (PD), International Commission of Non-Ionising Radiation Protection (ICNIRP), Base Transceiver Stations (BTS), Trifield EMF meter, non-ionizing radiation (NIR)

Introduction

Due to technological advancements in the world and particularly Nigeria, the world is becoming a global village. The wireless telephone system, particularly the Global System for Mobile (GSM), which currently uses low-intensity, pulsed microwave radiation (Busari, 2009), can be regarded as one of the world's fastest-growing and most demanding telecommunication applications today. The ease with which mobile phone users access the internet and increased broadband penetration no doubt have contributed to this rapid growth. There is still great prospect for growth in the telecommunication industry especially as more developing countries realize the positive correlation between growth/development in the telecommunication sector and economic growth/development (Karen & Jacobsen, 2003).

The telecom mast station is believed to cause serious human and environmental challenges, through the emission of electromagnetic fields. There is no doubt that this issue is one of the most controversial areas in the telecommunication industry. This is due to the claims and counter-claims from experts that the emission of electromagnetic fields (EMF) constitutes health challenges and dangers.

Radiation is the energy that comes from a source and travels through space and may penetrate various materials. BTS and other electronic devices expose people to a type of microwave radiation which is also known as radiofrequency (Rf) radiation emit at varying frequencies. All frequencies transmitting radio signals between 3 kHz and 300 GHz are referred to as RF (Akpolile *et al.*, 2014). On average, Wi-Fi applications and microwave ovens utilize 2450 MHz. Cell phone technology uses transmission signals between 800 MHz and 3 GHz, while cell phone towers typically operate between 900-1800 MHz . These towers have electronic equipment and antennas that receive and transmit cell phone signals using radiofrequency (RF) waves. Electromagnetic wave (EMW) refers to the waves of the electromagnetic field, propagating through space, carrying electromagnetic radiant energy. It includes radio waves, microwaves, infrared, (visible) light, ultraviolet, X-rays, and gamma rays.

The level of daily EMF exposure has become more intensive than ever. There is much greater involuntary exposure now, and it is almost unavoidable, even for those who choose not to go wireless. Cell phone users, parents-to-be, young children, and pregnant women are at particular risk (Vasile *et al.*, 2014).Exposure to EM radiation is widely believed to be the major cause of a variety of illnesses and hereditary disorders. It is possible to be affected by both somatic and genetic factors. Somatic factors are injuries that only the individual who was exposed to radiation can experience since the body's normal cells are damaged. Mokobia & Akpan (1997) note that harm to the germ cells in the genital organs can also lead to genetic or hereditary effects that affect the future generation.

In previous studies, several methods were employed to investigate the possible health effects of human exposure to electromagnetic field radiation (EMF) from mobile phone base stations. The following are a few findings from this study, According to study (Santini *et al.* 2002), people living in the vicinity of mobile phone base stations have the greatest chances of suffering from the following disorders: fatigue, sleep disturbances, headaches, feeling of discomfort, difficulty in concentrating, depression, memory loss, visual disruptions, irritability, hearing disruptions, skin problems, cardiovascular disorders, and dizziness.

Shalangwa, (2010), Study the Measurement of exposure of radiofrequency field (RF) radiation from global system for mobile communication (GSM) masts, in the study measurement were carried out carefully with precision and the results obtained established that GSM RF has insignificant correlation or no effect on human health because the low power emission has no sufficient ionization energy to destroy any part of the cell in the human body. The work is a preliminary study that used a mathematical approach to establish the relationship between RF radiation with Human health, however, the study has a deficiency to prove biologically that exposure to RF radiation has an association with human health. Therefore, recommendations were made for further studies which may require a multi-disciplinary research group to ensure more positive results.

Also, Elechi, *et al.*, (2019) investigate the analysis and evaluation of the specific absorption rate of the GSM signal in Port Harcourt, Nigeria, and concluded that the electromagnetic radiation emitted by base stations for mobile phones was measured in terms of electric field strength as a function of distance. In the study locations, measurements were taken at five BTS stations operated by three different GSM networks (MTN, Globacom, and Airtel). Based on the measured values, the specific absorption rate of body tissues and the power density were assessed for health risks. It was found that certain directions were safer than others. According to the results of the study, the values of SAR and power density for the five base stations selected were between 0.0037 W/kg and 0.0084W/kg and 1.5183W/m^2 and 9.5083W/m^2 respectively. This is much lower than the international standard of 0.08 W/kg for the average SAR of the whole body set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). As a result, it can be concluded that no serious health risks exist for residents residing near the base stations for the mobile service providers in the area.

Materials and Methods

This study was done in central part of Delta State, Nigeria. The study locations consist of six local government areas of the Delta central region (Figure 1). The locations are Ethiope East (ETE), Ethiope West (ETW), Sapele (SAP), Uvwie (UVW), Okpe (OKP), Udu(UDU), Ughelli North (UGN), and Ughelli South (UGS)LGA of Delta state.

The network operators that were chosen randomly are MTN, Airtel, Etisalat, and Globacom. A total of 40 base stations were picked at random, with 5 from each local government area in the Central part of Delta State. These were chosen based on their proximity to buildings, as well as their proximity to other base stations and the local populace. Each base station was assigned a unique code. Almost all the base stations use three sectoral antennas, each of which extends over an area of 1200 square meters. Table 1 shows the codes and locations of the stations, as well as the mast's identification number, GPS coordinates, and proximity to the nearest building. An adjustable tripod stand, meter tape, and an electromagnetic meter (Trifield EMF meter) were used to carry out the measurements. Figure 2 illustrates the measurement setup, which includes an adjustable stand built specifically for this project. An adjustable tripod stand was used to keep the RF meter at a constant height above ground level. Height measurement was taken at 1.5 m and 1.7 m, with the meter point directly at the base station. Readings were taken every 20 m for a 100 m radius from an arbitrary distance of 0 meters near the foot of each telecommunication mast measurement. Measurement was taken in suitable directions away from the base station. The value of Power density was taken and recorded after a few minutes when there is a consistent/stable value from the meter at the two heights. An average of five readings was taken at each measurement position for each particular height above the ground, 60 measurements were made at each location and 2,400 measurements were made for the 40 base stations assessed. Additionally, the BTS' proximity to the nearest building was measured. The average height for males and girls in Nigeria between the ages of 18 and 25 is 1.7 meters for males and 1.58 meters for females, according to WordData.info (ND), which explains why the measurement was taken at that height.

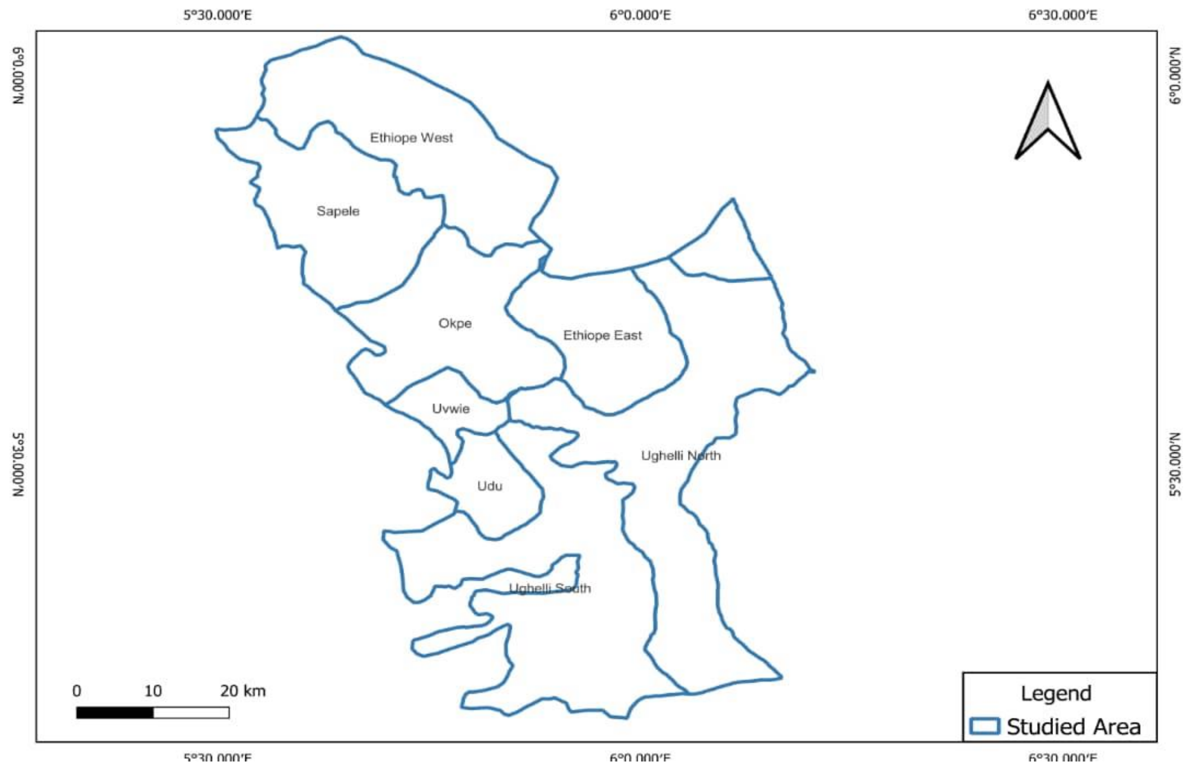

Figure 1: Map of Central Part Delta State showing the study locations

Table 1: Proximity of BTS to Nearest Building and location of the MBS

Code	LGA	**Proximity to Nearest Building (m)**	**Identification No**	**Latitude**	**Longitude**
ETE 1		7.0	T2012	5.790385	6.098379
ETE 2		3.0		5.795394	6.115407
ETE 3		4.0	DL2995	5.793705	6.113384
ETE 4	Ethiope-East	23.0	DL3399	5.79145	6.121943
ETE 5		1.4		5.786064	6.114454
ETW 1		5.0	DL0717	5.439593	5.872153
ETW 2		3.0	OGH006	5.435664	5.874133
ETW 3	Ethiope-West	3.4	DL3354	5.464323	5.910431
ETW 4		2.0	DL0377	5.456889	5.903829
ETW 5		3.0	DL0773	5.464323	5.910431
UGS 1		15.0		5.488197	5.969544
UGS 2		10.0	401274	5.489523	5.97033
UGS 3	Ughelli-South	6.0	DEL1211	5.492309	5.982431
UGS 4		20.0		5.476824	6.020044
UGS 5		2.5	DL0192	5.4769	6.023094
UGN 1		3.0		5.641422	5.894769
UGN 2		2.6	DL4088	5.64121	5.895579
UGN 3		2.2	2680	5.632746	5.88469
UGN 4	Ughelli-North		DL0527	5.635736	5.880071
UGN 5		2.5		5.633683	5.85896
OKP 1			T2610	5.50697	5.785459
OKP 2		1.6		5.502971	5.794024
OKP 3		3.0	401190	5.497701	5.799457
OKP 4	Okpe	5.0	HIS-DEL-120313	5.504419	5.790273
OKP 5		4.4	DL0097	5.504458	5.800204
UDU 1		25.0	DL0771	5.578513	5.782824
UDU 2		1.3	B4277	5.575933	5.783739
UDU 3		3.0	DL0635	5.572021	5.78849
UDU 4	Udu	9.0	2656	5.571292	5.786118
UDU 5		5.0	WAR0061	5.442096	5.778213
UVW 1		4.0	401229	5.871763	5.710375
UVW 2		20.0	T2682	5.876763	5.708883
UVW 3		6.0		5.864403	5.705755
UVW 4	Uvwie	6.0	2910	5.867582	5.703496
UVW 5		3.0		5.871886	5.704367
SAP 1		2.0	T2603	5.941088	5.681612
SAP 2		3.0	DL0564	5.951469	5.695273
SAP 3		1.4	DL1016	5.951855	5.695459
SAP 4	Sapele	7.0	627019	5.951774	5.697576
SAP 5		1.4	T2773	5.9545	5.688367

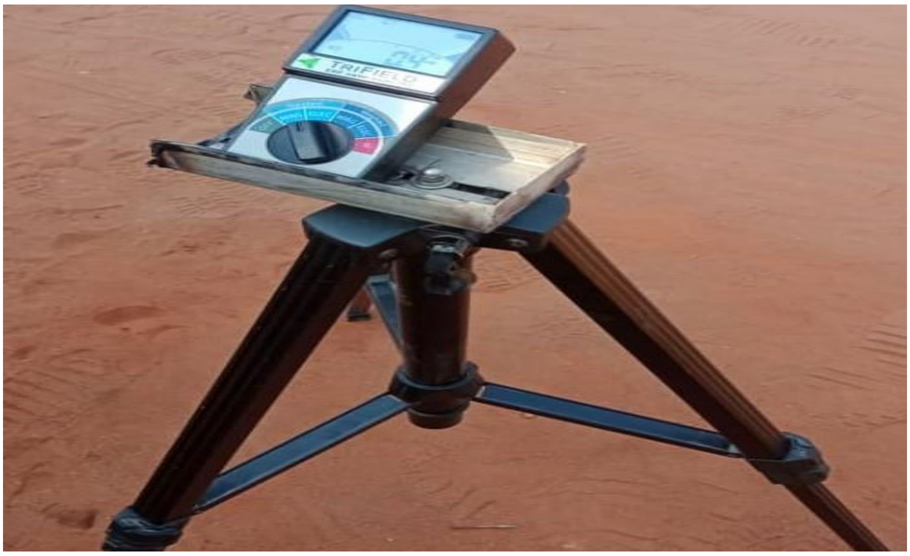

Figure 2: Measurement set-up

Results and Discussion

Figure 3 and figure 4 illustrate the PD levels measured at different distances from the BTS at 1.5 m and 1.7 m heights. As indicated in the figures, the measured values varied with the height, distance as well as location. In all, The maximum PD was determined to be 20.000 mWm^{-2} at 20 and 60 m at 1.5 m above ground level, as well as at 0, 40, and 80 m at 1.7 m above ground level from ETE2, 20 m at 1.7 m above ground level from ETE3, 80 m and 100 m at 1.7 m above ground level from UGN 2, and 20 m at 1.5 and 1.7 m above ground level from UDU 3. The minimal PD was determined to be 0.299 mWm^{-2} at 80 m from SAP 3 at 1.5 m above ground level. Most of the measured PD values at a height of 1.7 m were all noted to be higher than those measured at 1.5 m, implying a direct proportion of the PD with height. This indicates that human interception of the RF radiation from the base stations at 1.7 m height and above has a higher chance of exposure to high PD levels. Test of significance by one-way analysis of variance (ANOVA) shows no significant differences ($p \geq 0.05$) exist between the obtained average PD data, except for the ICNIRP references. The maximum and minimum distribution of PD at 1.5 m and 1.7 m heights of investigated base stations within the study location is depicted in the Contour map shown in Figures 5 and 6 respectively, with Ethiope-East and Ughelli-SouthLGA having a higher range. Table 1 shows the proximity of the MBS to the nearest building and the locations.

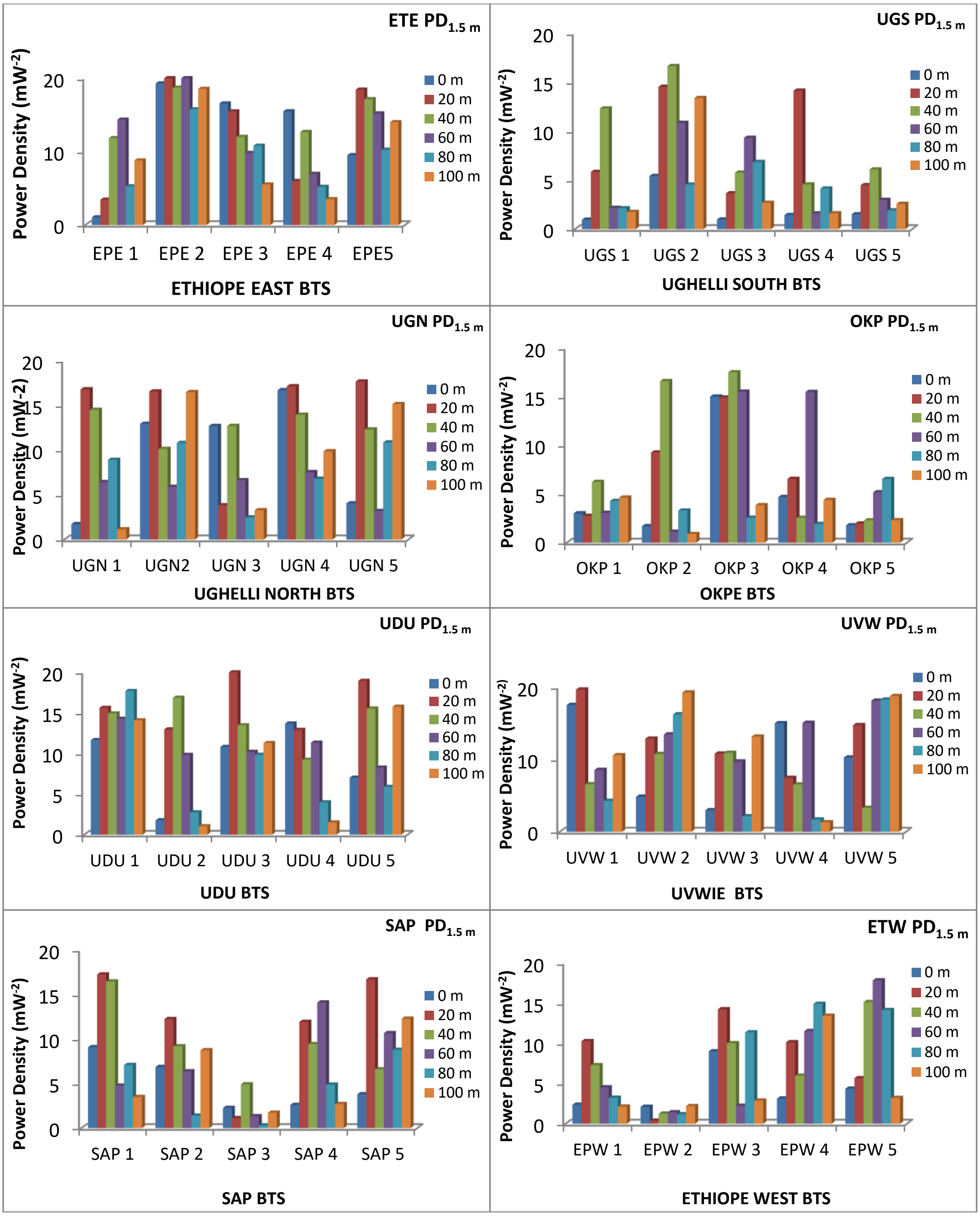

Figure 3: Measured PD levels of Base transmission stations at a height of 1.5 m

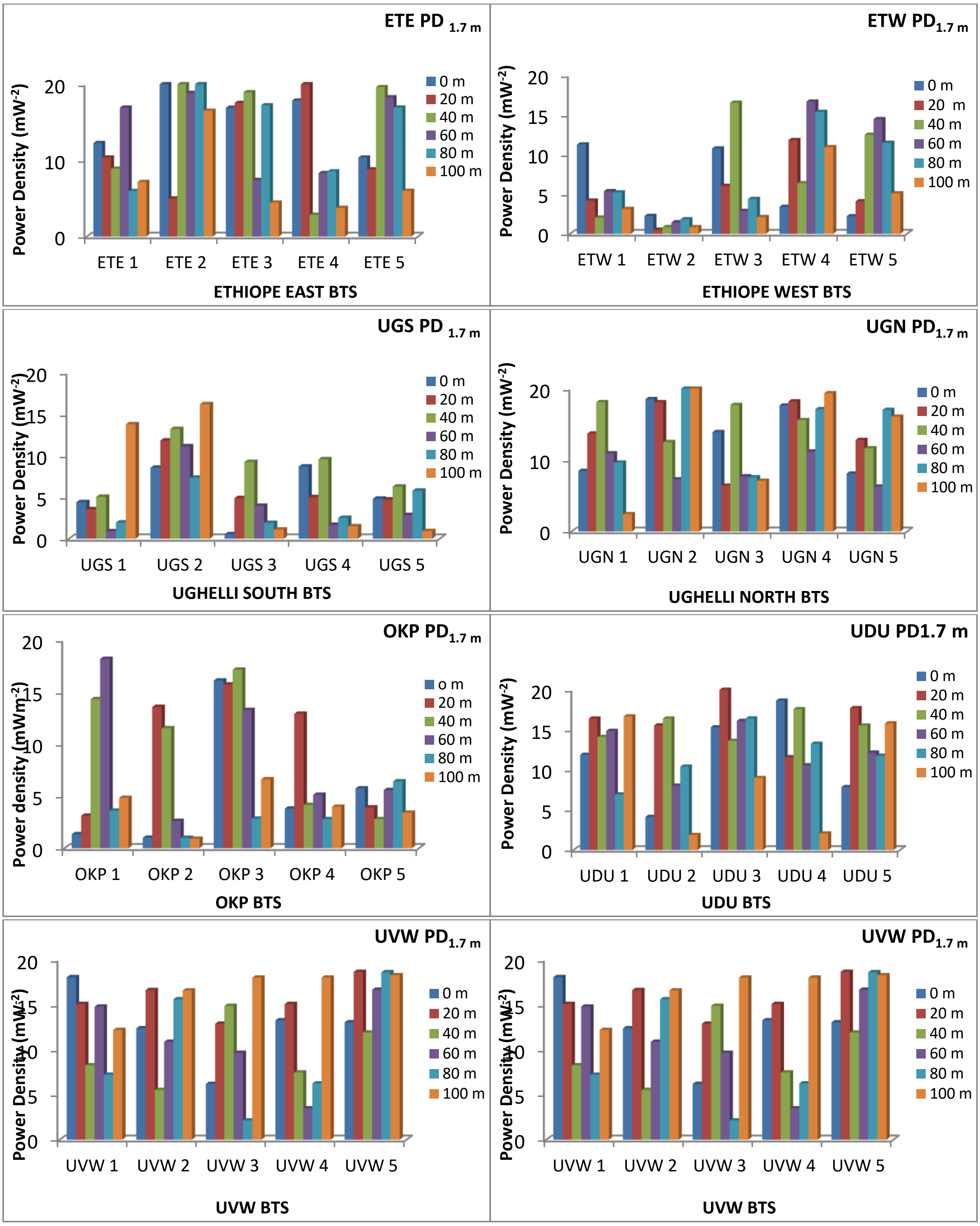

Figure 4: Measured PD levels of Base transmission stations at a height of 1.7 m

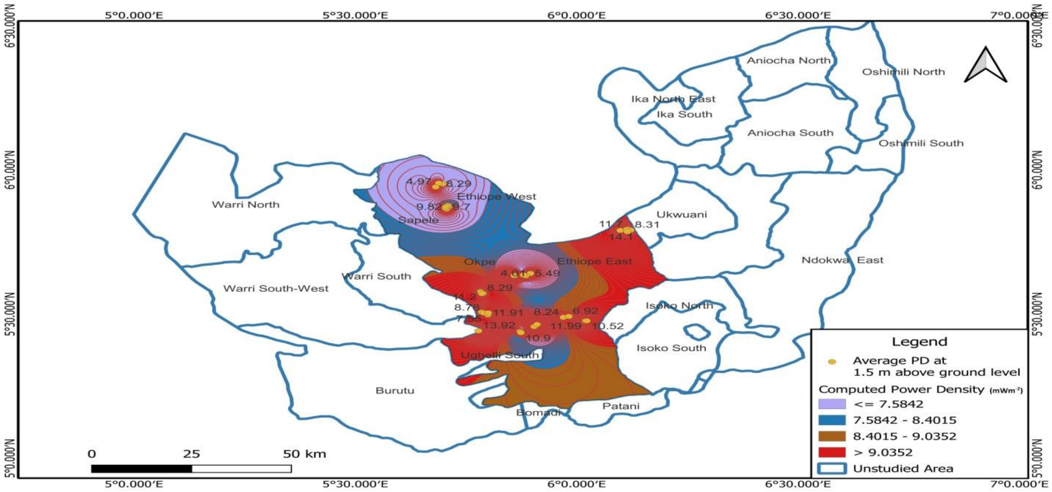

Figure 5: Contour map distribution of maximum and minimum RF radiation PD of selected BTSs at a height of 1.5 m

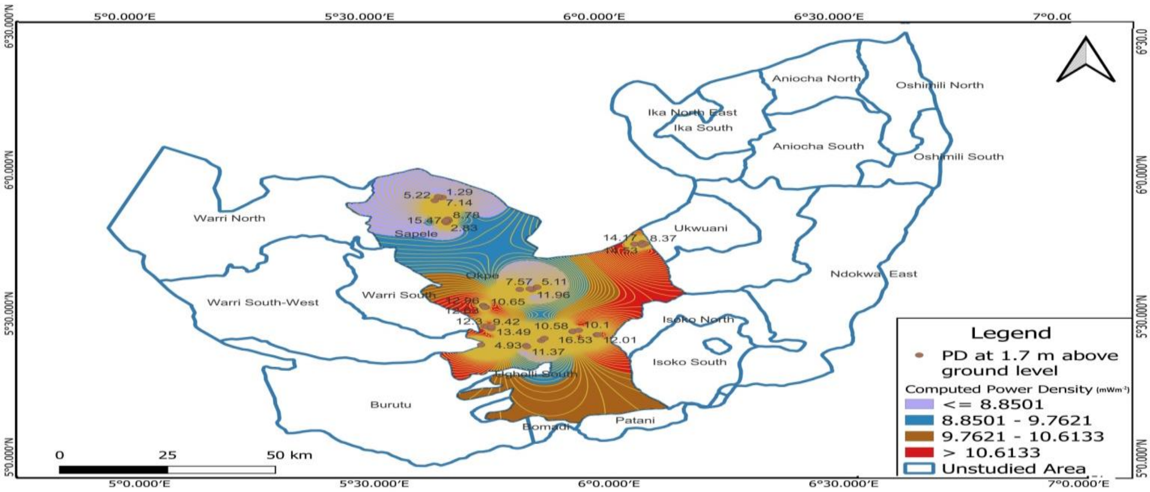

Figure 6: Contour map distribution of maximum and minimum RF radiation PD of selected BTSs at a height of 1.7 m

Figures 7–14 show the plot of the obtained PD with distance. As observed, the PD variation with distance follows a polynomial trend of order 5 as against the inverse square rule which can be attributed to scattering, interference from electromagnetic radiation sources such as receivers, TV antennas, moving objects, as well as other MBS clustered around. Also, the observed fluctuation of the PD cannot be ruled out with structures like buildings, and trees that are within the radius of measurements (Ajiboye and Osiele, 2013). It has been speculated amplification and attenuation of electromagnetic radiation PD can be aided by these structures owing to reflection, refraction, diffraction as well as absorption (Lapinsky and Easty, 2006;Ajiboye and Osiele 2013).Generally, the obtained PD values of identified base masts in all the study locations are far less than the ICNIRP (1998) recommended general public exposure limit of 4.5 Wm^{-2} for GSM 900 AND 9 Wm^{-2} for GSM 1800, respectively for the general public exposure. However, continuous long-term exposure to RF radiation PD by people living close to the base stations may result in cumulative health effects in later years. This study also discovered that approximately 87.5% of the masts assessed in the study area violated the Nigerian Communication Commission (NCC) and National Environmental Standards and Regulations Enforcement Agency (NESREA) safety regulations of 5 m and 10 m away from residential or official buildings, respectively. Due to the continuous installing and updating GSM towers/masts, the contour mapping of the power density and electric field is not static. The picture produced in this study should therefore be periodically reevaluated. Therefore the measured PD in the studied area are very much below the values capable of initiating any noticeable health risk to the general public.

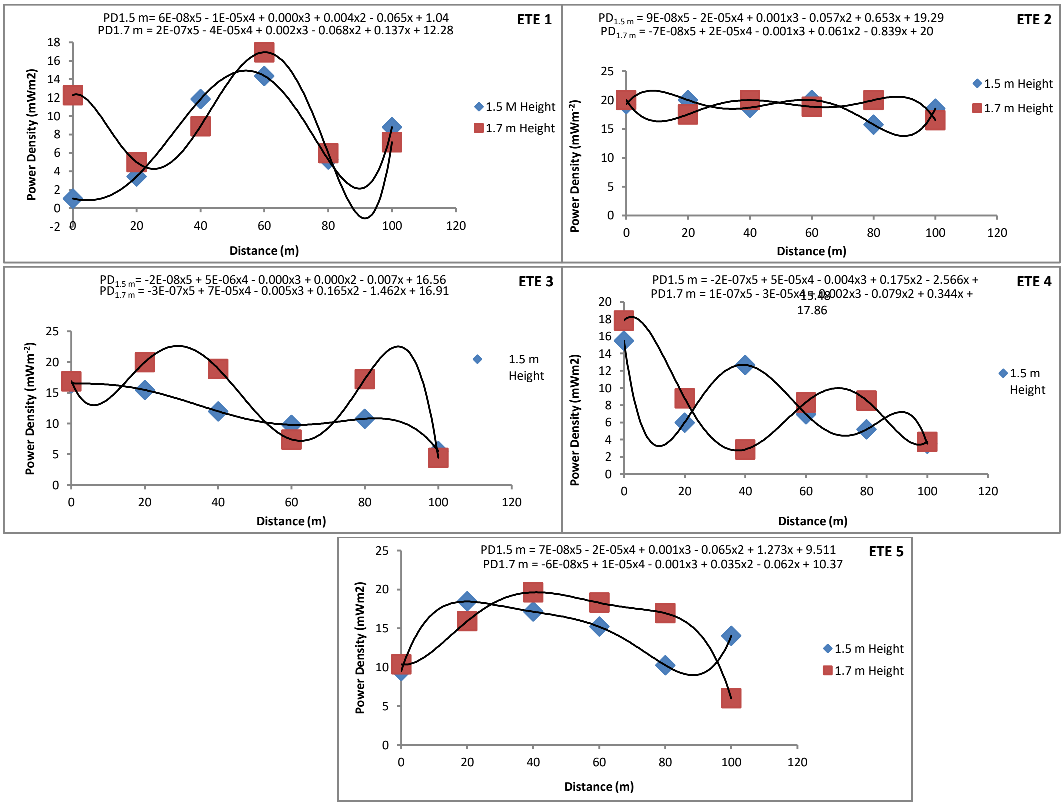

Figure 7: PD against distance in Ethioe East LGA

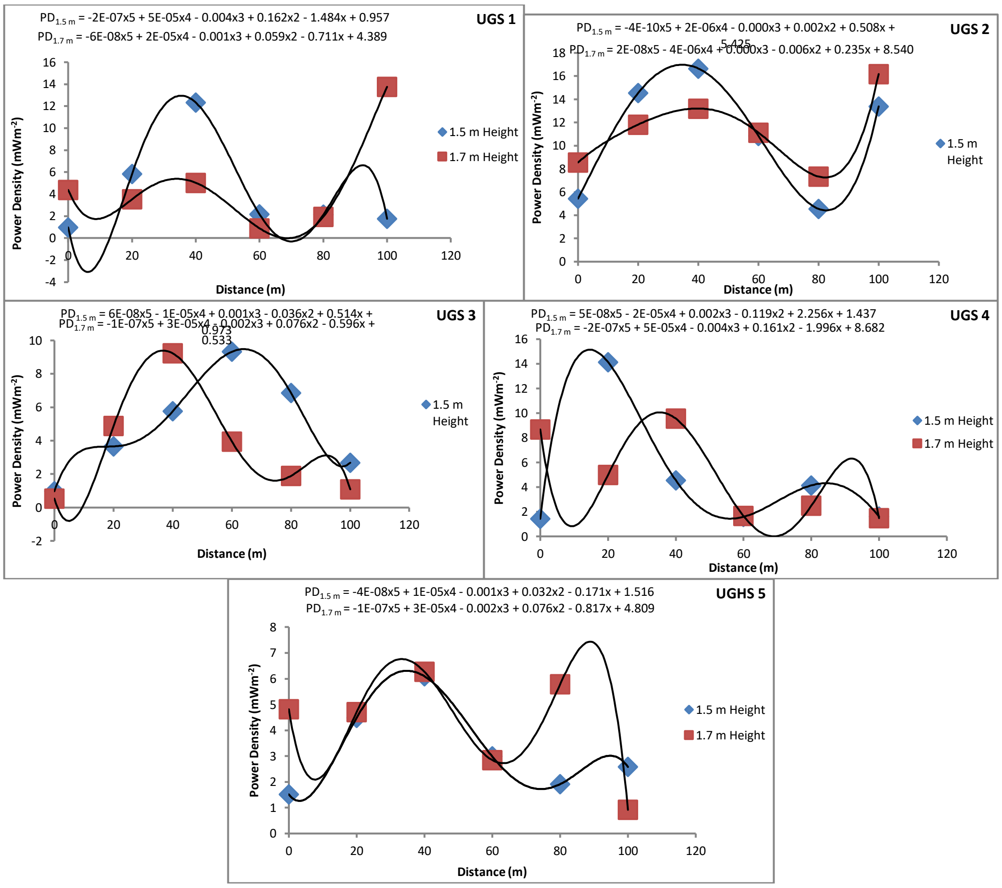

Figure 9: PD against distance in Ughelli South LGA

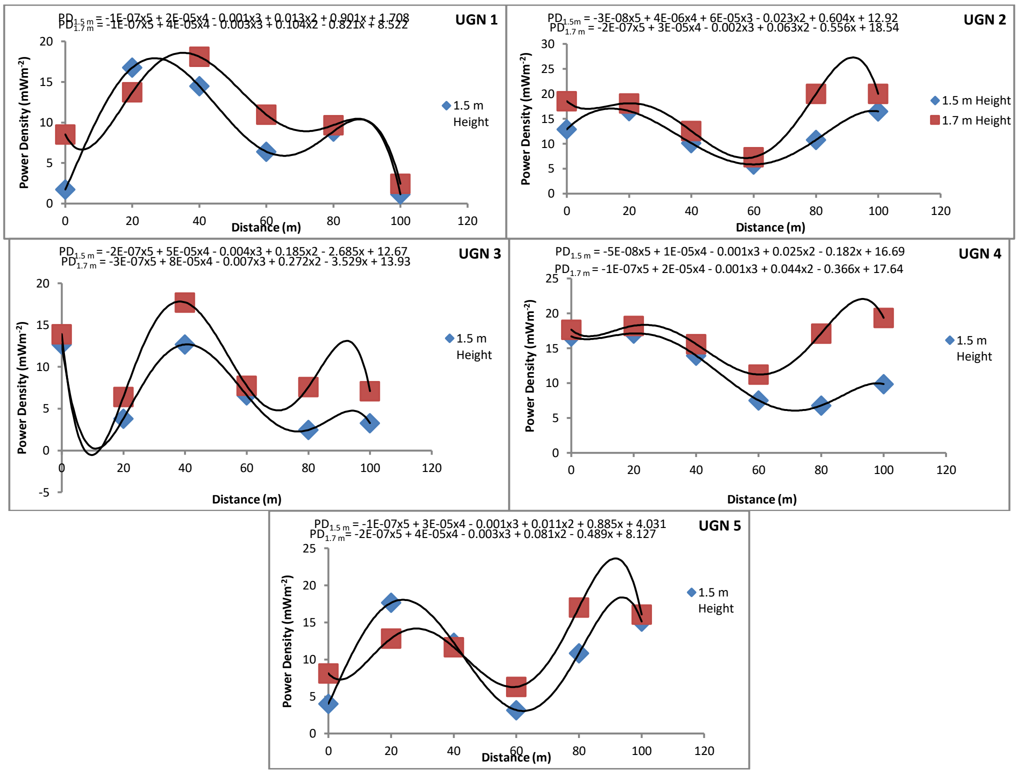

Figure 10: PD against distance in Ughelli North LGA

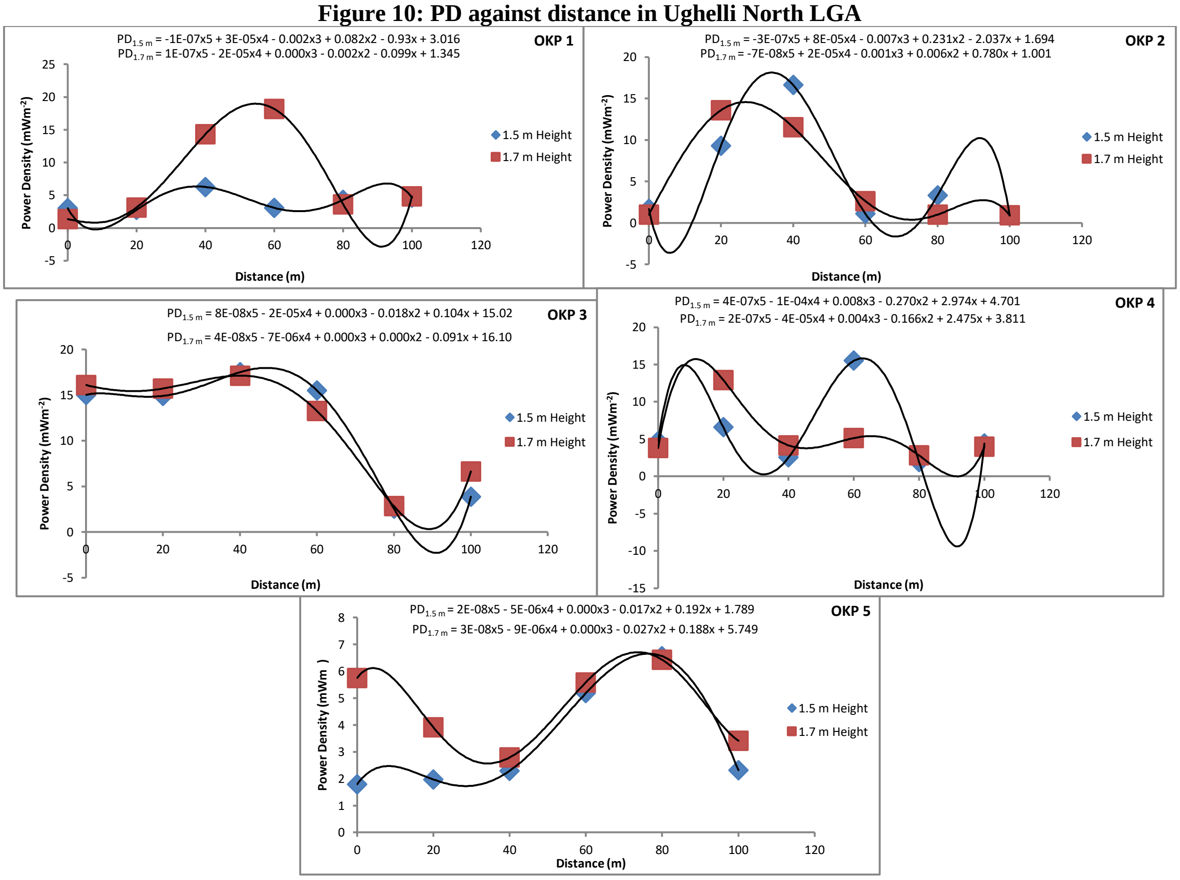

Figure 11: PD against distance in Okpe LGA

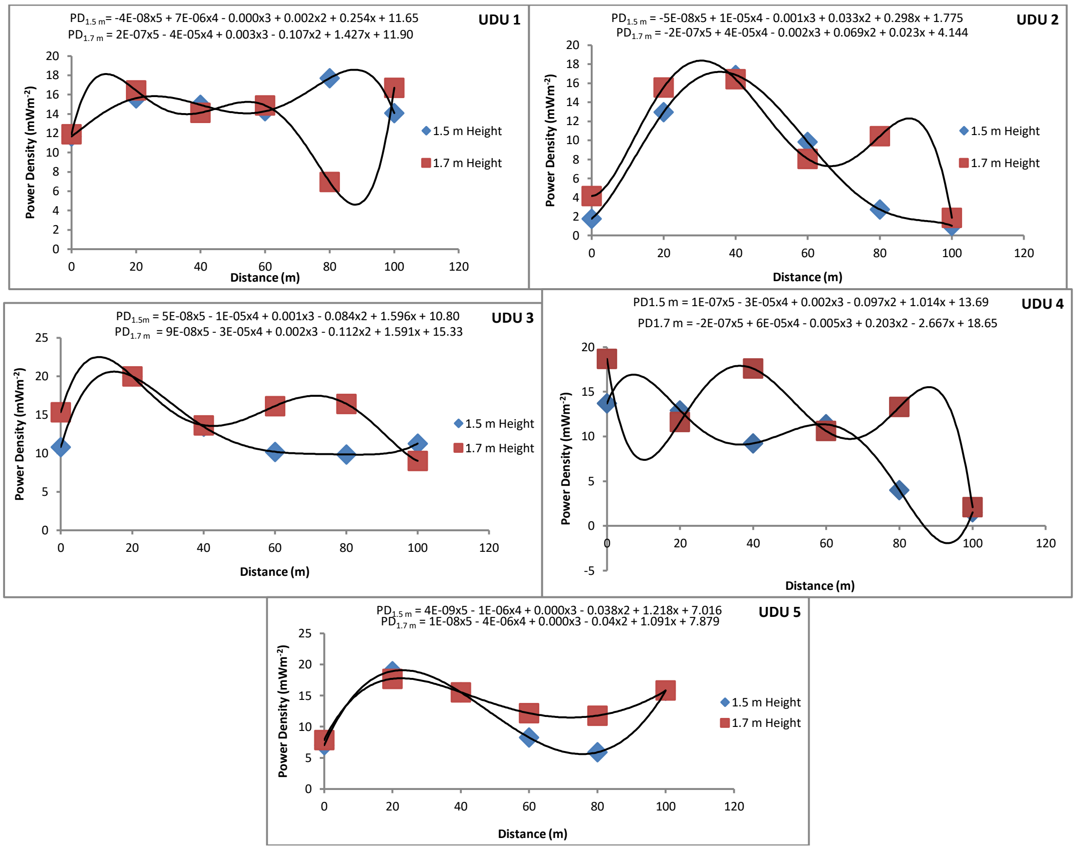

Figure 12: PD against distance in Udu LGA

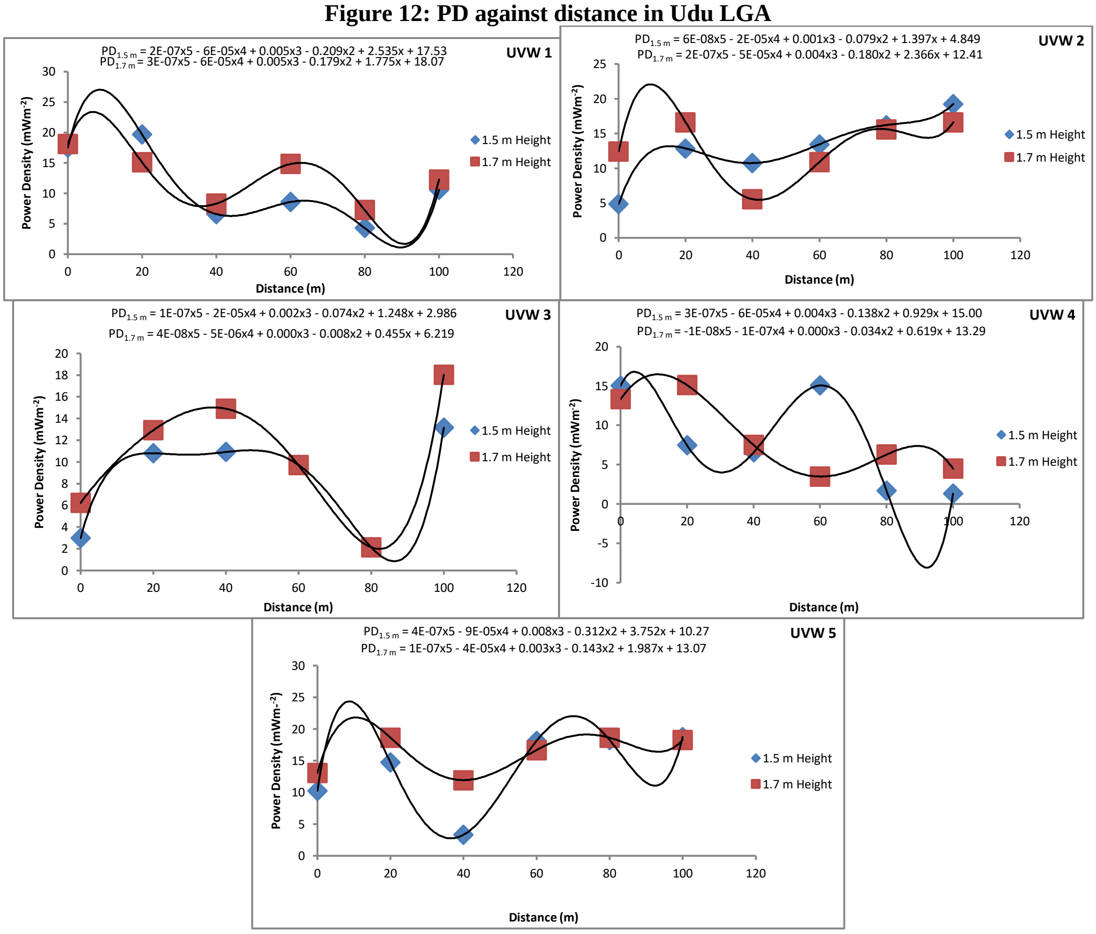

Figure 13: PD against distance in Uvwie LGA

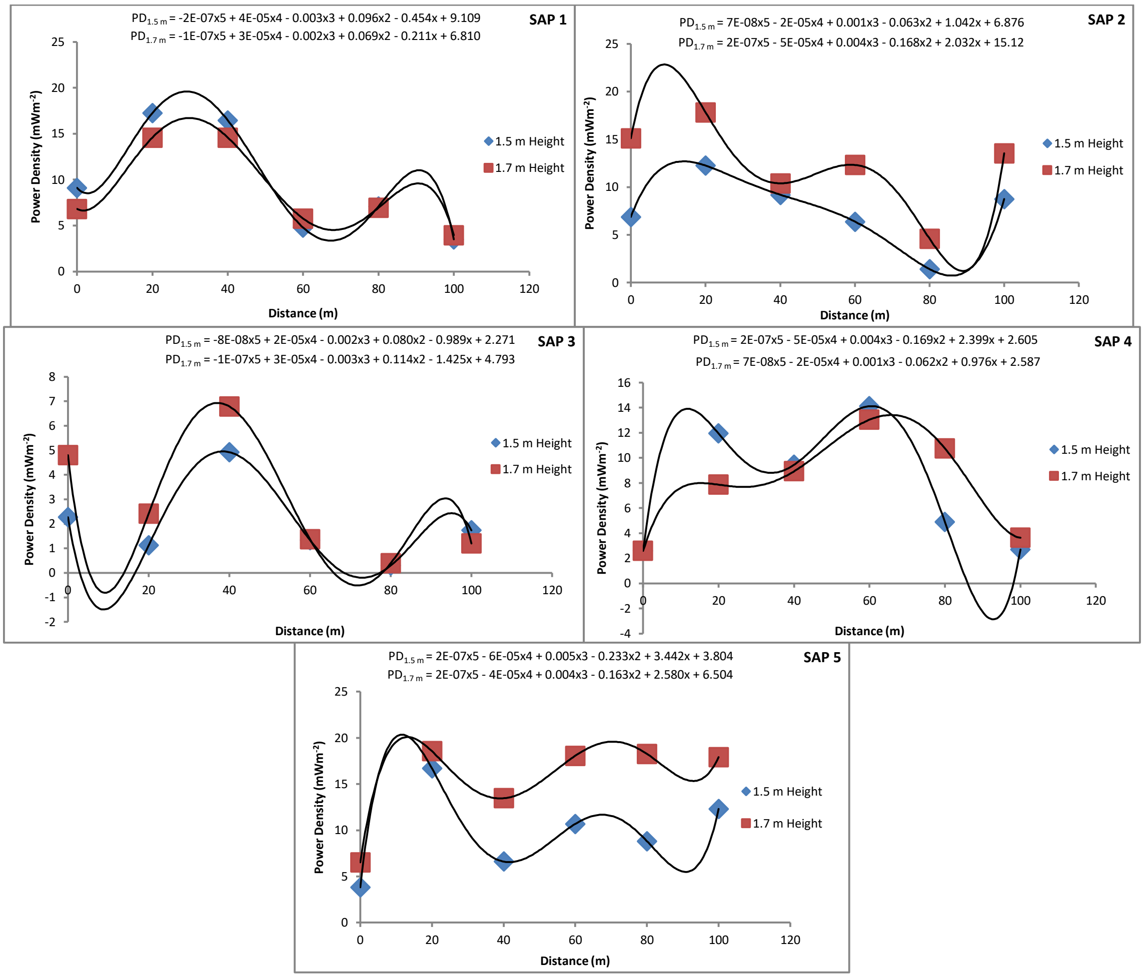

Figure 14: PD against distance in Udu LGA

Conclusion

This study evaluated the environmental impact of radiofrequency PD on selected base transmission stations in Delta State's central region.Most of these chosen BTS was close to the residential and official building which violates the 5 m and 10 m of the Nigeria communication commission (NCC) and National environmental standards and regulation enforcement agency (NESREA) respectively. It was observed that masts from Ethiopia-East, Ughelli-North, andUdu LGA have the highest PD values. In most cases, the average power density values obtained at heights of 1.7 m above the ground were higher than those measured at 1.5 m

This result shows irregular variations in the PD graph up at 1.5 m and 1.7 m above ground level without any definite pattern or correlation with the inverse square law, which might be a result of reflection, scatter, and refraction from the ground, windows, and attenuation by trees and buildings. It was revealed that the obtained PD values in all the study locations were far less than the ICNIRP recommended general public exposure limit of 4.5 Wm^{-2} and 9 Wm^{-2} for GSM 900 MHz and GSM 1800 MHz, respectively.

Based on this information, we can conclude that the PD levels of base stations in the Delta central region are significantly below those capable of posing any observable health risk to the general public. However, cumulative effects due to long-term exposure by nearby residents could manifest in the future. Nevertheless, People living nearby may experience cumulative effects over the long term due to continuous exposure. Given the non-static PD values of the RF radiation from the base masts and the likelihood of more base masts being installed in the future, we recommend routine monitoring of RF radiation pollution and PD exposure levels of the general public in the Delta Central region to detect areas that need to be addressed promptly.

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