ENVIRONMENTAL ASSESSMENT OF RADIOFREQUENCY POWER DENSITY WITH DISTANCE FROM TELECOMMUNICATION BASE TRANSMISSION MASTS IN THE SOUTHERN PART OF DELTA STATE, NIGERIA

Okpaidi Oluwaseun Sunday[1*], Mokobia Chukwuka Emmanuel [1], Ugbede Fredrick Oghenebrorie [2], Akpolile Franklin Anita[1]

1. Department of Physics, Delta State University, Abraka, Nigeria
2. Department of Physics, Dennis Osadebay University, Asaba, Nigeria

*Corresponding author email: okpaidi.oluwaseun@delsu.edu.ng

Abstract

The environmental pollution and health consequences of exposure to radiofrequency radiation emitted from base transmission masts (BTMs) have become an issue of concern due to the increasing number of base mast installations. A Trifield EMF meter was used in this work to measure power density at altitudes of 1.5 and 1.7 m above the ground for varying distances ranging from 0 – 100 m away from 29 masts variously sited in the study area. Distances between the telecommunication masts from the nearest buildings were also measured. The results obtained range from 0.0902 to 20.000 mWm^{-2} at 1.5 m and 0.1372 to 20.000 mWm^{-2} at 1.7 m. These results of the power density show that the measured values are low relative to the 4500 $mWm^{-2}$and 9000 $mWm^{-2}$for GSM900 and GSM1800 stipulated by International Commission on Non-Ionising Radiation Protection (ICNIRP). These indicate that exposure of the populace in the Southern part of Delta State to Non-Ionising Radiation (NIR) does not pose any radiological threat. The Nigerian Communication Commission and the National Environmental Standard and Regulations Enforcement Agency safety regulations of 5 and 10 m respectively were also violated by 65 % of the masts in this study.

Keywords: Radiofrequency exposure, Power Density (PD), Distance variation, Mobile base mast, and Health risk

INTRODUCTION

Due to the widespread usage of mobile phones for sharing information in our daily lives, mobile communication has almost become a part of human existence. At this point, it is nearly impossible to separate mobile communication from our daily routines. Due to their widespread availability and use, the Global System for Mobile Communications (GSM) and Universal Mobile Telecommunication System (UMTS) are the most significant and prevalent mobile systems (Koprivica *et al.,* 2015). Like every other wireless technology, radio frequency (RF) is used in mobile communication to transmit information. All frequencies transmitting radio signals between 3 kHz and 300 GHz are referred to as RF (Akpolile *et al.*, 2014). Every mobile communicating signal is linked to a base transmission mast (BTM) that supports antennas at an elevated height where they transmit as well as receive radiofrequency waves. The installation of BTMs by service providers has dramatically increased over the past 20 years in response to the growing number of phone users and their needs for high-quality services and accessibility. As a result of this, additional sources of RF electromagnetic (EM) radiation were introduced into the human environment (Koprivica *et al.,* 2015).Due to the widespread use of RF devices nowadays, different degrees of public exposure to radiofrequency electromagnetic radiation are now present all over the world. The public has given particular attention to the health implications of EM radiation exposure, despite the fact that the scientific community is still perplexed and engaged in a contentious debate due to the increasing density of base masts in metropolitan areas. Many people believe that ongoing exposure to EM radiation is the root of many diseases and genetic conditions. Both somatic and genetic influences may be present. Somatic effects arise from damage to the ordinary cells of the body, resulting in injuries that affect only the irradiated person. However, harm to the germ cells in the genital organs can also happen and have hereditary or genetic effects that can influence the next generation (Mokobia & Akpan, 1997). The evaluation of RF power density (PD) of telecommunication base stations has been studied in several parts of the world. The following are a few findings from this study: RF power density measurements of telecommunication masts were carried out by Akpolile *et al.* (2014) in various specified regions of Delta State. They got measurements ranging from 0.03 mWm^{-2} to 5.66 mWm^{-2}. When compared to the suggested worldwide maximum acceptable exposure limit of 4500 mWm^{-2}, it was shown that the exposure levels in these locations are modest, and hence do not pose a substantial health risk to those living near telecommunication masts. Promise *et al.,* (2009) conducted research in Port Harcourt, Nigeria to study the Analysis and Evaluation of specific absorption rate (SAR) of GSM Signal. The study looked at the electric field strength for mobile phone BTS radiation as a function of distance. To analyze the health problems, the measured data were used to compute the power density and whole-body tissue SAR. Some paths were discovered to have height risk than others. The SAR and PD values for the five base stations chosen for the study were in the range of 0.0037 Wkg^{-1} to 0.0084 Wkg^{-1} and 1.5183 mWm^{-2} – 9.5083 mWm^{-2} respectively, according to the results. These figures are well below the 0.08 Wkg^{-1} limit set by the ICNIRP for the whole-body average SAR. This shows that there is no major health risk for residents living near the various mobile service provider's BTS. Blettner *et al.,* (2008) researched mobile base station and negative health impacts to determine the connection between proximity to MBS and health complaints. A population-based, multi-phase, cross-sectional study in which 30,047 people out of 51,444 responded to questions about how mobile phone base stations affect their health. The findings revealed that 18.7% of the 30,047 participants were concerned about the mobile base station's negative health consequences, while another 10.3 percent ascribed their negative health effects to their exposure to them. Participants who lived near 500 meters of a mobile phone base station reported slightly higher health issues than those who did not. Moreover, Santin *et al.* (2002) examined the effects of BTS on people who live within 100m – 300m of a base station and found that they experienced fatigue, headache, and nausea. Based on their findings and the precautionary principle, BTS should be sited 300 m away from people. This study provides the environmental assessment of RF power density with distance from telecommunication base transmission masts in the southern part of Delta State.

MATERIALS AND METHODS

This study was carried out in Southern part of Delta State, Nigeria. Delta state is located between latitude 5º.00.00’N and longitude 6º.30.000’E and produces both agricultural products and oil. The study locations consist of six local government areas of the Delta south region as shown in Figure 1. The locations are Bomadi (BOM), Isoko North (ISN), Isoko South (ISS), Patani (PAT), Warri-North (WRN) and Warri-South (WRS) local Government Areas.

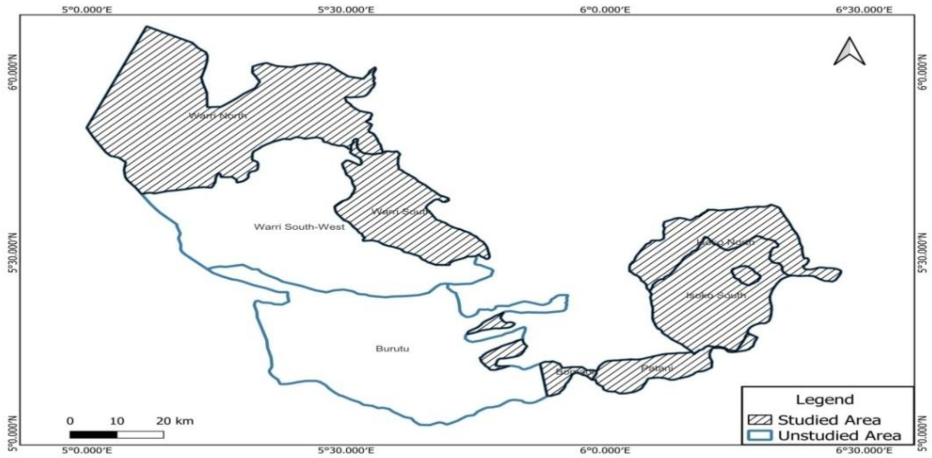

Figure 1: Map of Southern Part Delta State showing the study locations

A total of 29 BTS operated by the four major telecommunication service providers in Nigeria were chosen at random from the study region. Accessibility to the base stations and proximity to buildings were major criteria for selection. Five base stations were selected from each location, except Warri-North having four. Most of the BTS have at least 3 sectoral antennas and each antenna covers a distance of 1200m radius. A Trifield EMF meter (Model, TF2) was used to measure the PD of radiofrequency radiation from the base stations. The meter is a broadband device for monitoring high-frequency radiation in the range of 20 MHz to 6 GHz, covering most of the wireless communication frequency spectrum. *In-situ* measurements of PD in milliwatts per square meter (mWm^{-2}), of RF radiation from selected BTS, were made at heights of 1.5 m and 1.7 m starting from the feet of the BTS to a distance of 100 m away at 20 m intervals. The EM meter was placed on an adjustable tripod stand as shown in Figure 2 which ensures that the meter was maintained at a constant height above ground level. Measurements were taken at the line of sight to the BTS antenna (Ayinmode and Farai, 2013). Five repeated *in-situ* measurements at an interval of 5 minutes were taken at each distance from the base of the base station. This was done to take into consideration the fluctuating nature of the RF radiation occasioned by obstructions along a line of transmission and also to estimate the worst-case scenario of exposure at each location. The average of the five readings was computed and taken as the average PD reading for each position.

Figure 2: Measurement set-up

RESULTS AND DISCUSSION

Levels of PD measured at heights of 1.5 m and 1.7 m at varying distances away from the BTS at the different stations are presented in Figures 3 and 4 respectively. As indicated in the figures, the measured values varied with the height, distance as well as location. In all, maximum PD of 20.00 mWm^{-2}, 20 m away from BTSs WRN 4 and ISS 4 at 1.5 m and 1.7 m height respectively was recorded, while minimum PD of 0.09 $mWm^{-2}$was obtained 60 m away from BTS PAT 4 at height 1.5 m. 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 difference ($p \geq 0.05$) between the obtained average PD data, except for Warri-South having higher PD values. This might be as a result of base masts clustered within the city of Warri. The multitude of the base masts within the city can lead to interference of signals, thereby resulting in a higher power to operate (Ardoino *et al.*, 2004; Inyang *et al.*, 2008).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 maps shown in Figures 5 and 6 respectively, with the Warri South area having a higher range. Table 1 shows the proximity of the mobile base station to the nearest building.

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

Code	LGA	**Proximity to Nearest Building (m)**	**Identification No**	**Latitude (^{0}N)**	**Longitude (^{0}E)**
PAT 1		5.0	401797	5.204706	6.197363
PAT 2		8.0	B4581	5.229561	6.192980
PAT 3	Patani	7.8	DL 0087	5.233473	6.190886
PAT 4		10.0	T2689	5.210272	6.155462
PAT 5		5.7	DL1302	5.208018	6.149314
BOM 1		7.0	T2442	5.162571	5.958671
BOM 2		5.0	DL0122	5.159187	5.924295
BOM 3	Bomadi	40.0		5.128273	5.911312
BOM 4		30.0	T2692	5.171413	5.910686
BOM 5		35.0	DL183B	5.139725	6.003063
WRS 1		5.0	DL 2836	5.5280461	5.7663575
WRS 2		3.0		5.5273724	5.76025751
WRS 3	Warri –South	4.5	DL 0585	5.5307346	5.7584551
WRS4		5.0	HIS WAR-0926B	5.5281862	5.7518705
WRS 5		6.0	WAR 009	5.5287978	5.7561504
WRN 1		20.0	401158	5.969559995	5.5158166
WRN 2		6.4	T2651	6.00638333	5.46646666
WRN 3	Warri – North	15.0	DL0009	6.00113000	5.46084833
WRN 4		8.4	KK0001	6.003569	5.4487885
ISN 1		7.0	DL 0149	5.5952362	6.1946345
ISN 2		6.4		5.5903298	6.1952978
ISN 3	Isoko –North	11.0	T2771	5.5702777	6.1767295
ISN 4		7.5	DL 0887	5.546370	6.228883
ISN 5		9.0	T2698	5.544751	6.231868
ISS 1		8.0	T2654	5.469752	6.205487
ISS 2		5.0	DL 0460	5.466608	6.207552
ISS 3		7.0		5.466078	6.208866
ISS 4	Isoko –South	6.0	401175	5.454263	6.202006
ISS 5		5.0		5.449490	6.19850

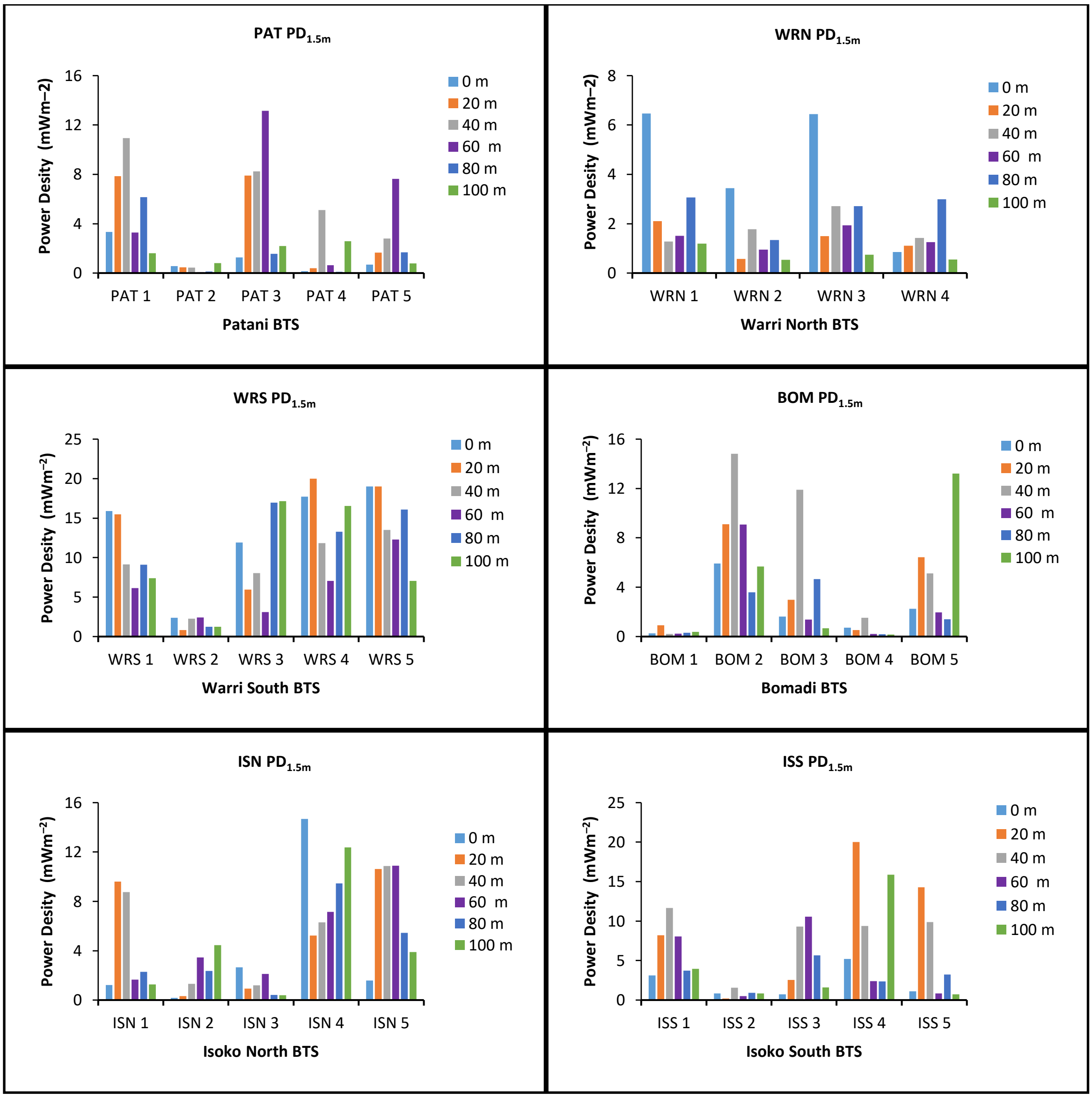

Figure 3: Measured Power density levels of Base transmission stations at a height of 1.5 m

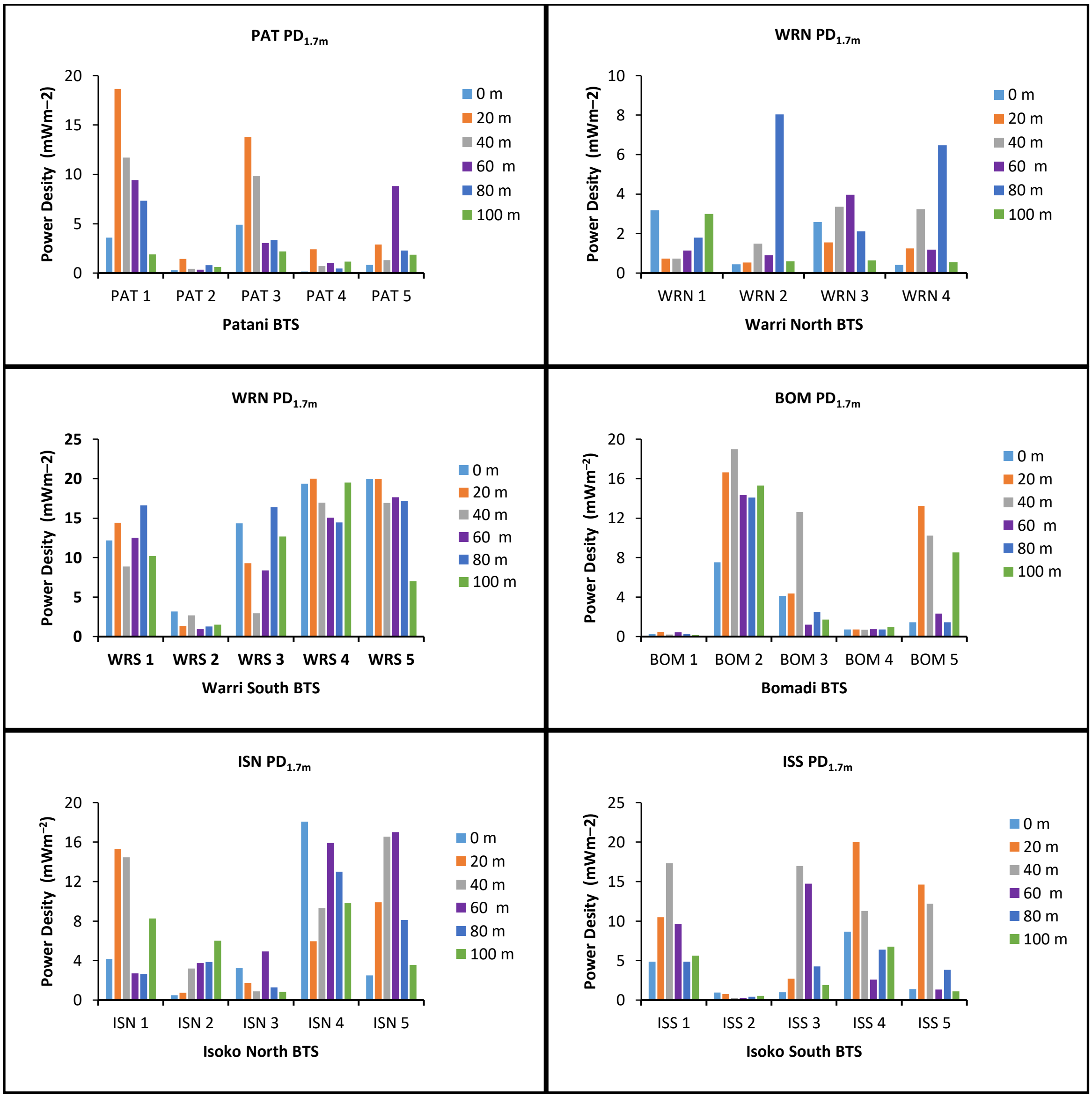

Figure 4: Measured Power density levels of Base transmission stations at a height of 1.7 m

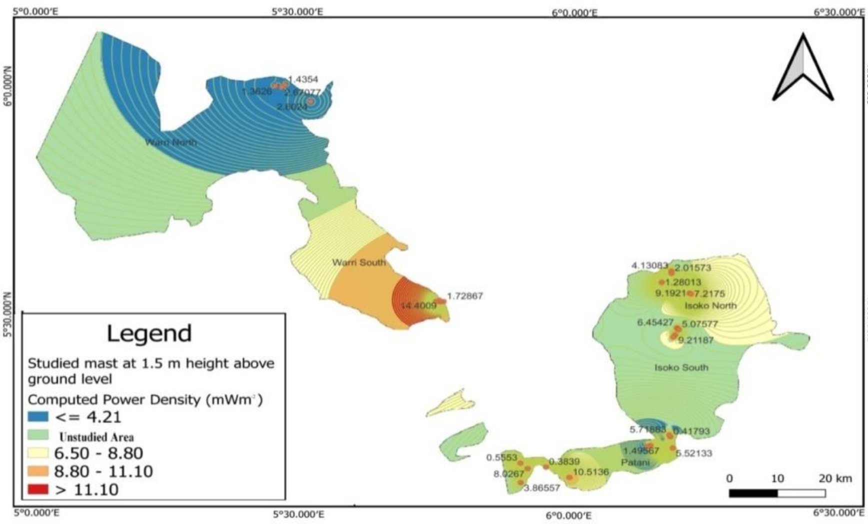

Figure 5: Contour map distribution of maximum and minimum RF radiation power density of selected BTSs at a height of 1.5 m

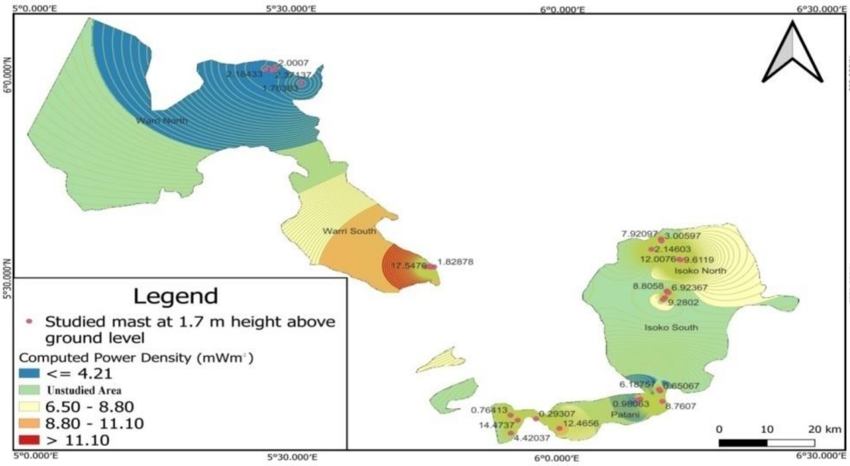

Figure 6: Contour map distribution of maximum and minimum RF radiation power density of selected BTSs at a height of 1.7 m

Figures 7–12 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 mobile base station lustered 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).As observed in Figures 3 and 4, the maximum PD radiated from the BTSs, on average, is between distances of 20 to 60 m awayfrom the BTS in the study locations. This observation correlates with earlier studies indicating the higher value of PD at a 50 m radius from BTS than at the base (Haumann et al, 2002; Osahon et al., 2013). The implication of this is that within this radius the radiofrequency radiation from the base masts has a higher propensity to penetrate through the human skin upon interception. In effect, dielectric heating of tissues is much possible at this point with the consequences varying from transitory disturbances in cell functions to permanent destruction (Bennet et al.,2017; Akpolilie and Ugbede, 2019). In another study, however, maximum PD from BTS in the cities of Ibadan (Ayinmode and Farai, 2013) and Lagos (Ibrahim and Oluseyi, 2016) was observed at 200 m and 160 m radius respectively. 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. Also, the values are far less than IEEE (2005) limits of 6 and 12 Wm–2 for GSM 900 MHz and GSM 1800MHz, respectively for the general public exposure. The distance between the human body and the BTS is a crucial determinant of the amount of radiation absorbed. However, the majority of the investigated base masts violate the Nigerian Communication Commission (NCC, 2009) and NESREA's (2011) safety restrictions of 5 m and 10 m, respectively away from residential and official buildings. There have been speculations about the likelihood of nausea, fatigue, headache, and sleeplessness among people living close to base masts due to exposure to RF radiation of higher PD(Eltiti et al., 2007; Yurekli et al., 2009).The high PD of RF radiation from base masts can modify protein expression in human skin due to an induced electric field (Basandrai and Dhami, 2016). Going by the ICNIRP (1998) guidelines, the PD levels of investigated base stations in Delta South are very much below the values capable of initiating any noticeable health risk to the general public. 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.

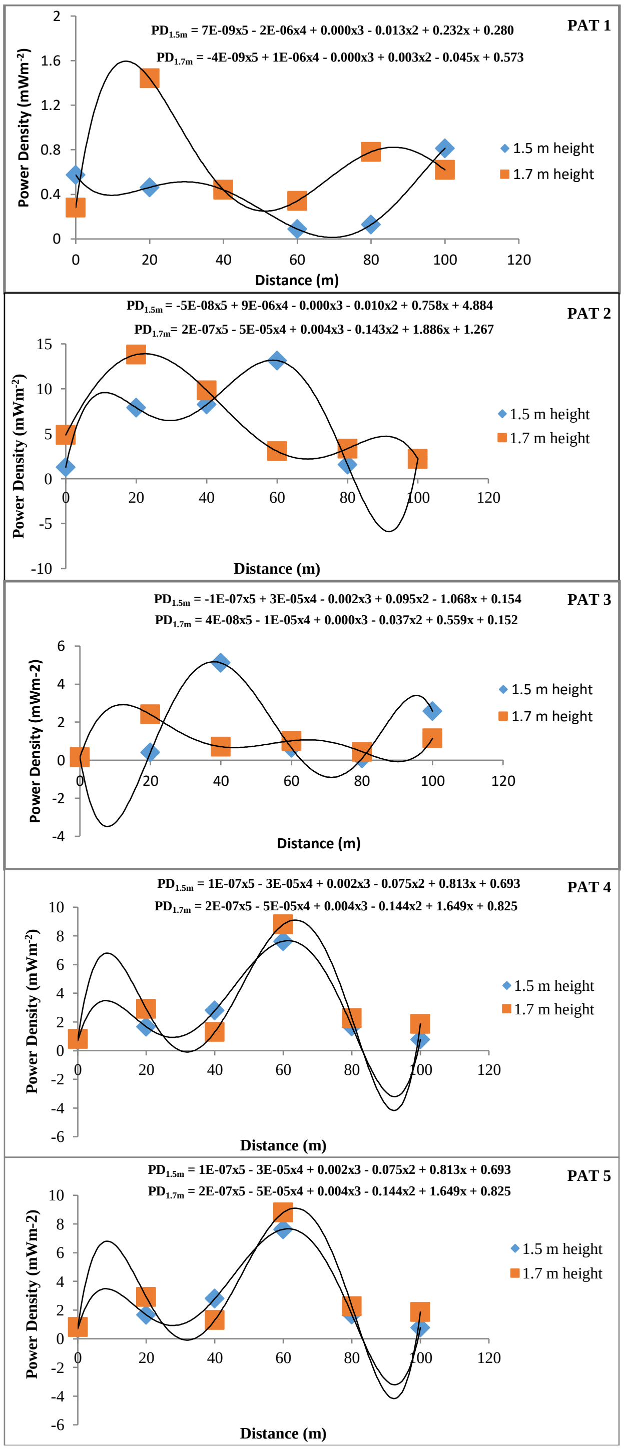

Figure 7: Variation of BTS power density with distance in Patani

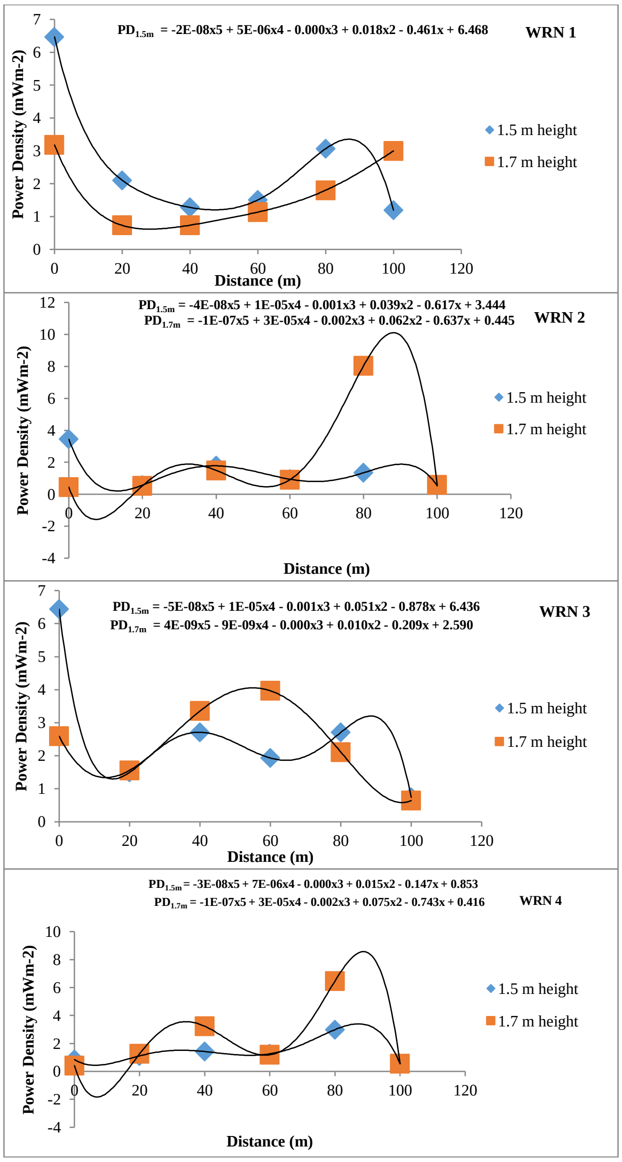

Figure 8: Variation of BTS power density with distance in Warri North

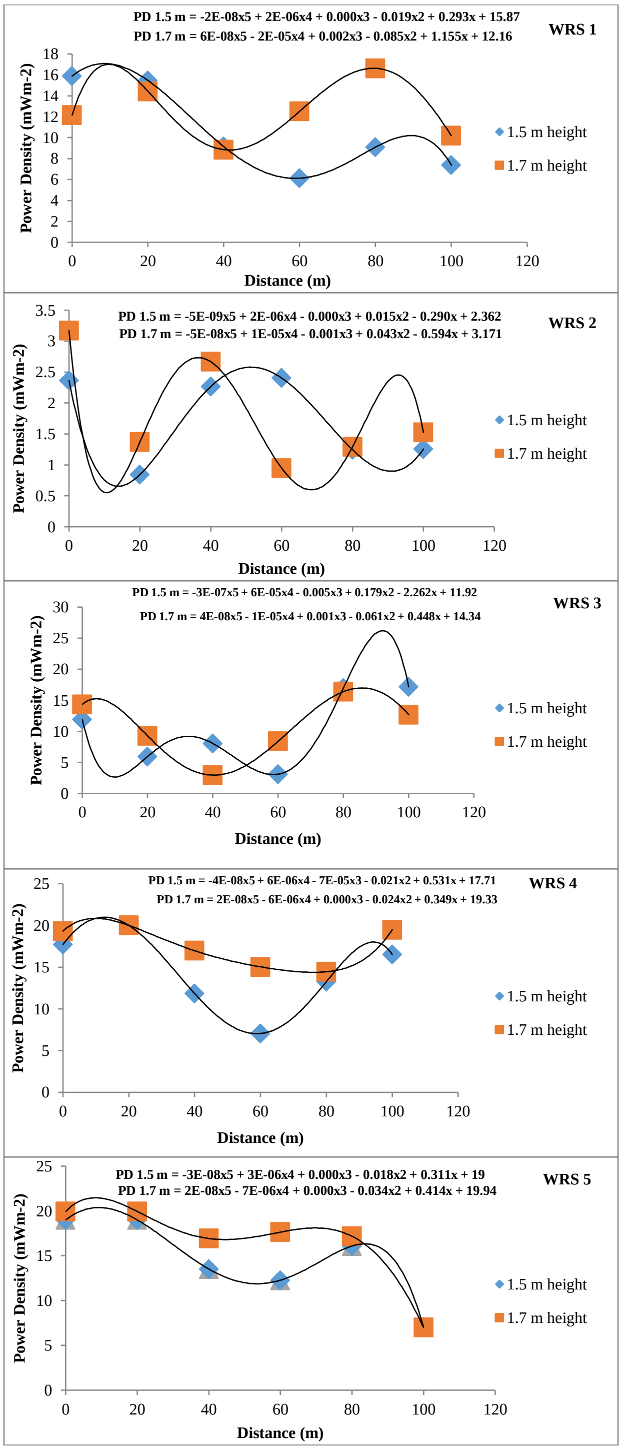

Figure 9: Variation of BTS power density with distance in Warri South

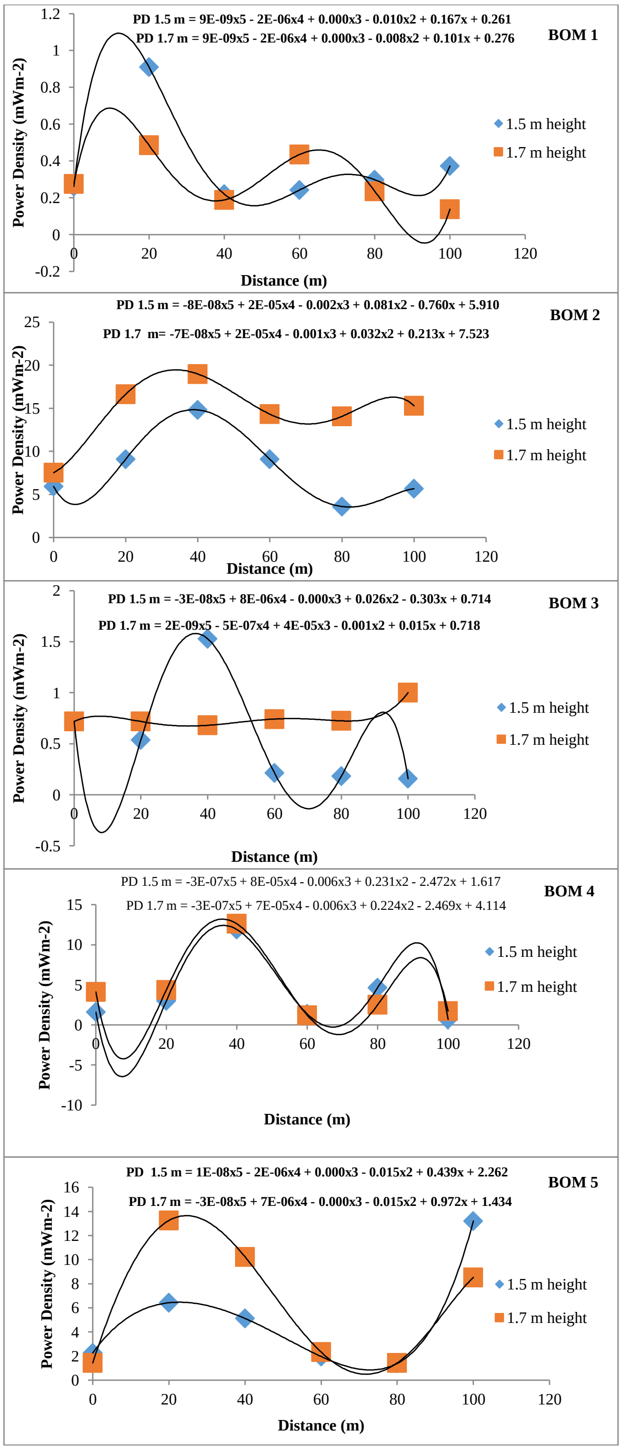

Figure 10: Variation of BTS power density with distance in Bomadi

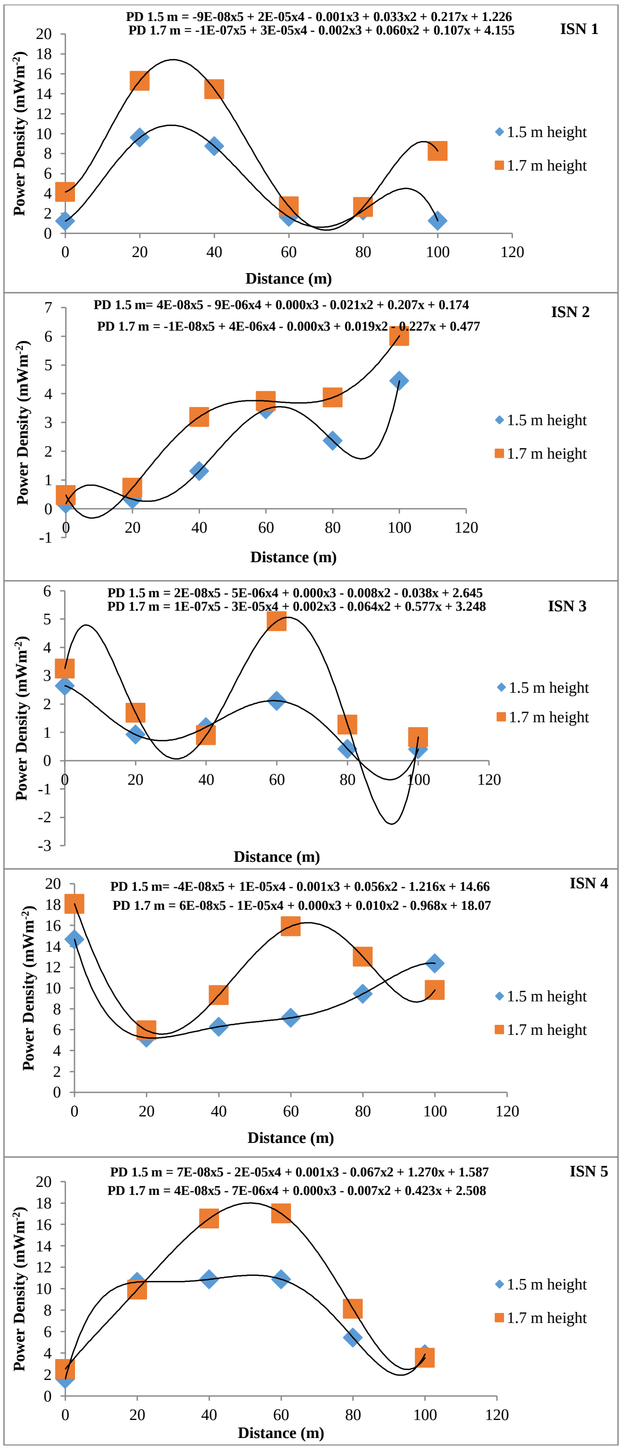

Figure 11: Variation of BTS power density with distance in Isoko North

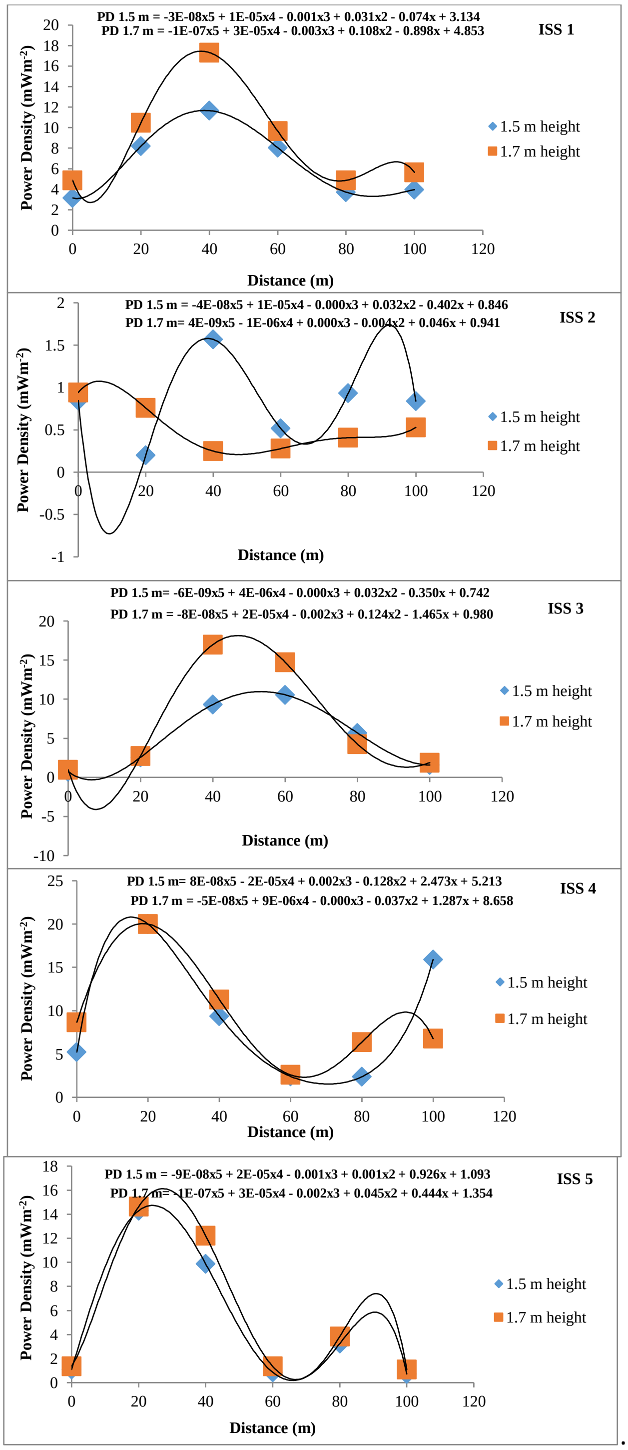

Figure 12: Variation of BTS power density with distance in Isoko South

CONCLUSION

Environmental assessment of radiofrequency PD of selected base transmission stations in the Southern region of Delta State has been implemented in this study.The majority of the investigated base stations were positioned quite close to a residential or official building, violating the proximity safety restrictions of NCC and NESREA. It was noted that based masts from Warri south have the highest PD values. Average PD measured at 1.7 m height presented higher values than those obtained at 1.5 m. Variation of the PD with distance from the base masts shows no defined trend with distance, rather presented a fluctuation of the fifth-degree polynomial. 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}as well as that of IEEE limits of 6 and 12 Wm^{-2} for GSM 900 MHz and GSM 1800 MHz, respectively. It is, therefore, safe to conclude at this point that the PD levels of base stations within the Delta South region are very much below the values capable of initiating any noticeable health risk to the general public, however cumulative effects owing to continuous exposure over a long term by people living nearby may result in later years. Since the PD values of the RF radiation from the base masts are not static owing to installation upgrading for maximum and effective service delivery and that more base masts are likely to be installed in future.

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