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Assessment and Analysis of Radio-Frequency Exposure Level from Mobile Base Transceiver Stations in Dakingari, Kebbi State, Nigeria.

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ABSTRACT-

Base Transceiver Stations (BTSs) are critical components of any Global System for Mobile Communication (GSM) network. As telecommunications subscribers connect to the network, radio frequency (RF) radiations are continuously emitted. Because of the thermal effects on human bodies, although being non-ionizing, this radiation poses a health concern to anyone living near GSM base transceiver stations. In fact, the International Agency for Research on Cancer (IARC) has declared that RF areas are likely carcinogenic to humans. Sometime around 2012, telecoms businesses' BTSs in New Delhi, India, broadcast RF transmissions that exceeded the allowed limits imposed by the country's telecommunications authorities. They were instructed to turn off and restart the BTSs only when the regulations were met. The goal of this research is to examine and analyze the RF emission levels from Dakingari's BTSs. The emitted radio frequency radiated power densities from four BTSs were measured with a handheld three-axis RF meter(TM-195). The maximum radiated power densities for the four BTSs (DK1-DK4) measured $1033\mu W/m^2$, $133.4\mu W/m^2$, $313.7\ \mu W/m^2$ *and* $1457\mu W/m^2$ *respectively. These values are significantly lower than the ICNIRP's maximum safety levels. Furthermore, all the three GSM operators' BTSs adhered to the IEEE minimum distance of 4.35m between all structures and base stations, ignoring a residential building's 8% distance departure from MTN (DK4). As a result of this investigation, it was concluded that the radio frequency radiations from the evaluated base transceiver stations in Dakingari town pose no health risk.*

Key Words: Dakingari, Base Transceiver Stations (BTSs), Power density and Radio Frequency (RF) radiations.

I. INTRODUCTION

The Global System for Mobile Communication (GSM) has greatly impacted on the lives of Nigerians, whether directly or indirectly. Ernest Ndukwe believes that the Information and Communication Technology (ICT) revolution has ensured that many low-income earners may fulfill their basic daily necessities and have a secure future [1]. According to available data from Nigerian Communication Commission in 2010, Nigeria has over 70 million telephone subscribers of whom approximately 62 million are GSM subscribers. This vast number of customers, which is likely to grow in the future, continuously utilize the radio-frequency resources of the base transceiver stations (BTS) of whatever place they may be in. The BTS is the GSM component that manages the radio interface to the network.

Ref [2] mentioned that a typical BTS is made up of radio amplifiers, combiners, duplexers, splitters, power supplies, antenna systems, and the software necessary to operate the base station. Radio-frequency signals are continuously emitted by the BTS. One way to visualize a radio signal is as a wave that propagates from its source (the antenna). It is frequently described as an electromagnetic wave with connected electric and magnetic components. Radiofrequency fields are the names for the electric and magnetic elements that make up an electromagnetic wave. It has been determined that this radio frequency energy is non-ionizing radiation. Atoms and molecules cannot be ionized by RF electromagnetic waves because their photon energies are insufficient. However, it causes the creation of heat in bodily tissue [3].

Human tissue is injured when exposed to excessive amounts of radio frequency energy because the body is not equipped to consume the superfluous volumes of heat generated. Skin burns, severe burns, heat exhaustion, and heatstroke are all possible injuries. The eyes are particularly vulnerable to extensive exposure to radio frequency energy; a lack of blood flow to cool the cornea can result in cataracts [4].

A related study found that exposing the human body to electromagnetic radiation causes various vibrations of broadcasting frequencies within the body, resulting in localized heat. This causes boils and dehydration of fluids near the eyes, joints, brain, belly, and heart, among other things [5]. People react differently to similar levels of EMF radiation. Small-time effects of cell tower broadcast disclosure may include headaches, sleep difficulties, impaired memory, psychic excitation, agitation, tension, discomfort, hunger distress, and lethargy in a small number of people [6].

On a similar note, the International Agency for Research on Cancer (IARC) has classified RF areas as "possibly carcinogenic to humans," based on insufficient evidence of a potential risk of brain tumors among phone users and a lack of evidence for other types of cancer [6].

Despite the health concerns, the number of base station towers is rapidly expanding. These towers and their communications antennae are built in close proximity to schools and residential structures with no regard for people's health and well-being.

Because of the large sums of money accrued from leasing or selling land to telecommunication companies for the purpose of installing telecommunication masts at the expense of their health and the needed luxury of space for proper ventilation, the erection of these antennas has caused many problems between families and friends, tenants and landlords [7]. As a result, the purpose of this study is to assess and analyze the level of exposure of Dakingari people to radio frequency emissions from the GSM base transceiver station.

As a result of the International Agency for Research on Cancer (IARC) labeling the region potentially harmful to humans [7], researchers all over the world would continue to conduct study in the area of radio-frequency emission. Around 2012, in New Delhi, India, seven telecom carriers were found to be in violation of government radiation standards following a random measurement check at a location in Mumbai. When measurements were taken in some houses facing nearby BTS antennas, eleven BTSs of Reliance Communications, Tata Teleservices Maharashtra, Airtel, Vodafone, Idea Cellular, Aircel, and Loop Telecom BTSs were found to be radiating beyond the permissible limits of the new radiation norms. The seven operators were given orders to halt radiating from these BTSs with immediate effect. The BTSs were only to resume operation after the sites were made compliant, and information to that effect was verified by the Telecom Enforcement and Resource Monitoring (TERM) Cell in Mumbai. The new radiation norms, which went into effect in September 2012, reduced the limit of emission from telecom towers by one-tenth compared to earlier ICNIRP MPE limits in India.

According to the new guidelines, emissions from telecom antennas mounted on mobile towers should be equivalent to the frequency range in which the antenna operates; for example, an antenna operating in the frequency range of 400 MHz will be allowed to emit 400 watts of energy per 2,000 square meters of area, and the minimum distance of a tower (with two antennas) from a residential building is set at 35 meters [8].

Ref [9] attempted to bridge the gap in this research field by measuring and analyzing radio frequency radiation exposure levels from several mobile base transceiver stations in Ajaokuta and surrounds. They used a three-axis handheld radio frequency meter to measure the power density of electromagnetic radiation emitted by mobile stations in the research region. According to the study, GLOBACOM, MTN, and AIRTEL base stations had the maximum emission at 50m, 75m, and 125m, respectively. The radio frequency radiation emissions from the base stations are always less than $10^7 \mu W/m^2$ (the standard limit specified by the International Commission on Non-Ionizing Radiation Protection).

Ref [10] investigated the health implications of radiations from Global System for Mobile Communication (GSM) handsets. Non-ionizing radiations from different models of GSM handsets were measured at various distances from the handsets using an electromagnetic field tester (MT2008-0026). The obtained measurement results from the GSM handsets were also compared with other household devices. The results demonstrate that the radiations emitted by GSM handsets were within the International Commission on Non-Ionizing Radiation Protection's (ICNIRP) standard. The released radiations from the handsets pose no health concern.

When compared to the values obtained from other household equipment, the measured values of the radiated radiations from GSM handsets did not indicate any excessive variance. However, if the handsets are used for an extended period of time, the radiations induce an increase in body temperature. The study recommended that phones should not be used for more than 30 minutes without a break, and that pregnant women should use phones with caution to avoid harm to their unborn baby.

Ref [11] in another related study, analyzed the radio-frequency radiation exposure level from various selected mobile base stations in Kaduna State. The RF radiations emitted by the selected base transceiver stations were measured using a 2658A spectrum analyzer. Measurements were made at 20m intervals from the base stations over a radial distance range of 20m to 100m. The measured power density values range from 9.29 nW/m2 to 58.08 nW/m2. This result falls below the International Commission on Non-Ionizing Radiation Protection's (ICNIRP) standard limit value of 4.5W/m2 for 900MHz systems. This indicates that the exposure levels in the research area are low, representing no substantial health risk.

II. STATEMENT OF THE PROBLEM

GSM Base Transceiver Stations (BTSs) are frequently located near schools and residential structures. These BTSs continuously emit non-ionizing radiations (NIR), which pose a health risk to people depending on the source's vicinity and penetrating ability. This explains why, in 1974, the International Radiation Protection Association (IRPA) organized a working group to investigate the issues of NIR protection. The group collaborated with other international organizations, including the World Health Organization (WHO), the International Non-Ionizing Radiation Committee (INIRC), and others, to produce a scientific data base for the formulation of NIR exposure limits and codes of practice (ICRP, 1998).

For example, the International Commission on Non Ionizing Radiation Protection (ICNIRP) established exposure levels for GSM transmission at 900MHz to 4.5 W/m2 and 1800MHz to 9.0 W/m2 [12]. Similarly, the Institute of Electrical and Electronics Engineers (IEEE) recommends that the antenna's foot be 4.35 meters away from residential buildings [13].

It is therefore necessary to analyze the extent to which the residents of Dakingari are exposed to radio frequency radiation in order to attract their attention, as well as the government's, to it. Finally, the investigation will determine whether or not radio frequency radiations from BTSs in Dakingari pose a health concern.

III. OBJECTIVES OF THE STUDY

The main aim of this research work is to assess and analyse the radio-frequency radiation exposure level of inhabitant of Dakingari from Base Transceiver Stations (BTS) of GSM telecommunication networks. However, this research work shall meet the following specified objectives:

1. To quantify the Radio-Frequency Radiation exposure level of Dakingari inhabitant via measurement of the power density of the radiated emission in W/m^2 from all BTS within Dakingari town.

2. To show the variation of the radiated power density with radial distance from the BTS antenna.

3. To compare the radio frequency exposure level in Dakingari with safety limit level set by international organizations.

4. To determine whether or not the proximity of the BTS to schools and residence in the study area conforms to international safety standard.

IV. METHODOLOGY

STUDY AREA:

This research work was carried out in Dakingari town. Dakingari town is the head quarter of Suru Local Government area of Kebbi State. Currently there are four functional Global System for Mobile Communication (GSM) Base Transceiver Stations (BTSs) in Dakingari. The fifth one adjacent to National Youth Service Corp (NYSC) Orientation Camp is under construction. The four existing BTSs spread in different locations in Dakingari town constituted the sites for this study. All these four sites are potential sites to be studied because they are surrounded by one type of physical structures or the other (residential buildings, schools, markets or shops).

SITE SELECTION /SAMPLING

The research was carried out in all the four sites in Dakingari Town. The four BTSs sites are identified by ID of DK_n where n takes value from 1 to 4. Table 1.0 below shows the sites ID, the GSM operator and location of the sites.

Table 1.0: Description of the Base Transceiver Stations (BTSs)

S/N	ID	GSM OPERATOR	LOCATION
1	DK_1	**MTN**	Dakingari Daily Market
2	DK_2	**AIRTEL**	Behind Nizzamiya Primary Sch.
3	DK_3	**GLO**	Behind Marafa Landi House
4	DK_4	**MTN**	Behind Tashar Daji

DATA COLLECTION:

In this research work, data for the research was collected using primary data collection and secondary data collection procedure.

- **Primary Data Collection**

1. Preliminary Investigation:

Preliminary investigation of the sites was first carried out. This entails identifying the site geographical coordinate using GPS software in an android phone and inspecting the site to uncover any relevant characteristics that may influence or impact upon the readings (for example, the presence of obstructions such as trees, buildings, reflecting objects, metallic structure etc.)

2. Measurement of Base Transceiver Stations (BTSs) Radio Frequency Parameters:

The radio frequency parameters such as Electric Field Intensity (E) in V/m, Magnetic Field Intensity (H) in A/m and Power Density (S) in W/m^2 were measured using a broad band TM 195, handheld three-axis RF meter (electrosmog meter). The deployed meter is capable of measuring frequency radiation in the range of 50 *MHz* to 3.5 *GHz*. Most GSM base stations are equipped with at least three sectorial antennas, which means that their radiations cover a 360^o sector area [9,14]. This means that measurements can be taken in any convenient direction around the station. To measure the maximum instantaneous power density at each place, the meter was set to maximum instantaneous measurement mode. Measurements are taken every 20m to 100m radius from each base station. Each measurement was taken by holding the meter at arm's length, 1.5m above sea level, and pointed towards the mast [15]. When the meter was stable (approximately 3 minutes), the values of the measured parameters such as electric field intensity, magnetic field intensity and power densities were taken and recorded [9]. Precautions were taken to ensure that the measured value is not impacted by other factors. To decrease

high field strength readings caused by electrostatic charges, the meter was moved while taking measurements [9] .The frequencies of the transmitted radio frequency radiations for sites DK_1 to DK_4 were obtained from each operator and validated using the following established equations:

$$P_D\ (^W/_{m^2}) = \frac{\frac{10^{(P-G)}}{10}}{1000\times\frac{4\pi}{\Lambda^2}} \quad (1)$$

Where $P_D\ is\ the\ power\ density\ in(^W/_{m^2})$, P is the measured radiation in dbm, G is the receiving antenna gain (RF instrument) in dBi and Λ is wave length of the transmitted radiation in m.

$$P\ (watt) = \frac{P_{dbm}}{1000} \quad (2)$$

$$P_D\ (^W/_{m^2}) = \frac{P\times 4\pi f^2}{C_0^2\times G} \quad (3)$$

Where $P_D\ is\ the\ power\ density\ in(^W/_{m^2})$, P is the measured radiation in watts, G is the receiving antenna gain (RF instrument) in dBi, f is the frequency of the transmitted radiation in Hz and C_o = Velocity of light.

This is done so as to ascertain the safety standard criteria to be adopted for each sites. 4.5 W/m^2 for GSM transmitting at 900MHz and 9.0 W/m^2 for GSM transmitting at1800 MHz [12].

3. Measurement of Radial Distance of Structures from the BTSs.

The radial distances of all structures with a direct line of sight to the BTSs were measured using a tape rule to ensure compliance with the minimum distance of 4.35m from the BTSs [13]. The result obtained is presented in table 2.

- **Secondary Data Collection**

Secondary data for this study was obtained from a survey of scholarly literature on RF radiation publications, ICT industry reports and publications, international journals and publications, and internet data. Secondary data contributed significantly to the development of the frameworks employed in primary data collection.

V. RESULT

Table 1: Power density in $\mu W/m^2$

S/N	**Distance (m)**	**(DK1) MTN**	**(DK2) AIRTEL**	**(DK3) GLO**	**(DK4) MTN**
1	20	167.4	125.3	151.5	256.1
2	40	226.6	141.8	153.2	426.7
3	60	643.8	155.4	243.2	997
4	80	1033	146.2	315.7	1457
5	100	145.9	73.2	88	341.2

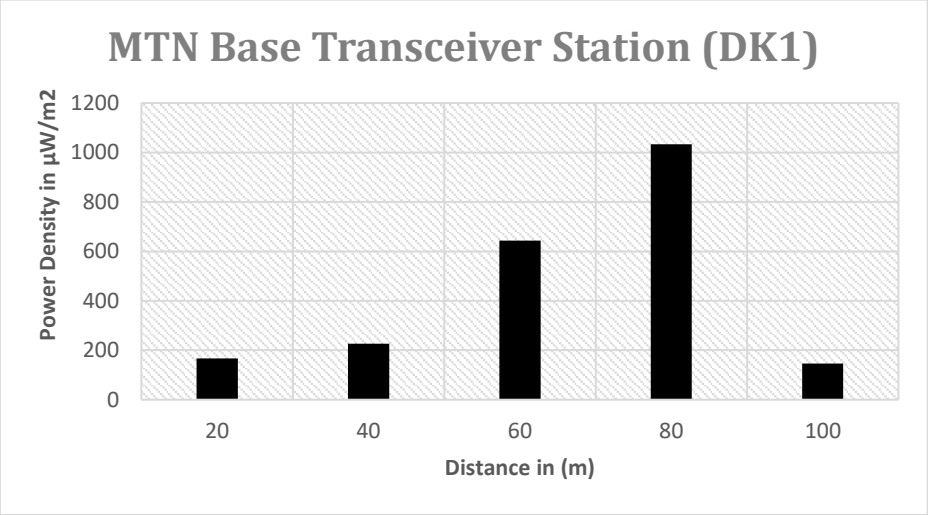

Figure 1: Plot of power density (µW/m^2) against distance (m) for DK1

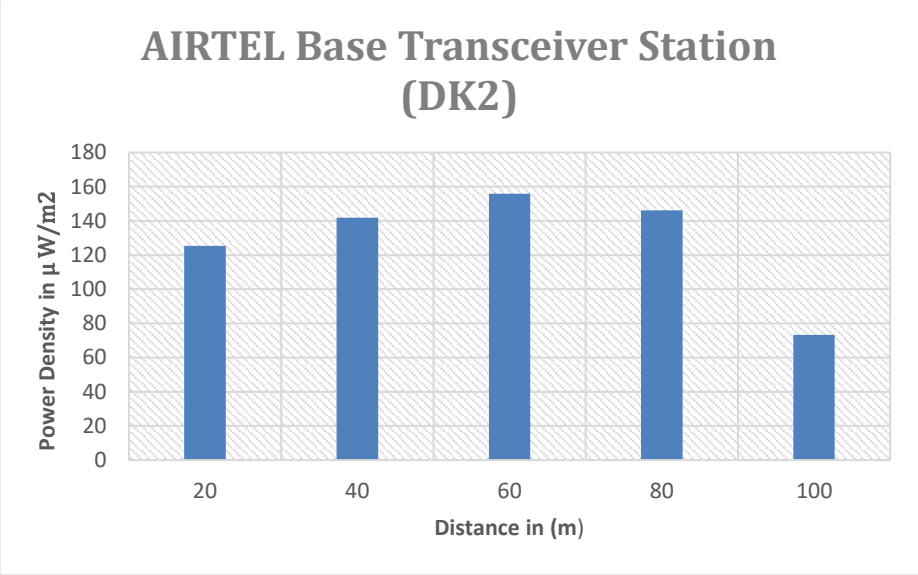

Figure 2: Plot of power density (µW/m^2) against distance (m) for DK2

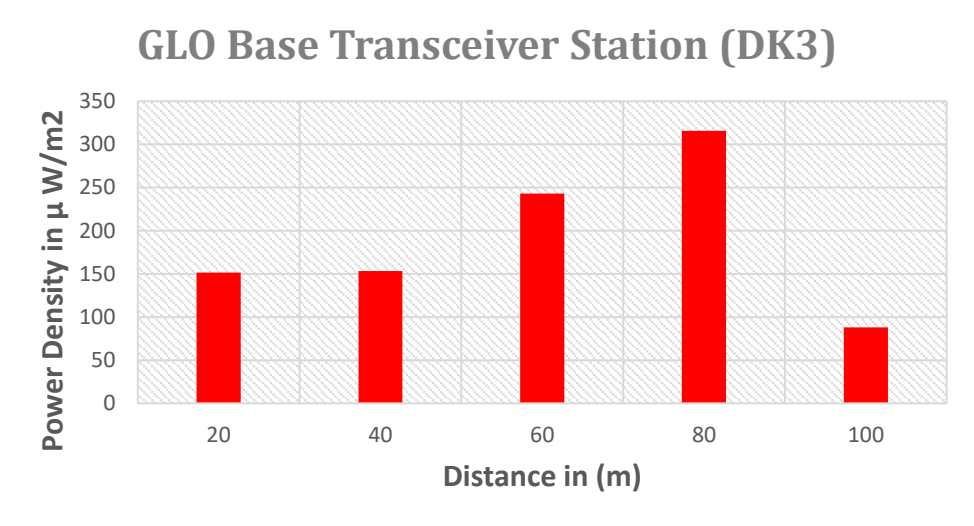

Figure 3: Plot of power density (µW/m^2) against distance (m) for DK3

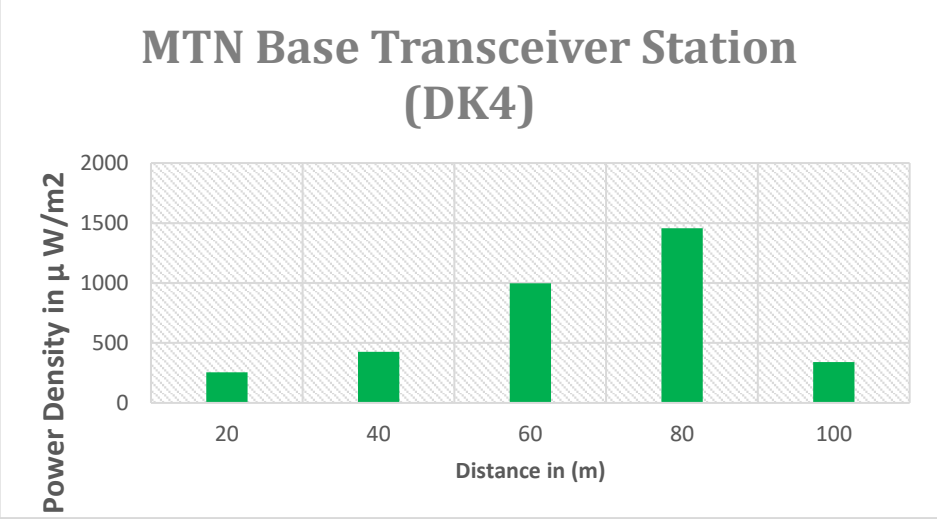

Figure 4: Plot of power density (µW/m^2) against distance (m) for DK4

Table 2: Radial distance (m) of structure from BTS			
S/N	**Operator/Site ID**	**Distance (m) of structure from base station**	**Structure Type**
1	MTN (DK1)	13.4	Store
2	MTN (DK1)	9.84	Store
3	MTN (DK1)	10.6	Residential building
4	AIRTEL (DK2)	11.7	Residential building
5	AIRTEL (DK2)	12.5	Residential building
6	AIRTEL (DK2)	13.5	School
7	GLO (DK3)	9.4	Store
8	GLO (DK3)	7.8	Store
9	GLO (DK3)	24.5	Store
10	MTN (DK4)	4.0	Residential building
11	MTN (DK4)	11.0	Residential building
12	MTN (DK4)	8.0	Residential building
13	MTN (DK4)	15	Residential building

VI. DISCUSSION

Table 1 shows that at MTN (DK1), a maximum power density of 1033 $\mu W/m^2$ was measured. This is equivalent to 0.00103W/m^2 . Regardless of the GSM transmission frequency, this value was determined to be well below the ICNIRP maximum safety value criterion. At a radial distance of 60m from the base station, AIRTEL (DK2) has a maximum power density of 155.4 $\mu W/m^2$. This is equivalent to 0.000155W/m^2 . This value is significantly lower than the maximum safety value required for a GSM station operating at 900MHz or 1800MHz [12]. GLO (DK3) and MTN (DK4) had maximum power densities of 315.7 $\mu W/m^2$ and 1457 $\mu W/m^2$ respectively. These values are equivalent to 0.00031W/m^2 for GLO (DK3) and 0.0014$\mu W/m^2$ for MTN (DK4).These values are substantially below the ICNIRP's maximum safety values.

The minimum radial distance of all structures measured from MTN (DK1) is 9.84m, according to table 2.This figure complies with IEEE standards, which call for a minimum distance of 4.35m from base stations. Similarly, the minimum radial distance recorded from AIRTEL (DK2) for all structures is 11.7m. This measured value complied with the IEEE standard. Table 2 readings also revealed that GLO (DK3) followed the IEEE guidelines, with a minimum radial distance of 7.8m from all structures.

Except for a residential building, which is roughly 4.0 m from MTN (DK4), all structures measured from MTN (DK4) complied with the IEEE minimum distance of 4.35m.

VII. CONCLUSION

The observed radio frequency radiated power from all four studied Dakingari town base transceiver stations met ICNIRP safety standard criteria. Similarly, all three GSM providers' BTSs adhered to the IEEE minimum distance of 4.35m between all structures and base stations, ignoring the 8% distance departure of a residential building from MTN (DK4).As a result, it is fair to infer that the radio frequency radiations from the evaluated base transceiver stations in Dakingari town constitute no health risk.

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