ESTIMATION OF RADIO-FREQUENCY RADIATION EXPOSURE FROM CHOSEN MOBILE BASE STATIONS IN YENAGOA, BAYELSA STATE.

ABSTRACT

Mobile Base Stations produce non-ionizing (RF) energy that is radiated through its antennas into space. There are health effects that can occur when the human body is exposed to high levels of radio frequency (RF) energy. The health implication associated with exposure from telecommunication masts is demanding attention, due to the expansion of telecommunication networks and base station installations. In this study, power density from various telecommunication masts of different network providers was measured using the Electrosmog Meter Cornet Model. RF radiation within radial distances of 100m, at 10m intervals in seven (7) communities in Yenagoa town in Yenagoa Local Government Area of Bayelsa State was measured. The measured values range between 0.650mWm^{-2} to 9.810mWm^{-2} with a mean value of 4.0569mWm^{-2}. Nevertheless, values changed as a result of other influences, such as wave interference from nearby other electromagnetic sources, such as reference base stations. The findings demonstrate that the radiation exposure level is below the 900 MHz system's standard limit of 4.5Wm^{-2} set by the International Commission on Non-ionizing Radiation Protection (ICNIRP) and other regulatory bodies. This demonstrates that the exposure levels in these regions are modest and as a result won't significantly endanger the health of those residing in the research area.

Keywords: Electrosmog meter, Radio Frequency, Non-ionizing, Mobile based station

1. INTRODUCTION

Nigeria's telecommunications business has been transformed by mobile phone technology. Mobile phone technology has expanded quickly in the recent decade due to its benefits. To fulfill the increased communication demand, there are currently over 6.9 billion mobile subscriptions worldwide and over 1.4 million mobile base transceiver stations (BTS), with the number steadily increasing (WHO, 2006). The Global System of Mobile (GSM) communication has shown to be extremely beneficial to society, particularly in developing countries like Nigeria where alternative kinds of communication are scarce.

The GSM wireless communication system generates a steady pulsed signal. Even when no one is using the phone, the cellular base stations continue to transmit. The number of cell towers is rapidly expanding without regard for the negative consequences. The possibility of radiation emitted from base transceiver stations being too close to residential and other public places was a major issue around the world.

There are two types of radiation effects on humans: thermal and non-thermal effects. Cooking with a microwave oven has similar thermal consequences. Non-thermal effects aren't fully characterized, but they're said to be 3 to 4 times more powerful than thermal effects. The radiation emitted by telecommunication masts is also harmful to the environment because it adds to the background radiation (background radiation is a measure of the level of ionizing radiation present in the environment at a specific location that is not due to the deliberate introduction of radiation sources) and has a negative impact on plants and animals (Girish, 2010).

A Base Transceiver Station (BTS) is a wireless communication infrastructure component that houses the radio that defines a cell and coordinates radio link protocols with mobile devices such as Global System Mobile (GSM) phones. A typical BTS is made up of radios, amplifiers, combiners, duplexers, splitters, power supplies, an antenna system, and the software that controls the base station (Godfrey, 2015). Telecommunication masts or towers are tall structures that support antennas or aerials that transmit telecommunication signals. In order to transmit this signal, these masts use electromagnetic radiation (a type of energy that has both electric and magnetic components and is propagated through space).

The placement of cellular telecommunications antennas near or even on schools, daycares, retirement homes, and residential buildings has an impact on everyone's health and well-being. Radiation is the emission of streams of particles such as electrons, protons, high energy photons or an emission of a combination of these (Parker, 1989). In order to transmit this signal, these masts use electromagnetic radiation (a type of energy that has both electric and magnetic components and is propagated through space). The placement of cellular telecommunications antennas near or even on schools, daycares, retirement homes, and residential buildings has an impact on everyone's health and well-being (Ike 2010). Examples are alpha, beta, gamma and x-rays.

Non-ionizing radiation (NIR) is any electromagnetic radiation with insufficient energy to remove an electron from the atoms or molecules it comes into contact with. Any sort of electromagnetic radiation that does not have enough energy per quantum (photon energy) to ionize atoms or molecules is also referred to as infrared.

Electromagnetic radiation consists of waves of electric and magnetic energy moving together i.e radiating through space at the speed of light. Radio waves and microwaves emitted by transmitting antennas are one form of electromagnetic energy and they are collectively referred to as radiofrequency of RF radiation or energy. The frequency of an RF signal is usually expressed in terms of unit called Hertz (Hz). One Hz equals one cycle per second. One megahertz MHz equals one million cycle per second. The most important use of RF energy is in providing telecommunication services. Radio and television broadcasting, cellular telephones, personal telecommunications services, business radio, satellite communication are just a few of the many telecommunication applications of RF energy.

1.1 Communication Antennas

An antenna is a device used for converting electromagnetic radiation in space into electrical currents in conductors and vice versa, depending on whether it is being used for receiving or transmitting respectively. Electricity flowing into the transmitter antenna makes electrons vibrate up and down in it, producing radio wave which travels through the air at the speed of light. When these waves arrive at the receiver antenna, they cause electrons to vibrate inside the receiver.

This produces an electrical current that recreates the original signal. Antennas are essential components of all equipments that use radio. They are used in systems such as radio broadcasting, broad cast television, two-way radio, communications receivers, radar, cell phones, satellite communications, as well as other devices such as garage door openers, wireless microphones, bluetooth-enabled devices, wireless computer networks, baby monitors, and Radio-Frequency Identification (RFID) tags on merchandise. (Carolyn, 2007) A communication antenna consists of arrangement of metallic conductors electrically connected to the receiver or transmitter. An oscillating current of electrons forced through the antenna by a transmitter will, create an oscillating magnetic field around the antenna elements, while the charge of electrons also creates an oscillating electric field along the elements. These time varying fields radiate away from the antenna into space as a moving transverse electromagnetic field wave. Conversely during reception the oscillating electric and magnetic fields of incoming radio wave exert force on the electrons in the antenna elements causing them to move back and forth, creating oscillating currents in the antenna. Communication antennas can be designed to receive and transmit radio waves in all horizontal directions equally (omni directional antenna), or in a particular direction (directional or high gain antenna).

Radio waves are electromagnetic waves which carry signal through the air (or space) at the speed of light with almost no transmission loss (Schantz. 2003) Telecommunication antennas demonstrate a property known as reciprocity, which means that an antenna will maintain the same characteristics regardless if it is transmitting or receiving. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. An antenna must be tuned to the same frequency band of the radio system to which it is connected; otherwise the reception and the transmission will be impaired. When a signal is fed into an antenna, the antenna will emit radiation distributed in space in a certain way. A graphical representation of the relative distribution of the radiated power in space is called a radiation pattern.

Mobile tower antennas transmit in the frequency range of 869-894 MHz (CDMA), 935- 960MHz (GSM 900) and 1810-1880 MHz (GSM 1800). Also 3G has been deployed in some areas in which base station antennas transmit in the frequency range of 2110-2170 MHz. Mobile phone operators divide a region in large number of cells, and each cell is divided into number of sectors. The base stations are normally configured to transmit different signals into each of these sectors. In general there may be three sectors with equal angular coverage of 120 degrees in the horizontal direction as this is a convenient way to divide a hexagonal cell. If number of users is distributed unevenly in the surrounding area, then the sectors may be uneven. These base stations are normally connected to directional antennas that are mounted on roofs of buildings or on free standing masts. The antennas may have electrical or mechanical down tilt so that the signals are directed towards the ground level. A base station and its transmitting power are designed in such a way that mobile phone should be able to transmit and receive enough signal for proper communication up to a few kilometers. Majority of these towers are mounted near residential or office buildings to provide good mobile network coverage to the users. These base transceiver stations transmit radiations all the time. So people living within 10‘s of meters from the tower will receive 10,000 to 10,000,000 time‘s stronger signal than required for mobile communication (Girish, 2010).

In Nigeria many people reside within these high radiation zones. GSM antennas will either be directional or non-directional. Non-directional antennas, also known as helical antennas, can receive signals from any direction; they are essentially employed for broadcast transmission and reception (Lai et al, 1996). Directional antennas usually have more gain, that is, more sensitivity to signal, than non-directional antennas. Directional antennas accomplish this greater sensitivity because they are able to focus their energy patterns onto a smaller area than non directional antennas. However, to receive signal, directional antennas must be pointed in the specific direction from which the signal is emanating. By doing so, directional antenna will be able to transmit and receive maximum energy in one direction only. Consequently, directional antennas are used for radio telephony and other point to point links. A radio frequency (RF) electromagnetic wave (EMW) has both an electric and magnetic fields. Different forms of electromagnetic energy are categorized by their wavelengths and frequencies. The RF part of the electromagnetic spectrum is generally defined as that part of the spectrum where EMW have frequencies in the range of about 3 kilohertz (3 KHz) to 300 gigahertz (300GHz). Microwaves are specific categories of radio waves 11 that can be loosely defined as RF energy at frequencies ranging from about 1 GHz and above (Blettner et al. 2008). GSM 900 system has been allotted two frequency bands, 890-915 MHz for the uplink (mobile phone to base station) and 935-960 MHz for the downlink (base station to phone) system. The downlink of a particular channel is 45

MHz higher than the uplink (duplex operation) (Firstenberg. 1997). The GSM 1800 system uses bands of 1710-1785 and 1805-1880 MHz, respectively. The 1st generation (analog) systems use frequency bands around 450 and 900 MHz, while the coming Universal Mobile Telecommunications System (UMTS) is allocated bands of 1900-2025 and 2110-2200 MHz. Emissions from these systems are not included in this evaluation only GSM 900 MHz system was used. In the GSM systems, each link is allocated a bandwidth of 200 kHz (0.2 MHz). Thus, the allocated spectrum could theoretically encompass 124 (GSM 900) or 374 (GSM 1800) different channels (pairs of links) (Girish, 2010). However, the need to have a few cell‘s separation between re-use of the same frequency, and the fact that a single operator is usually only allocated a part of the frequency band, limit the number of possible channels to be used in each cell, and thus also the total emitted power. One channel (the control channel) from each base station is always transmitting with essentially a constant power regardless of the traffic intensity. Other channels (traffic channels) do only send when the traffic requires, and may also use a power regulation system. Accordingly, the emitted power from a base station may vary over the day and week from a minimal power of e.g. 10W during period with low to modest traffic, to perhaps up to 5 times that level at peak traffic (if there are four traffic channels in addition to the control channel) (Fejes et al, 2006). From a GSM base station with more than one channel, there are thus a variety of reasons for variations in the transmitted power at any given time: how many channels are in use, how many of 12 the time slots in the traffic channels are used, and whether discontinuous transmission (DTX) is used or not. Any attempt to characterize the exposure around a base station should take this traffic-dependent time-variation into account. Information from the operator of the base station on traffic statistics could provide a basis on how this should be done. Options could include sampling (for average situation) and choosing a probable maximum traffic time (for worst case situation). Near and Far Field Regions of an Antenna The exposure from telecommunication mast can be classified as near field or far field depending on its position to the antenna. Near field is the region in the field of the antenna that is located close to the antenna and the electric and magnetic field do not have a substantial plane wave character but varies from point to point. On the other hand the far field is the region of the antenna in which the angular field distribution does not depend on the distance from the antenna (Dina,2000) and the field is used for assessing public exposure level and the radiation intensity reduces with distance thus obeying the inverse square law (Bolaji and Idowu, 2012).

1.2 History of Communication Antennas: The study of wireless communication started from mid 1800s and much evolution had occurred since. The first experiments with wireless communication are on record in 1867 but little details are available. A major breakthrough is noted for Guglielmo Marconi with a wireless call that travelled to boats across the Atlantic Ocean (Kyle, 2004). Previous to this feat radio transitions had a very limited range such that houses or boats very close could talk to each other, but communication over great distances was unlikely. Radio communication was only a series of tones, known as mores code, but it now provided the ship industry with an element of safety that it do not have before Marconi. The next breakthrough was in 1916 when operators at Radio Arlington were able to transmit the sound of a human voice up and down the Atlantic coast. This was a major breakthrough and the beginning of AM (Amplitude Modulation) radio. This sparked an interest in radio and during the mid 1920s many citizens were putting wire array antennas on their roofs to talk to other people nearby. The frequencies used by citizens were in the high frequency range lower than 200 meters wavelength. Because of this, people who use this band are known as shortwave or —ham‖ operators. People quickly realized that the shorter the wave the further it propagates through space. Therefore people operating in the range below 50 meters were able to make contact around the world in the early 1920s (Eltiti et al, 2008)

1.3 **Biological Effect of Microwave and Radiofrequency Radiation:** When a human body is exposed to electromagnetic radiation, it absorbs radiation, because human body consist of 70% liquid. It is similar to that of cooking in the microwave oven where the water in the food content is heated first. Microwave absorption effect is much more significant by the body parts which contain more fluid (water, blood, etc), like the brain which consist of about 90% water. Effect is more pronounced where the movement of the fluid is less, for example, eyes, brain, joints, heart, abdomen, etc. also human height is much greater than the wavelength of the cell tower transmitting frequencies, so there will be multiple resonances in the body. This results in boils, drying up of the fluids around eyes brain, joints, heart, abdomen, etc. (Girish, 2010).The biological effects of electromagnetic radiation probably begin with the organism acting like a radio antenna. The pulsed radiofrequency (RF) radiation generates eddy currents flowing through it and (in the case of cell cultures) also through the surrounding medium. When they impinge on the delicate membranes that surround its individual cells, they disturb their ionic structure and destabilize them. The same is true of the membranes that divide cells into their various internal compartments and organelles. The human body makes a good antenna since blood vessels, which have low resistance pathways filled with a highly conductive salty fluid, connect virtually all of its parts. Even cell membranes, which have a high resistance to direct current (DC) allow radio-frequencies through because of their high capacitance (Andrew, 2008).

1.4 ~~**Health**~~ **hazards associated with telecommunication masts;**

1.4.1 Effect on Cell Membrane Ca^{2+}: Electromagnetic radiation that is far too weak to cause significant heating can nevertheless remove calcium ions from cell membranes (Blettner et al, 2008). Later, Carl Blackman showed that this occurs only with weak pulsating radiofrequency RF radiation because they allow more time for dislodged calcium ions to diffuse clear of the cell membrane and be replaced by different ions, before the field reverses. Pulses are more effective than smooth sine waves because their rapid rise and fall times catapult the ions quickly away from the membrane and leave even more time for them to be replaced by different ions before the field reverses (Andrew, 2008).This is probably why the pulsed radiation from mobile phones can be particularly damaging. Free calcium ions normally occur in calcium salts but, like other positive ions, they can also bind to the negatively charged membranes of living cells. These membrane-bound ions are in chemical equilibrium with the corresponding free ions in the surrounding medium, but there is a disproportionately large amount of calcium because it has two positive charges (i.e. it is divalent), which attracts it more strongly to the negative membrane (Blackman et al, 2008). Most of the other readily available ions in living cells (e.g. potassium) have only one charge (i.e. they are mono-valent). However, the extra charges on the divalent ions such as calcium and magnesium let weak alternating electromagnetic fields remove them selectively from the membrane, which can have dire metabolic consequences (Blackman et al, 2009). Positive ions strengthen cell membranes because they help bind together the negatively -charged phospholipid molecules that form a large part of their structure. Calcium ions are particularly good at this because their double positive charge enables them to bind more strongly to the surrounding negative phospholipids and hold them together like cement. However, monovalent ions are less able to do this(Ha, 2005).Therefore, when electromagnetic radiation replaces calcium with monovalent ions, it weakens the membrane and makes it more likely to tear and form pores, especially under the stresses and strains imposed by the moving cell contents (Melikov et al, 2001). Normally, small pores in phospholipid membranes are self-healing but, while they remain open, the membrane will have a greater tendency to leak. Membrane leakage can explain almost all of the adverse effects of electromagnetic radiation, including those from mobile phones and their base stations.

1.4.2 **Effect on DNA:** Lai and Singh (1996) were the first to show effect of pulsed RF radiation in cultured rat brain cells, and it has since been confirmed by many other researchers. They found that pulsed RF - radiation like that from mobile phone base station antenna and GSM handsets caused both single and double stranded breaks in the DNA of cultured human and animal cells. Not all cell types were equally affected and some, such as lymphocytes, seemed not to be affected at all (Diem et al, 2005). However, in susceptible cells, the degree of damage depended on the duration of the exposure. With human fibroblasts, it reached a maximum at around 16 hours. Because of the very high stability of DNA molecules, they are unlikely to be damaged directly by weak radiation. The most plausible mechanism is that DNase (an enzyme that destroys DNA), and possibly other digestive enzymes, were leaking through the membranes of lysosomes (organelles that digest waste) that had been damaged by the radiation. If so, there is also likely to be considerable collateral damage to other cellular systems. If similar DNA fragmentation were to occur in the whole organism, we would expect a reduction in male fertility from damage to the DNA of developing sperm, an increased risk of cancer from DNA damage in other cells (this may take many years to appear) and genetic mutations that will appear in future generations. Microwave radiation can also interfare with the natural processes involved in DNA replication and repair by subtly altering molecular conformation (architecture). Another possibility of DNA damage is via free radical formation inside cells. Free radicals kill cell by damaging macromolecules such as DNA, protein and membrane and are shown to be carcinogenic. Several reports have indicated that electromagnetic frequency (EMF) from telecommunication masts enhance free radical activities in cells (Diem et al, 2005). The Fenton reaction is a catalytic process of iron to convert hydrogen peroxide, a product of oxidative respiration in mitochondria into hydroxyl free radical which is a very potent and toxic free radical. Thus EMF affects the DNA via an indirect secondary process. Damage to DNA is a central mechanism for developing tumors and cancer. When the rate of damage to DNA exceeds the rate at which DNA can be repaired, there is the possibility of retaining mutations and initiating cancer. DNA damage in brain cells can affect neurological functions and also possibly lead to neurodegenerative diseases.

1.4.3 Blood Brain Barrier: The brain is protected by tight junctions between adjacent cells of capillary walls by the blood brain barrier (BBB), which selectively lets nutrients pass through from the blood to the brain but keeps toxic substances out. Experiments conducted on young laboratory rats found that RF from mobile phones can significantly open the BBB in animals and cause leakage of albumin from blood vessels in inappropriate locations (neurons and glial cells surrounding the capillaries) in the brain (Girish, 2010). The presence of albumin in brain tissue is a sign that blood vessels have been damaged and that the brain has lost some of its protection. A closer look at the cells within the brain also revealed that exposed animals had scattered and grouped dark neurons often shrunken with loss of internal cell structures. Neuronal damage of this kind may not have immediate consequence but in the long run, it may result in reduced brain reserve capacity that might be unveiled by other later neuronal diseases. It must be noted that the BBB and neurons are the same in a rat and a human being. In another research, a single two-hour exposure to a cell phone just once during its lifetime permanently damaged the BBB and, on autopsy 50 days later, was found to have damaged or destroyed up to 2% of an animal‘s brain cells, including cells in areas of the brain concerned with learning, memory and movement. (Girish, 2010).

1.4.4 Irreversible Infertility: It might be expected that DNA damage in the cells of the germ line to result in a loss of fertility. Several studies have shown significant reductions in sperm motility, viability and quantity in men residing close to phones mast (Agarwal et al, 2006). So it is advisable for men to keep their mobile calls to a minimum. The effects of phone mast use on female fertility are not yet known since the eggs are formed in the unborn fetus and it will have to be waiting until the child reaches puberty to see the full effects of the mother‘s mobile phone use. So far, similar investigations have not been performed with the radiation from mobile phone base stations, but it cannot be assume that they are necessarily safe just because they are further away. Radiation levels, even hundreds of meters from the mast, can still give biological effects and living near one will involve a considerably longer exposure than from just making the occasional phone call (Agarwal et al, 2007). Study shows that men who made lengthy calls have fewer rapidly motile sperm.

1.5 Radiation

The emission of particle streams like electrons, protons, high-energy photons, or a combination of these, is known as radiation (Parker, 1989). Since then, radiation has been present everywhere in our surroundings, coming from the sky, the ground, and even our own bodies. In other words, from the time of conception till the time of death, we are naturally exposed to radiation. Since radiation is invisible, human senses cannot directly detect it. Although it has some benefits, it also poses a health risk and, if used incorrectly, can harm live tissue. Man can therefore alter or affect his surroundings in both positive and harmful ways. Ionizing radiation and non-ionizing radiation are the two different forms of radiation.

1.5.1 Ionizing Radiation

These electromagnetic waves have an extraordinarily high frequency, enough photon energy to generate ionization by rupturing the atomic bonds holding the molecules in cells together, and the potential to harm genetic material. Ionization depends on the energy of the individual particles or waves that are impinging, not on how many there are. Ionized molecules are prone to instability and fast chemical transformations, which might result in the production of free radicals that can harm molecules nearby. Ionizing radiation can cause mutations in DNA, which can be harmful to cells. This can cause the cell to die or cause cancer. Depending on the dose, ionizing radiation can harm every cell in the body (Ike, 2010).Examples are alpha, beta, gamma and x- rays. The evidence that small amounts of some types of ionizing radiation might confer a net health benefit in some situations is called radiation hormesis

1.5.2 Non Ionization Radiation

Any electromagnetic radiation that does not have enough energy to remove an electron from the atoms or molecules it comes into contact with is referred to as non-ionizing radiation (NIR). Any electromagnetic radiation that does not have enough photon energy per quantum to ionize atoms or molecules—that is, to fully remove an electron from an atom or molecule—is also referred to as such. The electromagnetic radiation only has enough energy to excite an electron, which moves it to a higher energy level, rather than creating charged ions when it interacts with matter. They consist of UV rays, radio waves, microwaves, infrared, and visible light. Global System of Mobile Telecommunication (GSM) masts, phones, electrical hightension wires, sun radiation, etc. are some sources. NIR has been associated with dielectric heating, in which polar molecule rotation caused by an electromagnetic field heats biological tissues. Additionally, a study from Greece discovered a causal link between DNA deterioration and cell phone radiation (Achudume et al, 2010). A recent study showed that when people used a cell phone for 50 minutes, brain tissues on the same side of the head as the phone‘s antenna metabolized more glucose than did tissues on the opposite side of the brain. Inhabitants living near mobile phone base stations suffered from frequent headaches, memory changes, dizziness, tremors, depressive syndrome and sleep disturbance (Bevelaqua, 2015).

Both ionizing and non-ionizing radiation can be harmful to organisms and can result in changes to the natural environment. In general, ionizing radiation is far more harmful to living organisms per unit of energy deposited than non-ionizing radiation. Ultraviolet radiation in some aspects occupies a middle ground, in having some features of both ionizing and non-ionizing radiation. Although nearly all of the ultraviolet spectrum of radiation is non-ionizing, at the same time ultraviolet radiation does far more damage to many molecules in biological systems than is accounted for by heating effects (an example is sunburn). These properties derive from ultraviolet's power to alter chemical bonds, even without having quite enough energy to ionize atoms.

2. MATERIALS AND METHOD

The materials used are Electrosmog meter, tape meter for distance measurement, Global Positioning System (GPS) receiver (A smart phone with the application). The research was conducted in seven (7) communities in Yenagoa, Yenagoa Local Government Area of Bayelsa State, Nigeria. A Global Positioning System (GPS) was used to determine the latitude and longitude of each position of BTS. The locations were chosen for their ease of access and low cost. The three most prevalent network providers, Globacom, MTN, and Airtel, were represented by a total of 7 base stations. These were picked based on their closeness to buildings, the number of antennas put on their masts, their proximity to other base stations, and the density of the population in the area.

The mobile base stations given codes ranging from B1 to B7. Human population residing near the BTS, vegetation, and other masts in line of sight was used to estimate B1 to B7. The Base stations with at least 2 to 3 sectoral antennas, each spanning a radius of 100 meters, were evaluated for good results. At every 10m intervals for a 100m radius from the foot of each telecommunication pole, measurements were taken in a convenient direction around the base station.

Measurement was made with an Electrosmog meter to determine the Power Density (mW/m^2), Electric field intensity (V/m) and the magnetic field strength (uT) or (A/m). Each measurement was taken with the electrosmog meter held away from the body and at a height of roughly 1m above ground level, pointing at any sector of the antenna. Measured values were recorded only around 5 minutes after the meter value has stabilized to avoid measured power density fluctuation.On getting to the site, a quick environmental assessment were carried out by using the density of houses around, vegetation and the visibility of any other mast in line of sight. The proximity of residential buildings to base stations is the reason for choosing this range of distance.

2.1 Measurement of Radiofrequency Radiation

An RF electromagnetic wave has both an electric and magnetic component (electric field and magnetic field), and it is convenient to express the intensity of the RF environment at a given location in terms of units specific to each component. Power density is used to characterize the total electromagnetic field. Power density is mostly appropriately used when the point of measurement is far enough away from an antenna to be located in the far field of the antenna.

Figure1: Electrosmog Meter Cornet Model

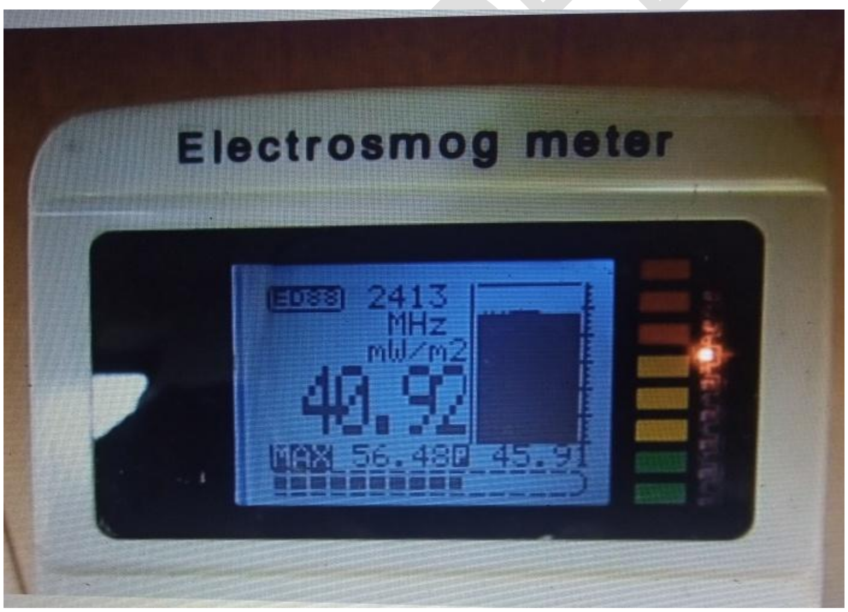

Figure 2: Interface of theElectrosmog Meter Cornet Model

3.RESULT AND DISCUSSION

3.1 Result

The result of power density in microwatts per square metre (mWm^{-2}) obtained at different distances for 7 mobile base stations (MBS) are presented in Table 1.The value of the maximum power density was found to be 9.810 mWm^{-2} observed at 40 m from an MTN BTS (location B1) in Akenfa while the minimum power density was found to be 0.650 mWm^{-2} observed at 10m from a Globacom MBS (location B6).The maximum power density of 9.810 mWm^{-2} obtained is below the ICNIRP maximum permissible limit of 4.7 Wm^{-2} for GSM 900. In order to have a clearer picture of the power density distribution over all locations, the average of the power density over the entire locations at an interval of 10m from the foot of each base station up to 100 m was obtained as presented in Table 2.The average highest value of power densities over all locations (B1 to B7) and over all distance intervals from the base stations was found to be 5.8400 μWm^{-2} which is below the ICNIRP maximum permissible limit of 4.7 Wm^{-2}

Quantitative data collection method was used by measuring the mobile base stations. Data used in this study was mainly primary. The primary data was collected through field measurement in seven (7) communities in Yenagoa town in Yenagoa Local Government Area of Bayelsa State. The data collected will be used to check and compare with the international accepted standard of International Commission on Non-Ionizing Radiation Protection (ICNIRP), National Radiation Protection Board (NRPB) to know the exposure levels in these areas whether they are low and as such not able to produce significant health risks among the people living in these areas.Power received by an antenna at a distance R is calculated by using

$P_r = p \times G \times Area/4\pi R^2$ (Wm^{-2}) ………………………………. 3.1

The radiation level absorbed by the body is calculated by multiplying the power density at a particular distance by the possible human area at that point. The average human surface area considered were 1.9 m^2 for adult men, 1.6 m^2 for adult women, 1.33 m^2 for children (12 – 13 years), 1.14 m^2 for children (10 years), 1.07 m^2 for child of about 9 years of age and 0.5 m^2 for a child of 2 year old. The body surface area is calculated using Mosteller formula simplified as

Body surface area = $\frac{\sqrt{\text{weight (kg) x height (m)}}}{3600}$ …………………3.2 (Mosteller, 1987)

Table 1EXPERIMENTAL RESULTS FOR THE ESTIMATION OF RADIO FREQUENCY EXPOSURE OF SOME MOBILE BASE STATIONS IN YENAGOA

Mobile Base Stations	Distance (m)	Power Density (mW/m^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Coordinates of measurement Site	
MBS 1	10	1.509	0.440	0.891	N5^{o}00’06” E6^o 22’ 52”	
	20	0.750	0.550	0.745		
	30	2.245	0.670	0.689		
	40	9.810	5.880	0.543		
	50	5.781	0.775	0.432		
	60	4.245	0.837	0.324		
	70	4.051	0.673	0.289		
	80	3.840	0.567	0.221		
	90	3.759	0.432	0.180		
	100	3.892	0.405	0.112		
MBS 2	10	0.670	0.450	0.630	N4^o 58’ 47” E6^o 22’ 17”	
	20	1.245	0.570	0.540		
	30	6.710	0.450	0.470		

	40	7.340	0.320	0.310		
	50	5.470	0.670	0.410		
	60	4.360	0.550	0.230		
	70	2.670	0.420	0.270		
	80	3.540	0.360	0.310		
	90	2.430	0.230	0.110		
	100	1.220	0.120	0.220		
MBS 3	10	1.520	0.410	0.891	N4^{o} 57’ 20” E6^{o} 21’ 40”	
	20	0.780	0.520	0.745		
	30	2.360	0.410	0.680		
	40	9.110	0.350	0.543		
	50	5.270	0.660	0.440		
	60	4.250	0.520	0.324		
	70	4.640	0.420	0.289		
	80	3.840	0.370	0.240		
	90	3.759	0.210	0.180		
	100	3.750	0.120	0.110		
MBS 4	10	1.520	0.410	0.630	N4^{o} 57’ 15” E6^{o} 21’ 38”	
	20	0.780	0.520	0.540		
	30	3.110	0.410	0.470		
	40	9.110	0.350	0.310		
	50	5.270	0.660	0.410		
	60	4.250	0.520	0.230		
	70	4.640	0.420	0.270		
	80	3.840	0.370	0.310		

	90	3.759	0.210	0.110		
	100	3.750	0.120	0.630		
MBS 5	10	0.670	0.520	0.745	N4^{o} 56' 53" E6^{o} 21' 06"	
	20	1.245	0.410	0.689		
	30	6.710	0.350	0.543		
	40	7.340	0.660	0.432		
	50	5.470	0.520	0.324		
	60	4.360	0.420	0.289		
	70	2.670	0.370	0.221		
	80	3.540	0.210	0.180		
	90	2.430	0.120	0.112		
	100	0.670	0.520	0.745		
MBS 6	10	0.650	0.440	0.630	N4^{o} 56' 19" E6^{o} 20' 13"	
	20	1.245	0.550	0.540		
	30	6.710	0.670	0.470		
	40	7.340	5.880	0.310		
	50	5.470	0.775	0.410		
	60	4.360	0.837	0.230		
	70	2.670	0.673	0.270		
	80	3.540	0.567	0.310		
	90	2.430	0.432	0.110		
	100	1.220	0.405	0.220		
MBS 7	10	8.880	0.570	0.745	N4^{o} 55' 31"	

					E6^{o} 19’ 04”	
	20	8.670	0.450	0.689		
	30	8.450	0.320	0.543		
	40	7.560	0.670	0.432		
	50	6.750	0.550	0.324		
	60	5.770	0.420	0.289		
	70	4.670	0.360	0.221		
	80	3.620	0.230	0.180		
	90	2.780	0.120	0.112		
	100	1.250	0.570	0.745		

Table 2: Average Power Density of MBS

MBS	**Average Power Density mWm^{-2}**	**Coordinates of the Locations**
MBS1	3.9882	N5^{o} 00’ 06” E6^{o} 22’ 52”
MBS2	3.5655	N4^{o} 58’ 47” E6^{o} 22’ 17”
MBS3	3.9279	N4^{o} 57’ 20” E6^{o} 21’ 40”
MBS4	4.0029	N4^{o} 57’ 15” E6^{o} 21’ 38”
MBS5	3.5105	N4^{o} 56’ 53” E6^{o} 21’ 06”
MBS6	3.5635	N4^{o} 56’ 19” E6^{o} 20’ 13”
MBS7	5.8400	N4^{o} 55’ 31” E6^{o} 19’ 04”

3.2 Discussion

The results obtained from the graph above showed that the maximum level of RF which an individual can be exposed to is 9.810mWm^{-2}, this value was obtained at a distance of 40m from the base station of location B1. This high value can be due to the presence of other high powered mobile MBS clustered around the location. The presence of trees and buildings reduced the RF measurements taken in location B1 especially the low level of RF observed at 10m distance from the foot of the antenna this is because trees and building walls obstruct a portion of the external wireless radiation. Hence, similar patterns were observed for measurements made for both locations B2 and location B7 due to reflection and absorption by residential buildings, 0 10 20 30 40 50 60 70 80 90 100 B1 B2 B3 B4 B5 B6 B7 Power density (mWm^{-2})

The power density decreases and also fluctuate as the distance increases for most masts obeying the inverse square law. The fluctuations in the readings obtained were mainly due to interference from nearby and distant masts. The measured power density deviated from the inverse square law at some locations, because of reflection, scatter and refraction from the ground, windows, and attenuation by trees and buildings. Radio waves are refracted the same way as light waves. On a hot day the surface of the ground can be heated and this causes air to rise. Hot air and the colder air have slightly different values of refractive index and this causes the wave to bend. Also, the distance between two masts is another factor considered; this is due to the fact that each antenna is linked with the other antenna via a line- of- sight communication link and thus, the RF field from one antenna influences the measurements made from the other antenna. For an area within a radius of 100 m and which is characterized by clusters of base stations, RF energy tends to concentrate more at some points than the others. It was observed that in most residential areas, the base stations are closely located and usually have 6 sectoral antennas. Some base stations were found to be within 100 m radius of a reference base station; the RF emissions of antennas of such base station were shielded by buildings. It is expected that base stations with 6 or more sectoral antennas would have high RF emission but the reverse is the case. The reason is that the RF signal level around a base station at any instant depends on the number of simultaneous calls handled by that base station and the caller‘s position relative to the base station. Thus, when there is high call rate at a base station there would be more RF emission. Therefore mobile MBS with small number of Sectoral antennas will emit more radiation than those with higher number of sector antennas.

GRAPH PLOTS

MBS 1

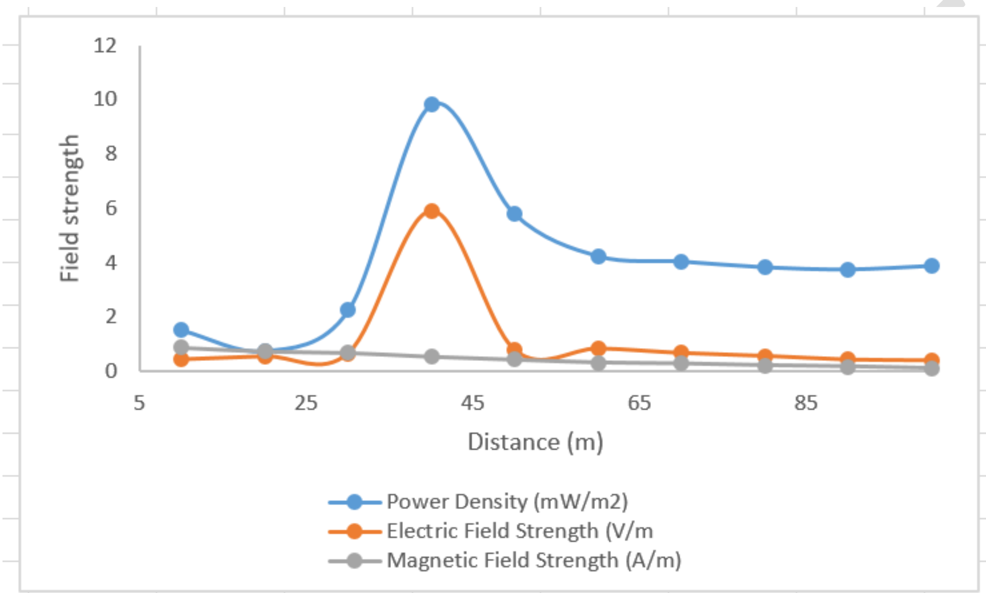

Figure 3: Power density Vs distance is 9.810mWm^{-2} and 40m

MBS 2

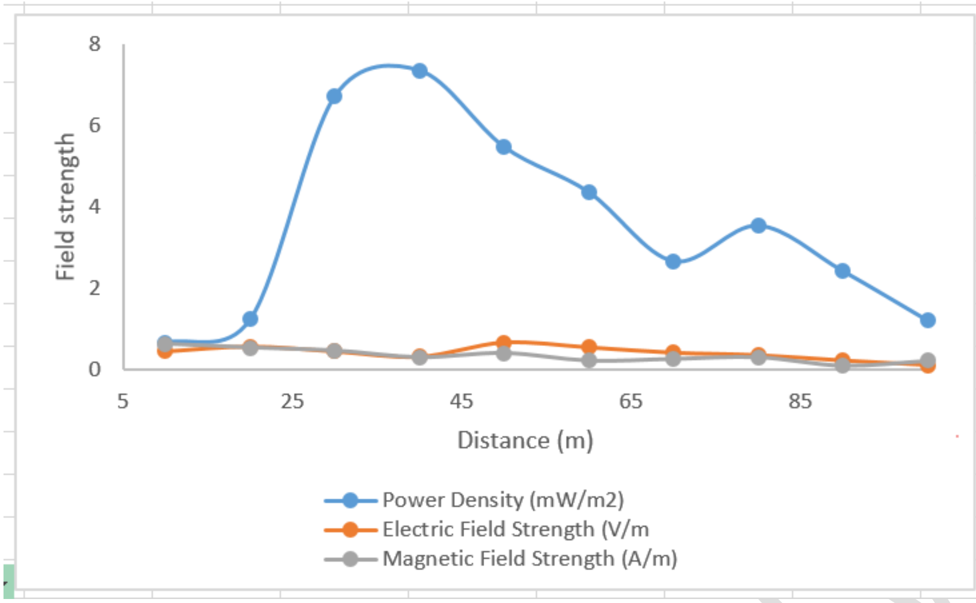

Figure 4: Power density Vs distance is 7mWm^{-2} and 45m

MBS 3

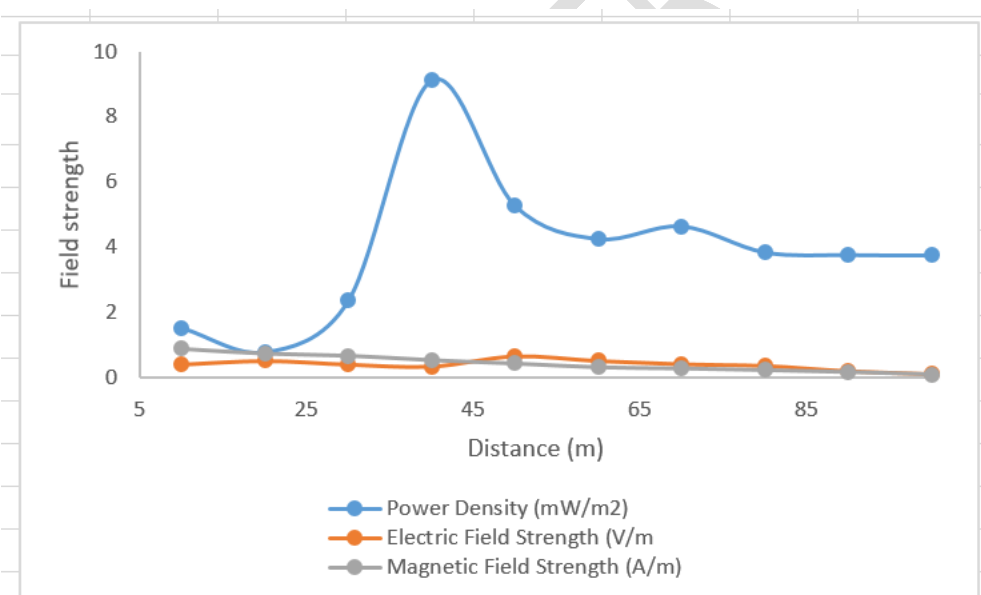

Figure 5: Power density Vs distance is 9mWm^{-2} and 40m

MBS 4

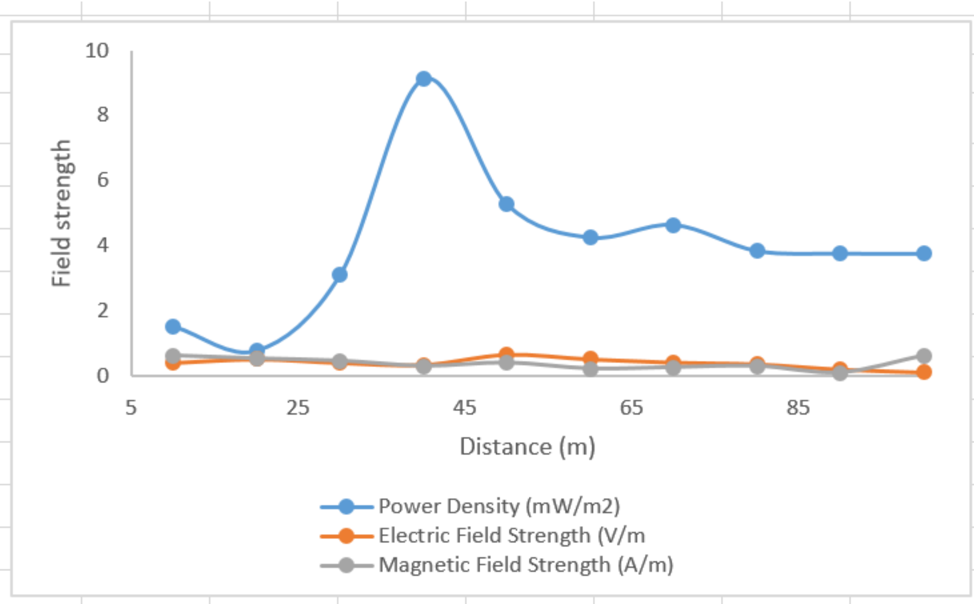

Figure 6: Power density Vs distance is 9mWm^{-2} and 40m

MBS 5

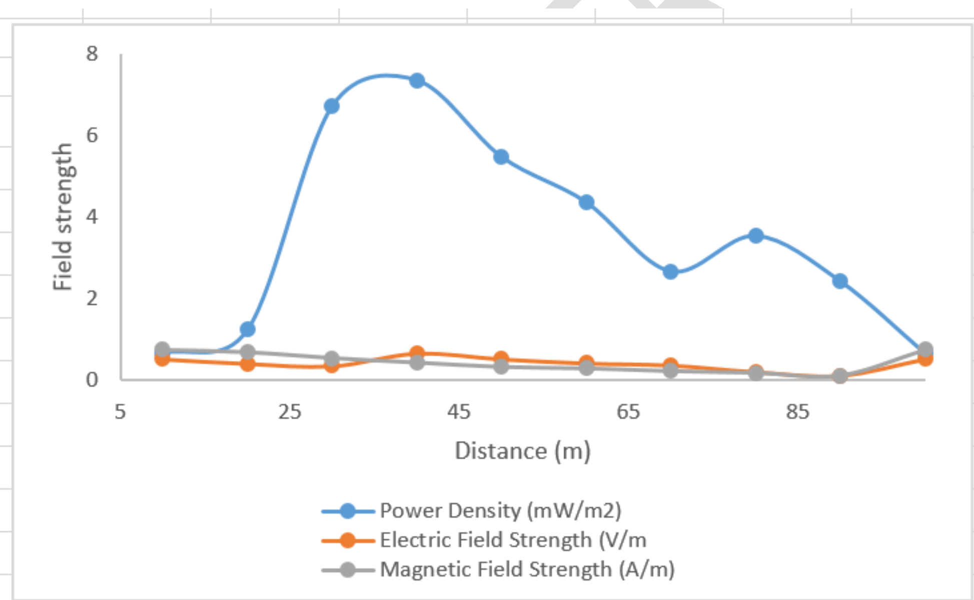

Figure 7: Power density Vs distance is 7mWm^{-2} and 38m

MBS 6

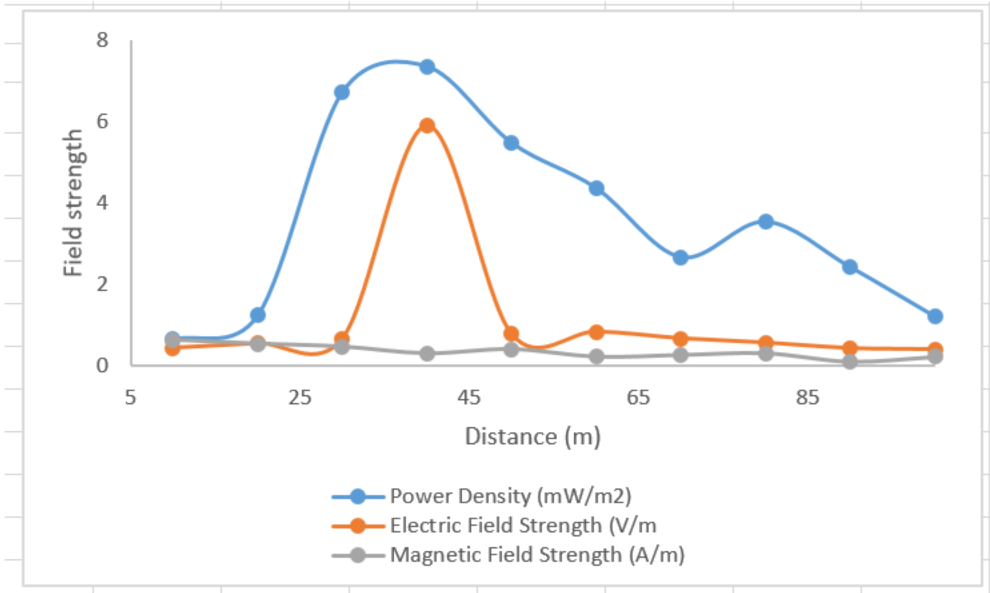

Figure 8: Power density Vs distance is 7mWm^{-2} and 40m

MBS 7

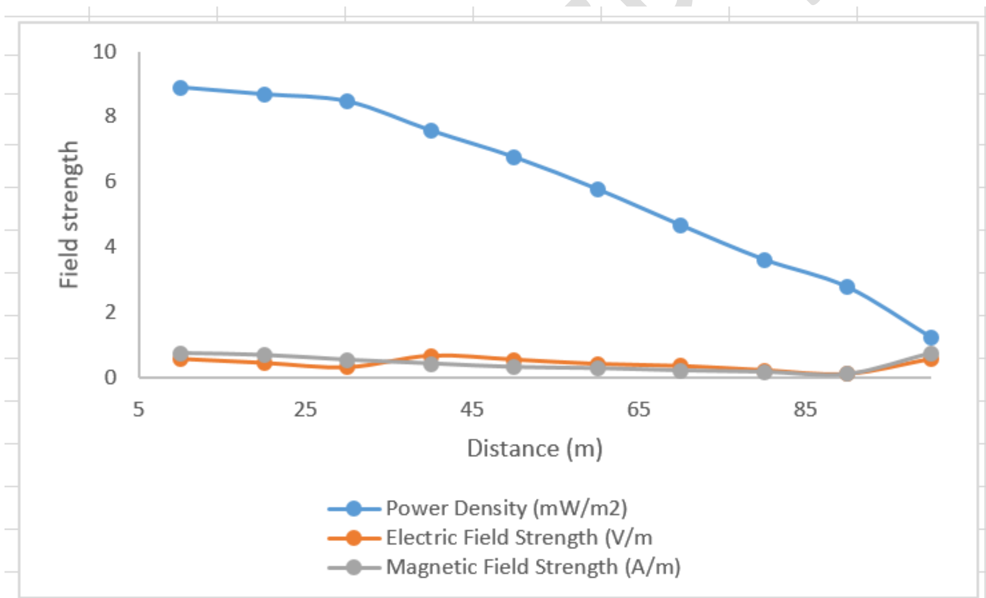

Figure 9: Power density Vs distance is 9mWm^{-2} and 7m

4. CONCLUSION

The level of the maximum power density was found to be 9.810 mWm^{-2} and it was obtained at a distance of 20m from the base station of location MBS1. The average power density over all locations was evaluated to be 4.0569 mWm^{-2}. The maximum power density as well as its average value is by far less than the maximum level of 4.5 Watt m^{-2} for GSM system. Therefore, radio frequency emissions from the selected serving MBS do not exceed the maximum permissible exposure limits. The distance from the MBS is a major factor that determines the level of radiation absorbed by the human body. The closer the distance of human body to the MBS, the higher the rate of radiation absorbed by the body and the higher the possibility of occurrence of illness. Majority of the selected MBS were located very close to residential places. Some were within 3.5 m radius from the foot of the antenna to residential buildings which fail to comply with the safety limits of 4.35m as suggested by the Institute of Electrical Electronics Engineers (IEEE, 1999).

The average power density of base stations decreased as the radial distances (away from the base stations) were increased, and radiation intensity varied from one mobile base station to another (even at the same distance away).We observed that Mobile base stations with little or no fluctuation (in power density with distance) have little or minimal interference from external sources, while those with noticeable data fluctuations had significant interference from external sources. Fluctuations were due to one or more of these five factors observed during measurement: (i) obstruction constituted by immobile structures placed or erected within the line of sight of measurement (ii) wave interference from other sources of electromagnetic fields around reference base station, such as radio and TV antennas, receivers etc. (iii) interference from radiation (wave) and/or noise from moving objects such as vehicles, motorcycles etc. (iv) topography (or elevation) of the land area around reference base station with respect to radial distance away from base station and (v) wave (EM fields) interference from other mobile base station(s) around a reference base station.

Table 3 National and International Guidelines Exposure levels to GSM and TETRA

Body	Exposure Limits in W/m^2		
	GSM		TETRA
	900 MHz	1800 MHz	1400 MHz
NRPB (UK)	33.0	100.0	26.0
ICNIRP	4.5	9.0	2.0
IEEE (USA)	6.0	12.0	2.7
EU COUNTRIES			

(Girish, 2010).

TETRA in telecommunication means Terrestrial Trunked Radiois a digital trunked mobile radio standard developed to meet the needs of traditional Professional Mobile Radio (PMR) user organizations such as: Public Safety, Transportation, Utilities, Government.

REFERENCE

Bolaji, O.A., and Idowu, P.F.(2012). Risk Associated with Low Level RF exposure at close proximities to mobile phone base stations. The Pacific Journal Of Science 13(2), 331-335.

Blettner M., Schlehofer B., J Breckenkamp, Kowall B., Schmiedel S., Rels U., Potthoff P., Schuz J., and Berg G Beckhoff (2008). Mobile phone base station and adverse health effeScts: phase 1 of a population-based cross-sectional study in Germany. Occupational Environmental Medicine. 66(2):118- 23.doi:10.1136/oem.2007.037721. Epub.Nov 18.

Carolyn, N.K, (2007). The Physics of cell phones, Yale New Haven Teachers Institute

Dina Simunic (2000), ―Measurement and exposure assessment for standard compliance‖. University of Zagreb, Faculty of Electrical Engineering and Computing 10000 Zagreb, Croatia. PP 1 – 11.

Fejes I., Zavaczki Z., Szollosi J., Koloszar S., Daru J., Kovaks L., and Pal A.(2006). 'Is there a relationship between cell phone use and semen quality?'ArchAndrolog y 51: 385-393.

Firstenberg A (1997). Microwaving our planet: the Environmental impact of the wireless revolution, cellular phone taskforce Brooklyn, NY 11210.

Girish Kumar (2010). Advantages and Disadvantages of Cell Phone Technology. Report on Cell Tower Radiation. Report sent to Departmant of Telecommunications, Delhi, India.

Godfrey E. Ekata (2015). A Model for Assessing base Stations for Compliance with Safety Limits for Human Exposure to Electromagnetic Fields (EMFs) in Nigeria. International Journal of Engineering Research & Technology.4(6): 791-798.

Ike, E.E. (2010). Ionizing Radiation, Man and the Environment. Unijos Inaugural Lecture Series 43:PP 13-28.

Kyle Isreals (2004). An Introduction to Communication Antennas. Proceedings Paper for Engineering 302 Spring 2004. PP 1-9.

Lai H. and Singh N.P., (1996). Single and Double Strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation. International Journal of Radiation Biology. 69(4): 513-21.

Parker, S.P., (1989). Dictionary of Scientific and technical Terms. 4th Ed. McGraw Hill Co. NY.

Schantz, Hans Gregory (2003). ―Introduction to ultra-wideband antennas Proceedings of the 2003 IEEE UWBST Conference

World Health Organization (2006) Electromagnetic Fields and Public Health. Media Centre fact sheet 304. Retrieved 31 May, 2016 from www.who.int/mediacentre/factsheets/fs304/en