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GSM BTS RADIATION WITHIN COMMUNITIES ONDO - CITY, NIGERIA AS A CASE STUDY

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ABSTRACT

The nature of communication base stations entails the emission of non-ionizing radiation due to the presence of transmitting and receiving antennas mounted on them. When the values of charges are varied harmonically with time, antenna tend to release energy, which is inversely proportional to the square of the distance from the antenna. Several government regulates the level of energy that an antenna can release to the environment. This study attempts to assess the compliance of communication providers with regulations and the underlying health implications of the variation in radiations with respect to distance from different base stations. Furthermore, the work adopted mathematical methods to analyze the radiation pattern around base stations from different communication networks. The study revealed the presence of high radiation level from all the base station in the studied area. Therefore, H-field tool is critical to radiation measurement from the RF base station because of its simplicity. The study concluded that agencies of government should put in place information and awareness-raising campaigns on the risks of potentially harmful long-term biological effects on the environment and on human health of radiation, especially targeting children, teenagers and young people of reproductive age.

KEYWORDS: Base stations, radiations, emission level, weighting effect

INTRODUCTION

Knowledge management is based on the process of capturing, sharing, and effectively using organizational knowledge [1]; it refers to a multi-disciplined approach to achieving organizational objectives by making the best use of knowledge. The Council of Europe within the last ten years have resolved that there is a need to reduce exposures to electromagnetic fields from cell phones with **"**continuous pulse waves**",** the kind emitted by GSM phones (e.g. AT&T & T-Mobile) but not by CDMA (Verizon, Sprint). CDMA cell phones do not pulse their signals. Studies have shown GSM phones to emit about 28 times more radiation on average compared to CDMA phones [2]. Moreover, the toxicology research suggests that GSM phones are more biologically reactive compared to CDMA phones. Moskowitz [2] recommends those wishing to reduce radiation from cell phones may want to switch to the CDMA carriers. This may be responsible for the early adoption of the CDMA in the United States while GSM began its popularity from Europe. The potential health effects of the very low frequency of electromagnetic fields surrounding power lines and electrical devices are the subject of ongoing research and a significant amount of public debate. According to the World Health Organization, electromagnetic fields of all frequencies represent one of the most common and fastest growing environmental influences, about which anxiety and speculation are spreading. All populations are now exposed to varying degrees of electromagnetic fields, the levels of which will continue to increase as technology advances. Nigeria is one of the country in the world with the fastest growth in telecommunication infrastructure and teledensity. Most of the providers of this service in Nigeria are m
ultinational corporations that are more often driven by competition and profit leading to the temptation to cut corners and with the ever willing corrupt regulation officials, it becomes necessary to try to ascertain the activities of these segment of the society. As regards standards or threshold values for emissions of electromagnetic fields of all types and frequencies tends to follow the one prescribed by international organizations. One of such is the ALARA or "as low as reasonably achievable" principle, covering both the so-called thermal effects and the athermic or biological

effects of electromagnetic emissions or radiation. Moreover, the precautionary principle should be applicable when scientific evaluation does not allow the risk to be determined with sufficient certainty, especially given the context of growing exposure of the population, including particularly vulnerable groups such as young people and children, which could lead to extremely high human and economic costs of inaction if early warnings are not available..
Global System for Mobile Communication (GSM) is a cellular network used by mobile phone. GSM networks operate in four different frequency ranges which are 900 MHz band, 1800 MHz band, 850 MHz band and 1900 MHz band. GSM 900 and GSM 1800 standard are the most commonly used standard. 850 MHz band and 1900 MHz band are introduced because the 900 MHz and 1800 MHz frequency bands were already allocated. GSM 1800 standard provide more bandwidth and less power requirements than GSM 900MHz. The transmission power in the mobile phone is limited to a maximum of 2 watts in GSM 850 and GSM 900 while maximum power of 1 watt in GSM 1800 and GSM 1900 [3]. The specification of GSM 900 and GSM 1800 are as shown in Table 1.

Table 1: Specifications of GSM 900 and 1800[3]

	GSM900	GSM 1800
Downlink Frequencies	935-960 MHz	1710-1785 MHz
Uplink Frequencies	890-915 MHz	1805-1880 MHz
Channel Spacing	200kHz	200kHz
Modulation	GMSK	GMSK
Typical Mobile Transmit Power	2W	1W
Maximum Base Station Transmit Power	320W	20W
Maximum Distance	35km	8km
Speech Encoding	LPC (13bits)	LPC (13bits)
Bit Rate	270kbps	270kbps

Mobile communication is currently the fastest growing communication system in the telecommunication industry. Due to the increased number of user using the mobile phone, the concern is now focusing on the electromagnetic wave produced by the mobile phone itself. Electromagnetic radiation can be classified into (i) ionizing and (ii) non-ionizing radiation. *Ionizing radiation* is the radiation with high energy which will remove tightly bound between electrons and atoms resulting in tissue damage while *non-ionizing radiation* is the radiation that has enough energy to vibrate the atoms and molecule but do not remove the electrons in the molecule. This radiation mainly occurred at low frequency range. Mobile phone is designed with low power transceiver in order to transmit voice and data to a few kilometers to where the base station is located. The mobile phone sends radio signals to the closest radio base station antennas which in turn are connected to a mobile switch [4]
The power transmitted from a mobile is dependent on the received coverage level from the base station. Signal strength from the base station varied depending on the distance of the mobile to the base station. The nearer a mobile phone to the base station, the higher the signal strength and vice versa. Mobile phones and base stations are designed to transmit the lowest amount of power as required to sustain a call in order to minimize the possibility of interference to the system. This value is dependent on the Effective Isotropic Radiated Power (EIRP) of the antenna. This value is used to calculate the coverage area of particular base station site and expressed in watts or dBm (EIRP=Pt-L+G), where Pt-radiated power, L- cable losses and G-gain. Many portable phone terminals are designed with monopole antennas. This type of antenna has approximately half a wavelength in length in order to increase the antenna gain with the actual length is 3/8ʎ or 5/8ʎ. This is due to the impedance matching considerations at the antenna feed point. A monopole antenna is a type of radio antenna formed by replacing one half of a dipole antenna with a ground plane at right-angles to the remaining half [5].

Radio frequency used by mobile phone in communication has the ability to penetrate through semi-solid substances like meat, and living tissue to a distance proportional to its power density [6]. It also can cause dielectric heating effect or thermal effect [3]. Thermal effects are the temperature rise in the body cause by energy absorption from oscillating electric fields or electromagnetic radiation. Thermal radiation also induced when mobile phone is used to make a call or receive a call for a long period of time. Thermal radiation is generated when heat from the movement of charged particles within atoms of the mobile phone's case is converted to electromagnetic radiation and related to the Specific

Absorption Rate (SAR). SAR is defined as the rate of RF power absorbed per unit mass by any part of the body. SAR values are dependent on the separation distance of the body and the mobile phones. The nearer the distances of the radiation source to human, the higher the SAR values [7]. Safety factors are incorporated to arrive at specific levels of exposure hence providing sufficient protection for various segments of population, studies on the RF exposure to human body by both numerical simulation and experimental measurements [8] has shown.
A general idea is that at the minimum, important cell phone safety advice be given very serious consideration. It is of immense value that easy steps should all be taking at every opportunity to reduce our overall exposure to this radiation, hence this study. Until we get better preventive measures adopted, switching to a CDMA phone may be a simple way for some people to reduce their cell phone radiation exposure and risk. This however will only be applicable to countries where both technologies are available and where the technological know-how is not a challenge. This distinction could explain why some people are sensitive to cell phone radiation and others are not, and why activism is far stronger in Europe, where GSM is the standard, unlike the United States where there is also the CDMA option. More research has been recommended to confirm if pulsed radiation is much more harmful since the true intensity is not provided as it is "averaged" during a period of time (30 minutes for public exposure in US). The average of the pulse (maximum reading) and the minimum reading may give a false low reading. Many engineering measurements record averages (RMS) but living organisms react to extremes so these average readings may under estimate the potential for harm if the radiation is pulsed.

GSM HAZARD EVALUATION

This study involves the measurements of electromagnetic field strength from the BTS for MTN, GLO and AIRTEL networks (the three leading GSM services provider in Nigeria) within a given Nigerian environment using appropriate field strength meter. Area survey was done to know the number and location of all the GSM BTS's, after which pre-measurement using a TEMS (Test Mobile Systems) pocket was done to be able to differentiate between the sites feeding a particular location where measurements are to be taken, since nearly all the networks are collocating. Results of measurements was compared to ITU-R electromagnetic health standards to be able to know if the research area is safe or not.

2.1 Electromagnetic Field and Anatomy Effect

Exposure to low frequency electric and magnetic fields normally result in negligible energy absorption and no measurable temperature rise in the body. However, exposure to EMF (electromagnetic field) at higher frequencies can lead to significant absorption of energy and an increase in temperature (Table 2). Safety standard was introduced indicating an acceptable degree of exposure of a human body to the electromagnetic waves with the standard level of irradiation of the surface of the human body is $1mW/cm^2$.
Human body is made up of approximately 65-70% water, electrolytes and ions. Human body has its own weak electromagnetic field and each of the cells has its own EMF too. Therefore, weak EMF such as RF radiation emitted from mobile phone will interact with human body and affect the human body's own weak EMF. As the human body's own weak EMF were interfered, the body's natural healing processes is interfered with causing the displacement of electrolytes and ions thus weakening the defense mechanism of the body and reducing expenditure of energy to redress this imbalance.

Table 2: Effects of Human exposure to RF Electromagnetic fields (IEEE Standard C95.1-1999)

Frequency range	Bio mechanism	Dosemetric quantity
VLF/LF (3-100kHz)	Neuromuscular simulation	Current density in excitable tissues
Intermediate RF (100kHz-3GHz)	Tissue Heating	Specific Absorption Rate in W/Kg
Microwave and MM (3-30GHz)	Surface Heating	Power density in W/m2

2.1.2 Thermal and Non-thermal Effects

Thermal effect is a direct result of heating resulting from a measurable temperature increase, which is beyond the body's normal thermoregulatory process. The heating effect occurs in the exposed biological material such as tissue and cells. When using a mobile phone, most of the heating effect will occur at the surface of the head then causing the skin temperature to increase by a fraction of a degree. When the tissue temperature is increasing, the brain's blood circulation easily disposes of excess heat by instantaneously increasing local blood flow. However, the cornea of the

eye does not have this temperature regulation mechanism. Tissues at some parts of the human head are more sensitive to damage due to increases in temperature. Nerve fiber is one part of human head, which is sensitive to temperature increase because of poor vasculature structure. Non-thermal effects resulted from a direct interaction between the RF radiation and the organism and can be carried away by thermoregulatory process. This effect could be reinterpreted as a normal cellular response to an increase in temperature [9].

Many studies have investigated the biological effects of pulsed high frequency electromagnetic field (EMF) emitted by mobile phones with human and animal experiments. In the experiments with human being, researchers recorded the subjects' physiological parameters such as electroencephalograph (EEG), blood pressure, heart rate, breath rate and regional cerebral blood flow [10]. They also tested the hypothesis that long-term mobile phone use increases the risk of brain tumor.

In animal experiments, rats were usually expose to EMF with higher intensity for a longer time compared with human being to simulate the long-term exposure and then behaviour and physiological tests were done to indicate the chronic effects of EMF from mobile phones. Neuronal damage in rat brain cells was reported in [11] after in vivo exposure to 900MHz radio frequency (RF) fields for 15 minutes. They also observed decrease of the amount of N-methyl-d-aspartate (NMDA) receptors at the postsynaptic membrane. Study [12], reported that following 2 hours in vivo exposure to 900 MHz RF fields for 30 days, the collagen fibril architecture was disturbed only in males while the fibril diameter was decreased in both males and females while [13] found no evidence that the exposure of male and female B6C3F1 mice to both 900MHz and high 1800 MHz GSM RF radiation at a whole-body SAR of 4 W/kg induce any carcinogenic effect. Most studies on animal carcinogenicity found no evidence of carcinogenic effects from RF field exposures.

3. Knowledge Creation and Data Acquisition

RF EMF Strength meter (model 480836) shown in Fig. 1 was used for the measurement of mobile phone base station antenna radiation power density. This meter is a broadband device for monitoring high-frequency radiation in the specific range of 900MHz, 1800MHz and 2.7GHz. Other measurements can be made for reference purposes only using the entire range of 50MHz to 3.5GHz. The non-directional electric field and high sensitivity also allow measurements of electric field strength in TEM cells and absorber rooms. At high frequencies, the power density is of particular significance. It provides a measure of the power absorbed by a person exposed to the field. This power level must be kept as low as possible at high frequencies. The meter can be set to display the instantaneous value, the maximum value measured or the average value.

Figure 1: RF EMF Strength Meter (model 480836)

The meter is a small portable instrument that measures the electric field in the atmosphere of the sensor's surroundings. The measurement of the field is done by moving the aerial of the sensor in the desired measured environment. The 3-channel sensor is located at the top of the meter. The three voltages generated by the sensor are fed back to the meter. In far-fields, an E-field sensor is preferable due to the greater bandwidth. The E-field sensor frequency ranges from 50MHz to 3.5GHz (calibration accuracy only supports measurements in the 900MHz, 1800MHz and 2.7GHz ranges, other measurements made in the 50MHz to 3.5GHz range are for references purposes only). The human body shields electromagnetic fields. The E-field sensor is isotropic; it does not require special handling. It measures the field

according to three axes without the aerial having to be moved in the three planes. It will only be pointed at the target to make measurement.

RESULTS AND DISCUSSION

The results obtained from the measurement are shown in Table 3. It can be revealed that E-field components part of radiation show steady decrease from (294.8 mV/m to 178.5 mV/m) for distances 1 m, 10 m through 20 m from the base station. Similar trends were obtained for H-Field and power density components with variations of 781.9 μA/m to 547.8 μA/m and 230.5 μW/m2 to 107.5 μW/m2 respectively. The outcomes of the weighting analysis indicate a highest sensitivity with change in distance from 1 m to 10 m from the RF station for the three parameters (E-field, H-field and power density). Power density remained the most sensitive having highest reduction weighting ratio from 1 to 0.49, at a distance of 1 to 10 m apart and the least sensitive beyond 10 m. E-field and H-field parameters were steadily decreasing with increasing in distance apart from the RF base station that varying degrees. However, H-field component of radiation remained consolidated at highest weighting value than other parameters (Fig. 2). Therefore, H-field tool is critical to radiation measurement from the RF base station because its reduction in weighting value will bring less weighting effect of radiation over other stated parameters.

Table 3: Radiation levels at different distances to RF base station

S/n	Distance to Base Station (m)	E-Field (mV/m)	E-Field Weighting	H-Field (μA/m)	H-Field weighting	Power Density (μW/m2)	Power Density weighting
1	1	294.8	1	781.9	1	230.5	1
2	10	209.1	0.7	631.5	0.8	112.6	0.49
3	20	178.5	0.6	547.8	0.7	107.5	0.47

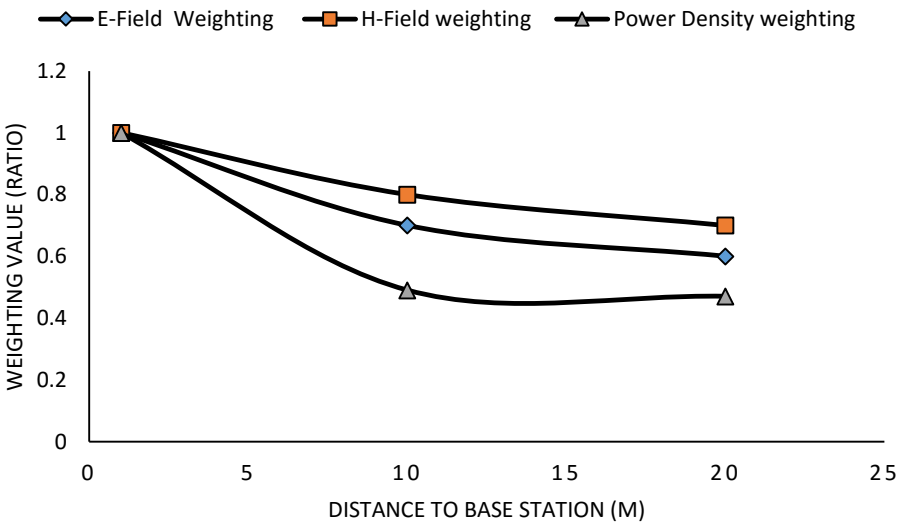

Figure 2: Radiation weighting value from the base station

CONCLUSION

Going by field measurement of radiation levels at different distances to the RF base station, it is evident that the radiation is stronger closer to the base-station while the RF radiation fades as you move away from the base station. This implies that people living close to the base-station are more at risk of radiation hazard than people that are far away from the radiating antenna.

Therefore, H-field tool is critical to radiation measurement from the RF base station because its reduction in weighting value will bring less weighting effect of radiation over other stated parameters. Regulatory agencies of government should enforce the communication mast building regulation as it relates to residential community to forestall any health implication to the citizenry. Regulatory agencies should take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones and BTS, and particularly the exposure to children and young people who seem to be most at risk from head tumours. It will be beneficial to reconsider the scientific basis for the present electromagnetic fields exposure standards set by the International Commission on Non-Ionizing Radiation Protection, which have serious limitations and apply "as low as reasonably achievable" (ALARA) principles, covering both thermal effects and the athermic or biological effects of electromagnetic emissions or radiation based on the current studies going on and the fact that most effect of radiation is over the long time. The classification of BTS radiation as carcinogenic by WHO/IARC is of significant concern and cannot be ignored lightly. It is therefore recommended that agencies of government should put in place information and awareness-raising campaigns on the risks of potentially harmful long-term biological effects on the environment and on human health of radiation, especially targeting children, teenagers and young people of reproductive age;

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