IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 6 Issue 8, August 2019
ISSN (Online) 2348 – 7968
www.ijiset.com

# Assessment of Human Exposure to Non-Ionizing Radiation Emitted from Mobile Base Stations in Gusau, Zamfara State

**Maduka N. C.[1], Abdulmuminu I .[2], and Ahmad M. U. [3]**

[1,2,3]Department of Physics, Federal University Gusau, P.M.B 1001, Zamfara State, Nigeria.

Corresponding Authors' Email & Phone no.: nosytron@yahoo.co.uk, Tel.: +2348037434986

## Abstract

Base transceiver stations (BTS) or 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 densities from various telecommunication masts of different network providers were measured using a spectrum analyser. RF radiations within a radial distance of 100m around some selected areas in Gusau Local Government Area were measured. The values highest mean power densities recorded for MTN, Airtel and 9mobile were 45.60nW/$m^2$, 22.08nW/$m^2$ and 34.56nW/$m^2$, while the least values were 11.59nW/$m^2$, 18.62nW/$m^2$ and 33.42nW/$m^2$ respectively. Although values fluctuated due to the influence of other factors including wave interference from other electromagnetic sources around reference base stations. The results show that the measured mean power densities from individual mobile transceiver stations (MTN, Airtel and 9mobile) have been compared with a standard limit set by International Commission on Non-Ionizing Radiation Protection (ICNIRP). The measured radiation exposure level is below the standard limit of 4.5 W/$m^2$ for 900 MHz system. This shows that the exposure levels in these areas are low and as such will not pose significant health risks to the people living in the study area.

**Keywords**: Base Transceiver Station, Non-Ionizing, Radio frequency, Power density, Spectrum Analyser, GSM Network.

## 1. INTRODUCTION

Mobile phone technology has revolutionized the telecommunication industry in Nigeria. Due to its merits, mobile phone technology has grown rapidly in the last decade. Presently, there exist more than 6.9 billion mobile subscriptions globally and over 1.4 million mobile Base Transceiver Stations (BTS) exist worldwide to meet the growing communication demand and the number is increasing significantly [1]. The Global System of Mobile (GSM) communication has proved to be of monumental benefit to the society especially in a developing country like Nigeria, where other forms of communication exist to a very limited extent. For phones to work effectively there are communication antennas that transmit frequency that aid the connection of phone users. These communication antennas are usually housed in a center called the base station. Mobile base stations are radio transmitters with antennae mounted on either free standing masts or on buildings. Its operates on the principle that radio signals are fed through cables to the antennas and then launched as radio waves into the area known as a cell around the base station. GSM technology of wireless communication produces constant pulsed microwave radiation. The cellular base stations are transmitting ceaselessly even when nobody is using the phone. The number of cell towers is massively increasing without taking into consideration its demerits. The risk associated with the radiation emitted from base transceiver stations with respect to its proximity to residential and other public areas were of great concern worldwide. The radiation effects on humans are divided into thermal and non-thermal effects. Non thermal effects are not well defined but it has been reported that it is about 3 to 4 times greater than thermal effects. Radiation emitted from telecommunication mast is also harmful to the environment by adding to the background radiation and also have negative effect on plants and animals [2].

### 1.1 AIM AND OBJECTIVES

This research is aimed at assessing the human exposure to non-ionizing radiation emitted from mobile base stations in the study area. The objectives of this research include:

- To measure and evaluate the radiation emitted from mobile base stations in Gusau
- To assess the human exposure to the measured radiation.
- To determine the exclusion zones or safe regions around the mobile base stations.

## 1.2 JUSTIFICATION OF RESEARCH

The harmful effects of radiation cannot be ignored; radiation of all kinds after a long period of exposure can cause various health problems in humans, ranging from cancer to mutation. We cannot prevent radiation but we can avoid and limit human exposure as much as possible and minimise its effects to the least minimum.

In Nigeria and precisely Gusau LGA of Zamfara state, the macrocellular base stations are currently being used, and due to an ever increasing number of mobile phone users, the numbers of such base stations are increasing proportionately. The human populace who live around these mobile base stations are evidently not aware of the harmful effects of the radiation emitted from them and tend to live in negligence and ignorance, despite the recommendations by the Nigerian Communications Commission (NCC) that people should not build or live within 100meters of these communication towers. In this study, the BK spectrum analyzer was used to measure and evaluate the amount of radiation emitted by the mobile base stations.

The study involves the measurement and analysis of human exposure to radiofrequency radiation within the area of study. Readings were taken with the BK spectrum analyzer.

## 2. REVIEWED LITERATURES

The range of frequencies that comes in the band of 3kHz to 300GHz are known as radio frequencies. These frequencies are used in various applications such as radio broadcasting, television broadcasting and cellular mobile communication. These applications require radio waves. A radio wave propagated by an antenna in free space is called as EM wave**.** These waves have different energy levels transmitted from a source and generally known as EM radiation. The various examples of EM radiation waves are from radio and television broadcast transmitters, microwave transmitters and mobile base station towers.

From cellular base universally accepted system to get solutions for connectivity in point-to-point and point-to-multipoint applications is Cellular communication system. The examples of wireless communications are AM and FM radio, television broadcasting, cellular phones, radar and microwave systems etc. The EM frequency spectrum consists of two main categories ionizing and non-ionizing radiation.

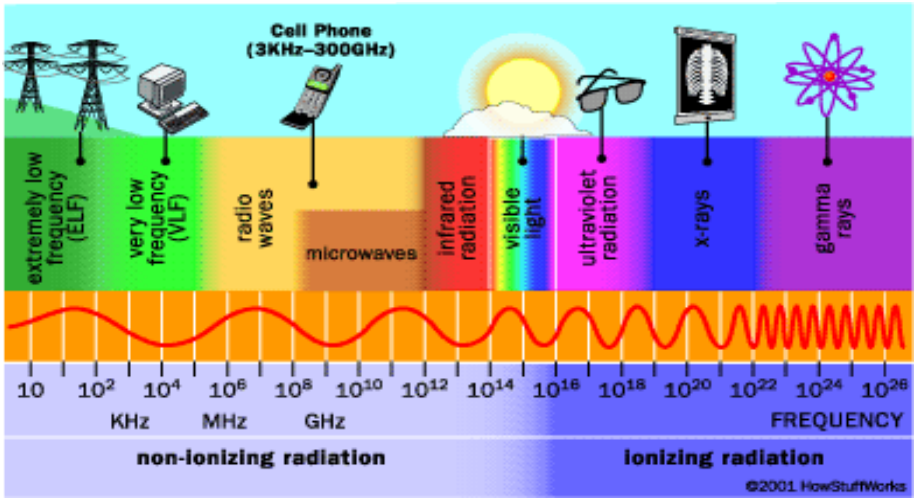


Figure 2.1 Electromagnetic spectrum (open source image)

.

The figure 2.1 shows a graphical representation of the spectrum of EM energy or radiation. Each frequency range has its corresponding application area. The radiation from cellular base stations comes under non-ionizing radiation and frequencies used are 900, 1800, 1900 and 2100MHz. Ionizing radiation affects the human organs in greater extent. The cellular base stations which radiates the Non-ionizing radiation does not change the atomic structure of creatures, but still affects the human cells in extent that may create negative human health effects. The EM radiation station is of Non-ionizing radiation.

The effect of mobile base station radiation herein referred to as Base Transceiver Stations (BTS) or mobile base stations has become a subject of interest and study in recent times, as a result of the increase in the use of mobile phones around the globe. The Mobile Phone (MP), one of the fastest growing technological developments, has become popular and of great important in modern life. The widespread use of mobile phone in recent years has raised the research activities in many countries to determine the effect of the emitted electromagnetic radiation from it. Mobile phones use electromagnetic radiation in the microwave range. In 2013 Koprivica [3] opined that as a result of dense installations of public mobile base station, additional electromagnetic radiation occurs in the living environment. Also in 2007 Kovach [4] complained that exposure to electromagnetic radiation (EMR) is increasing and becoming a serious health threat. Studies have linked exposure to EMR to development of brain tumors, genetic damage, and other exposure-related conditions. The mobile phone emitting 900MHz electromagnetic radiation, this emitting radiation may be absorbed by various body organs according to the places where they are

carried [5-6]. There is accumulating evidence that exposure to the radio frequency radiation from mobile telephones or their base station could affect people's health [7]. Herein if there is any impact on health from mobile telephones, it will affect almost everyone in the world [8]. The use of cellular phones in recent years has raised many questions about their safety, because the operator is exposed to electromagnetic (radio frequency) radiation (EMR) in the ultra-high frequency range (i.e., 300-3000 MHz), the effect of which on the body depends on its frequency and power. There has been increasing interest in the biological effects and possible health outcomes of weak, high-frequency electric and magnetic fields [9].

To evaluate the possible impact of exposure to electromagnetic radiation from mobile communications, studies have been carried out in the area of exposure field measurement and possible consequences of human exposure to such fields [10-14]. In spite of the effort of scientific community, little is known about general public exposure from mobile communication systems and contribution of different types of services [12-13] [15]. Different counties have taken the review of electromagnetic field exposure from base stations and concluded that in some cases electromagnetic field exposure is high and in some it is well below standard reference level [16-18].

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 [19].

## 3. MATERIALS and METHODS

Below are the materials that were used for data collection in this research work, based on suitability and relevance to the topic.

- BK PRECISION 2658A spectrum analyzer
- Measuring tape

To carry out this research work, three Base station transmitters were selected within Gusau L.G.A, MTN network, Airtel network and 9mobile network Base stations respectively, the spectrum analyzer was used to take readings at measured distances from the transmitting

tower, the distances were in increments of 20metres, so measurements were taken at 20, 40, 60, 80 and 100meters respectively from the tower.

Table 3.1 contains various basic information on the selected three Base stations of Network providers.

**Table 3.1:** Shows information for the three selected Base stations.

| BASE STATIONS | MTN | Airtel | 9mobile |
|---|---|---|---|
| Antenna type | Sectorial | Sectorial | Sectorial |
| Antenna height | 20-70meters | 20-65meters | 20-65meters |
| Address | Tudun Wada (kurma secondary school) | Hayin malam sani, Nasarawa Area. | Tudun Wada, Gamzaki Road. |
| Power transmitted | 1-30dBm | 1-30dBm | 1-30dBm |
| Antenna gain | 29-45dBm | 29-45dBm | 29-45dBm |
| Frequency | 1845MHz | 1815MHz | 1830MHz |
| Technology | 2G and 3G | 2G and 3G | 2G and 3G |

### 3.1 Geography of study area

The geographical coordinates of Gusau are 12° 10’ 12.86’’ North (latitude) and 6° 39’ 50.83’’ East (longitude). The characteristic and basic features of Gusau are buildings and a sprinkling of sparse trees.

### 3.2 Data collection

The mobile base stations were selected according to their proximity to buildings, number of antennas mounted on their towers, and the population density around them, in order to get a good result. Most of the base stations have at least 3 sectoral antennas and each antenna covers $120^0$ radius.

Measurements were taken in a convenient direction around the base station at every 20m interval for 100m radius from each of the transmitting towers. The Measurements were taken using BK Precision spectrum analyzer (Model 2658A) capable of measuring received radiated power in decibel relative milli-watts (dBm). Each of the measurements was made by holding the spectrum analyzer away from the body and at about 1.5m above the ground level with the meter pointing towards any sector of the antenna. The measured power densities fluctuated and thus, measured values were recorded only about 5 minutes after the meter value was stable. The front view of BK Precision spectrum analyzer is as shown in Figure 3.1.

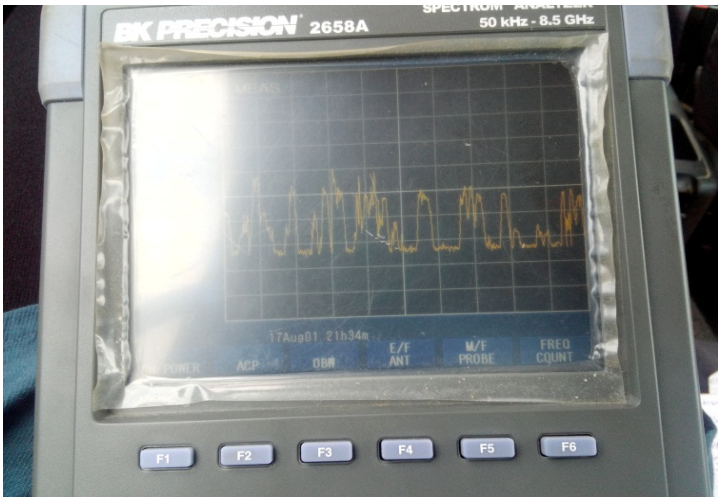


**Figure 3.1** Screen of BK Precision spectrum analyzer.

However, the received signal powers detected by the measuring instrument at various distances are the received radiated powers with respect to distances from the transmitting tower.

Power density $P_d$ at a distance R is calculated using equation 3.1 [2]

$$P_d = \frac{P_t \times G_t}{4\pi R^2} \quad (\text{Watt}/\text{m}^2) \qquad (3.1)$$

Where $p_t$ = transmitted power or received signal strength in Watts.

$G_t$ = gain of transmitting antenna

R = distance from the antenna in meters.

Power received $P_r$ (watts) by an antenna at a distance R is calculated using equations 3.2 and 3.3

$$P_r = \frac{P_t \times G_t \times Area}{4\pi R^2} \quad (3.2)$$

OR

$$P_r = P_d \times Area \quad (3.3)$$

The measured radiated power is in decibel relative milli-watts (dBm) whereas international standards are in terms of power density ($Wm^{-2}$). Therefore, Power in decibel relative milli-watts (dBm) is converted to watts using equation 3.4

$$P\ (watt) = \frac{P\ (dBm)}{1000} \quad watt \quad (3.4)$$

Where P (dBm) = power in decibel relative milli-watts.

The data collected were used to calculate power density from the selected mobile Base stations using equation 3.1 which was used to check the level of exposure faced by those living in the areas.

## 4. RESULTS and DISCUSSION

Absolute power density of the radiofrequency radiation from selected mobile base stations was measured with the aid of BK spectrum analyzer at different selected areas with their proximity to the residential buildings.

**Table 4.1:** Power density at different distances

| | **Power density ($nWm^{-2}$)** | | | | |
|---|---|---|---|---|---|
| **Base stations** | **20m** | **40m** | **60m** | **80m** | **100m** |
| **MTN** | 45.60 | 44.77 | 44.26 | 12.33 | 11.59 |
| **Airtel** | 22.08 | 21.23 | 20.28 | 20.08 | 18.62 |
| **9mobile** | 34.56 | 34.44 | 34.36 | 34.20 | 33.42 |

The measured values of mean power densities at different base stations are given in Table 4.1. It is observed that the maximum power density is 45.60 $nWm^{-2}$ obtained at 20m from the MTN BS while the minimum power density is 11.59 $nWm^{-2}$ at 100m also from MTN BS. It is also observed that the closer to BS the higher the power density. The various variations of the power densities of the test BSs at measured distances is as illustrated in Figure 4.1.

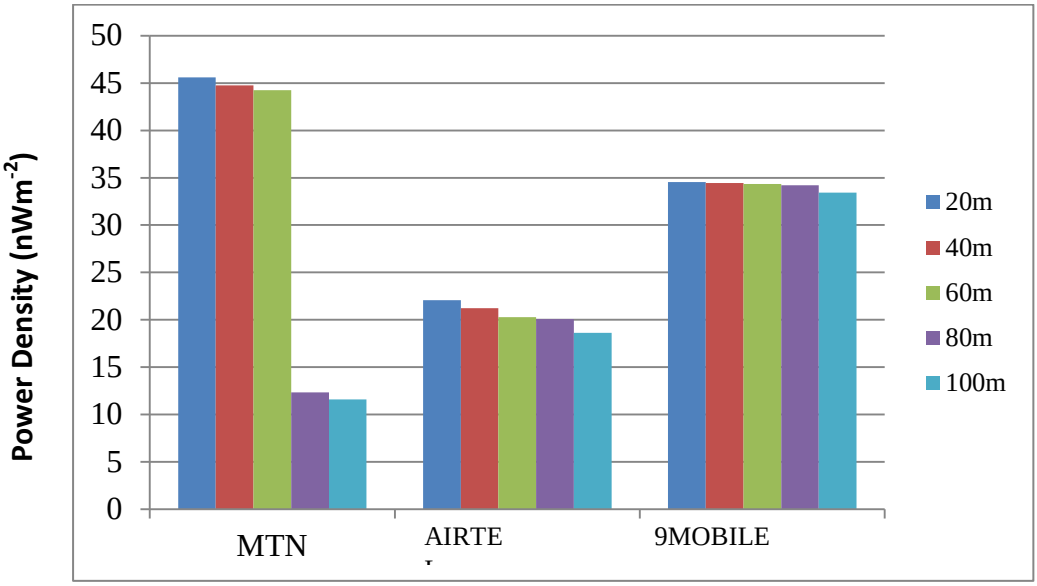


**Fig. 4. 1:** Power densities at different distances for tested base stations

The results obtained from the graph of figure 4.1 showed that the maximum level of RF which an individual can be exposed to is 45.60$nWm^{-2}$, this value was obtained at a distance of 20m from the MTN base station. The maximum power density obtained is below the International Commission for Non Ionizing Radiation Protection (ICNIRP) maximum permissible limit of 4.7 $Wm^{-2}$ for 890-915 MHz (GSM900). This value can be due to the presence of other high powered mobile Base Transceiver Stations (BTS) clustered around the location. The presence of trees and buildings reduced the RF radiation this is because trees and building walls obstruct a portion of the external wireless radiation.

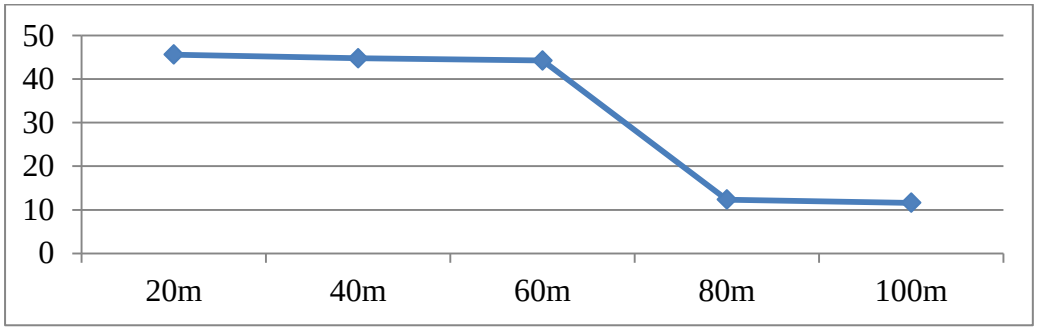


**Fig. 4.2** Power density against distance (MTN Base station)

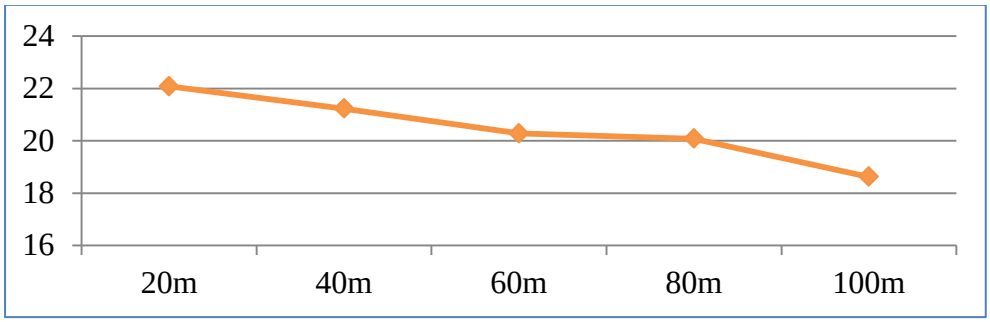


**Fig. 4.3** Power density against distance (Airtel Base station)

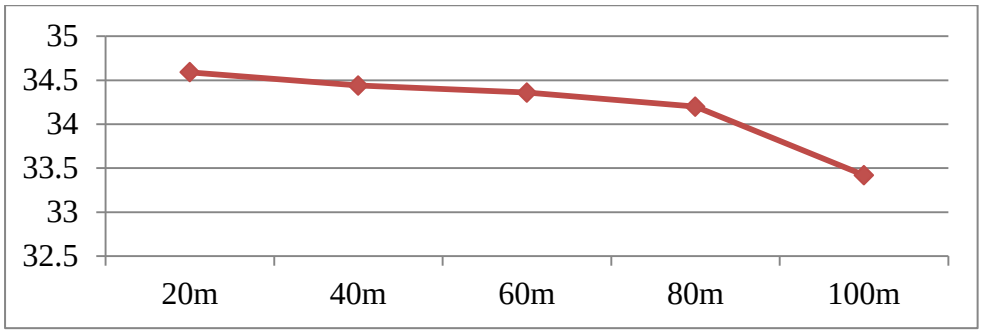


**Fig. 4.4** Power density against distance (9mobile Base station)

Figure 4.2 to 4.4 show the power density of each of the mobile Base stations: MTN, Airtel and 9mobile at an interval of 20m from the foot of each Base station up to 100m away. The power density decreases 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 is because of reflection, scatter and refraction from the ground, windows, and attenuation by trees and buildings

It is observed also from figure 4.2 to 4.4 that MTN Base station has more variations in power density as the distance increases away from the base of the station, compared to Airtel and 9Mobile Base stations, with 9Mobile having least variations. This may be as a result that 9Mobile has higher radiating power than the other two network providers. These deviations may be as result of an integration of wave interference from other sources of EMR around reference mobile transceiver stations such as TV, Radio antennas and receivers.

## 5. CONCLUSION

This study was carried out with the sole aim to assess the RF radiation exposure from mobile transceiver stations. From the findings it has been observed that the measured values of power densities across all the sites are well below the RF radiation exposure safety limit set by ICNIRP for the general public and occupational exposure when compared with the findings in this study. Thus, RF radiation exposure from these mobile base stations (MTN, Airtel and 9mobile) may pose no health risk to the people living within the areas researched on. However, mobile network providers should site mobile transceiver stations at least 25m distance away from residential building areas. The distance from the BTs is a major factor that determines the level of radiation absorbed by the human body. The closer the distance of human body to the BTs, the higher the rate of radiation absorbed by the body and the higher the risk of occurrence of illness.

## REFERENCE

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

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

[3] Koprivica, M., et al., (2013). Statistical analysis of electromagnetic radiation measurements in the vicinity of GSM/UMTS base station antenna masts. Radiation protection dosimetry. 158.10.1093/rpd/nct230.

[4] Kovach S. (2007). The Hidden Dangers of Cell Phones Radiation, Life Extension Magazine.
[Online] http://www.lef.org/magazine/mag2007/aug2007_report_cellphone_radiation_01.htm

[5] Ozguner, F., et al., (2005). A Novel Antioxidant Agent Caffeic Acid Phenethyl Ester Prevents Long-term Mobile Phone Exposure-induced Renal Impairment in rat. Prognostic Value of Malondialdehyde, N-acetyl-beta-D-glucosaminidase and Nitric oxide Determination. Mol. Cell. Biochem., 277: 73-80.

[6] Oktem, F., at al (2005). Oxidative Damage in the Kidney Induced by 900MHz-Emitted Mobile phone: Protection by melatonin. Arch. Med. Res., 36: 350-355.

[7] Repacholi, M.H., (2001). Health Risks from the use of Mobile Phone. Toxicol. Lett., 120: 323-331.

[8] Cox, D.R., (2003). Communication of Risk: Health Hazards from Mobile Phones. J. R. Stat. Soc.: Ser. A Stat. Soc., 166: 241-246.

[9] Knave, B., (2001). Electromagnetic Fields and Health Outcomes. Ann. Acad. Med. Singapore, 30: 489-493.

[10] Cenelec (2002). “Basic Standard for Calculation And Measurement of Electromagnetic Field Strength And Sar Related to Human Exposure From Radio Base Stations and Fixed Terminal Stations for Wireless Telecommunications System” (110 Mhz – 40 Ghz), Cenelec Standard En 50383.

[11] Cenelec (2006). “Basic Standard for the Evaluation of Human Exposure to Electromagnetic Fields From Stand Alone Broadcast Transmitter” (30 Mhz–40 Ghz), Cenelec Standard En50420.

[12] Cenelec (2008). “Basic Standard for In-Situ Measurement of Electromagnetic Field Strength Related to Human Exposure in the Vicinity of Base Stations”, Cenelec Standard, En50492.

[13] Cenelec (2004). “Basic Standard to Demonstrate the Compliance of Fixed Equipment for Radio Transmission (110 Mhz – 40 Ghz) Intended for use in Wireless Telecommunication Networks With the Basic Restrictions or the Reference Levels Related to General Public Exposure to Radio Frequency Electromagnetic Fields, When put Into Service, Cenelec Standard En50400.

[14] Kim, B. C., et al (2008). “Methods of Evaluating Human Exposure to Electromagnetic Fields Radiated From Operating Base Stations in Korea ” Bio- Electromagnetics, Vol. 29, No. 7, Pp. 579– 582, Oct.

[15] Larchˆ Eveque, E., et al (2005) “Analysis of Electric Field Averaging for In-Situ Radio Frequency Exposure Assessment,” Ieee Trans. Veh. Technol.,Vol. 54, No. 4, Pp. 1240–1250, Jul.

[16] Bornkessell, M., et al (2005) “Measurement and Calculation of General Public Electromagnetic Exposure Around GSM and UMTS Cellular Base Stations”

[17] Carla, O., (2007) “The Monit Project: Electromagnetic Radiation Exposure Assessment in Mobile Communications” Ieee Antennas and Propagation Magazine, Vol. 49, No. 1.

[18] Wackerly, D. D., (2008). Mathematical Statistics with Applications, 7th Ed. Duxbury, Ma: Thomson, Pp. 839–849.

[19] Bevelaqua, Peter, J., (2015). Types of Antennas and Antenna Theory [Online] http://www.antenna-theory.com/antennas/main.php