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Measurement And Analysis of Radiation Levels From Mobile Phone Base Station in Lilongwe Urban

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Abstract: The associated potential health threatening effects of Radiofrequency (RF) radiation are highly debatable among scholars and science experts with emphasis on those originating from mobile phone base stations (BTS). On one hand, the population of these BTSs has increased globally and Malawi in particular. City locations have generally larger number of users and also obstructions which in compensation, allows a lot more BTSs to cover demand with possible cell sizes of about 2-5km radius or less. EM and RF fields are classified as carcinogenic in nature with others being sleeping problems, fertility problems, chromosome alterations, dizziness as well as nausea as detrimental health problems associated with BTSs.

In order to evaluate the measured radiation levels from the BTS, the study employed a descriptive study design where a Spectran HF V4 spectrum analyser was used to measure RF radiation levels in Watts per square meter ($W.m^{-2}$) at every 25m interval from the fence of the BTS to a maximum distance of 150m. Quantitative data management used Microsoft excel and IBM® SPSS® statistics version 23.0 for organization and analysis to further answer the research question(s)

A total of 17 BTSs in Lilongwe were purposively selected and their RF radiation levels at different distances from the BTS fence was measured and analysed. The investigation registered a maximum radiation level of $0.00139W.m^{-2}$. All the recordings were found to be below the ICNIRP standard guidelines of $1 – 10W.m^{-2}$ and safe for the public.

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When compared to other epidemiological studies, similar radiation levels were reportedly linked with other public health concerns in the literature. It is important to consider roof top BTSs as well as street mounted towers in similar studies in the future and intensify on number of base station measurements. Civic educating the public on better safety aspects on such EM and RF radiation sources could be commendable while on one hand making the information available.

Keywords: Base stations, Ionizing Radiation (IR), Non-Ionizing Radiation (NIR) Radiofrequency (RF) radiation, Specific Absorption Rate (SAR), Power density, ICNIRP guidelines

1. Introduction

Over the decades, there has been an increased number of mobile phone BTSs and other radio communication facilities that have spawned a global concern because of its effect on the environment, both in urban and rural areas. The effects from them are as a result of their released energy which when exposed to, has attracted a state of diverse reception from the scientific community on its potential health problems, particularly on the public. As such, people living in close proximity to mobile phone Base Transceiver Stations (BTSs) are reported to be at risk of developing neuropsychiatric problems due to an extensive exposure to Radiofrequency (RF) radiation that comes from the usage of mobile communication (Azimzadeh, et al., 2018).

Base Transceiver Station (BTS) is a term often times used to denote a base station in Global System for Mobile (GSM) communication, allocated at cell site and provides the control and radio air interface for each cell. It is a radio transmitter/receiver that maintains the communication between the network and the wireless device users through a radio link by sending and receiving signals from mobile phones and other wireless devices that connects with the central hub (EMSS, 2009; CDPH, 2015).

Pattern and the directivity of the radiated energy from BTS, are always within a specific direction towards the horizon in a narrow beam like a spot light, a few degrees downwards with the main beam's energy being maximum and not directly transmitted down to the ground or behind the antennas (Blettner & Berg, 2000). The radiant energy then reduces drastically from the source outwards according to the Inverse Square Law in which the intensity of energy coming from a given point varies inversely with the square of the distance from that point as a source (Serway, 1992; IEEE, 2006; Voudoukis & Oikonomidis, 2017). It is hypothetical that the levels within 50m at the foot of the BTS are not appreciable enough to compromise public safety (Ayinmode & Farai, 2012).

Science experts do categorize radiation into two; Ionizing Radiation (IR) and Non-Ionizing Radiation (NIR). The IR's energy is capable of scraping off electrons from the atoms and molecules resulting into free radical production in the body and the environment (IARC, 2011). NIR has radiative energy that, instead of producing charged ions when passing through matter, it only have sufficient energy for excitation whose spectrum is divided into two main regions, optical radiations and electromagnetic fields (Kwan-Hoong, 2003). According to Kwan-Hoong, optical radiation is further sub-divided into ultraviolet, visible, and infra-red while the electromagnetic fields are further divided into radiofrequency for example; microwave, very high frequency and low frequency radio wave.

In terms of sources, NIR comes from a spectrum of sources which could be of natural or man-made origin. Natural sources include sunlight or lightning discharges while man-made sources include Wi-Fi in wireless networking technology, industrial applications like those in food processing and smart building that includes internet of things but also scientific and medical applications like those in Magnetic Resonance Imaging (MRI). Mobile phone BTSs radiation belongs to NIR together with microwave radiation that are found within the frequency range of 300MHz - 300GHz and 3kHz – 300MHz whose effects are thermal in nature based on its ability to induce cellular tissue or body temperature to be raised by 1^0C or more (IARC, 2011).

In May 2011, the International Agency for Research on Cancer (IARC) evaluated cancer risks from RF radiation based on human epidemiological studies. These gave evidence of increased risk for glioma and acoustic neuroma, that led into classifying RF radiation as Group 2B, a possible human carcinogen (IARC, 2011; Hardell, 2017). The guidelines by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) were also set based on the Specific Absorption Rate (SAR) which measures the rate at which energy is absorbed by the human body when exposed to RF electromagnetic field (Blettner & Berg, 2000).

The value for having the national guidelines on RF and EM fields is quite enormous and need not to be over emphasized. Among others, it allows needful periodic reviews due to emerging public and technological concerns acceptable at all levels at national level (Nahuku, et al., 2018). Perhaps such reasons drove recommendations by the Communications Regulators Association of Southern Africa (CRASA) for Southern African Development Community (SADC) member states to establish their own national guidelines on RF and EM fields (CRASA, 2015). Perhaps as any standard, these guidelines can provide people and organizations with a basis for mutual understanding while on one hand, be used as tools to facilitate communication and measurement.

RF radiation concerns over its effects on the environment has grown and the levels of concern are now high within the general population especially for those living in close proximity to the base station (Ayinmode, et al., 2013; Berg-Beckhoff, et al., 2014) and yet the use of wireless digital technology has increased tremendously over the past decades (Hardell, 2017). Cancer, sleeping problems, fertility problems, chromosome alterations, dizziness as well as nausea among others have been reported as its associated potential health problems for the public (Eger, et al., 2004; Kumar, 2010; Đinđić, et al., 2011; Azimzadeh, et al., 2018). Most of these symptoms were reported especially when the radiation levels released into the environment for public exposure were found to be higher than the standard safety guidelines on EM-fields like those of the ICNIRP.

According to (Osahon, Ushie, & Ojo, 2017), potential health issues surrounding cell phone BTS antennas and other wireless communication facilities have brought a new school of thought, emphasizing the need to have an accessible and easy to understand information on EMR and RF radiation levels in the surrounding environment. Despite this and to our knowledge, only a few studies like Nahuku, et al., (2018) was able to make an analysis of radiation levels from mobile phone BTSs in selected urban areas of Blantyre. This perhaps makes it difficult to access and understand the information on EMR as well as RF that the public is being exposed to and whether the levels are within the international safety guidelines. This study was aimed at measuring and evaluating the RF radiation levels from selected BTSs in the urban city of Lilongwe specifically in order to quantify the levels but also compare them with the used ICNIRP standard safety guidelines on EM and RF fields.

2. Methodology

The study was descriptive and conducted in the city of Lilongwe. The city has undergone a high urbanization rate due to government capital and administrative city relocation from Zomba in 1975 as well as head office relocation from Blantyre in 2005 (UN-HABITAT, 2011). This has contributed to the recent high population growth, infrastructure development, Information Communication Technology (ICT) as well as telecommunication services in the city. The ICT and telecommunication sector through its infrastructure development, have contributed to high numbers of BTSs in its urban locations as the need to improved internet access and affordable ICT services by government is overemphasized (MoDPC, 2010; MACRA, 2014).

Actual measurement of values on the ground within the city's urban location was chosen in this study.

The method was easy and affordable as compared to the Computational Method. According to (Miclaus & Becket, 2007), selective frequency meters are better placed when taking measurements because of their calibrated antennas. They are good for in situ measurements and easier to use because of their inbuilt frequency range settings.

The BTSs were purposively selected and investigated for RF radiation levels specifically for GSM 900 and GSM 1800. Measurements were done using a hand held Aaronia AG spectran HF-6065 V4 spectrum analyzer as a simple hand held meter of 10MHz to 6GHz frequency band at every 25m interval distance from the fence, measured using a well-marked 30m cable. The values were recorded, analyzed and later evaluated. The BTS location coordinates were done using a Garmin GPS-Map 60Cx within an error of about +/-3m using the Universal Transverse Mercator (UTM) scale as described in Nahuku, et al., (2018).

The analyzer had well predefined settings for GSM 900, GSM 1800 as well as the Universal Mobile Telecommunication Systems (UMTS). Before taking measurements at a point of interest, the analyzer was set to either GSM 900 or GSM 1800 predefined settings with units selected to power density in Watts per square meter ($W.m^{-2}$).

The analyzer's antenna was moved slowly while pointing in the direction of the source of RF until maximum power was registered after 3 minutes while set at max-hold to record the maximum power density received and later recorded numerically. The measurements were also taken at approximately above 1.5m from the ground but also at arms' length in order to minimize RF radiation reflections from the body and the ground. At least two recordings were made at each point for GSM 900 and 1800 and later averaged.

3. Results

A total of 17 selected BTSs were used in the urban locations of Lilongwe during the study and measurements were done from base station site number 1 to base station number 17 (BTS 1-BTS 17). The results obtained for the RF radiation levels were plotted against distance for each selected base stations as shown in Figure 1 and Figure 2 while figure 3 and figure 4 presents the averaged levels at each distance.

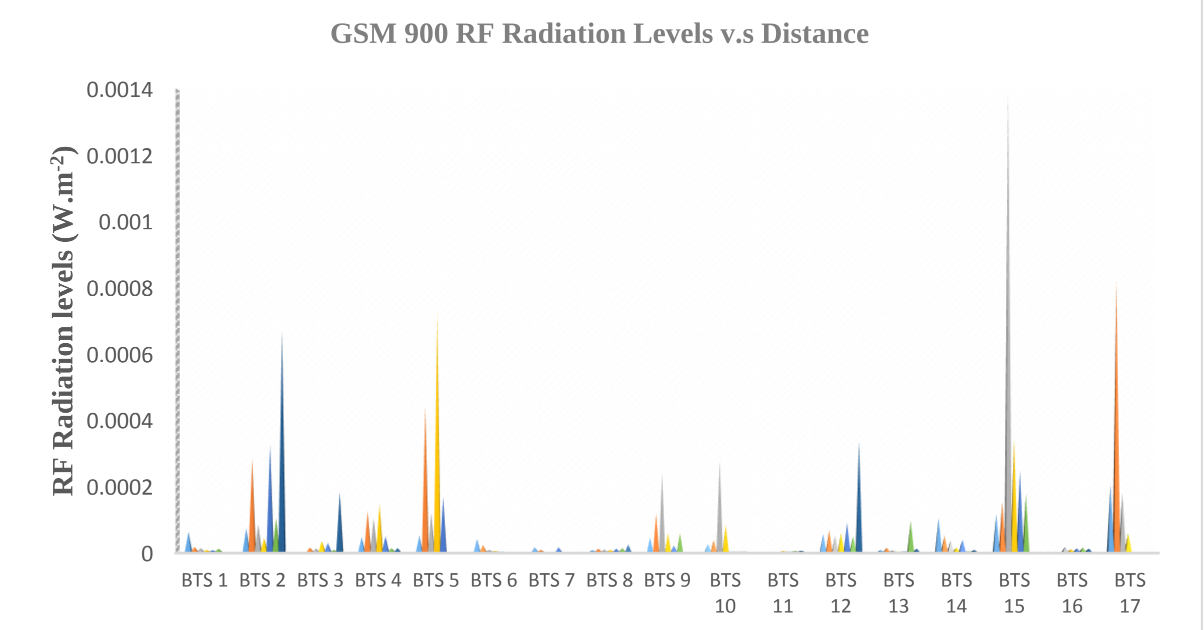

Figure 1: GSM 900 RF Radiation Levels as Power Densities ($W.m^{-2}$) Recorded at Different Distances from the Fence of the Base Station

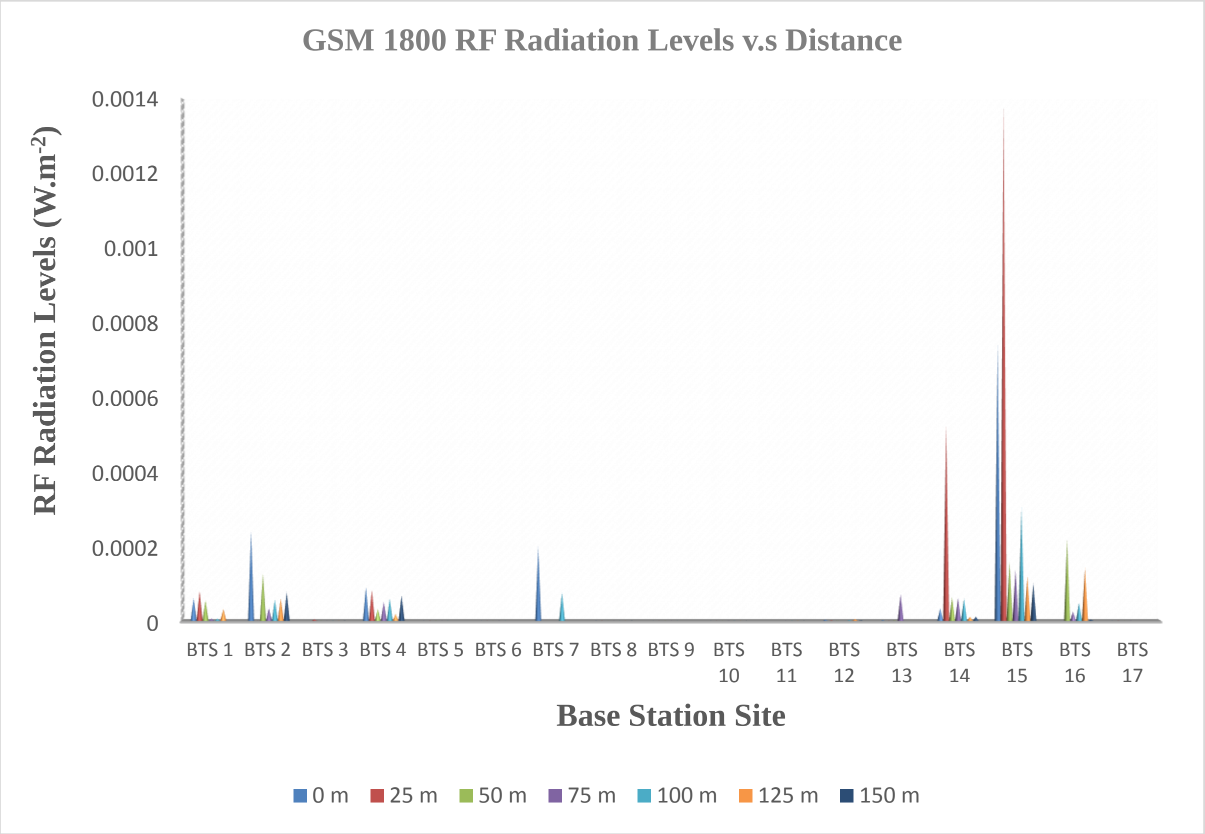

Figure 2: GSM 1800 RF Radiation Levels as Power Densities ($W.m^{-2}$) Recorded at Different Distances from the Fence of the Base Station

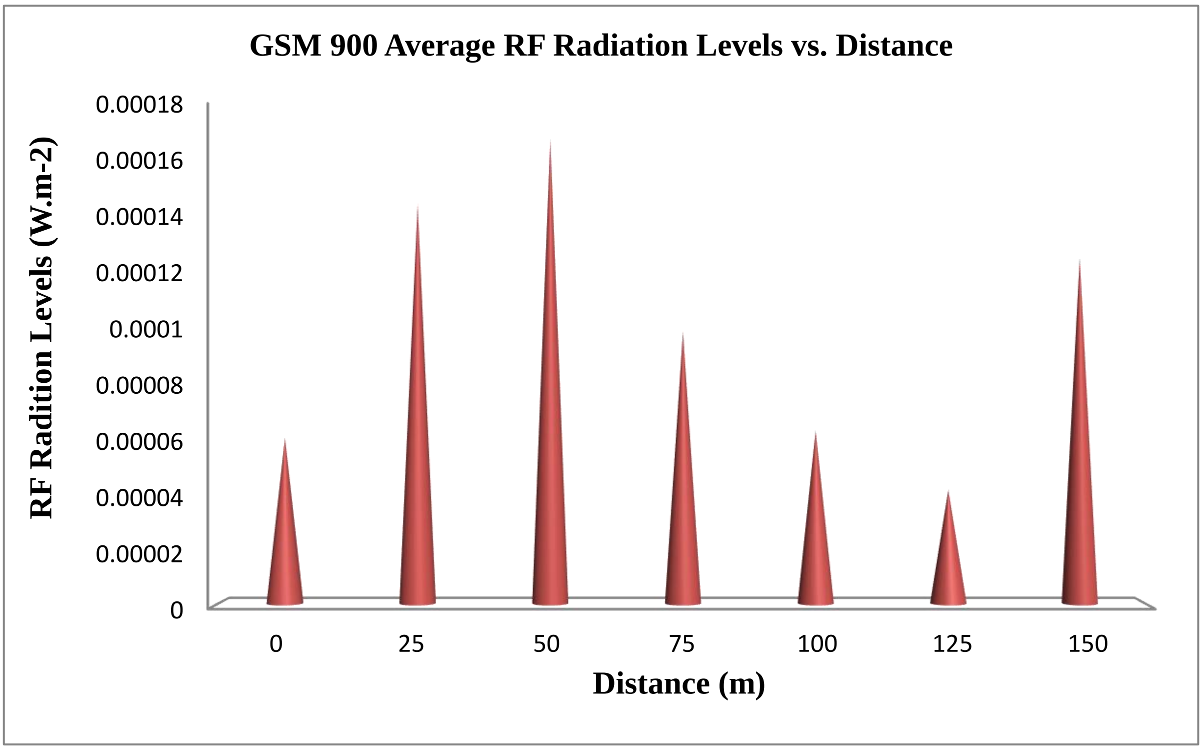

Figure 3: Graph of GSM 900 Average RF Radiation Levels ($W.m^{-2}$) (Mean STD Error of 1.81×10^{-5}) Plotted Against Distance (m) from the Fence of the Base Station

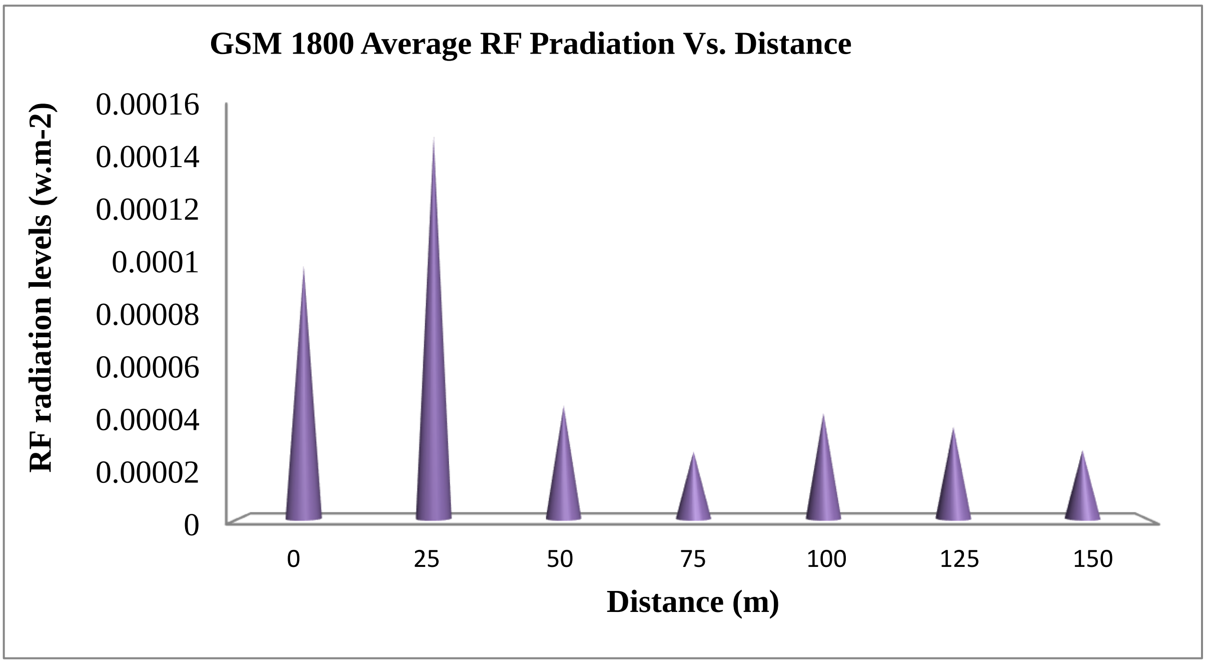

Figure 4: Graph of GSM 1800 Average RF Radiation Levels (W.m^{-2}) (Mean STD Error of 1.75 x 10^{-5}) Plotted against Distance (m) from the Fence of the Base Station

4. Discussion

Seventeen (17) base stations (BTS 1- BTS 17) were investigated for RF radiation levels for GSM 900 as well as GSM 1800 at different distances from the BTS fence. From the investigated BTSs, 0.00139 W.m^{-2} at 25 m (BTS 15) and 1.024 x 10^{-8} W.m^{-2} at 125m (BTS 10) were recorded as maximum and minimum received power densities for GSM 900. On one hand, GSM 1800 registered 0.00139 W.m^{-2} at 25m (BTS 15) and 5.97 x 10^{-9} W.m^{-2} at 100m (BTS 6) as its maximum and minimum received power densities respectively. On average, the selected urban locations registered a power density of 0.0001006 W.m^{-2} for GSM 900 and 6.10 x 10^{-5} W.m^{-2} for GSM 1800.

Highest power densities were recorded at BTS 15, especially at 75m and 50m for GSM 900 and GSM 1800 respectively. Reflections from the surrounding buildings, vegetation as well as number of nearby RF radiation sources within the site were potential causes of high recordings at BTS 15. Inconsistencies in recorded levels of radiation from BTSs with distance were observed. Ideally, low levels in power densities were expected with increasing pattern within 30m to 150m distance in densely populated areas but with a reducing pattern from 200m as reported by Bergqvist, et al., (2000) which unfortunately was observed not be the case in this study.

RF and EMF for the ICNIRP safety guidelines recommends maximum permissible power densities levels of 4 - 10 $W.m^{-2}$ which is 40 – 60$V.m^{-1}$ equivalent (Thuróczy, et al., 2010; ICNIRP, 2009). All recorded RF radiation levels from the BTS selected sites were found to be below the 1998 ICNIRP standard safety guidelines. The results were also consistent with other major studies in Africa like Ushie, et al., (2013) and Aminu, et al., (2014) in Ajaokkuta and environs as well as Kaduna state in Nigeria respectively, Thuróczy, et al., (2010) in Europe and Nahas, et al., (2011) in south of Saudi Arabia. This means that the levels were safe and of no detrimental health problems to the public.

Studies in Ayinmode et al., (2012, p. 333) and Kumar, (2010, p. 23) reported fatigue, irritability, sperm count problems, skin problems, dizziness, nausea, headache, tiredness, appetite loss, sleeping disturbances, cardiovascular issues and other hazards most of which are neuropsychiatric problems (Azimzadeh, et al., 2018). Importantly and with more controversies, in most of these reported symptoms, the RF radiation levels were found to be within and below the ICNIRP guidelines.

These RF radiation levels together with the previous published ones in Nahuku, et al., (2018) are within the ranges reported in (Ayinmode, et al., 2012) and (Kumar, 2010). Ruling out RF radiation exposure as a cause of similar reported health symptoms and problems in our local health facilities of the country comes out to be hard as this could suggest a strong connection. Monitoring of these exposure levels could be vital in order to avoid detrimental health effects on the public but also the environment.

5. Conclussion

Measurement of radiation levels from mobile phone base stations in our cities and smart buildings is not optional but rather of mandatory importance to safeguard public safety from its detrimental health effects. A hand held Aaronia AG spectran HF-6065 V4 meters was handy and easy to use at the same time efficient and effective in the project because of its better and wide frequency band.

Use of different methodology like the theoretical methods, highly sensitive simulative methods in order to further quantify the RF radiation levels from mobile phone base stations in the country in most BTSs, development of national standard guidelines on RF and EM-Fields that can act as a benchmark for meeting the international standard guidelines by government, the industry and others that takes into account technological and public concerns were highly recommended in our previous study. This is important in order to improve this country's radiation protection and its sustainability especially for mobile Phone BTSs and other EMF sources.

The need for vibrant initiatives to civic educate the public by government and private institutions is highly recommended for these non-ionizing radiation sources as there is a robust growth in the use of HIGH-TECH RF technology in the country. Emphasis on similar studies has to be revitalized to help create start off points in development of EM and RF field national standards but also monitoring of these exposures in order to avoid detrimental health effects on the public and the environment. Provision of people, organizations and the industry with a basis for mutual understanding that can be used as tools to facilitate communication and measurement could be helpful in removing careless but also erroneous activities around the BTSs by the public.

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