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Advances in Ecological and Environmental Research (ISSN 2517-9454, USA), 145-154 | Science Signpost Publishing

# Analysis of Radiation Levels from Mobile Phone Base Stations in Selected Urban Areas of Blantyre

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Received: March 26, 2018 / Accepted: April 28, 2018 / Published: August 25, 2018

**Abstract:** The numbers of Base Transceiver Stations (BTSs) have increased across the globe over the past decade and Malawi is not an exceptional, especially in the major cities. The associated potential health effects of the released Radiofrequency (RF) radiation is a topic of debate among scholars and science experts.

The study employed a descriptive design and used Spectran HF V4 spectrum analyser to measure radiofrequency radiation levels in $W.m^{-2}$ at every 25m interval from the fence of the BTS to a maximum radial distance of 150m. Microsoft excel and IBM® SPSS® statistics version 20 were used for a quantitative data management, organization and analysis to further answer the research question(s).

The study evaluated the existing RF radiation levels from 15 selected BTS in Blantyre through the analysis of RF radiation levels at different radial distances from the-base stations. The city registered a maximum power density of $0.00422W.m^{-2}$ and it was registered at BT 5. All values recorded were found to be below the ICNIRP standard guidelines of $1 – 10W.m^{-2}$ with far fields reaching the ground approximately at 30 m to 150 m.

Even though the radiation levels were below the ICNIRP guidelines but when compared to other epidemiological studies, similar radiation levels were reported to be associated with public health concerns in the literature. It is important to consider roof top BTSs in similar studies in the future.

**Key words:** Base stations, Radiofrequency (RF) radiation, Electromagnetic Radiation (EMR), Specific Absorption Rate (SAR), Power density, ICNIRP guidelines.

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# 1. Introduction

The use of cell phones was first introduced in Malawi in1995 when the first mobile phone operator was licensed in the country (MACRA, 2014). Since then, number of subscribers has been on the rapid increase in Malawi with a projected growth of 34% by the year 2015(MoDPC, 2010).Because of such projections and provisions by government through the Malawi Communications Regulatory Authority (MACRA) to improve internet access and Information Communication Technology (ICT) in the country, new High-Tech ICT equipment, ICT system upgrades and number of Base Transceiver Stations (BTS) or just base stations were observed to have exceptionally increased in the country especially in the urban cities.

The main function of BTSs is to connect wireless devices to a central hub allowing a connection to a network by holding antennas that send and receive signals from cell phones and other wireless devices. The devices use Radiofrequency (RF) or Electromagnetic Radiation (EMR) for communication (EMSS, 2009). Global Positioning System (GPS), radar, radio and television broadcasting, Wireless Fidelity (Wi-Fi) networks and other cordless phones are among others that use RF for communication (CDPH, 2015).

The RF radiation from the BTS is radiated direct towards the horizon in a narrow beam like a spot light in a specific direction, a few degrees downwards. It is within this main beam that the energy is maximum and not directly transmitted down to the ground or behind the antennas (Blettner & Berg, 2000). Within the narrow beam, the radiation decreases exponentially with an increased distance from the source according to the Inverse Square Law (IEEE, 2006) but it is idealized that the levels within 50m at the foot of the BTS are very small and cannot be a threat to the public (Blettner, et al, 2000; Ayinmonde et al, 2012).

The associated health effects of RF radiation are generally classified into two: either ionizing in nature or non-ionizing. The ionizing radiation is capable of ejecting electrons from the atoms and molecules with a resultant production of free radicals in the body while the non-ionizing is based on the thermal effect. The RF radiation from mobile phone BTSs is classified as non-ionizing (Ushie, et al., 2013; IARC, 2011) based on the fact that it can increase cellular tissue or body temperature by $1^0$C or more(IARC, 2011) and get classified into group 2B by the International Agency for Research on Cancer (IARC) of being carcinogenic in nature. The current guidelines like those of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines were set basing on the measure of the rate of absorption of RF radiation in the body called the Specific Absorption Rate (SAR) of value 1-2W.kg$^{-1}$ (Blettner, et al., 2000).

There is lack of national guidelines in Malawi on RF and EMF fields which take care of genuine preferences of domestic stakeholders in providing valuable information, making it easy for regulatory body to use as a

basis for legislation and make them mandatory within the jurisdiction covered by the legislation. It also allows periodic reviews at national level with respect to emerging public and technological concerns. These could be potential reasons why Communications Regulators Association of Southern Africa (CRASA) emphasizes the need for Southern African Development Community (SADC) member states to develop their own national standard guidelines on radiofrequency field (CRASA, 2015).

Also, increased number of base stations might not necessarily mean an increase in the RF radiation in the environment and more exposure to the public but rather how long one is exposed to RF radiation and how far one is from the radiating source. The longer one is exposed, the higher the risk. The closer the RF source, in this case the BTS, the stronger the EM field that the public is exposed. BTS proximity increases the chance of being exposed to high levels of the radiated RF which can worsen its associated effects on the environment.

Of late, RF radiation from the BTSs has become a concern (Ayinmode, et al, 2013 ) and a center of debate due to the associated health effects on the public. Other major studies have reported cancer, sleeping problems, fertility problems, chromosome alterations, dizziness as well as nausea (Eger, et al., 2009) as RF radiation associated potential health symptoms for the public especially when the levels released into the environment for public exposure are found to be higher than the standard safety guidelines on EM-fields like those of the ICNIRP.

The country does not have its own national guidelines on EM-fields and also little or no research is available on RF radiation levels. To answer whether the levels that the public is being exposed to are within the used international safety guidelines, this study was aimed at evaluating the RF radiation levels from selected BTSs in the urban city of Blantyre. This was done in order to quantify the levels but also compare them with the current used ICNIRP standard safety guidelines on EM field.

## 2. Methodology

In order to assess public exposure and make them comparable to the standard safety limits, computational methods or actual measurement of values using the appropriate systems and methodology can be adopted (Miclaus, et al., 2007). The computational method requires sound financial capabilities since expensive professional software is needed that counts the environmental conditions in high detail while the other method actually measures the values on the ground. This method is cheap and involves the use of either broadband meters or selective frequency meters sometimes called spectrum analyzers which can be used with well calibrated antennas for in situ measurements (Miclaus, et al., 2007) and was adopted for this study.

A total of 15 base stations were purposively selected and investigated for RF radiation levels in Blantyre

specifically for GSM 900 as well as 1800.

A Garmin GPS-Map 60Cx was used to locate the BTSs with an error of about +/-3m using the Universal Transverse Mercator (UTM). The coordinates were taken close to the BTS but not necessarily below the BTS to reduce interferences between the satellite and the BTS signals. The coordinates were marked when stable on the GPS receiver and later numerically recorded.

A hand held Aaronia AG spectran HF-6065 V4 spectrum analyzer whose frequency band is 10MHz to 6GHz was used as a simple handheld meter to measure RF radiation for GSM 900 and 1800 at every 25m distance measured using a well-marked 30m cable. Alternatively thirty-three (33) footsteps were approximated for 25m using a standard average human step of about 0.75m moving in a straight line from the reference point (mostly BTS fence). The analyzer had 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

The following results were obtained during the study at each base station site where B1 to B15 represents base station site number 1 to base station number 15. The RF radiation levels plotted against distance for each selected base stations as shown in Figure 1 and Figure 2.

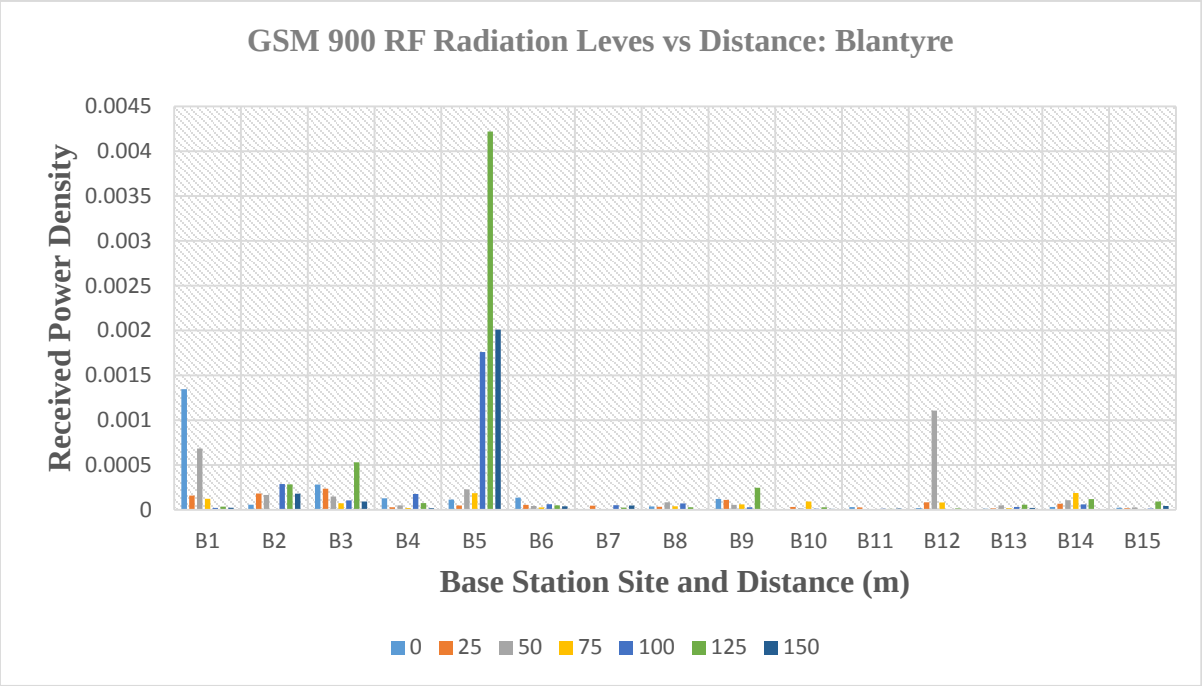


Figure 1: A plot of GSM 900 RF radiation levels (W.m-2) vs. Distance (m) recorded at each selected Base station.

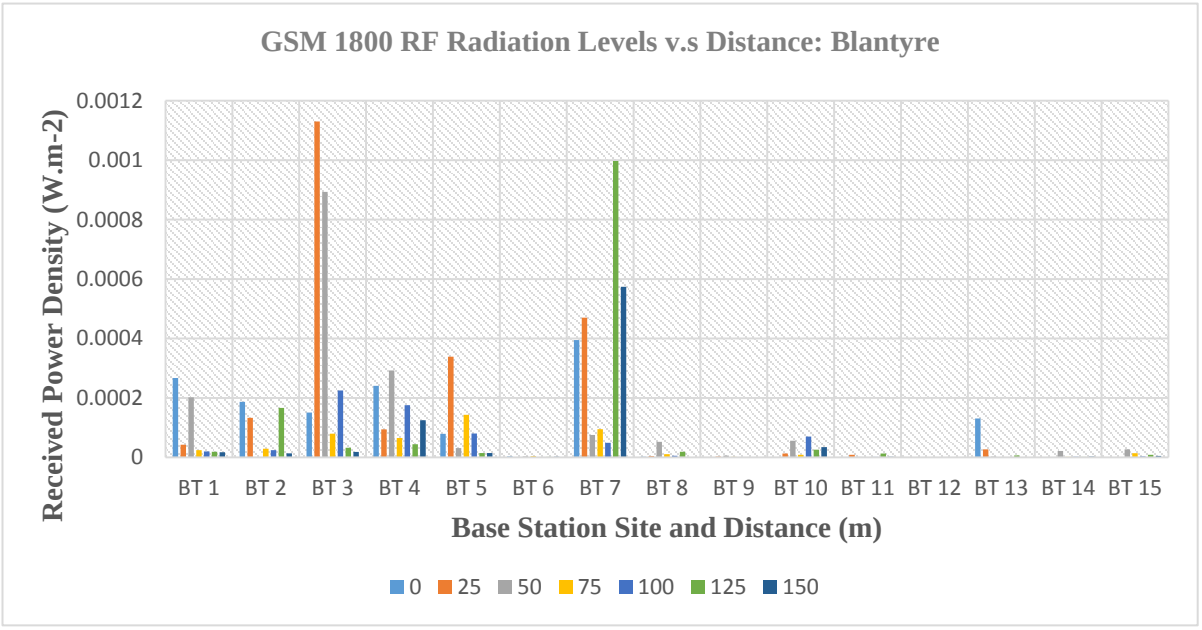


Figure 2: GSM 1800 average RF radiation levels as power densities (W.m-2) recorded at different distances from the fence of the base station: Blantyre.

Basing on the presented data in Figure 1 and Figure 2, Table 1 shows the averaged RF radiation levels recorded as power densities at each radial distances from the fence of the base station for GSM 900 and 1800 in Blantyre.

Table 1: GSM 900 and GSM 1800 average RF radiation levels as power densities ($W.m^{-2}$) recorded at different distances from the fence of the base station for Blantyre.

| **Distance (m) From the Fence** | **Average RF Radiation Levels in $W.m^{-2}$ Recorded for Each GSM Type – Blantyre** | |
|---|---|---|
| | **GSM 900** | **GSM 1800** |
| **0** | 0.0001678 | 0.0001324 |
| **25** | 0.0000761 | 0.0001617 |
| **50** | 0.0001850 | 0.000111 |
| **75** | 6.2099E-05 | 3.40E-05 |
| **100** | 0.0001801 | 4.38E-05 |
| **125** | 0.000388 | 9.00E-05 |
| **150** | 0.0002272 | 7.34E-05 |

From the data in Table 1, a graph of average RF radiation levels was plotted against distance in meters (m) from the fence of the BTS as shown in Figure 2 and Figure 3.

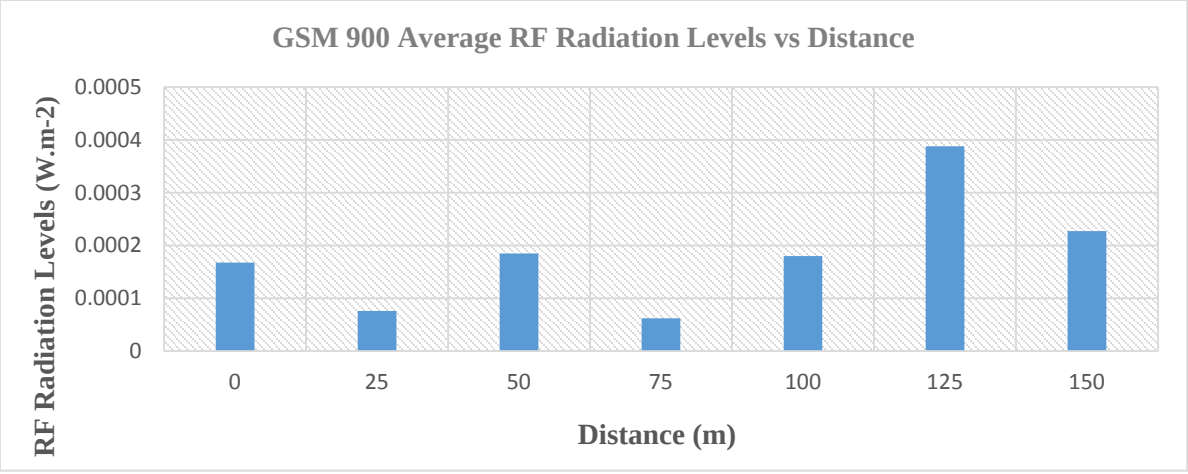


Figure 1: Graph of GSM 900 average RF radiation levels ($W.m^{-2}$) plotted against distance (m) from the fence of the base station: Blantyre.

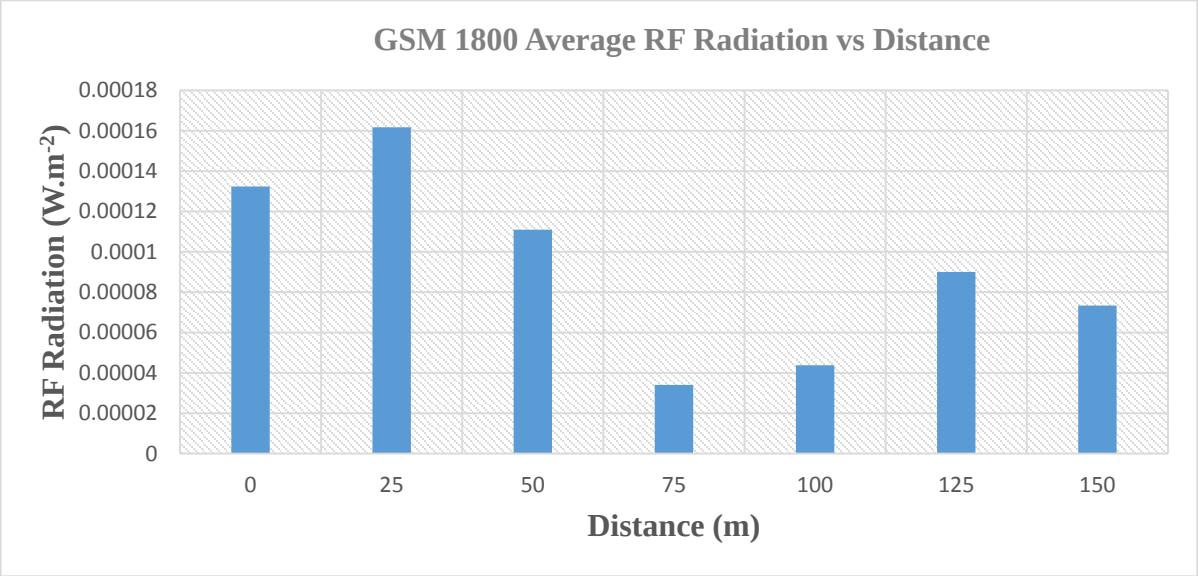


Figure 2: Graph of GSM 1800 average RF radiation levels ($W.m^{-2}$) plotted against distance (m) from the fence of the base station for Blantyre.

## 4. Discussion

A total of 15 base stations were investigated for RF radiation levels for GSM 900 as well as GSM 1800 at different distances from the fence of the BTS. From the 15 BTSs, a registration of 0.00422 $W.m^{-2}$ and 9.31 x $10^{-7}$ $W.m^{-2}$ was recorded as maximum and minimum values at 125 m and 75m radius respectively for GSM 900. The maximum value was registered at BT 5 while the minimum value was at BT 2.

Comparatively, GSM 1800, registered 0.00113 $W.m^{-2}$ and 2.28 x $10^{-8}$ $W.m^{-2}$ as its maximum and minimum received power densities at BT 3 and BT 12 respectively. The values were recorded at 25m and 50m radius from the fence of the BTS. On average, the selected urban locations registered a power density of 0.000182 $W.m^{-2}$ for GSM 900 and 0.0001264 $W.m^{-2}$ for GSM 1800.

Even though this was the case, it was observed from Figure 3 and 4 that there were existing variations in the recorded levels of RF radiation for GSM 900 and GSM 1800 with distance. According to (Bergqvist, et al., 2000), low levels of radiation are expected to be recorded with an increasing pattern within 30m to 150m in a densely populated areas where BTSs are many followed by a reducing pattern from 200m.There was a very high value recorded at BT 5, especially at 125m for GSM 900 with possible causes being reflections from buildings and the vegetation, the ground and other sources of RF radiation within the site. It is important to note the difficulty of predicting the variations of radiation from masts due to number and position of buildings,

vegetation, concentration of BTS just to mention a few.

The recommended maximum permissible values for RF radiation levels according to (Thuróczy, et al., 2010) is 4-10W.m$^{-2}$ equivalent to about 40 – 60V.m$^{-1}$recommendedstandard RF and EMF for the ICNIRP safety guidelines. When compared, all values registered and the average RF radiation levels in the selected BTS sites in Blantyre were found to be below the 1998 ICNIRP standard safety guidelines. When compared with other studies, 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..

Many epidemiological studies have reported numerous recorded RF radiation levels, which were within the ICNIRP guidelines, to be associated with some potential health hazards. Studies like Hutter et al. (2006), Wolf et al. (2003) as in Ayinmonde et al., (2012, p. 333) reported fatigue, irritability, nausea, headache, tiredness, appetite loss and other hazards.. This study's recorded values falls within some ranges that were reported in Ayinmonde et al. (2012) and others could be associated with some potential hazards within the base station site population. From this perspective, much as the recorded values are within the ICNIRP standard guidelines and being classified as safe, the current similar health symptoms reported in the local hospital, clinics and health centers of the country could be linked to RF radiation exposure from these mobile phone BTSs even though there could be numerous causes of such symptoms.

## 5. Conclusions

This study managed to quantify RF radiation levels in the selected base station sites using a simple handheld spectrum analyzer. The study proposes use of different methodology for example theoretical methods or use of other highly sensitive simulative methods in order to further quantify the RF radiation levels from mobile phone base stations in the country in most BTSs including those that are roof top mounted.

The study further recommends development of national standard guidelines on RF and EM-Fields which will act as a benchmark for meeting the international standard guidelines by government, the industry and others while taking into account technological and public concerns. This will further enable swift reaction and need based reviews of the guidelines by the regulatory body in order to address such concerns. It is also important for the public to be civic educated on such matters that affect them. Emphasis on similar studies can also be encouraged that can help create start off points in developing the national standards.

## Acknowledgements

The researcher would like to thank the e-Communications Research Group (e-CRG) CHANCO, Physics Department from where the equipment was hired and the Biomedical Sciences Department (CoM) for financial support.

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