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The Effect of Network Mode on Mobile Phone Radiation

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Abstract
The ubiquitous nature of mobile phones in recent times has led to growing concerns over the health implications of radio frequency radiation exposure particularly cancer. It has been generally accepted that the specific absorption rate of a mobile device is indicative of the expected electromagnetic fields generated. Many researchers have proposed that other external factors affect these levels. This study investigates the effect of network mode (2G and 3G) on mobile phone electromagnetic fields (EMF). Measurements of EMF around a mobile phone operating in 2G and 3G mode were recorded using an RF EMF meter. After careful analysis, the results showed 2G mode had higher initial (on contact) but rapidly decreasing fields while 3G mode showed lower but slower decaying fields such that after 65cm, 3G EMF values were higher. It can be concluded that the network mode has an effect on radiation and distance of use is a determining factor in personal exposure levels. Therefore, it is recommended that mobile phone subscribers apply the specified minimum separation distance (usually between 0.5 and 2.5cm) while using their mobile devices.
Keywords: EMF, Radiation, 3G, 2G, Mobile Phone.

1. Introduction

The United Nations Department of Economic and Social Affairs estimates worldwide mobile phones use to be at seven billion. The Nigerian Communications Commission (NCC) puts Nigeria's mobile phone concentration at over 167 million. While concerns about the effect of mobile phone usage began in the early 90s in the United States, they are relatively new in Nigeria but growing at an extensive rate.

The NCC has reported a growing number of enquiries and questions from the general public about the effects of electromagnetic radiation on health (NCC, 2012). The Consumer Affairs Bureau continuously educates and informs the public that no ill effect has been consistently demonstrated when appropriate mobile phone safety guidelines are applied. However, the recent World Health Organization (WHO) classification of mobile phones as possibly carcinogenic (Guadin, 2011) and the media frenzy that accompanied it, has reintroduced fears and concerns amongst mobile phone users.

Today, mobile phone radiation safety standards are applied to the mobile devices right from the design stage ensuring that their specific absorption rates (SAR) are below guideline limits. However, many researchers have asserted that radio frequency electromagnetic fields (RF EMF) are not only dependent on the design characteristics of the mobile device but also on other factors such as temperature, geographical area, network operator and so on. These assertions create further worries with regards to the application of ideal safety specifications to a real environment. It leaves one wondering how safe it really is to apply European and American safety standards in Sub Saharan Africa – Nigeria in particular.

This study considers the effect of network mode on the RF EMF of mobile phones. The 2015 Ericsson Mobility Report estimates 3.6 billion 2G subscriptions, 2.2 billion 3G subscriptions and 1 billion 4G subscriptions worldwide with a 2021 forecast of 1.3 billion, 3.2 billion and 4.1 billion for 2G, 3G and 4G respectively. In Africa and the Middle East, there is currently a majority of 2G only mobile subscriptions with a projected shift to 3G dominance in Sub Saharan Africa by 2021. With Nigeria's mobile phone penetration nearing 90%, concerns about the health implications of mobile phone use make it important to investigate other external factors – in this case, network mode – that may contribute to personal radiation exposure levels.

2. Related works

In recent times, there have been calls for changes in the guideline exposure limits (Yakymenko and Sidorki, 2010) to account for possible biological effects such as (Johansson, 2009):

1. Changes in the level of melatonin (Kumlin et al, 2005; Stevens and Davis, 1996)
2. Increase in heat shock protein (Jorge-Mora et al, 2010)
3. Memory Problems (Fragopoulou et al, 2010; Lai et al. 1994)
4. Changes in the concentration of calcium in the cell (Walleczec, 1992)
5. Changes in the permeability of the blood brain barrier (Nittby et al, 2009)
6. Genotoxicity (Reudiger, 2009; Lai and Singh, 2004) and many more

Other issues such as tinnitus, tumours and certain types of neuromas have been linked to mobile phone

radiation (Hardel et al, 2005; Hardell and Carlberg, 2009).

Muscat et al (2000) investigated the relationship between cell phone usage and risk of brain tumour. They conducted structured interviews in order to characterise cell phone usage among 469 cancer cases and 422 controls. At the end of the study, there was no link discovered between cell phone use and brain tumour risk.

Hepworth et al (2006) found no relationship between increased glioma risk and cell phone use. The study was carried out by selecting cases from hospitals and cancer registries. Computer aided interviews were conducted to define cell phone radiation exposure by detailing the number of calls made, model of the phone, network operator, area of usage and so an. Any positive association between glioma and cell phone radiation was attributed to recall bias and over reporting.

Stankovic et al (2017) calculated the mobile phone electromagnetic field induced in the pituitary gland of children. They created a 3D replica of a seven year old child head and determined the electric field distribution and SAR in the gland region. These were obtained using finite integration technique (FIT) at 900MHz, 1800MHz and 2100MHz. They found that the electric field strength was higher and warned against childhood exposure to mobile phone radiation.

Navarro et al (2003) carried out a survey on the health of subjects in the vicinity of a base station. The cell phone base station was operating in the 1800MHz frequency range. 95% of respondents reported exposure times of 6 hours and above every day. The power densities in the home of subjects were measured and analysis showed a significant relationship between power density and the severity of ill health symptoms reported.

Amoako et al (2009) conducted a survey of the RF EMF radiation near 50 base stations. They measured the EMF levels emitted by installed antennas using a handheld spectrum analyser. Their results showed variations in power densities ranging from 0.01 to 10 μW/m² in the 900MHz range and 0.001 to 100 μW/m² in the 1800MHz frequency range. While these results were higher than what is generally obtainable, they were well within the guidance level as recommended by the ICNIRP.

Paljanos et al (2016) characterized the near field radiated power of a mobile phone during active use. They focused on voice and data applications in UMTS and LTE technologies. Applying statistical analysis of the collected data showed that highest radiation levels where encountered during uploading for both UMTS and LTE. Their results showed that on average, LTE technology produces higher radiation levels than UMTS for the same application type.

Panagopoulos et al (2015) discussed the need for the use of real life EMF from mobile devices in clinical experimentation. Simulated EMF emissions which are currently applied in investigations have fixed and predictable parameters – very different from the real world. Mobile phone radiations are constantly varying and these variations are an important parameter. They went on to say that experimental studies using simulated emissions are generally inconsistent with only 50% reporting outcomes. On the other hand, real mobile phone exposures show a 100% consistency. They concluded that experimental findings need to reflect reality and this can be achieved by investigating real commercial handheld cell phones in real environments.

3. Methodology

The investigation was carried out by measuring the radio frequency electromagnetic fields around a mobile phone in a real environment.

3.1 Materials and Equipment

The radio frequency meter employed in this study is the Extech Radio Frequency (RF) Electromagnetic Field (EMF) strength meter, model 480836.

Figure 1. Radio Frequency EMF meter

The meter is a broadband device for measuring high frequency radiation in the entire range of 50MHz to 3.5GHz. The measurement types are expressed in electric field strength in V/m, magnetic field strength in A/m and power density in W/m2.

The mobile equipment under test is the 2017 Samsung Galaxy A5 mobile phone with FCC ID value: A3LSMA520F.

3.2 Location

The investigation was carried out at the Nigerian Communications Commission (NCC) located at No. 23, Igbodo Street, Old GRA, Port Harcourt, Rivers State with coordinates given as 4o47'32.6''N 7o00'10.3''E. It is located in a densely populated urban area consisting of banks, offices and hotels.

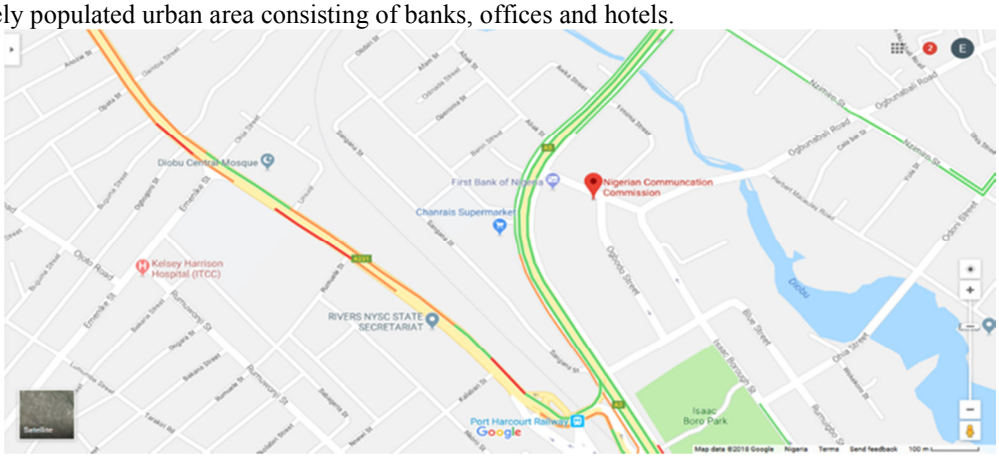

Fig. 2: Map View of the Location (Source: Google Maps)

3.3 Measurement

The RF EMF meter was placed on a non-conducting surface and the ambient electromagnetic fields were measured in order to establish a baseline. The mobile equipment under test is switched on and set to operate in the 2G only network mode. It is then introduced at a distance of 0cm from the test meter i.e. direct contact. After an exposure time of thirty seconds, the maximum average readings are taken for electric field strength, magnetic field strength and power density. The mobile phone is then moved away from the test meter in increments of 0.2m and the measurements are repeated up to 1m.

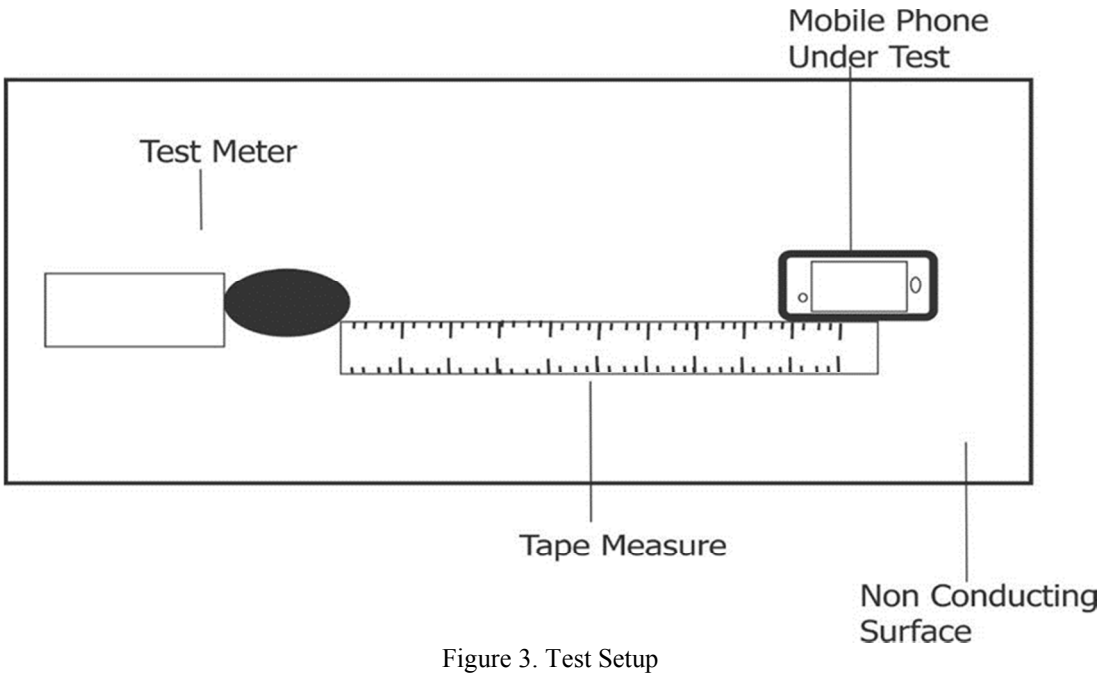

Figure 3. Test Setup

These measurements are taken when the device is in idle phase. Idle phase as used here, describes the state where the mobile device is switched on but not in active use by the subscriber; there is still constant communication between the device and the nearest base transceiver station (BTS).

The mobile device is then switched to 3G network only mode and the test procedure described above is repeated.

4. Results and discussion

The electromagnetic field measured in the different network mode were corrected by subtracting the baseline values. The baseline values were as follows:

Electric Field: 183.3 mV/m

Magnetic Field: 486.2 µA/m

Power Density: 89.1 µW/m2.

Table 1. Summary of Results

Distance	2G			2G (Corrected)			3G			3G (Corrected)		
(meter)	*E (V/M)*	*H(A/m)*	*S(W/m²)*	E (V/M)	H(A/m)	S(W/m²)	*E (V/M)*	*H(A/m)*	*S(W/m²)*	E (V/M)	H(A/m)	S(W/m²)
0	9.42E-01	2.50E-03	2.35E-03	7.58E-01	2.01E-03	2.26E-03	4.12E-01	1.13E-03	4.98E-04	2.29E-01	6.45E-04	4.09E-04
0.2	7.38E-01	1.97E-03	1.47E-03	5.55E-01	1.48E-03	1.38E-03	3.89E-01	1.04E-03	4.04E-04	2.06E-01	5.49E-04	3.15E-04
0.4	4.73E-01	1.26E-03	6.01E-04	2.89E-01	7.74E-04	5.12E-04	3.83E-01	1.02E-03	3.89E-04	2.00E-01	5.29E-04	3.00E-04
0.6	3.85E-01	1.02E-03	3.92E-04	2.01E-01	5.33E-04	3.03E-04	3.60E-01	9.55E-04	3.40E-04	1.77E-01	4.69E-04	2.50E-04
0.8	2.61E-01	7.04E-04	1.92E-04	7.75E-02	2.18E-04	1.03E-04	3.41E-01	9.04E-04	3.08E-04	1.57E-01	4.18E-04	2.19E-04
1	2.10E-01	5.57E-04	1.17E-04	2.66E-02	7.05E-05	2.77E-05	3.33E-01	8.87E-04	2.97E-04	1.50E-01	4.01E-04	2.08E-04

Measured and corrected values for electric field, magnetic field and power density in 2G and 3G mode

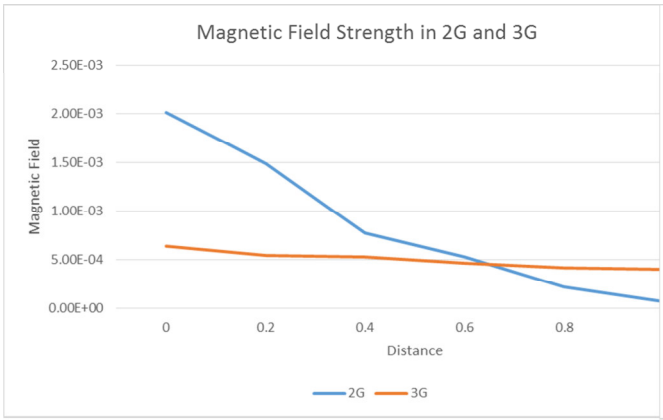

Figure 4a. Magnetic field in 2G and 3G

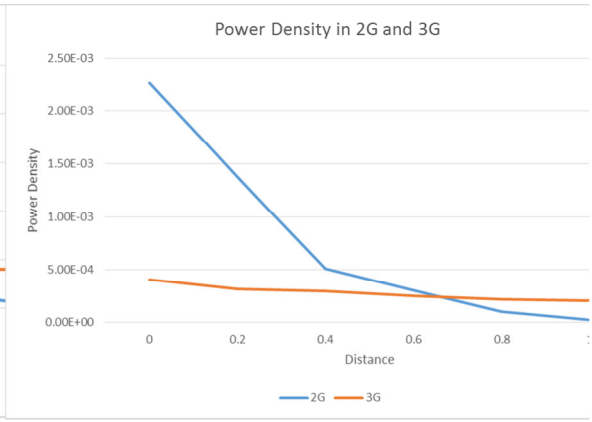

Figure 4b. Power Density in 2G and 3G

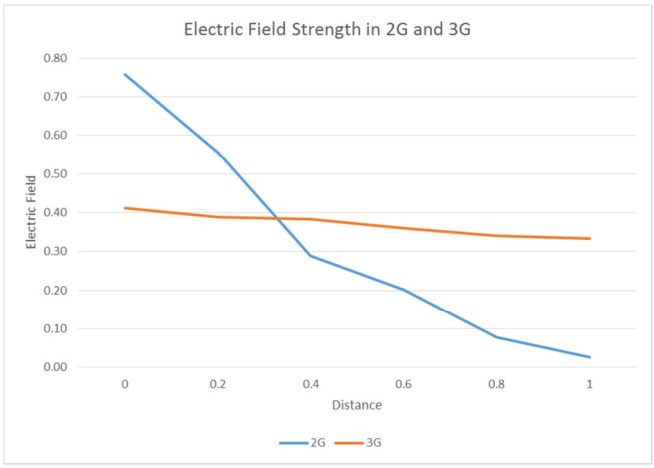

Figure 4c. Electric Field in 2G and 3G

The data obtained and analysed in Table 4.1 show that there is a significant variation in the electromagnetic fields produced by a mobile phone depending on the network mode and distance. A mobile phone operating in a 3G only network emits less radiation than in a 2G only network when used in close proximity. 2G network emissions decline at a much faster rate such that at distances above 65 cm, the recorded 2G electromagnetic field is lower than in 3G.

5. Conclusion

The general notion that personal exposure levels to mobile phone radiation can be determined solely from the specific absorption rate of the mobile equipment is false. This study has shown that the electromagnetic radiation from handheld mobile devices is also dependent on the operational network mode and distance. A mobile phone operating in a 3G only network emits less radiation than in a 2G only network when used in close proximity. 2G network emissions decline at a much faster rate such that at distances above 65 cm, the recorded 2G electromagnetic field is lower than in 3G. Still, all data recorded was significantly lower that the guideline limits for both occupational and general public exposure as set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

This finding compels one to consider the effects of other external factors such and temperature, geographical area and others on mobile phone RF EMF. While the debate on the possible athermal effects of non-ionizing radiation and consequently, the safety of mobile phone usage will not reach a conclusion soon, it is important that further research takes into consideration these factors and its implication on inter-regional adoption of standards and safety limits.

This paper provides practical data to show that there can be variations in the RF EMF of mobile phones due to external factors – in this case network mode – irrespective of the SAR and its dependence on the distance of separation. The following recommendations are made:

1. Mobile phone users should maintain the recommended separation distance (usually 0.5 – 2.5cm).
2. Limit exposure to radio frequency radiation especially in children.
3. Use only NCC approved mobile devices.
4. Widespread re-introduction of fixed telephony especially in homes and offices.

5. Increased funding for the provision of facilities and equipment for further research.

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