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**Research Article**

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# Experimental Investigation of Electromagnetic Field Radiation Exposure from Selected Brand of Mobile Phones via in-situ Measurements Approach

**J. Isabona, A. Salawu, E. Alli**

Department of Physics Federal University Lokoja, PMB 1154, Lokoja, Kogi State, Nigeria

**Abstract** Over the last decade, the widespread use of mobile phones as essential means of communication has been enormous and is still on the rise. However, the concern expressed by the phone users about the possible adverse human health effects associated with exposure to the electromagnetic fields (EMF) radiation generated by them and their supporting broadcasting base stations at close proximity have not been fully clarified. In this work, near EMF radiation intensity measurements in terms of electric field and magnetic field strength were conducted on four brands and ten models of mobile phones in an indoor environment using Extech radio frequency meter. The phone brands are Itel, Techno, Nokia and Sony Ericson. The different phone models were placed facing the radio frequency meter in an active call modes at 0.05m measurement gaps, up until a distance of 0.2m in tri-axis planes. The results obtained have revealed that the EMF radiation exposure intensity from the mobile phone varies and depend on the phone model brand and the phone network service providers. The highest radiation exposure intensity was recorded in active call modes during the dial (before picking). In particular, we observed from the results, that the amount of EMF radiations in some phones were higher than the value recommended by the International Commission on Non-ionizing Radiation Protection (ICNIRP) for human safety and this calls for a caution.

**Keywords** Mobile, Phones, Radiation, Exposure, Intensity, Field, Human, Health, Networks.

## 1. Introduction

Over the last decade, the worldwide mobile phone subscription and usage as an essential means of communication has increased considerably and is still on the rise. As pointed out in Ericson Mobility report, (2016), the total global mobile phone subscriptions stood at 7.3 billion in the third quarter of 2015 alone. According to the report, India grew the most in terms of net additions (+13 million) during the quarter, followed by China (+7 million), the US (+6 million), Myanmar (+5 million), and Nigeria (+4 million). However, this substantial global mobile phone subscriptions and widespread use have also been paralleled by a growing concern expressed for many years about the possible adverse human health effects associated with exposure to electromagnetic fields (EMF) radiation generated by them and their supporting broadcasting base stations. According to environmentalists, the EM radiation occupies the fourth pollution source besides air, water and noise in our surroundings.

Given the health risk concern, there have been quite a number of research studies using different techniques to probe the intensity of EMF radiation from mobile phones and their base stations transmitters in the past 50 years.

Experimental studies [1-8] have been reported that below the EMF exposure limits, EMF radiation generated by mobile phones induces a number of biological and health issues ranging from brain tumour, blood-brain barrier function, eye and liver damage, and among others

Interestingly however, other investigations such as reported by Schuz et al, [9], indicated that glioma or meningioma is not associated with EMF radiation from mobile phone usage. Many of such similar reports are also contained in Myers, 1990; Zeni et al, 2008; Kleinlogel et al, 2013, Silke, et al, 2008, and Ombati et al, 2001 [9-14].

The above conflicting reports in the current body of knowledge on effect of exposure to EMF sources have made researchers to continue to study the issue.

In this work, measurements of EMF radiation in terms of electric field strength have been conducted on commonly used models of mobile phones in an indoor campus environment via the call-related factors using three commercial telecom service providers whose networks operates at 400–2,000 MHz frequency range.

## 2. Materials and Methods

### 2.1 Electric Field Strength and Power Density

In radio mobile telephony and broadcasting, it is appropriate to examine the electric field strength at specific distance from the transmitter or radiating source. For plane wave of wavelength, λ (m), the relationship between the field strength, E (V/m) and the available power, $P_a$ (W) at the isotopic receiving antenna is giving by equation 1 [15-17].

$$E = \left( \frac{480\pi^2 P_a}{\lambda^2} \right)^{1/2} \quad (1)$$

$$P_a = \frac{\lambda^2}{4\pi} \frac{P_t}{4\pi d^2} \quad (2)$$

where, $P_t$ is the equivalent isotropically radiated power at a distance*d* from the transmitter.

Consequently, the electric field strength can be rewritten in terms of the radiated power, $P_t$ using equation 2as follows:

$$E = \left( \frac{30 P_t}{d^2} \right)^{1/2} \quad (3)$$

The power flux density, $P_d$ is given by the characteristic relations of a plane wave,

$$P_d = \frac{E^2}{\eta} \quad (4)$$

Where $\eta$ indicate the medium characteristic impedance during measurement. In free space, $\eta = 120\pi.$

### 2.2 Field Measurement and Techniques

The tools used during measurement consist of ten models of mobile phones, Extech RF meter, Metre rule, Timer, and lab stools. As diagrammatically shown in figure 1, the RF meter is three dimensional EMF probing device which measures EMF radiation intensity by means of electric field strength, magnetic field strength and power density.

Here, in terms of electric field strength, near EMF radiation exposure measurement from the experimented ten models of phones were conducted at close proximity using the Extech RF meter. The different phone models were placed facing the RF meter in an active call mode at 0.05m measurement gaps, up until a distance of 0.2m in tri-axis planes. The measurements were conducted using three GSM wireless network service providers. The service providers are MTN, Etisalat and GLO Nigeria Limited. The experimental set-up during measurement is depicted in figure 2. Presented in Table 1 are various mobile phone models used and their abbreviations.


*Figure 1: RF Extech Meter*

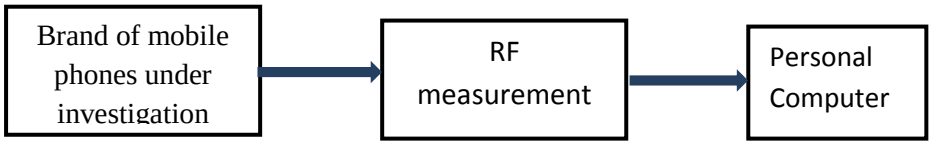


*Figure 2: Experimental setup with RF Extech Meter*

**Table 1**: Mobile Phone Models and abbreviation

| Mobile Phone | Acronym |
|---|---|
| Itel phone, Model 6800 | IT-6800 |
| Itel phone, Model 6800 | IT-520 |
| Techno phone, Model P5 | TN-P5 |
| Techno phone, Model P3 | TN-P3 |
| Techno phone, Model 340 | TN-T340 |
| Nokia phone, Model 105 | NK-105 |
| Nokia phone, Model E51 | NK-E51 |
| Nokia phone, Model 2700 | NK-2700 |
| Sonny Ericson phone, Slid model | SE-SL |
| Sonny Ericson phone, Plip model | SE-PL |

## 3. Results and Discussion

Presented in this section are the acquired measurement results in terms of electric field strength for the ten mobile phone models which were collected at different distances from the RF meter using three GSM Networks. The RF meter readings were collected in active modes before and after picking calls.

These results displayed in figures 3 to 5 are plots of measured electric field strength acquired in active call mode before picking for the8 phone models at different distances using MTN, GLO and Etisalat networks respectively. From figures 3 and the results summary in table 2, it is revealed that measured electric field strength using the Etisalt and GLO networks for IT-6800 phones model are about 5 and 4% higher than the 41.25V/m recommended ICNIRP value for general public limiting exposure of EMF radiation. However, for MTN networks, all measured electric field strength values from the ten phone models are all below the 41.25V/m recommended ICNIRP value for general public limiting exposure. These results clearly shows that the mobile phone network service provider also play key role in determining the amount and intensity of EMF radiation from mobile phones. The results also revealed that the intensity of measured field strength depends on the proximity of phones to the RF meter. Thus, placing the phone at about 0.05m from the body during conversion is highly recommended.

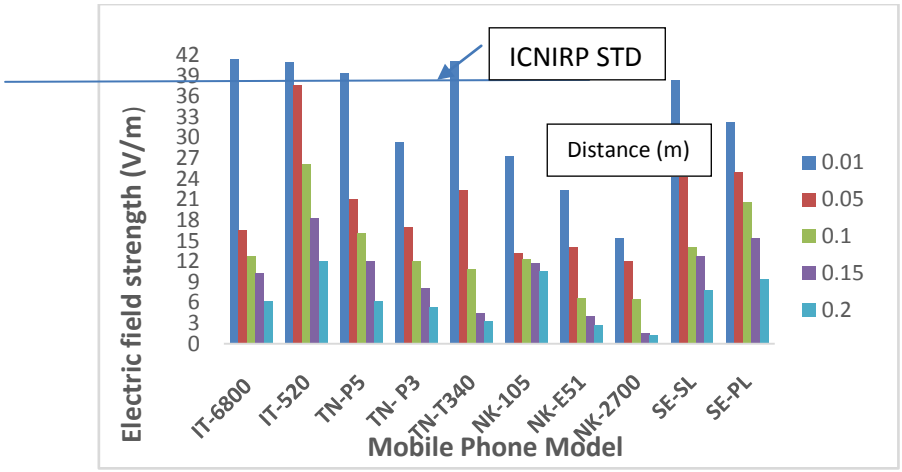


*Figure 3: Measured Electric Field Strength for the mobile phone models at different distances using MTN Network before picking a call*

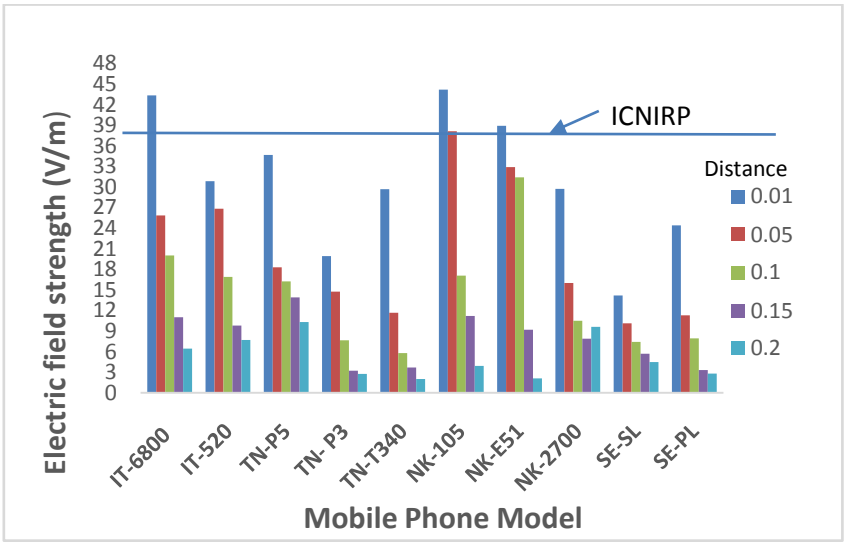


*Figure 4: Measured Electric Field Strength for the mobile phone models at different distances using Etisalat Network before picking a call*

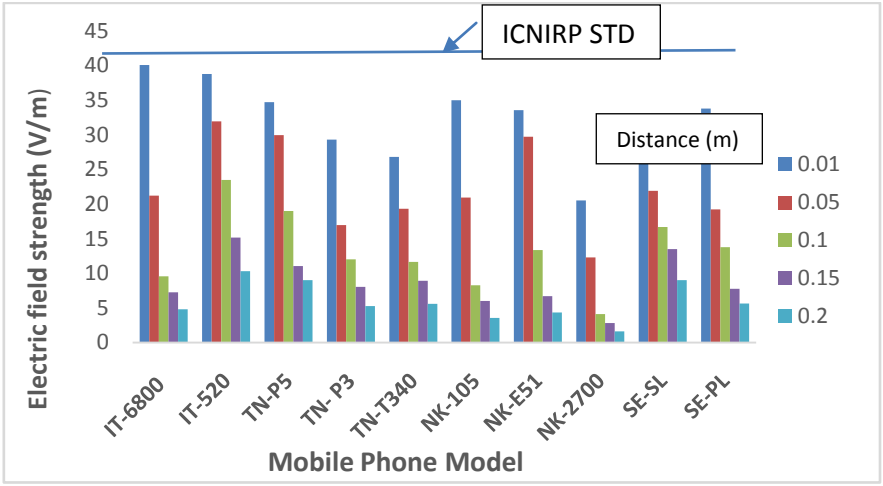


*Figure 5: Measured Electric Field Strength for the mobile phone models at different distances using GLO Network before picking a call*

These results displayed in figures 6 to 8 are plots of measured electric field strength acquired in active call mode after picking the calls for the 10 phone models at different distances using MTN, GLO and Etisalat networks

respectively. From the figures and results summary in table 3, it is clearly seen that the measured field strength after picking calls on any of the three network service providers for all the ten phone models are quite below the 41.25V/m recommended ICNIRP value for general public limiting exposure. Thus, from these results, it is advisable to allow the receivers to pick their calls before the caller place the phone closed to the ear for conversation.

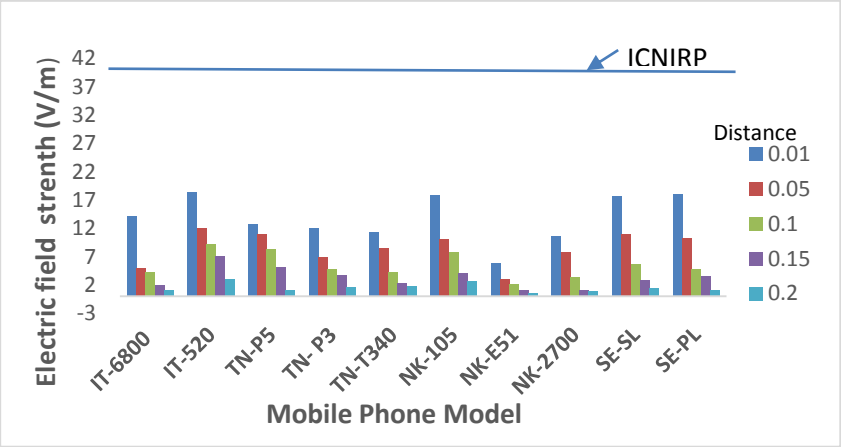


*Figure 6: Measured Electric Field Strength for the mobile phone models at different distances using MTN Network after picking a call*

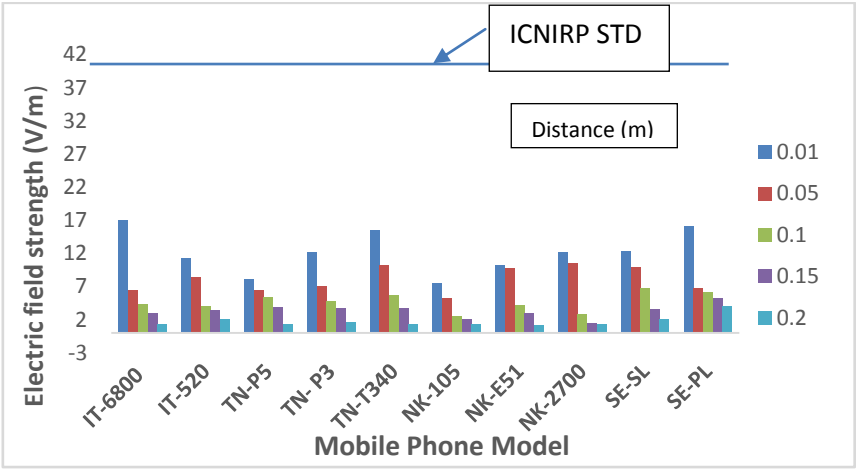


*Figure 7: Measured Electric Field Strength for the mobile phone models at different distances using GLO Network after picking a call*

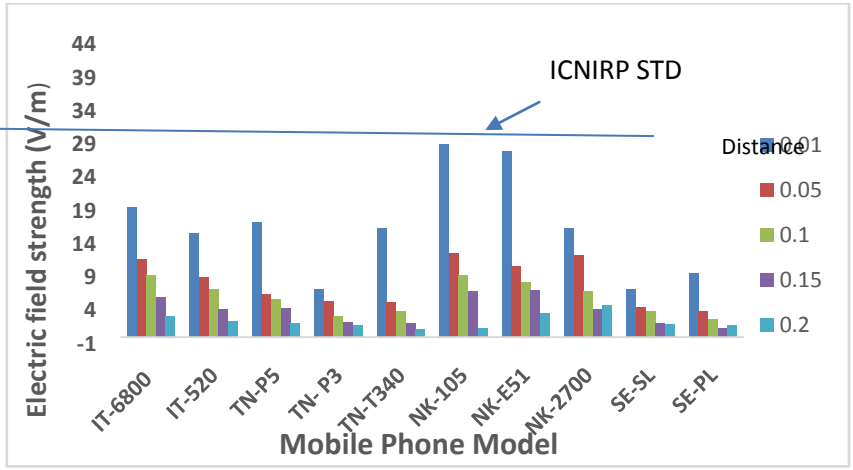


*Figure 8: Measured Electric Field Strength for the mobile phone models at different distances using GLO Network after picking a call*

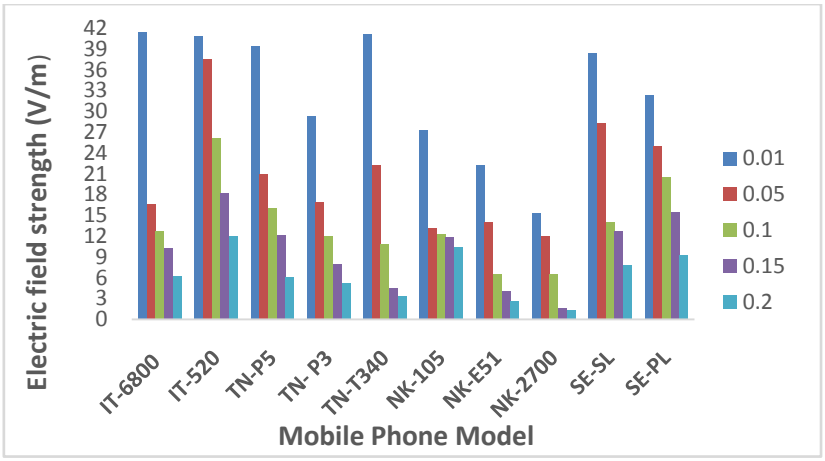


*Figure 9: Measured Magnetic Field Strength for the mobile phone models at different distances using MTN Network before picking a call*

The displayed results in the plots of figures 11 to 16 are the measured Magnetic field components of the EMF radiation quantity acquired in active call mode before and after picking a call from the 10 phone models at different distances and also using different networks such as MTN, GLO and Etisalat. From the figures, it is revealed that measured Magnetic field strength values acquired before picking calls were also far higher than the ones obtained after picking calls. The highest Electric field and Magnetic field strength values attained at 0.01m distance with the ten phone models using MTN, Etisalat and GLO networks before and after picking calls were displayed in tables 2, 3 and 4, 5 respectively.

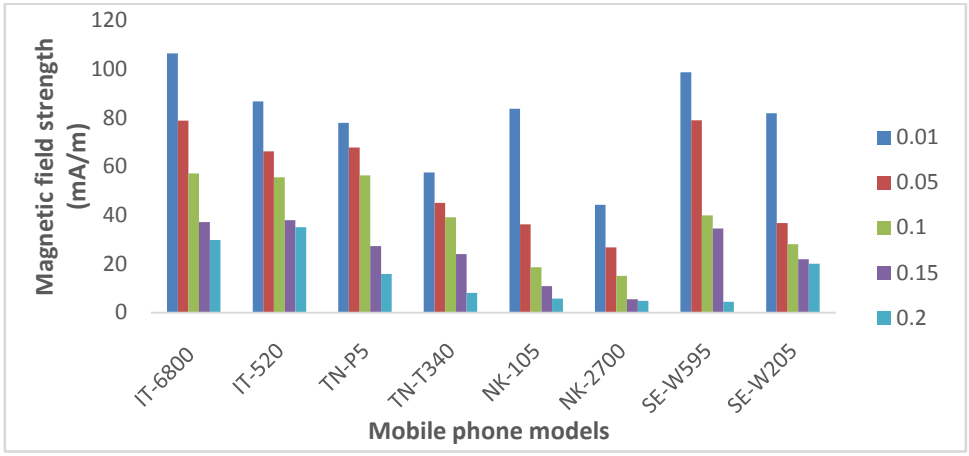


*Figure 10: Measured Magnetic Field Strength for the mobile phone models at different distances using Etisalat Network before picking a call*

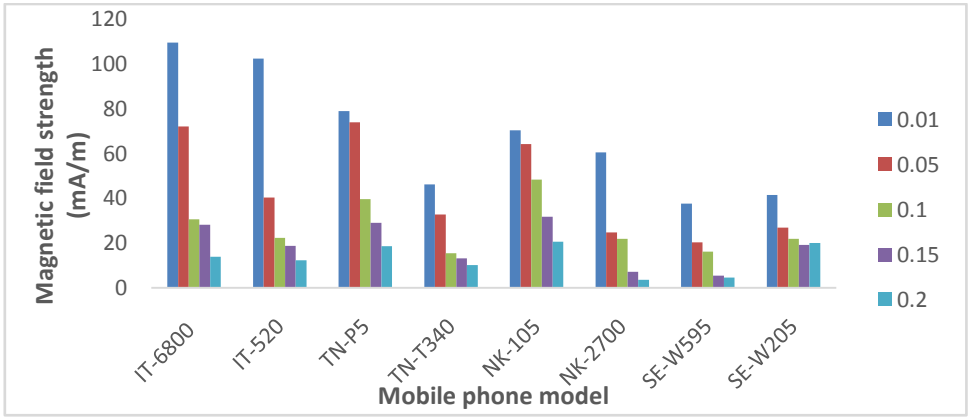


*Figure 11: Measured Magnetic Field Strength for the mobile phone models at different distances using Etisalat Network before picking a call*

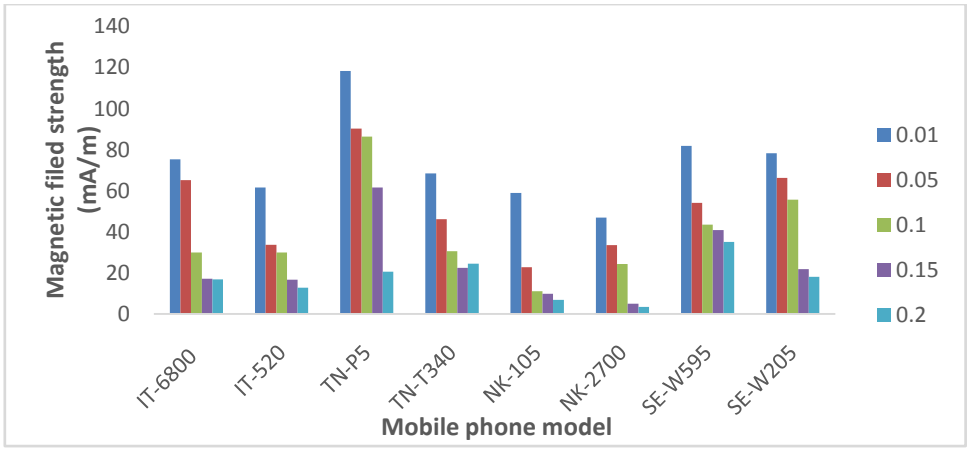


*Figure 12: Measured Magnetic Field Strength for the mobile phone models at different distances using GLO Network before picking a call*

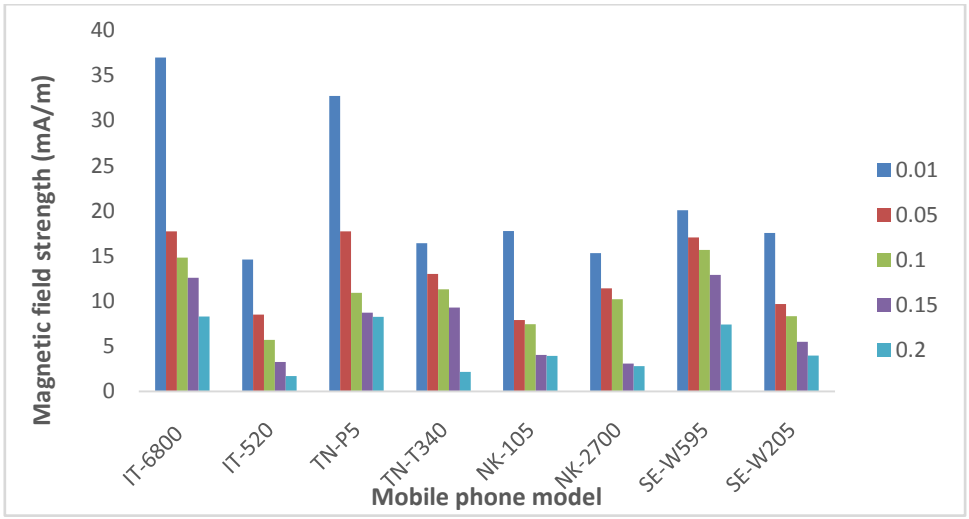


*Figure 13: Measured Magnetic Field Strength for the mobile phone models at different distances using MTN Network after picking a call*

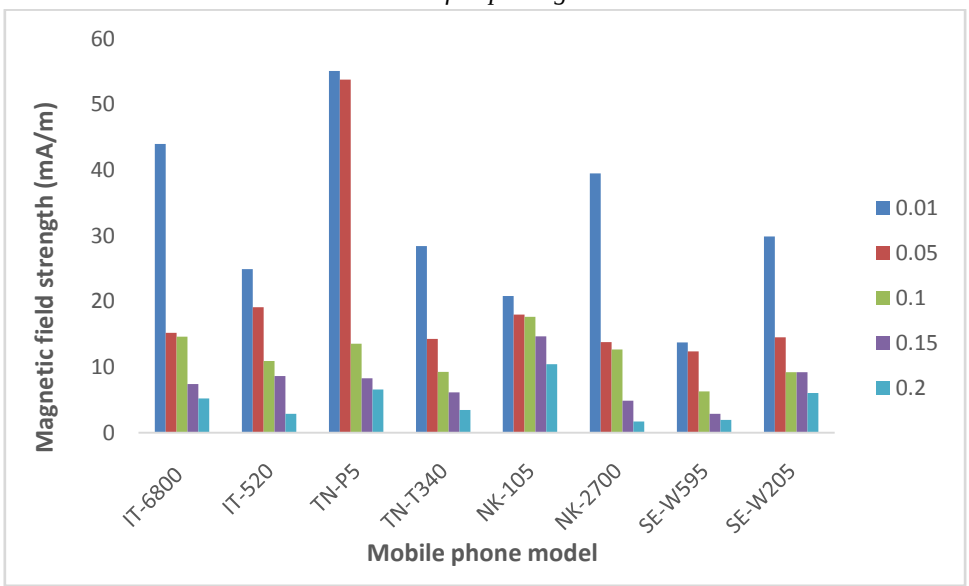


*Figure 14: Measured Magnetic Field Strength for the mobile phone models at different distances using Etisalat Network after picking a call*

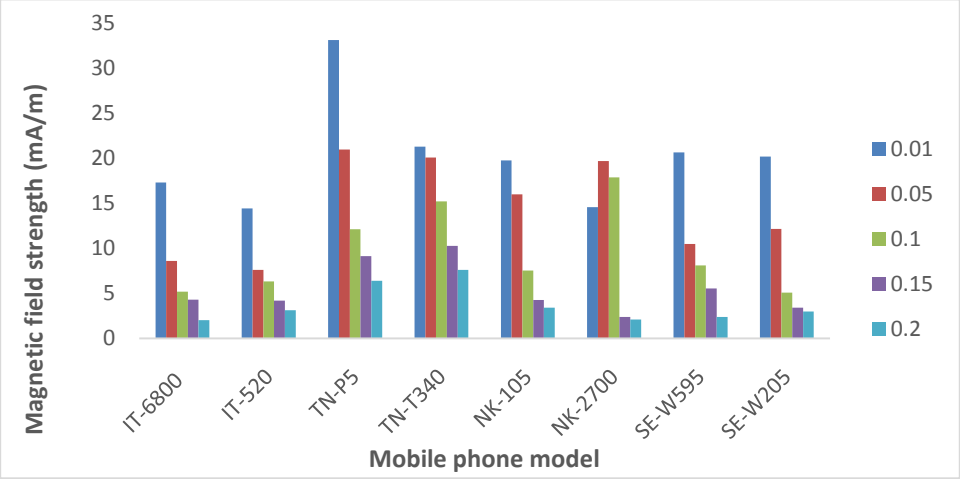


*Figure 15: Measured Magnetic Field Strength for the mobile phone models at different distances using GLO Network after picking a call*

**Table 2:** Measured Electric Field Strength (V/m) obtained from the mobile phone models at 0.01m distance using Etisalat, GLO and MTN Networks before picking a call

| Network Type | Phone Models | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **IT-6800** | **IT-520** | **TN-P5** | **TN-T340** | **NK-105** | **NK-2700** | **SE-W595** | **SE-W205** |
| Etisalat | 43.32 | 30.83 | 34.65 | 29.67 | 44.19 | 29.7 | 14.2 | 24.38 |
| GLO | 41.48 | 40.92 | 39.43 | 29.3 | 41.21 | 27.32 | 22.32 | 15.3 |
| MTN | 40.07 | 38.75 | 34.69 | 29.3 | 26.78 | 34.98 | 33.53 | 20.5 |

**Table 3:** Measured Electric Field Strength (V/m) obtained from the mobile phone models at 0.01m distance using Etisalat, GLO and MTN Networks after picking a call

| Network Type | Phone Models | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **IT-6800** | **IT-520** | **TN-P5** | **TN-T340** | **NK-105** | **NK-2700** | **SE-W595** | **SE-W205** |
| Etisalat | 19.59 | 15.51 | 17.29 | 7.2 | 16.32 | 28.99 | 27.89 | 16.4 |
| GLO | 14.08 | 18.42 | 12.66 | 12.07 | 11.29 | 17.91 | 5.81 | 10.7 |
| MTN | 16.9 | 11.22 | 8.1 | 12.07 | 15.49 | 7.45 | 10.2 | 12.1 |

**Table 4:** Measured Magnetic Field Strength (mA/m) obtained from the mobile phone models at 0.01m distance using Etisalat, GLO and MTN Networks before picking a call

| Network Type | Phone Models | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **IT-6800** | **IT-520** | **TN-P5** | **TN-T340** | **NK-105** | **NK-2700** | **SE-W595** | **SE-W205** |
| Etisalat | 109.4 | 102.3 | 78.89 | 46.08 | 70.29 | 60.5 | 37.58 | 41.4 |
| GLO | 75.3 | 61.59 | 118.4 | 68.43 | 58.88 | 47 | 81.84 | 78.23 |
| MTN | 106.5 | 86.7 | 78 | 57.6 | 83.75 | 44.3 | 98.7 | 81.84 |

**Table 5:** Measured Magnetic Field Strength (mA/m) obtained from the mobile phone models at 0.01m distance using Etisalat, GLO and MTN Networks after picking a call

| Network Type | Phone Models | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **IT-6800** | **IT-520** | **TN-P5** | **TN-T340** | **NK-105** | **NK-2700** | **SE-W595** | **SE-W205** |
| Etisalat | 44.00 | 24.95 | 55.12 | 28.44 | 20.84 | 39.5 | 13.74 | 29.92 |
| GLO | 17.33 | 14.45 | 33.16 | 21.3 | 19.77 | 14.6 | 20.67 | 20.2 |
| MTN | 36.94 | 14.6 | 32.7 | 16.4 | 17.74 | 15.3 | 20.04 | 17.53 |

## 4. Conclusion

A lot of researches have been conducted in the past to investigate if the EMF radiations from mobile phones and their base station alike have adverse effect on human health, but the results from most of the previous works are inconclusive. In this work, near EMF radiation intensity measurements in terms of electric field strength were conducted on four brands and ten models of mobile phones in an indoor environment using Extech radio

frequency meter. The different phone models were placed facing the radio frequency meter in an active call modes at 0.05m measurement gaps, up until a distance of 0.2m in tri-axis planes. The results obtained have revealed that the EMF radiation exposure intensity from the mobile phones varies and depend on the phone model/brand and the phone network service providers. The highest radiation exposure intensities were recorded in active call mode during the dial (before picking). In particular, we observed from the results that, the amount of EMF radiation in some phones were higher than the ICNIRP recommendations for human safety during active call mode before picking as compared to after picking. Thus, it is advisable to allow the receivers to pick their calls before the caller place the phone closed to the ear for conversation.

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