**Adamawa State University Journal of Scientific Research**
Volume 8 Issue 2, 2020; Article no. ADSUJSR 0802007
ISSN: 2705-1900 (Online); ISSN: 2251-0702 (Print)
*http://www.adsujsr.com*

# Determination of Electromagnetic Radiation Emitted from the Sides of Different Brand of Cell Phones

**Lazarus G. Ndatuwong and Ijantiku John**
Department of Pure and Applied Physics, Adamawa State University, Mubi

*(Received in July 2020; Accepted in September2020)*

**Abstract**

The study aims at determining the electromagnetic radiation emitted at the front and back side of different brand of cell phones (ITEL, INFINIX and TECNO) when charging, fully charged and at low charge when placed at call mode, text mode and standby mode. A portable near field electromagnetic radiation tester 9024-EN-00 was used to measure the electromagnetic radiation levels. The wave power density was computed as a function of modes (call mode, text mode and standby mode) for all the phone models when fully charged and when at low battery. Further computation of the power density was done as a function of distance from the test phones when charging. Result of the study shows that there is little or no radiation on the back side of all the phones when placed in any of the mode when either fully charged or at low battery. The front side of the phones exhibit different values of the radiation intensity. With the call mode having the highest intensity followed by the text mode and finally the standby mode. A comparison between when the phones are fully charged and when they are at low battery show that the intensity of radiation is higher when the phones are at low battery than when fully charged for all the different mode experimented. The wave power density levels also significantly varied with distance up to 40cm when there is little or no radiation from all the phones.

**Keywords:** Electromagnetic radiation; Mobile phone; Radiofrequency; Power Density; Exposure.

## Introduction

Electromagnetic radiation (EM radiation or EMR) refers to the waves (or their quanta, photons) of the electromagnetic field, propagating (radiating) through space, carrying electromagnetic radiant energy. It includes radio waves, microwaves, infrared, (visible) light, X-rays, and gamma rays. Classically, electromagnetic radiation consists of electromagnetic waves, which are synchronized oscillations of electric and magnetic fields (wikipedia). Mobile or cellular phones are now an integral part of modern telecommunications. In many countries, over half the population use mobile phones and the market is growing rapidly. In 2014, there is an estimated 6.9 billion subscriptions globally (World Health Organization WHO, 2019). In some part of the world, mobile phones are the most reliable or the only phones available for communication. Given the large number of the mobile phone users, it is important to investigate, understand and monitor the electromagnetic radiation emitted by it and the potential public health impact. Electromagnetic fields are present everywhere in our environment but are invisible to the human eye. Electromagnetic field can be broadly divided into static and low frequency electric and magnetic fields, where the common source includes power lines, household electrical appliances, computers and high-frequency or radio-frequency fields for which the main source are radar, radio and television broadcast facilities, mobile telephones and their base stations, inductions heaters and anti-theft devices. Low frequency electric fields influence the human body just as they influence any other material made up of charged particles. Low frequency magnetic field induced circulating currents within the human body (World Health Organization (WHO), 2019; Olorufemi et al, 2016).

Electromagnetic fields in the radio-frequency range are used for telecommunications applications,

including cell phones, televisions, and radio transmissions. The frequency of radio-frequency electromagnetic radiation ranges from 30 kilohertz (30 kHz, or 30,000 Hz) to 300 gigahertzes (300 GHz, or 300 billion Hz). One of the main characteristics that define an electromagnetic field is its frequency or its corresponding wavelength. The greater the frequency, the shorter the wavelength and the greater the energy transmitted. Fields of different frequencies interact with the body in different ways. The mobile phones emit 900MHz electromagnetic radiation, this radiation is in RF spectrum and may be absorbed by the various body organs according to the places where they are carried (Ozguner *et al.*, 2005; Oktem *et al.*, 2005).

Exposure to electromagnetic radiation via cell phones is almost inevitable. However, during the 20$^{th}$ century, environmental exposure to man-made electromagnetic fields has been steadily increasing as growing electricity demand, ever-advancing technologies and changes in social behavior have created more and more artificial sources. Everyone is exposed to a complex mix of weak electric and magnetic fields both at home and at work, from generation and transmission of electricity, domestic appliances and industrial equipment to telecommunications and broadcasting (Kottou et al., 2014). This study therefore seeks to determine the electromagnetic radiation emitted from the front and back side of different brand of cell phones (ITEL, INFINIX and TECNO) when charging, fully charged and at low charge with the phones being operated at call mode, text mode and standby mode.

## Materials and Methods

### *Study area*

The study was carried out in Mubi - a town in the northern part of Adamawa state northeastern Nigeria. It is a commercial city where the famous international cattle market is located, is the home to the state university, Adamawa State University, College of Health Technology and the Federal Polytechnic. It occupies an area of 192,307 km$^2$ and has a population of about 260,009 people (National Population Commission, 2006). It lies on the west bank of the Yedzeram River, a stream that flows north into Lake Chad, and is situated on the western flanks of the Mandara Mountains.

The materials used in carrying out this research are electromagnetic radiation taster (version 9024-EN-00) and a 1m measuring ruler. The electromagnetic radiation tester (Fig. 1) is an instrument used for detecting both electric field and magnetic field radiation. It's widely used to test and learn electromagnetic radiation situation indoor and outdoor.


**Figure 1:** 9024-EN-00 Electromagnetic radiation tester.

Broadband method was employed in taking measurements in this research work. The electromagnetic radiation tester is a broadband device for monitoring frequency radiation in the range of 5Hz to 3500MHz and electromagnetic field strength of 1V/m-1999V/m and 0.01μT-99.99μT respectively. The meter measures the value of the electric field E in V/m and magnetic flux density B in μT at the same time.

Three different brands of most frequently used cell phones [TECNO (K9), ITEL (1516 Plus) and INFINIX (Hot 6) phones] were use in this study. To measure the radiation emitted by these phones, the instrument is held with one hand to make the inductive zone at front end get closer to the electromagnetic radiation source to be tested slowly, the LCD digital screen display the radiation values after being processed by a control micro-chip.

Readings were taken when the cell phone battery is fully charged (95-100%), when the charge on the phone battery is low (5-15%) and when the phones are charging. All measurements were taken with the tester touching the surface (i.e at 0cm) of the front and back side of the phones at call mode, text mode, and standby mode and at a distance of 0cm to 40cm away from the tester.

***Theory***

Electromagnetic radiation consists of waves of electric and magnetic energy moving together (i.e., radiating) through space at the speed of light. Electric fields are associated only with the presence of electric charge, whereas magnetic fields are the result of the physical movement of electric charge (electric current). An electric field, E, is expressed in volt per meter (V/m), while the magnetic field can be specified in two ways as magnetic flux density, B, expressed in tesla (T), or as magnetic field strength, H, expressed in ampere per meter (A/m). The two quantities are related by the expression (International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, 2010);

$$B = \mu H \qquad \text{(i)}$$

Where μ is the constant of proportionality (the magnetic permeability); in vacuum and air, as well as in non-magnetic (including biological) materials, μ has the value $4\pi \times 10^{-7}$H/m. Thus, in describing a magnetic field for protection purposes, only one of the quantities B or H needs to be specified.

At radio and microwave frequencies, electric and magnetic fields are considered together as two components of electromagnetic wave. The intensity of these fields at a given location can be readily expressed in terms of a power unit relative to area (power density) in watts per square meter ($W/m^2$). In the far field region, the plane-wave model is a good approximation of the electromagnetic field propagation. The power density, S, in this region is related to the electric and magnetic fields by the expression (United State Department of Labour, 1990);

$$S = E_{rms} x H_{rms} \qquad \text{(ii)}$$

$E_{rms}$ is the root mean square (RMS) electric field strength in V/m

$H_{rms}$ is the root mean square (RMS) magnetic field strength in A/m

Where

$$E_{rms} = \frac{E}{\sqrt{2}} \; and \; H_{rms} = \frac{H}{\sqrt{2}} \qquad \text{(iii)}$$

**Results and Discussion**

The wave power density was computed as a function of modes (call mode, text mode and text mode) for all the phone models when fully charged and when at low battery. Further computation of the power density was done as a function of distance from the test phone when charging. All the computed values are done for the front and back side of the phones. Results of the computation are presented in Table 1 – 9 with B being converted to H using equation (i) and their corresponding S using equation (ii). The rms value for the E and H-field were calculated using equation (iii).

**Table 1:** Values of electromagnetic radiation emitted by ITEL phone when battery is fully charge

| | | Back side | | | Front side | | |
|---|---|---|---|---|---|---|---|
| S/N | Mode | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) |
| 1 | Call mode | - | - | - | 245.366 | 0.075 | 18.499 |
| 2 | Text mode | - | - | - | 231.223 | 0.026 | 6.114 |
| 3 | Standby mode | - | - | - | 233.345 | 0.015 | 3.545 |

**Table 2:** Values of electromagnetic radiation emitted by ITEL phone at low battery charge

| | | Back side | | | Front side | | |
|---|---|---|---|---|---|---|---|
| S/N | Mode | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) |
| 1 | Call mode | - | - | - | 268.701 | 0.126 | 33.864 |
| 2 | Text mode | - | - | - | 264.458 | 0.083 | 21.872 |
| 3 | Standby mode | - | - | - | 278.601 | 0.019 | 5.486 |

**Table 3:** Values of electromagnetic radiation emitted by ITEL phone when charging.

| | | Front side | | | Back side | | |
|---|---|---|---|---|---|---|---|
| S/N | Distance from phone (cm) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) |
| 1 | 0 | 1414.213 | 0.643 | 910 | 1414.214 | 0.693 | 980 |
| 2 | 5 | 217.789 | 0.354 | 77 | 258.094 | 0.198 | 51.1 |
| 3 | 10 | 166.170 | 0.106 | 17.625 | 135.057 | 0.156 | 21.01 |
| 4 | 15 | 137.886 | 0.085 | 11.7 | 91.924 | 0.127 | 11.7 |
| 5 | 20 | 81.317 | 0.071 | 5.75 | 53.033 | 0.084 | 4.5 |
| 6 | 25 | 63.639 | 0.042 | 2.7 | 42.426 | 0.042 | 1.8 |
| 7 | 30 | 31.113 | 0.028 | 0.88 | 31.114 | 0.028 | 0.88 |
| 8 | 35 | 20.506 | 0.007 | 0.145 | 14.142 | 0.014 | 0.2 |
| 9 | 40 | - | - | - | - | - | - |

**Table 4:** Values of electromagnetic radiation emitted by TECNO when battery is fully charged

| | | Back side | | | Front side | | |
|---|---|---|---|---|---|---|---|
| S/N | Mode | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) |
| 1 | Call mode | - | - | - | 176.069 | 0.075 | 13.274 |
| 2 | Text mode | - | - | - | 173.241 | 0.026 | 4.581 |
| 3 | Standby mode | - | - | - | 256.679 | 0.015 | 3.899 |

**Table 5:** Values of electromagnetic radiation emitted by TECNO phone at low battery charge

| | | Back side | | | Front side | | |
|---|---|---|---|---|---|---|---|
| S/N | Mode | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) |
| 1 | Call mode | - | - | - | 23.348 | 1146.756 | 33.864 |
| 2 | Text mode | - | - | - | 14.854 | 478.393 | 21.872 |
| 3 | Standby mode | - | - | - | 3.091 | 30.097 | 5.486 |

**Table 6:** Values of electromagnetic radiation emitted by TECNO phone when charging.

| | | Front side | | | Back side | | |
|---|---|---|---|---|---|---|---|
| S/N | Distance from phone (cm) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) |
| 1 | 0 | 1414.213 | 0.424 | 600 | 1414.213 | 2.468 | 3490 |
| 2 | 5 | 332.340 | 0.141 | 47 | 387.494 | 0.134 | 52.06 |
| 3 | 10 | 183.848 | 0.127 | 23.4 | 229.809 | 0.099 | 22.75 |
| 4 | 15 | 148.492 | 0.106 | 15.75 | 182.433 | 0.071 | 12.9 |
| 5 | 20 | 85.559 | 0.071 | 6.05 | 128.693 | 0.064 | 8.19 |
| 6 | 25 | 66.468 | 0.057 | 3.76 | 81.317 | 0.042 | 3.45 |
| 7 | 30 | 29.698 | 0.021 | 0.63 | 44.547 | 0.028 | 1.26 |
| 8 | 35 | 26.163 | 0.007 | 0.185 | 29.698 | 0.007 | 0.21 |
| 9 | 40 | - | - | - | - | - | - |

**Table 7:** Values of electromagnetic radiation emitted by INFINIX phone when battery is fully charge

| | | Back side | | | Front side | | |
|---|---|---|---|---|---|---|---|
| S/N | Mode | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) |
| 1 | Call mode | - | - | - | 516.188 | 0.075 | 38.916 |
| 2 | Text mode | - | - | - | 633.567 | 0.026 | 16.754 |
| 3 | Standby mode | - | - | - | 596.798 | 0.015 | 9.065 |

**Table 8:** Values of electromagnetic radiation emitted by INFINIX phone at low battery charge

| | | Back side | | | Front side | | |
|---|---|---|---|---|---|---|---|
| S/N | Mode | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) |
| 1 | Call mode | - | - | - | 704.278 | 0.126 | 88.758 |
| 2 | Text mode | - | - | - | 674.579 | 0.082 | 55.791 |
| 3 | Standby mode | - | - | - | 639.224 | 0.019 | 12.587 |

**Table 9:** Values of electromagnetic radiation emitted by INFINIX phone when charging.

| | | Front side | | | Back side | | |
|---|---|---|---|---|---|---|---|
| S/N | Distance from phone (cm) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) | $E_{rms}$ (V/m) | $H_{rms}$ (A/m) | S ($W/m^2$) |
| 1 | 0 | 1414.213 | 0.247 | 350 | 1414.213 | 0.763 | 1080 |
| 2 | 5 | 394.565 | 0.091 | 36.27 | 452.548 | 0.155 | 70.4 |
| 3 | 10 | 246.073 | 0.077 | 19.14 | 239.002 | 0.134 | 32.11 |
| 4 | 15 | 183.847 | 0.063 | 11.7 | 201.525 | 0.106 | 21.375 |
| 5 | 20 | 106.773 | 0.049 | 5.285 | 144.956 | 0.084 | 12.3 |
| 6 | 25 | 78.488 | 0.042 | 3.33 | 98.994 | 0.056 | 5.6 |
| 7 | 30 | 57.275 | 0.028 | 1.62 | 62.225 | 0.035 | 2.2 |
| 8 | 35 | 33.941 | 0.007 | 0.24 | 29.698 | 0.014 | 0.42 |
| 9 | 40 | - | - | - | - | - | - |

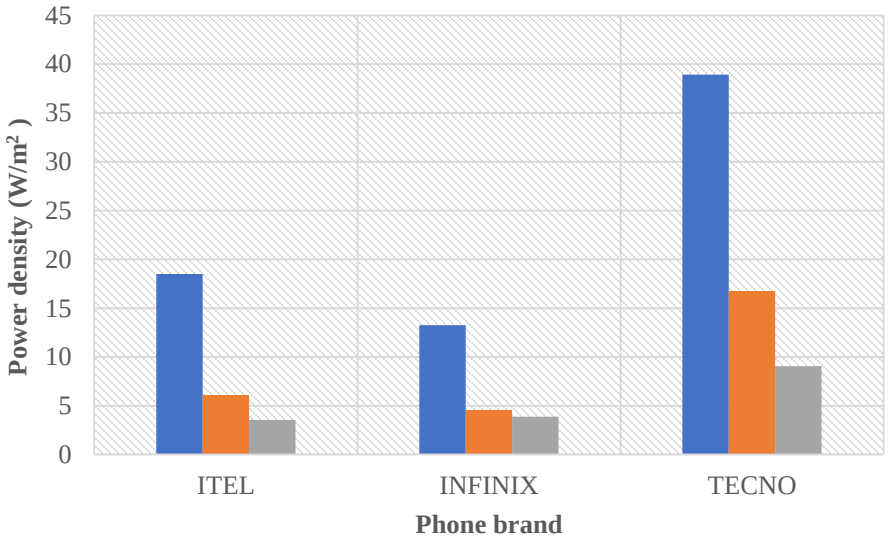


**Figure 2:** Variation in the wave power densities when battery is fully charged (95-100%)

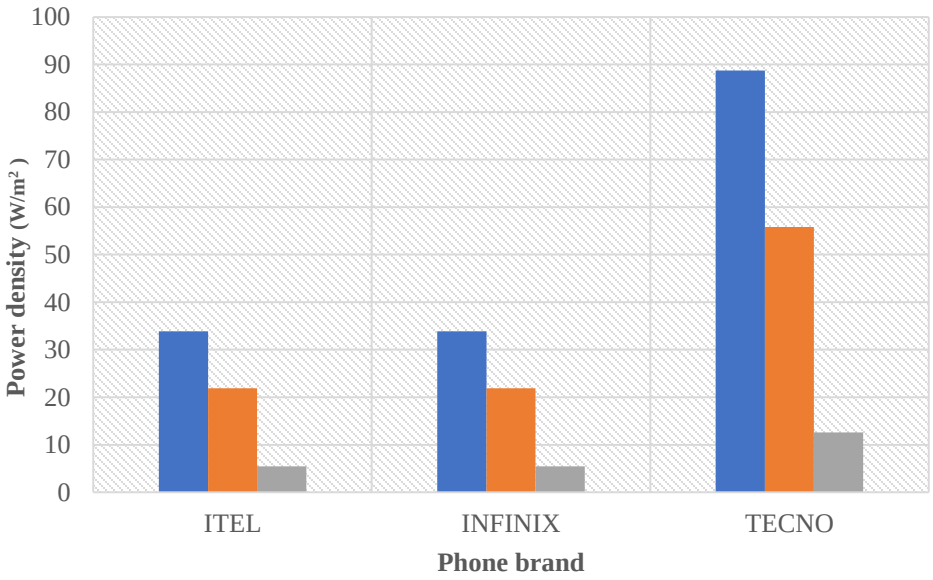


**Figure 3:** Variation in the wave power densities when battery is at low charged (5-15%)

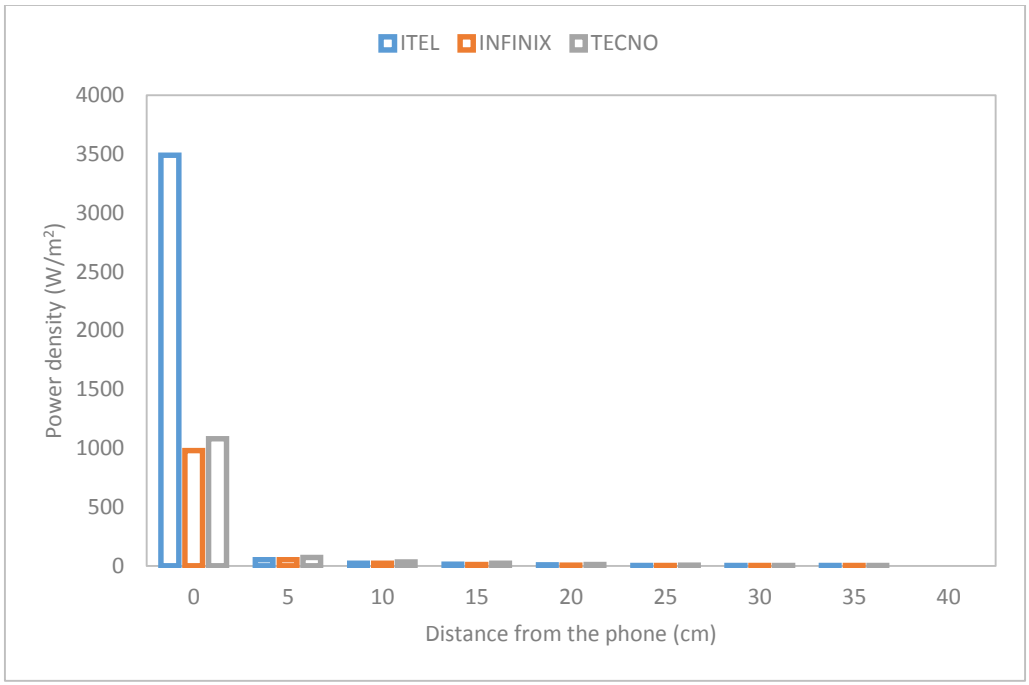


**Figure 4:** Variation in the wave power densities with distance when charging (back side)

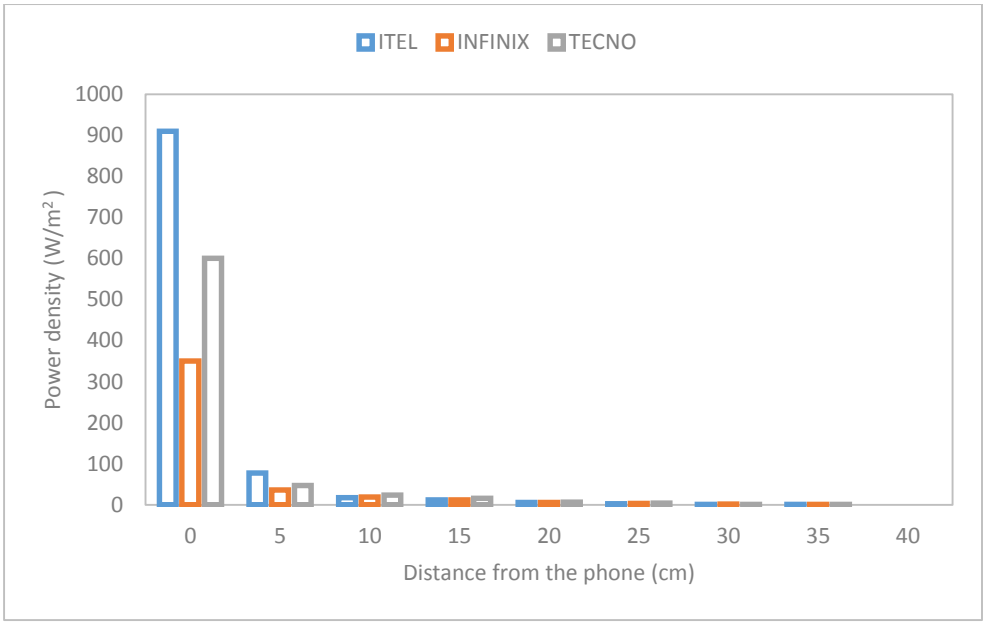


**Figure 5:** Variation in the wave power densities with distance when charging (front side)

Table 1, 4 and 7 is the result of the calculated wave power density obtained on the front and back sides of ITEL, INFINIX and TECNO phone respectively at call mode, text mode and standby mode when the phone is fully charged i.e at 95 – 100%. The result show that there is little or no radiation in front of all the phone when it is fully charged and placed in any of the three modes. The back side of the phones exhibit different values of the radiation intensity. Figure 2 show a bar chart of the back side of the three phones

when fully charged, the result shows that the call mode has the highest intensity followed by the text mode and finally the standby mode for all the three phones.

Table 2, 5 and 8 is the result of the calculated wave power density obtained on the front and back sides of ITEL, INFINIX and TECNO phone respectively at call mode, text mode and standby mode when the phone battery is low i.e at 5 – 15%. The result also shows little or no radiation in the front side of all the phones when placed in any of the three modes. The back side of the phones exhibit different values of the radiation intensity for the three phones as can be seen in figure 2. The call mode has the highest intensity followed by the text mode and finally the standby mode for all the three phones. A comparison between when the phones are fully charged and when they are at low battery show that the intensity of radiation is higher when the phones are at low battery than when fully charged for all the different mode experimented.

Table 3, 7 and 9 is the result of the front and back sides of the three phones when charging. The result shows that all the two sides exhibit radiation when charging, with the back side exhibiting higher values than the front side. The intensity of variation on both side is highest at 0cm i.e when the instrument is placed in contact with the test phone. It also shows an expected decrease in the power density as one moves farther away from the reference source until at 40cm when it shows little or no radiation at all for all the three brands of phones. Usman *et al* (2009), in a research paper "Wireless Phones Electromagnetic Field Radiation Exposure Assessment" using isotropic probe electric field meter (kept at 5cm away from the phones) which measures the frequency range of 100KHz-3GHz and electrical field strength of 10mV/m-100V/m finds that the highest and lowest readings are at 53.40 and 15.20V/m, as demonstrated by the different brands of phone used in the work.

**Conclusion**

The electromagnetic radiation emitted from the different cell phones used in this work was computed in terms of wave power density. The wave power density was determined for each phone brand when operating in call mode, text mode and standby mode with the phone battery fully charged and at low battery. Further computation of the power density was done as a function of distance from the test phones when charging. Result of the study shows that there is little or no radiation on the back side of all the phones when placed in any of the mode (call, text and standby) when either fully charged or at low battery. The front side of the phones exhibit different values of the radiation intensity. With the call mode having the highest intensity followed by the text mode and finally the standby mode. A comparison between when the phones are fully charged and when they are at low battery show that the intensity of radiation is higher when the phones are at low battery than when fully charged for all the different mode experimented. The wave power density levels also significantly varied with distance up to 40cm when there is little or no radiation from all the phones.

Various limit guidelines exist for exposure to radio frequency electromagnetic field by different countries based on either thermal effects, non-thermal effects and precautionary consideration. The limit varies from $<1 – 600 mW/cm^2$ for different countries (Physician for Safe Technology, 2016). There is no doubt that mobile phone technologies are beneficial, however, the electromagnetic radiation emanating from it constitute a potential health hazard on the user, zero radiation emission cannot be achieved from the technological world. The limit of exposure could not be established in this work, but the intensity of electromagnetic radiation emitted from the front and back side of the different brands of phone used in this work was determined with the back side having the highest emission. It is now difficult to deny the fact that all population or individual are exposed to varying degrees of electromagnetic radiation and the levels might continue to increase as technology advances. Biological effect depends on how much of the energy is absorbed in the body of a living organism, not just what exits in space (Levitt and Lai, 2010).

**References**

International Commission on Non-Ionizing Radiation Protection (ICNIRP). (2010) Statement on the "Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic fields (1Hz to 100 KHz)

Kottou, S., Nikolopoulos, D., Efstratios, V., Dionysios, K., Ermioni, P., and Panayiotis,

H. (2014) How safe is the environmental electromagnetic radiation. vol. 4 p 5

Levitt B.B and Lia H (2010). Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ. Rev. Vol 18 pp 369-395.

Physician for Safe Technology (2016). Wireless exposure in different countries. Available from http//: MDSafeTech.org. (Accessed July, 2020).

National Population Commision (2006). Nigerian population census report, 2006.

Oktem, F., Ozguner, F., Mollaoglu, H., Koyu, A., and Uz, E. (2005). Oxidative damage in the kidney induced by 900 MHz-emitted mobile phone: Protection by melatonin. Arch. Med. Res., vol. 36 pp 350-355

Olorunfemi, E., Ojo, J., Aboyeji, O.S, Akeju, M., and Okezie, C. (2016). Determination of electromagnetic radiation levels from cell phones and gsm masts in ile-ife, southwest Nigeria. vol. 18 pp 1044-1046

Ozguner, F., Oktem F., Ayata A., Koyu, A., and Yilmaz, H.R., (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-β-D-glucosaminidase and nitric oxide determination. Mol. Cell. Biochem., vol. 277 pp 73-80

United State Department of Labour (1990). Electromagnetic radiation and how it affects your instruments. OSHA Publication. Retrived 09-05-2010.

Usman A.D, Wan Ahmad W.F, Ab Kadir M.Z.A and Mokhtar M (2009): Wireless Phones Electromagnetic Field Radiation Exposure Assessment. American J. of Engineering and Applied Sciences 2 (4): 771-774.

World Health Organization, WHO (2019). Electromagnetic fields and public health: mobile phones www.who.int