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Analysis and Comparison of Mobile Phones Radiofrequency Radiation for Potential Hazard at Different Battery Levels

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Abstract

Mobile or cellular phones are now an integral part of modern telecommunications which has become an addiction to the present generation. These mobile phones emit radiation as it is being carried about by the user which is a function battery level. There are have been scientific debates on the adverse effect of radiofrequency radiation increase on human health. Most towns within the developing countries have inadequate power supply thereby causing their mobile phones to run on low battery levels. This study investigates, compares and analyse radiofrequency radiation emitted by the commonly used mobile phones (iPhone, Samsung and Tecno) at different battery levels (< 5%, < 15 %, 25 %, 35 %, 45 %, 55 %, 65 %, > 75%). The radiofrequency (RF) radiation components (electric field (V/m) and magnetic field (A/m)) emitted by these mobile phones were measured at close range using Extech radiofrequency meter, and the overall power flux density (μW\m²) of the radiation were calculated using the Poynting theorem. It was found that the radiofrequency radiation is a function of battery level, the radiation increases with a decrease in battery level with critical radiation below 15% battery level. iPhone was found to emit the highest radiation as battery level drops, follow by the Samsung Phone and the least power flux density of the radiation recorded in the Tecno phone. The relatively safe battery level was found beyond 25 % (that is. above one-quarter of a fully charged system). Base on this study results, it is recommended that maximum body contact should be avoided especially at battery level below 15%, cell phone headsets should be encouraged and usage of mobile phones should be discontinued at a very low battery level of less than 5% to prevent any adverse effect such as heating effect, Alzheimer, migraine, infertility, eye defect, insomnia and cancer.

Keywords: Radiofrequency radiation, Base station, Potential hazard

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1. Introduction

Among the latest and fastest-growing technology of the 21st century is the Global System for Mobile communications (GSM), which is a network for bilateral communication between users with the use of mobile phones (wireless devices). These cellular communication networks are connected by radio waves through a local antenna in the cell operate within an instantaneous frequency band (sub-divided into GSM spectrum for 2G (900/1800 MHz spectrum), UMTS region for 3G, 4G and now 5G (600 – 850 MHz for low band 5G, 25 – 35 GHz for high band 5G near the bottom of the millimetre wave band) (Adekunle et al., 2015). All these are still within the radiofrequency (30 Hz to 300 GHz) range in the electromagnetic spectrum where the communication is established artificially between transmitters and receiver of radio waves using mobile phones and base station (Sudan et al., 2016; Foerster et al., 2018). This function makes mobile phones an integral and essential instrument of passing information between users at different location even within megacities and rural areas.

With the present urbanization in the world today, the users of mobile communication devices have grown up to five (5) billion out of a total estimated population of around 7.4 billion, this resulting development regarding communication and user has shifted the attention of researchers towards the hazard that might be associated with these global devices and protocol in terms of health safety (Ayimode and Farai, 2012).

Mobile communication devices have become an integral part of our daily lives, these devices (mobile phones) now serves as radiofrequency radiation sources that move with us everywhere. Despite the fact that radio waves are non-ionizing radiation, but there is evidence of a heating effect when radio waves are absorbed, with this heating effect becomes significant at low battery level of the mobile phones (Ayimode and Farai, 2012). But there is limited evidence of the nonthermal effect of the radiation on humans and animal as disseminated by the International Agency for Research on Cancer (IARC), 2019).

Evidence of heating effect when radio waves are absorbed, with this heating effect becomes significant at low battery level of the mobile phones

It was said that there is insignificant proof regarding the association of radiofrequency emitted from a mobile phone with an ailment such as cancer (Baan et al., 2014), but this heating effect and emitted radiation level are suspected to have a hypothetical relationship with the battery level on the mobile phones.

Because of long term exposure to RF radiation, some researchers are beginning to relate human safety with mobile phone radiation, among the health threats are migraine, cancer, infertility, congenital abnormalities and so on. This is in line with global bodies with the hypothesis that radiofrequency majorly affects the eyes through optical transmittance and testes as a result of thermal interaction with these areas of the body with insufficient transportation of blood for thermal load dissipation (Hyland, 2000; ICNIRP, 2020 2005; Divan et al., 2008).

The potential hazard of radiofrequency has also been linked to women with pregnancy and this is through the use of mobile phones, exposing the embryo or various stages of foetus development to health risk. Since these radio waves interact with the eyes and the radiation can be transmitted during the process of sharing the information between optical nerves and the brain, thereby extending the risk to the human brain making it vulnerable to neurological manipulation (Dolk et al., 1997; Loque et al., 2004).

Base on the study of Walsh et al. (2018) on the radiation exposure with rodents as a sample to imitate human exposure, there has been a sufficient increase of some malignant gliomas, schwannomas, alteration of chromosomal DNA.

Mobile phone technology relies on the transmission of radiofrequency (RF) signal which generates electromagnetic fields (EMF).

There is a tremendous increase in the number of base stations and use of cell phone worldwide including developing countries in Africa such as Nigeria. These base stations and cell phones emit radiofrequency electromagnetic fields (Bashir et al., 2018).

With the above mentioned hypothetical relationship between RF radiation as a function of battery level based on the literature, then this study would compare the radiation level of commonly used mobile phones at the different battery level.

The motivation for this study is that an average citizen of metropolitan cities/town such as Ilaro in developing countries like Nigeria is suffering from the inadequate and unstable power supply for their electronic gadgets operation which includes mobile phones, therefore their mobile phones operate at low battery level most times and emit continuous radiofrequency radiation. This study investigates the relationship between battery level and radiofrequency radiation of the most commonly used mobile phones (iPhones, Samsung and Tecno).

This study identifies commonly used mobile phones by survey within Ilaro town and uses them as sources of radiofrequency radiation. Extech 48036 RF meter would be used to measure the radiofrequency radiation from the acquired mobile phones at the different battery level. These radiations would be compared and analysed for a potential hazard on the user.

2. Materials and Methods

Materials

The materials used for carrying out this study are listed

The Meter rule was used to measure the distance of the mobile phones from the rf meter to ensure equidistance and avoid a relative error.

Mobile Phones: Three different and commonly used mobile phones (Tecno, Samsung and iPhone) as shown in Figure (1 a, b and c) based on the survey result in Ilaro, Ogun state.

Phone Stand: this is to hold the mobile in a specific orientation and position.

Extech Radiofrequency meter was used to measure the radio waves emitted by three different phones (Tecno, Samsung and iPhone) in terms of power flux density as shown in Figure (1 d). The general specification of the RF meter and capability is indicated in Table (1) under which the device was utilized for data capturing

Table 1: General Specification of Extech 480836 rf Radiation Meter

	Specifications	Capacity
	Measurement methods:	Digita, Triaxial measurement
	Directional characteristics:	Isotropic, Triaxial
	Measurement Ranges	One continuous range
	Display Resolution:	0.1mV/m, 0.1uW/m^2, 0.001uW/cm^2
	Display Value	Instantaneous measured value, maximum value, or maximum average value
	Manual data memory and read storage	99 data sets.
	Operating Temperature Range	0ºC to +50ºC

(a) **(b)** **(c)** **(d)**

Figure 1: Commonly used mobile phones (a) Tecno (b) iPhone (c) Samsung and (d) Extech rf meter

Methods/Procedure

After acquiring all the necessary tools and instrument that would enhance accurate result.

- The experiment was carried out in a closed system by turning off all appliances/gadget that constitutes any background radio waves radiation or noise (Computers, Cell phones, Tablets, Wi-fi).
- A distance of 2 cm was measured between the RF meter and mobile phone stand; this is to imitate the closeness of the phone to the user in most cases.
- The Extech rf meter was set up and background radiofrequency was measured and recorded.

- The distance between the rf meter and mobile phone on the phone stand were maintained at 2 cm apart. Electromagnetic components were measure in terms of electric field and magnetic field at different battery level (< 5%, <15, 25, 35, 45, 55, 65, 75) % for the three mobile phones.
- Radiation power flux density was calculated from the electric and magnetic field components using the Poynting theorem (Isabona and Odesanya, 2015).

$$P_d = E \times H \quad (1)$$

where P_d is power flux density expressed in watt per metre squared (μW\m²), E, electric field strength in volt per meter (V/m), H, magnetic field strength in Ampere per meter(A/m).

- The results were tabulated for analysis and comparison.

3. Results

Radiation Level of Different Mobile Phones

The background radiofrequency radiation was found to be less than 10 μW/m² in the laboratory where the experiment was carried out.

Measurements were taken on the three (3) mobile phones at their different battery levels ranging (< 5%, <15, 25, 35, 45, 55, 65, 75). The calculated power flux density from the electric and magnetic field components using the Poynting theorem is tabulated (Table 2) as a function of battery levels on a percentage scale.

Table 2: Radiation Level of different Phones at various Battery Level

S/N	Battery Level (%)	RadiationLevel (μW/m²) **Tecno**	RadiationLevel (μW/m²) ***i*Phone**	RadiationLevel (μW/m²) **Samsung**
1	<5	673.00	1801.00	780.00
2	<15	611.00	1700.70	692.50
3	25	206.00	900.70	490.10
4	35	180.50	850.50	426.00
5	45	172.80	835.00	407.10
6	55	170.20	807.00	399.10
7	65	163.70	795.00	398.10
8	75	152.70	787.80	381.20

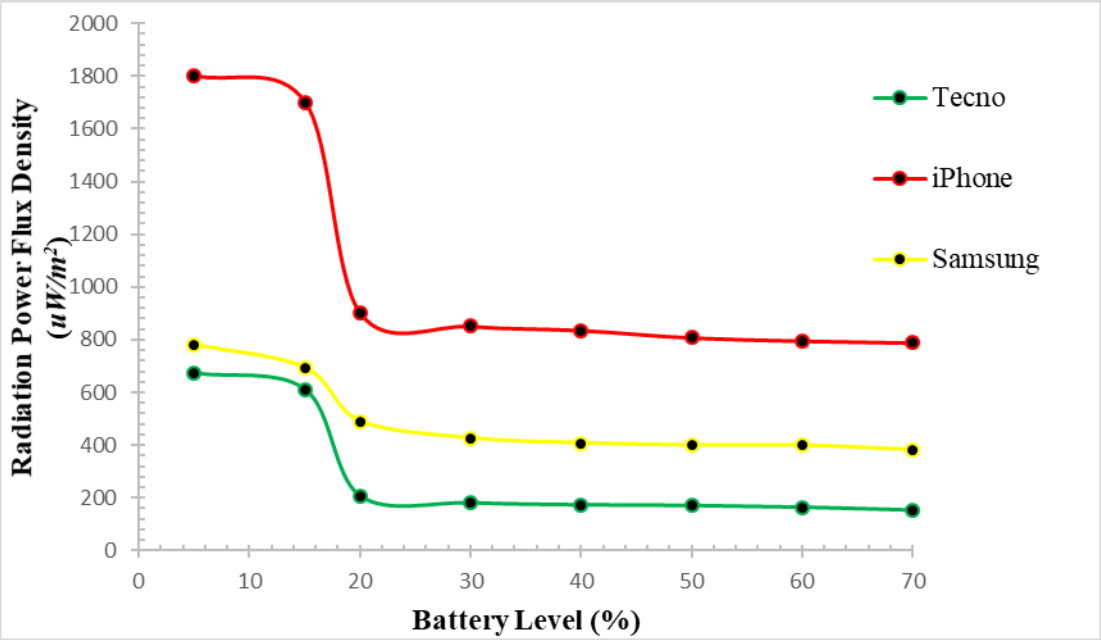

Figure 2: Radiation Level Profile as a Function of Battery Level

4. Discussion

Base on the results obtained during the experiment, the comparison among the radiation level of these mobile phones is explored using the graphical analysis of Figure 2.

It was found that the magnitude of radiation strongly depends on the battery level. As the battery percentage reduces for the three mobile phones, the level of radiofrequency radiation increases with the sharpest peak around battery level less than 15%. This simply implies a critical radiation level which is in agreement with the mobile phone manufacturers alarm or indication system at a battery level less than 15 and 4% respectively. It can also be associated with the reason why most mobile phones shut down at this critical level (4%) to prevent the user from being exposed to radiation beyond safety and recommended limit.

Therefore, from the results of this study the moderate level of radiofrequency radiation corresponds with the battery level greater than or equal to 25% which is found to be one-quarter and above of the fully charged mobile phones, beyond this region the system would be at steady-state and radiate within the specific absorption radiation rate.

Comparing the three commonly used mobile phones (Tecno, Samsung and iPhone) base on their relative radiation level, it was observed that the iPhone shows the highest level of radiation at any point in time as the battery level varies follow by Samsung phone and the least radiation was recorded in Tecno phone.

This variation can be attributed to the sophistication level in the mobile phones operating system since phones have been developed beyond making calls only, some applications are peculiar to the different mobile proprietor. Many users have reasons for going for a particular mobile phone, some prefer network service acquisition, processing speed, camera or sound quality, battery life span and many more. But all these facilities preferences come with a trade-off either in finance or sophistication, and this explains why iPhone emits the highest radiofrequency radiation because of the special design to handle network problem even in a remote area with an insignificant level of network service.

The Tecno phone emits the lowest radiation as its level of sophistication cannot be compared to that of Samsung and iPhone, but this device is relatively safe in terms of the radiofrequency radiation-related potential hazard.

5. Conclusion

This study was carried out to evaluate and compare the radiofrequency radiation level from the most commonly used mobile using Extech radiofrequency meter.

The radiation power flux density was calculated from the electric and magnetic field components of radiofrequency electromagnetic waves, these measurements were done at different battery level (< 5, < 15, 25, 35, 45, 55, 65, 75 %) to establish the relationship between radiofrequency radiation and battery level for three most commonly used mobile phones (Tecno, Samsung and iPhone) in Ilaro.

It was observed in the results of this study that radiofrequency radiation level is a function of battery level, mobile phones generate critical or highest rf radiation for battery level below 15% and devices are found to be relatively safer at a steady battery level state (i.e. above 25%). It can be concluded that the radiofrequency radiation level is exponentially inversely proportional to battery level with different critical point around 15% of battery level.

Based on the findings in this study, it is recommended that maximum body contact should be avoided especially at battery level below 15%, and cell phone headsets should be encouraged.

Usage of mobile phone should be discontinued at a very low battery level of less than 5% to prevent any adverse effect such as heating effect, Alzheimer, migraine, infertility, eye defect, insomnia.

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