CHARACTERIZATION OF RADIOFREQUENCY POWER DENSITY EMISSIONS FROM MOBILE PHONES

BY

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ND/23/SLT/PT/0363

BEING A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF SCIENCE LABORATORY TECHNOLOGY, INSTITUTE OF APPLIED SCIENCES (IAS), KWARA STATE POLYTECHNIC, ILORIN, KWARA STATE

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF NATIONAL DIPLOMA (ND) SCIENCE LABORATORY TECHNOLOGY

JULY, 2025

CERTIFICATION

This is to certify that this project has been read and approved as meeting part of the requirements for the award of National Diploma (ND) in Science Laboratory Technology in the Department of Science Laboratory Technology, Institute of Applied Sciences (IAS), Kwara State Polytechnic, Ilorin.

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DEDICATION

This project is dedicated to Almighty GOD, The First and Last, protects my life throughout all my ND program and my parents MR. & MRS. SULAIMON for their blessing over me.

ACKNOWLEDGEMENTS

All Glory and Adoration belongs to God Almighty for the success of my ND program through thick and thin. He made this course a reality for me, I also want to acknowledge the support of my parent because without God and my parent am nobody, they have been so supportive financially, physically, spiritual aspect throughout the course of the study.

My sincere Appreciation goes to my supervisor (MR. ZAKARI A.) for taking time to read and correct the manuscript and to my Head of Department of Business Administration and Management (HOD) DR. ABDULKAREEM USMAN and other lectures in Department of Business Administration and Management.

My profound gratitude to my parent; MR. & MRS. SULAIMON, may Almighty God bless you abundantly.

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ABSTRACT

This study investigates the levels of radiofrequency (RF) radiation emitted from commonly used mobile phones Infinix, Samsung, and Tecno among students of Kwara State Polytechnic, Ilorin. Using a handheld 3-axis RF meter, measurements were taken in both active and passive modes to determine the power density (PD) of RF radiation. The results revealed that while Infinix phones recorded the highest PD values, all phones remained within the safe exposure limits set by the Federal Communications Commission (FCC). Although RF radiation from mobile phones is non-ionizing, prolonged exposure may cause minimal heating effects, particularly around the brain, which could pose long-term health risks. However, based on current measurements, students using these devices are not exposed to harmful levels of radiation. The study underscores the importance of continued monitoring and public awareness of potential long-term exposure risks.

Keywords: Radiofrequency radiation, power density, mobile phones, non-ionizing radiation

CHAPTER ONE

INTRODUCTION

1.1 Background

The rapid evolution and widespread adoption of mobile phones have drastically transformed communication practices, providing users with instant access to others and enabling convenience in various aspects of daily life (Razzaq et al., 2017). Mobile communication has become an integral part of modern existence, facilitating both personal and professional interactions. However, this growing reliance on mobile devices has raised increasing concerns about their potential health implications, particularly due to the emission of radiofrequency (RF) radiation. Although RF radiation is non-ionising and generally less intense compared to ionising radiation such as X-rays or gamma rays, its consistent exposure through everyday mobile phone use has sparked questions about its potential effects on human health (Akhila et al., 2023).

RF radiation is a form of electromagnetic energy with lower frequencies and longer wavelengths. It is commonly used in wireless communication technologies, including mobile phones, to facilitate connectivity with cellular network towers. During typical mobile phone activities such as voice calls, text messaging, internet browsing, and media streaming, RF radiation is emitted from the device and absorbed by the user's body, especially when the device is in close proximity to the head or torso.

Numerous scientific studies have been conducted to assess the potential health risks associated with prolonged exposure to RF radiation from mobile phones. While the scientific community has not reached a definitive consensus, and results remain somewhat inconclusive, certain research has suggested possible links between RF radiation exposure and adverse health effects. These include increased risks of neurological conditions such as brain tumors, alterations in brain activity, reproductive health issues, and other physiological disturbances.

In response to these concerns, the International Agency for Research on Cancer (IARC), a specialized agency of the World Health Organization (WHO), has classified RF radiation as Group 2B—possibly carcinogenic to humans. This classification was based on limited evidence indicating a potential connection between RF radiation exposure and specific types of brain cancers (Meena et al., 2016). Despite this, health experts continue to call for more extensive research to establish definitive conclusions, as current findings remain inconclusive.

To address these uncertainties and protect public health, regulatory bodies worldwide have developed guidelines and safety thresholds for RF radiation exposure from mobile phones. These regulations, which may vary across countries, typically focus on the concept of Specific Absorption Rate (SAR)—a measure of how much RF energy the body absorbs during mobile phone usage. SAR limits are established to ensure that mobile phones operate within safe exposure levels, reducing potential risks to users.

Given the widespread use of mobile phones among young people, particularly students, it is crucial to examine the extent of RF radiation exposure they may be experiencing and whether these exposure levels align with international safety guidelines. Furthermore, assessing students' awareness and understanding of the potential health risks associated with RF radiation is essential in promoting safer habits and enhancing public health literacy.

This study aims to contribute to existing research by measuring and evaluating the RF radiation levels emitted by commonly used mobile phones among student populations. By providing empirical data on these exposure levels, the research seeks to raise awareness among students, educators, and policymakers. It also aims to encourage the adoption of preventive measures and informed decision-making regarding mobile phone use, ultimately fostering a safer and more health-conscious environment in the context of modern technology.

1.2 Problem Statement

Although mobile phones are ubiquitous among students, there remains a significant gap in understanding the levels of radiofrequency (RF) radiation emitted by these devices and the potential health implications associated with prolonged exposure. While regulatory standards have been put in place to limit RF radiation exposure, it is essential to assess whether these guidelines are being adhered to and whether mobile phones commonly used by students meet safety standards. One of the primary concerns is the lack of recent, focused research specifically examining RF radiation emitted by mobile phones used by students. Many existing studies are limited by small sample sizes, narrow demographic focus, or outdated data that may not reflect current trends in mobile phone usage.

Beyond measuring RF radiation levels, there is also a critical need to assess students' awareness and understanding of the potential health risks tied to long-term exposure. A knowledge gap in this area may impede informed decision-making and the adoption of safer mobile phone usage practices. This study, therefore, aims to provide up-to-date, comprehensive data on RF radiation levels emitted by mobile phones commonly used by students. It will also compare these findings with established regulatory standards to assess compliance. Additionally, the study will examine the level of awareness among students regarding the health risks associated with RF radiation, highlighting areas where targeted educational and public health interventions could be most effective in promoting safer mobile phone usage.

1.3 Research Aim and Objectives

The primary aim of this study is to measure the RF radiation levels emitted by mobile phones commonly used by students and to assess their compliance with regulatory standards. Furthermore, the study seeks to explore the level of awareness and understanding among students regarding the potential health risks associated with RF radiation exposure.

Research Objectives:

1. To measure and analyse the RF radiation levels emitted by mobile phones commonly used by students.
2. To compare the measured RF radiation levels with national and international regulatory standards for RF radiation exposure.
3. To evaluate students' awareness and knowledge of the possible health risks associated with RF radiation from mobile phones.

1.4 Research Questions

1. What are the RF radiation levels emitted by mobile phones commonly used among students?
2. How do the measured RF radiation levels compare with established regulatory standards for RF exposure?

3. What is the extent of students’ awareness and understanding of the potential health risks associated with RF radiation exposure from mobile phones?

1.5 Scope and Limitations

This study focuses on students from the Department of Physics at Kwara State Polytechnic and investigates the radiofrequency (RF) radiation levels emitted by mobile phones commonly used by this group. The research involves measuring and analyzing RF radiation levels from these devices, comparing the results against established national and international regulatory standards. Additionally, the study aims to assess the level of awareness and understanding among students regarding the potential health risks associated with RF radiation exposure. Data collection will be carried out using specialized RF measurement equipment, alongside structured questionnaires to evaluate students' knowledge. The gathered data will be subjected to appropriate statistical analysis to draw meaningful conclusions.

However, the study is subject to certain limitations. The findings may not be generalizable beyond the selected sample, as the research focuses exclusively on students from a single department within one institution. The relatively small sample size may also limit the statistical power and broader applicability of the results. Furthermore, the reliance on self-reported data introduces the possibility of response bias. Variability in the types and models of mobile phones used by participants may also affect the consistency of the measurements. Despite these constraints, the study aims to contribute valuable empirical data and promote awareness of safe mobile phone usage within the student population being studied.

1.6 Significance of the Study

This study is significant in its contribution to the growing body of knowledge on RF radiation levels emitted by mobile phones commonly used by students. By conducting empirical research, it addresses a critical gap in understanding the actual exposure levels students face and the potential health risks associated with regular mobile phone use. The findings will provide evidence-based insights that can support informed discussions surrounding RF radiation and public health.

A key significance of the study lies in evaluating the extent to which the measured RF radiation levels comply with established national and international regulatory standards. By comparing the data with existing safety limits, the study will help determine whether mobile phones used by students fall within acceptable exposure thresholds. This comparison is essential in assessing the adequacy and enforcement of current regulations and may reveal the need for policy reviews or stricter compliance measures.

Equally important is the study's focus on assessing students' awareness and understanding of the health implications of RF radiation. Identifying the level of awareness among students will help uncover knowledge gaps and inform the development of targeted educational campaigns aimed at promoting safe mobile phone usage. This aspect is critical in encouraging behavioral changes and precautionary practices that can reduce unnecessary RF radiation exposure.

Moreover, the findings of this research may influence institutional policies and public health guidelines regarding mobile phone use in educational settings. Empirical data and practical recommendations from the study could serve as a foundation for implementing safety-focused interventions or awareness programs tailored to student populations. Such initiatives would contribute to the creation of safer learning environments and promote student well-being.

Ultimately, the significance of this study lies in its potential to inform, educate, and protect. By combining data-driven analysis with an evaluation of awareness and policy implications, the research aims to empower students, educators, and policymakers to make better-informed decisions about mobile phone usage. This, in turn, would help mitigate the possible health risks associated with RF radiation exposure.

1.7 Definition of Key Terms

1. Radiofrequency (RF) Radiation: It refers to a type of electromagnetic radiation characterized by its relatively low frequency and longer wavelength. RF radiation is emitted by various electronic devices, including mobile phones, as they communicate wirelessly with cellular network towers.

2. Mobile Phones: Also known as cell phones or smartphones, mobile phones are portable electronic devices used for wireless communication. They enable voice calls, text messaging, internet browsing, and various other applications using cellular network connectivity.

3. Regulatory Standards: These are guidelines and limits set by regulatory bodies and governmental organizations to regulate and control RF radiation exposure from mobile phones. These standards define maximum allowable levels of RF radiation emissions to ensure the safety and protection of human health.

4. Awareness: In the context of this study, awareness refers to the understanding and knowledge that individuals possess regarding potential health risks associated with RF radiation exposure from mobile phones. It includes recognizing the existence of these risks and being informed about the safety precautions and guidelines.

5. Compliance: Compliance refers to the extent to which mobile phones adhere to the regulatory standards for RF radiation exposure. It assesses whether the emitted RF radiation levels from mobile phones fall within the acceptable limits specified by the regulatory guidelines.

6. Potential Health Risks: These are the possible adverse effects or harm that may be associated with prolonged or excessive exposure to RF radiation emitted by mobile phones. Such risks may include increased chances of certain health conditions, changes in physiological functions, or other potential impacts on human health.

7. Precautionary Measures: These are actions or practices aimed at minimizing or mitigating potential risks associated with RF radiation exposure from mobile phones. They may include practices such as using hands-free devices, maintaining distance from the phone during calls, limiting usage duration, and following recommended safety guidelines.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Radiofrequency Radiation

Radiofrequency (RF) radiation is a form of electromagnetic radiation that exists in the non-ionizing part of the electromagnetic spectrum (Akhila et al., 2023). Unlike ionizing radiation such as X-rays or gamma rays, RF radiation has lower frequency and longer wavelengths (Thukral et al., 2020). This type of radiation is emitted by a wide range of devices, including mobile phones, wireless communication systems, Wi-Fi networks, broadcast antennas, and radar technologies. In the context of modern communication, RF radiation plays a key role in enabling wireless communication, with mobile phones being one of the primary devices emitting RF radiation to establish and maintain connections with cellular network towers (Gondal et al., 2023). Through these connections, mobile phones support voice calls, text messaging, internet browsing, and various other wireless functions, revolutionizing communication by providing unparalleled convenience and connectivity (Patrick, n.d.).

However, as mobile phones have become ubiquitous in daily life, concerns have surfaced regarding the potential health risks of prolonged exposure to RF radiation (Clegg et al., 2020). Studies examining the effects of RF radiation on human health have yielded mixed and sometimes contradictory results. Some studies suggest a possible link between RF radiation exposure and adverse health effects, including an increased risk of brain tumors, changes in brain activity, fertility problems, and other physiological disturbances (Al-Sahly et al., 2018). Despite ongoing research, no definitive scientific consensus has been reached regarding the risks, underscoring the need for further investigation into the long-term health effects of RF radiation exposure (Clegg et al., 2020).

In response to public health concerns, regulatory bodies and governmental organizations have established guidelines and safety limits to control RF radiation exposure (Al-Sahly et al., 2018). These guidelines, which vary between countries, are typically based on measurements of the specific absorption rate (SAR)—a metric that quantifies how much RF energy is absorbed by the human body during exposure (Donya et al., 2015). Two major organizations, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and

Electronics Engineers (IEEE), have developed guidelines that set SAR value limits and recommend safe usage practices to minimize potential health risks (Donya et al., 2015). It is important to note that while RF radiation exposure from mobile phones is a concern, the levels of RF radiation individuals encounter in their daily environments are generally much lower than those used in laboratory experiments (Donya et al., 2015). The level of exposure is influenced by factors such as the distance from the source of radiation, the power output of the device, and the duration of use.

In conclusion, RF radiation, while essential for enabling wireless communication, has raised concerns about potential health risks. Despite extensive research, a clear scientific consensus on the risks of RF radiation exposure remains absent. Regulatory guidelines have been implemented to ensure safe exposure limits, but ongoing research is crucial to further understanding the long-term effects of RF radiation and refining safety standards to better protect individuals from potential health hazards.

2.2 Effects of Radiofrequency Radiation on Human Health

The effects of radiofrequency (RF) radiation on human health have been a topic of extensive scientific investigation and ongoing debate. While research in this field continues, current findings highlight both potential risks and significant uncertainties surrounding RF exposure.

The primary mechanism through which RF radiation interacts with the human body is thermal in nature, where high levels of RF radiation exposure lead to tissue heating. At extremely high exposure levels—well above what is typically encountered through everyday mobile phone use—this can result in burns or damage to sensitive tissues. However, these thermal effects are generally not a concern under normal usage conditions, as mobile phones and other common RF-emitting devices typically operate within safe exposure limits.

Beyond thermal effects, there is growing interest in the potential non-thermal effects of RF radiation. Some studies have proposed that RF radiation could influence biological systems through mechanisms other than heat. These potential non-thermal effects include alterations in cellular functions, changes in brain activity, and possible impacts on reproductive health. Despite these suggestions, a consensus on the existence and significance of such effects has not been reached. The evidence remains inconclusive, and further research is needed to determine whether non-thermal effects of RF radiation pose significant health risks.

One of the most widely discussed concerns is the potential link between RF radiation and cancer. The International Agency for Research on Cancer (IARC), part of the World Health Organization (WHO), has classified RF radiation as a possible carcinogen (Group 2B), based on limited evidence that suggests a potential association between RF radiation and certain types of brain tumors. However, this classification is based on inconclusive evidence, and the broader scientific consensus on the carcinogenic potential of RF radiation remains unclear. Consequently, more research is required to establish definitive conclusions regarding the long-term health risks, including the potential for cancer.

Additionally, some individuals report experiencing symptoms associated with electromagnetic hypersensitivity (EHS) when exposed to RF radiation. These symptoms, which include headaches, fatigue, and sleep disturbances, have not been consistently linked to RF exposure in scientific studies. While some people attribute their symptoms to RF radiation, the causes of EHS symptoms are still uncertain and may be related to psychological or environmental factors unrelated to RF radiation exposure.

To mitigate potential health risks, regulatory bodies and governmental organizations have established safety guidelines for RF radiation exposure. These guidelines often focus on limiting the specific absorption rate (SAR), which measures the amount of RF energy absorbed by the body during exposure. By setting exposure limits, these guidelines aim to ensure that RF radiation remains within safe levels for human health.

In conclusion, while RF radiation is widely recognized as a potential health concern, the primary risks appear to stem from thermal effects at high exposure levels, which are rare in everyday use. The existence and relevance of non-thermal effects, including the potential link to cancer, remain subjects of ongoing scientific research. Regulatory standards have been put in place to control exposure and ensure safe use of RF-emitting devices, but further research is crucial to fully understand the long-term health implications of RF radiation and refine the guidelines for safe exposure.

2.3 Regulatory Standards for Radiofrequency Radiation

Regulatory standards for radiofrequency (RF) radiation have been established by various national and international bodies to protect individuals from potential harm caused by exposure to RF radiation (Vijayalaxmi & Scarfi, 2014). These standards outline acceptable limits for RF radiation exposure to ensure human health is safeguarded. Some of the key regulatory standards for RF radiation are as follows:

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is a global organization responsible for creating guidelines that protect against non-ionizing radiation, including RF radiation. Their guidelines specify exposure limits based on the specific absorption rate (SAR), which measures the rate at which the body absorbs RF radiation. ICNIRP sets limits for both public and occupational RF radiation exposure to minimize potential health risks.

The Institute of Electrical and Electronics Engineers (IEEE) is a professional organization that sets standards for various technological sectors, including RF radiation. The IEEE's standards address RF safety, with specified exposure limits for RF radiation. These guidelines cover both public and occupational exposure, focusing primarily on SAR values to ensure safe levels of RF radiation exposure.

In the United States, the Federal Communications Commission (FCC) regulates RF radiation exposure from sources such as mobile phones and wireless communication devices. The FCC sets maximum permissible exposure levels based on SAR values to ensure that RF radiation exposure from these devices stays within safe limits. These regulations aim to protect consumers from excessive exposure to RF radiation.

The International Electrotechnical Commission (IEC) is another global standards organization that creates safety standards for electrical and electronic technologies, including RF radiation. The IEC’s standards address safety concerns related to RF exposure and offer guidance on compliance testing and measurement techniques, ensuring devices meet the necessary safety thresholds.

Many countries also have their own national regulatory bodies responsible for setting RF radiation standards and guidelines. These authorities may create specific exposure limits for both public and occupational environments, tailored to national regulations and local considerations (Redmayne, 2016).

It is important to note that regulatory standards for RF radiation may differ between countries and regions, as various organizations and authorities implement their own specific guidelines. These standards are periodically reviewed and updated based on new scientific research and advancements in understanding RF radiation's effects on health. Compliance with these standards is essential for minimizing potential health risks, and manufacturers of electronic devices, including mobile phones, are responsible for ensuring their products adhere to these regulations through appropriate testing and certification.

2.4 Previous Studies on Mobile Phone Radiation

Numerous studies have been conducted to explore the potential effects of mobile phone radiation on human health. While the scientific community has not reached a definitive consensus, these studies have contributed significantly to our understanding of the topic. One of the key studies, the **Interphone Study**, a multinational case-control research led by the International Agency for Research on Cancer (IARC), examined the link between mobile phone use and brain tumors. The study concluded that there was no overall increased risk of glioma or meningioma associated with mobile phone use. However, some analyses suggested a possible increased risk of glioma among heavy mobile phone users, indicating the need for further investigation (Hardell, 2013).

In 2011, the **World Health Organization (WHO)**, through the IARC, classified radiofrequency electromagnetic fields, including mobile phone radiation, as possibly carcinogenic to humans (Group 2B). This classification was based on limited evidence of a connection between mobile phone use and an increased risk of glioma, a form of brain tumor (Volkow, n.d.). This report raised concerns about the long-term health implications of mobile phone radiation and highlighted the need for more conclusive evidence.

In addition to these studies, **experimental research** has examined the biological effects of mobile phone radiation on brain activity, genetic damage, and fertility. Some studies reported changes in brain activity and minor impacts on sperm quality, yet the overall consensus in the scientific community is that the biological effects of mobile phone radiation are subtle and not fully understood (Kesari et al., 2013). These findings underscore the complexity of determining the precise effects of mobile phone radiation on human health.

Further, **systematic reviews and meta-analyses** have synthesized results from various studies on mobile phone radiation. These analyses generally suggest that while some studies point to a potential link between mobile phone use and certain health issues, the overall evidence is not sufficient to establish a clear causal relationship. These reviews often emphasize the need for more robust research methodologies and longer follow-up periods to draw definitive conclusions (Baudin, 2021).

It is important to note that there is ongoing controversy surrounding the interpretation of these studies, with differing opinions within the scientific community. Moreover, as technology continues to evolve and mobile phone usage patterns change, continuous research is needed to assess the potential long-term effects of mobile phone radiation. While existing studies offer valuable insights into potential health risks, further research is essential to develop comprehensive, evidence-based guidelines for safe mobile phone use.

2.5 Current Knowledge Gap

Despite the considerable body of research on mobile phone radiation, several critical knowledge gaps remain that need to be addressed. One major gap is the long-term effects of mobile phone radiation. Most studies have focused on short-term exposure or have had relatively brief follow-up periods. Therefore, there is a pressing need for studies that track individuals over extended periods to assess the cumulative effects of mobile phone radiation on human health. Such studies would provide a clearer picture of the potential long-term risks.

Another area that requires further exploration is non-cancer health outcomes. While many studies have concentrated on the potential link between mobile phone radiation and cancer, there has been limited research on other health issues, such as neurological disorders, reproductive health problems, cardiovascular effects, and the impacts on vulnerable populations, including children and pregnant women. Research into these areas would help broaden our understanding of the diverse health effects that may result from mobile phone radiation exposure.

A significant challenge in this field is the lack of standardized measurement and exposure assessment methods. Inconsistent methodologies across studies make it difficult to compare results and draw definitive conclusions. Standardizing how mobile phone radiation is measured and assessed would enhance the accuracy and reliability of findings and facilitate more comprehensive research in this area.

With the rise of new technologies like 5G and the use of additional frequency bands, there is an urgent need for research into the health effects of these emerging technologies. As mobile phone networks evolve, understanding the potential health risks associated with these new technologies and frequencies is crucial for ensuring public safety.

Another important gap is the interaction of mobile phone radiation with other environmental factors. Mobile phone radiation is just one element of the broader electromagnetic environment to which individuals are exposed. Research into how mobile phone radiation interacts with other environmental factors, such as ambient electromagnetic fields or chemical exposures, could provide valuable insights into the cumulative and potentially synergistic effects on human health.

Lastly, the mechanisms of action by which mobile phone radiation affects biological systems remain poorly understood. While some studies have suggested that mobile phone radiation can cause biological effects, the cellular and molecular mechanisms behind these effects are not yet fully elucidated. Investigating these mechanisms would offer critical insights into how mobile phone radiation impacts health at a biological level.

Addressing these knowledge gaps is vital for a more comprehensive understanding of the potential health effects of mobile phone radiation. Further research, particularly long-term studies using standardized methods, is necessary to fill these gaps and provide evidence-based recommendations for public health policies, regulatory standards, and safe mobile phone usage practices.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 **Research Design**

The research design for measuring radiofrequency (RF) radiation levels from commonly used mobile phones among students would incorporate the following components:

1. **Research Approach**: The study will adopt a quantitative research approach, enabling the systematic collection and analysis of empirical data on RF radiation levels and students' awareness. This approach will facilitate the precise measurement of RF radiation emitted by mobile phones and provide a structured method for assessing students' knowledge and awareness regarding potential health risks associated with exposure.

2. **Sampling**: A purposive sampling technique will be employed to select a representative sample of students from the chosen educational institution. This approach will ensure the inclusion of students from diverse academic disciplines and various mobile phone usage patterns, providing a comprehensive understanding of RF radiation exposure among the student population. The sample size will be chosen to ensure statistical significance and diversity in the data.

3. **Data Collection Methods**:

   - **RF Radiation Measurement**: Specialized equipment such as RF meters or dosimeters will be used to measure and record the RF radiation levels emitted by commonly used mobile phones. These measurements will be conducted in controlled environments to ensure consistency and reliability, with data captured at various intervals to account for different usage scenarios.

   - **Surveys**: A structured survey will be administered to participants to assess their awareness and understanding of potential health risks linked to RF radiation exposure. The survey will include questions on mobile phone usage patterns, knowledge of RF radiation, and familiarity with safety guidelines. The survey will be designed to capture both general awareness and specific information related to the students' usage habits and risk perceptions.

4. **Data Analysis Techniques**:

   - **RF Radiation Analysis**: Descriptive statistics will be applied to summarize the RF radiation measurements, including calculating the mean, median, and standard deviation of radiation levels. The measured RF radiation levels will also be compared to established regulatory standards to assess compliance with safety guidelines.

   - **Survey Analysis**: Survey responses will be analyzed using statistical methods such as frequency distributions, cross-tabulations, and chi-square tests. These techniques will help identify trends, patterns, and associations in the students' awareness levels, as well as any correlations between mobile phone usage and knowledge of potential health risks.

3.2 Materials and Method

A total of thirty (30) mobile phones, comprising ten (10) units each of Infinix, Samsung, and Tecno brands, were used to measure the power density (PD) emitted by mobile phones. These particular brands were selected based on their widespread use among students of Kwara State Polytechnic, Ilorin. A handheld 3-axis RF-meter, commonly referred to as an Electrosmog meter, was employed for the measurements. The device was set to the maximum instantaneous broadband mode for monitoring high-frequency radiation within a range of 50 MHz to 3.5 GHz. Mobile phones were assessed under both active and passive modes. The active mode involved scenarios such as phone call receiving (PCR), phone call dialing (PCD), and phone data on (PDO), whereas the passive mode referred to the phone being powered on but not actively in use (PPONU). Measurements were conducted by positioning the RF-meter at a near-field distance of 20 cm from each mobile phone. During the measurement process, care was taken to avoid movement of the RF-meter and to ensure that no obstruction existed between the mobile phone and the RF-meter. Power density readings were recorded upon observing a stable value on the RF-meter, following recommended measurement practices.

2. Method

Measurement Procedure base on the single and dual SIMs during call conversation

Different types of mobile phone which operate in one or all of the MTN, Airtel, GLO and Etisalat Global System for Mobile Communications

(GSM) network operator in Nigeria were placed 5 cm distance from the RF meter. Before each reading was taken, point of 5cm

was marked with the meter rule. The reading was then taken when the mobile phone was establishing a call with single and double SIMs;

when seeking for connection, call establishment and call conversation; with different network operators in Nigeria; when charging and

when not charging; with battery power levels and with signals levels of the mobile phones.

Considerable amount of electromagnetic energy is concentrated near the source and is inversely proportional to the square of distance,

hence the inverse square law given in (1),

$I = PrGo/4\pi r2$ (1)

Where I is the intensity of the electromagnetic radiation (mW/cm2), Pr is the radiated power (mW), r is the distance from the radiating

source (cm) and Go is the maximum gain as in (1), the intensity of radiation exposure decrease from the source. Thus maximum intensity

is absorbed next to the ear or the head of the mobile phone user Chen and Lin, as in [9]. The power density of the mobile phone decreases

as the distance between the mobile phone and its user increases as in (2).

$\rho = Pr/Ae$ (2)

Where ρ is the power density and Ae is the effective are.

$Ae = Gr\lambda 2$

4Π

As pointed in (3), the effective area cover by the mobile phone depends on wavelength of the electromagnetic wave.

Pr = (hthr)2

dn PtGtGr (4)

Where ht is the transmitted antenna height, hr is the received antenna height and d is the distance between the transmitter and receiver.

Height of the antenna also affects the received power density of the mobile phone. As in (4), the higher the antenna the better the receive

signal from the base station at any random function of time.

In determining the intensity of selected mobile phone radiation, the background radiation of the place was first measured as in (5).

$Ix = Ic - Ib$ (5)

Where Ix is the intensity of radiation emitted from handset under study, Ic is the cumulative power density and Ib is the intensity of background

radiation.

CHAPTER FOUR

4.1 RESULTS AND DISCUSSIONS

Figures 1 - 3 show the bar charts of calculated mean PD values for Infinix, Samsung and Results of power densities recorded from the Tecno brands respectively. Power density three brands of mobile phones used in this variations in all examined mobile phones may are presented in Tables 1-3. The least be attributed to signalstrength of each phone mean power densities (PD) were observed at which is associated to the constituent materials PPONU passive mode while the highest mean used by the manufacturer. Remarkably, no power densities were observed at PCR active measured PD emitted from each mobile phone mode for all mobile phones. Although, some or calculated mean PD for each phone brand phone models show higher PD values at PCD has value equal to or greater than the tolerable mode rather than

PCR mode. Notably, limit (570 μW/cm^2) set by FCC. Infinix HOT 4 increased mean PD value was observed in Infinix brand (91.113 μW/cm$_2$) when showed a greater PD value when compared compared to Samsung (5.219 μW/cm 2) and with 200 μW/cm^2 Austrian standard.

This is in Tecno (38.057 μW/cm$_2$) brands while Samsung conformity with the findings. However, previous studies on radiofrequency brand of mobile phones recorded the least PD radiation exposure have revealed deleterious values when compared with other brands. effect on biological tissue. It is therefore However, the minimum PD value (1.825μW/cm$_2$) recorded from all mobile important to emphasize that exposure to radiofrequency radiation emitted from mobile phones used in this study was observed in phones should be kept as low as reasonably Tecno L8. Infinix Hot 4 recorded the highest mean power density of 232.331 μW/cm^2.

Table 1: Power density of Infinix mobile phones measured in μW/cm^2

Infinix	Model Year	Phone Passive	Phone Data On	Phone Call Receiving	Phone Call Dialing	Mean Power Density

551	2012	0.009	0.752	69.340	39.240	27.335
X509	2012	0.001	66.610	175.100	169.400	102.777
NOTE1	2012	0.003	4.975	168.800	185.200	89.745
HOT4 LITE	2015	0.348	3.429	8.492	40.360	13.157
HOT4	2016	0.005	0.326	531.500	397.500	232.331
HOT5	2017	0.001	0.132	289.700	143.700	108.383
HOT6 PRO	2017	0.007	3.520	157.700	240.300	100.382
NOTE4	2017	0.001	0.246	184.400	254.400	109.761
HOT 5 LITE	2017	0.122	42.760	110.100	49.450	50.608
NOTE 4	2017	0.098	2.402	160.000	144.100	76.650
Overall Mean		0.0595	12.515	185.513	166.370	91.113

Table 2: Power density of Samsung mobile phone measured in µW/cm^2

Samsung	Model Year	Phone Passive	Phone Data On	Phone Call Receiving	Phone Call Dialing	Mean Power Density
Galaxy J Neo	2014	0.015	0.019	17.560	3.754	5.337
Galaxy J7 Pro	2015	0.028	0.495	9.474	1.697	2.924
S5	2015	0.002	0.015	16.830	2.764	4.903
Galaxy J3	2016	0.002	0.019	15.200	7.540	5.940
Galaxy A9 Pro	2016	0.004	0.015	13.300	4.544	4.466
Galaxy C9	2016	0.001	0.044	10.240	6.799	4.271
S6	2016	0.001	0.050	18.980	3.556	5.647
Galaxy Note 8	2017	0.054	5.027	14.360	10.94	7.595
Galaxy A7	2017	0.003	0.112	28.34	2.768	7.806
Galaxy J7	2017	0.020	0.374	10.11	3.476	3.495
Overall Mean		0.013	0.617	15.463	4.784	5.219

Table 3: Power density of Tecno mobile phone measured in μW/cm2

Tecno Phone	Model Year	Phone Passive	Phone Data On	Phone Call Receiving	Phone Call Dialing	Mean Power Density
WX3	2010	0.002	5.246	164.700	247.900	104.462
Y2	2011	0.002	0.450	15.970	10.200	6.656
K5	2012	0.002	2.526	18.910	21.500	10.735
DRO Ipad p904	2012	0.002	5.723	476.500	105.900	147.031
Y4	2013	0.005	6.035	23.580	17.540	11.790
J5	2014	0.005	3.300	25.470	9.970	9.686
L8 plus	2016	0.004	0.130	2.734	4.430	1.825
K7	2016	0.004	1.752	168.900	146.400	79.264
CAMNON CM	2017	0.001	2.937	3.372	7.124	3.919
CAMNON C5	2017	0.006	1.530	13.500	5.768	5.201
Overall Mean		0.003	2.963	91.364	57.729	38.057

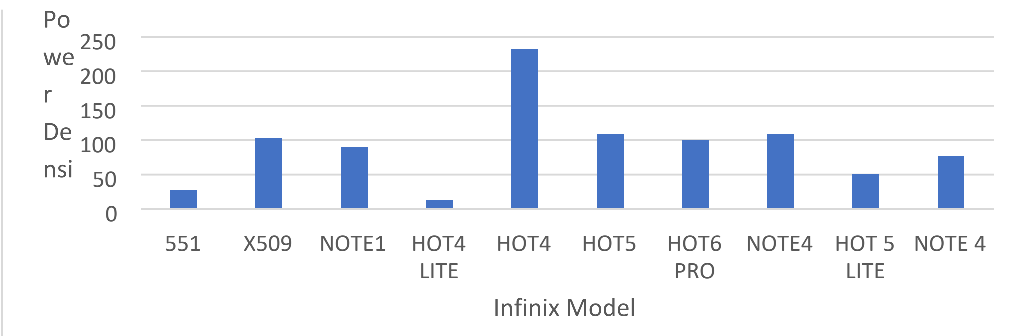

Figure 1: Bar Chart of the Mean Power Densities of Infinix Phone

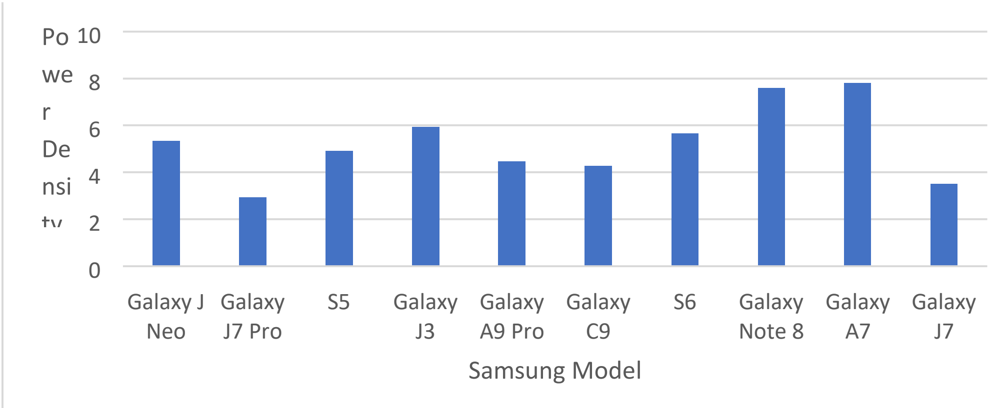

Figure 2: Bar Chart of the Mean Power Densities of Samsung Phone

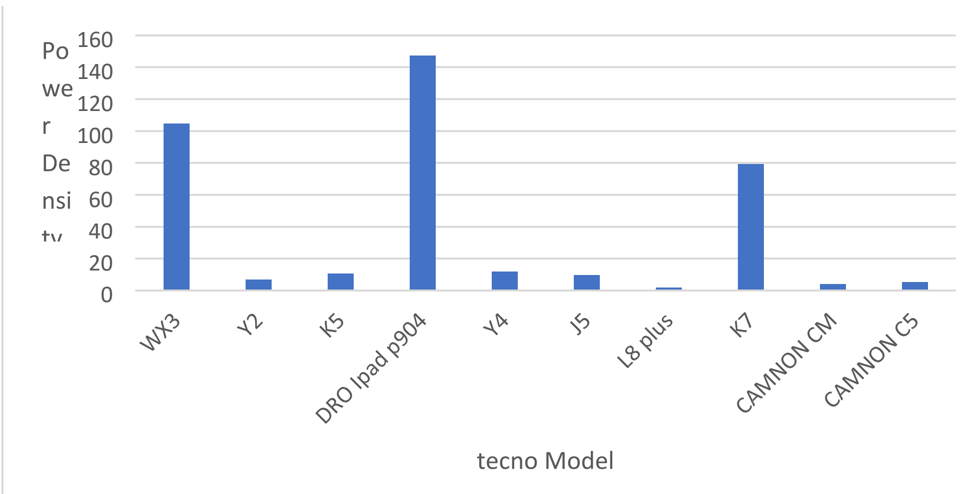

Figure 3: Bar Chart of the Mean Power Densities of Tecno Phone S

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

5.1 Summary

This study has revealed that the radiofrequency (RF) radiation emitted by GSM mobile phones, which is a form of non-ionizing radiation, has the potential to generate heat. The research indicated fluctuations in temperature around the brain during mobile phone use. However, these slight changes are often not noticeable to the individual making the call, as the temperature typically stabilizes over time. Despite this stabilization, even a slight increase in brain temperature could lead to minor tissue damage, especially if the brain's thermoregulatory system weakens over prolonged periods. As noted by Hardell (2007), using a mobile phone for one hour daily may significantly increase the risk of developing a brain tumor after ten years or more. Therefore, the effects of GSM radiation on the brain are gradual and develop over extended periods rather than immediately.

5.2 Conclusion

This study assessed the radiofrequency radiation levels from mobile phones manufactured by three different brands. The findings showed that Infinix mobile phones recorded higher power density values compared to Samsung and Tecno phones. However, it is important to note that none of the phones tested exceeded the maximum permissible exposure limit of 570.00 $\mu W/cm^2$, as recommended by the Federal Communications Commission (FCC). Consequently, the study concludes that students of Kwara State Polytechnic, Ilorin, who use any of the mobile phone models examined are unlikely to be exposed to harmful levels of radiation power density from their mobile phones.

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