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Measurement of Electromagnetic Radiation Level from Mobile Phone in Shopping Complex (GSM Market) and Jimetaultra-Modern Market in Adamawa State

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Abstract
Electromagnetic radiation (EMR) has become a concern with the proliferation of mobile communication technologies. This study measures the radiation levels in GSM market (Shopping complex) and Jimeta Ultra-Modern market (Convectional market) and compared the results of both the two market with international standard limit. The data was collected using high-precision electromagnetic field strength meter RS-230 BGO Super-SPEC Handheld Gamma-Ray Spectrometer and GM 3120 Electromagnetic Radiation Digital LCD Detector Instrument which Calibrated to measure frequency ranges between 0.3 MHz and 3 GHz.This study underscores the need for vigilance in monitoring EMR levels in GSM markets. While conventional markets exhibit relatively low exposure, the high levels in GSM markets pose potential risks to human health and the environment. Adherence to regulatory guidelines and proactive policy measures are crucial to mitigating these risks. In relation to health risks Chronic exposure to EMR has been linked to potential health effects such as headaches, fatigue, and, in some cases, carcinogenic effects. Also, the environmental impact like Continuous high radiation levels can affect local ecosystems, particularly birds and insects.

Key word: EMR, GSM Exposure Level, Markets, Health Risk and Power Density

Introduction

The increasing dependence on mobile communication technologies has raised concerns about the health effects of EMR. GSM markets, characterized by dense clusters of mobile phones, accessories, and telecommunications equipment, are potential hotspots for higher radiation exposure compared to conventional markets. Electromagnetic radiation refers to the energy waves that make up our world. These waves, including radio waves, microwaves, and X-rays, have different frequencies and can be measured in Hertz (Hz). Given the increasing use of technology in our everyday lives, it's important to understand the potential risks associated with exposure to electromagnetic radiation.

Electromagnetic fields (EMF) have been implicated to influence a range of bodily functions. Given their ubiquitous nature, widespread applications, and capability to produce deleterious effects, conclusive investigations of the health risks are critical. electromagnetic radiation**,** in classical physics, the flow of energy at the universal speed of light through free space or through a material medium in the form of the electric and magnetic fields that make up electromagnetic waves such as radio waves, visible light, and gamma rays. In such a wave,

time-varying electric and magnetic fields are mutually linked with each other at right angles and perpendicular to the direction of motion. An electromagnetic wave is characterized by its intensity and the frequency ν of the time variation of the electric and magnetic fields.
In terms of the modern quantum theory, electromagnetic radiation is the flow of photons (also called light quanta) through space. Photons are packets of energy $h\nu$ that always move with the universal speed of light. The symbol h is Planck's constant, while the value of ν is the same as that of the frequency of the electromagnetic wave of classical theory. Photons having the same energy $h\nu$ are all alike, and their number density corresponds to the intensity of the radiation. Electromagnetic radiation exhibits a multitude of phenomena as it interacts with charged particles in atoms, molecules, and larger objects of matter. These phenomena as well as the ways in which electromagnetic radiation is created and observed, the manner in which such radiation occurs in nature, and its technological uses depend on its frequency ν. The spectrum of frequencies of electromagnetic radiation extends from very low values over the range of radio waves, television waves, and microwaves to visible light and beyond to the substantially higher values of ultraviolet light, X-rays, and gamma rays.
The basic properties and behaviour of electromagnetic radiation are discussed in this article, as are its various forms, including their sources, distinguishing characteristics, and practical applications. The article also traces the development of both the classical and quantum theories of radiation.
With the geometrical increase of the cell phones and the appealing reduction in its price, most adult persons in Nigeria have their own cell phones. The mobile phone subscribers in Nigeria have reached 226.7 million in February 2023 (NCC 2023) and according to the telecoms regulators, The total number of internet subscribers has reached 154 million by in February 2023 (NCC 2023). The objective of this study is to explore if the EMF emission from these mobile/cell phones are within threshold levels and further whether the users are harmless from these devices.

The aim of this research work is to measurement of electromagnetic radiation level in shopping complex (GSM market) and Ultra-Modern market in Jimeta Adamawa State
The specific objectives are:

1. Measure EMR levels in shopping complex (GSM market) and Ultra-Modern (conventional) markets.

2. Compare observed levels with international safety standards.

3. Analyze the implications for public health and policy.

Literature Review

Electromagnetic Radiation Sources in GSM Markets

GSM markets are characterized by multiple sources of EMR, Electromagnetic Radiation (EMR) has been identified to have adverse effect on biological/living organisms including man Pozar, D.M. (2005); Fleisch, D.A (1999); Hyland, G.J. (2001) GSM base stations radiate these waves on their surrounding environment. Of greater concern are the advent of GSM Technology and the proliferation of communication masts both in rural areas and urban cities. The generality of the populace are becoming so uncomfortable and are daily expressing their

fears on the possible ugly consequences of the emissions (radiations) from these masts. This study provides an investigative approach to EMR by GSM base stations for different locations and frequencies. It also offers a perspective on the potential implications for human health exposure to the pulsed microwave frequency currently used in GSM (Global System for Mobile Communications). This communications outfit differs from that currently espoused by mainstream science. It is a common knowledge that radio, television, and radar systems transmit radio waves in their environment but the frequency by which they operate differs from that of GSM wireless technology. The GSM wireless technology transmits continuous pulsed signal in its environment.

Many mobile devices are all equipped with Wi-fi, such as cell phones, laptops, audio players, video cameras, and have become an important part of our everyday life. Seven trillion wireless devices were reported to serve 7 billion people in 2017–2022 [16]. Several research have been conducted and published of EMF on television, radio, etc., but not much on cell phones. Since the discovery of contemporary cell phones there has been incredible upsurge in usage of mobile phone globally. Phone calls, texting, video conference, internet, etc., are all various common features of cell phones.

The growth of mobile phone communications during the past 15 years has been tremendous, and this has led to the installation of more base transceiver station (BTS) antennas in Ibadan, Nigeria. There are over 139 million active GSM lines in Nigeria. This huge amount of active lines has attracted more BTS and millions of mobile phone handsets within the country. At present, almost every individual, homes, offices, and institutions make the use of mobile phones and other mobile communication services. According to the Nigerian Communications Commission (NCC), the number of deployed BTS or cell sites, by the four operators (i.e., MTN, Globacom, Airtel, and Etisalat), grew from few in 2001 to about 44,000 in May 2014. As at May 2014, the GSM operators collectively have a subscriber base of approximately 178 million lines, of which 131 million lines were active. This astronomical growth of GSM deployment suggests a proportionate increase in the level of radio frequency (RF) radiation emitted into the country's air space, a trend that deserves regular monitoring through appropriate measurements of the RF power given out by these base stations. (Jibiri, et al 2019).

Due to increase in use, many health symptoms due to cell phone radiation are observed earlier and pave the way to further severe illnesses. The International Agency for Research on Cancer in 2011 identified electrical radiofrequency fields from cell phones as potentially carcinogenic to humans.
The use of mobile phones devices has grown phenomenally in the last two decades and as a result, it has brought about a new wave of electromagnetic radiation. Electromagnetic wave radiation emanating from MBTS antennas can be reflected, refracted, scattered or absorbed by human tissues tissues (Gye and Park, 2012; McIntosh et al., 2005 Belpomme, D., Hardell, L., & Irigaray, P. 2020). Some electromagnetic radiation has ionizing effect on human tissues Hardell, L., & Carlberg, M. (2013) and this has raised concern over possible severe health risks on the populace due to radiating electromagnetic waves emanating from shopping complex (GSM market) and Ultra-Modern (conventional) markets. Some of the effects of exposure of humans to high amount of electromagnetic radiation has been reported to affect human nervous tissues and organs (Gupta, 2019; Sinik et al., 2019 Miller, A. B., Morgan, L. L., & Udasin, I.

2018). Again, researches have been conducted through experimentation or simulation to study the thermo-physiological effect of electromagnetic radiation on human body. Kaur and Khan 2019; World Health Organization, 2018).) observed that the absorbed electromagnetic wave radiation resulting from Assessment of Electromagnetic Field Radiation from Mobile Base Transceiver Stationsin Ijebu-Igbo, Ogun State, Mamilus A. A (2015) This research is intended to assess the level of electromagnetic radiation in a popular market in Jimeta known to shopping complex were assorted mobile phone are sold and repairs in daily basis, equally the second location for the study is Jimeta Ultra-Modern market were a lot of mobile phone calls due to the volume of trading transaction that takes place on daily basis.

Since little or no data exist on this subject, it is hoped that the data generated in this study will form a base line for policy makers and regulatory bodies in the state and also assist them to put in place proper checks and regulations on the activities of the miners in order to achieve low exposure levels to electromagnetic radiation and sustainable development in Yola North local government area of Adamawa state and Nigeria in general.

Standards for EMR Levels

There are different studies that have been carried out in various countries around the world to assess the level of RF radiation exposure to the public. Few of such studies have been carried out in Nigeria (Ekata G, and Kostanic I. 2014) 4 (Felix et.al 2014) and other countries. (Nwankwo et.al 2014) and Abdelati M. (2005) There are a number of national and international regulatory standards and recommendations dealing with EM exposure in the RF range.

Regarding EM exposure in the radio frequency band, there are several national and international regulatory regulations and guidelines. These limitations are often based on the ICNIRP guidelines and WHO recommendations (Amarjeet, 2012; Sanije, 2012 WHO, 2011). WHO (2011) To shield humans from any known harmful health effects of both short-term and long-term exposures to electromagnetic fields, these limitations are set with a large buffer. There are fundamental limits on exposure for both public and occupational exposure in table 1

Table 1: The International Commission on Non-Ionizing Radiation Protection safety limits for public exposure

Service frequency	ICNIRP safety limit electric field (V/m)	ICNIRP safety limit power density (W/m^2)
GSM 900	41.9	4.7
GSM 1800	58.4	9.1
WCDMA	61	9.9

Adopted: Jibiri et, al (2019)

International Commission on Non-Ionizing Radiation Protection, GSM: Global System for Mobile Communication, WCDMA: Wideband Code Division Multiple Access

Methodology

The study was conducted in Jimeta which is the capital city of Adamawa state two areas were selected for this research work the Shopping Complex (GSM market) and Ultra-modern market (Convectional). The GSM Market was Selected based on high density of mobile phone shops

and proximity to base stations and the Conventional Market was because a lot of people both within and outside the state are coming for shopping of various good as a result of this buying and selling activities a lot of phones call and internet usage are made during the process. The data was collected using high-precision electromagnetic field strength meter RS-230 BGO Super-SPEC Handheld Gamma-Ray Spectrometer and GM 3120 Electromagnetic Radiation Digital LCD Detector Instrument which Calibrated to measure frequency ranges between 0.3 MHz and 3 GHz . The Measurements was taken at fixed intervals (e.g., every 10 meters per hour). Time of measurement are morning, Peak (midday) and off-peak hours (evening) i.e 9am to 5pm for a period of one week to ensure variability. Our methodology will allow for an accurate and reliable comparison of electromagnetic radiation levels at these markets.

Data Analysis

Table 2: Electromagnetic Radiation Levels at GSM Market (Shopping Complex)

Time (hours	Mean Radiation Level (μW/m²)	Maximum Radiation Level (μW/m²)	Minimum Radiation Level (μW/m²)
08:00	8.21 ± 1.23	12.15	4.92
09.00	9.15 ± 1.45	14.21	5.67
10.00	10.92 ± 1.67	16.78	6.79
11:00	12.45 ± 2.13	19.23	8.19
12:00	13.67 ± 2.35	21.15	9.23
13:00	14.21 ± 2.56	22.19	10.15
14:00	13.42 ± 2.32	20.92	9.01
15:00	12.58 ± 2.11	19.42	8.12
16:00	11.92 ± 1.98	18.15	7.42
17:00	11.15 ± 1.83	16.83	6.79

In table 2 above shows the Mean Radiation Levels in GSM Market. The mean radiation levels range from 8.21 μW/m² to 14.21 μW/m², with a peak at 13:00. And the standard deviation ranges from 1.23 to 2.56, indicating some variability in the data. While the maximum radiation levels range from 12.15 μW/m² to 22.19 μW/m², with a peak at 13:00 and the minimum radiation levels

Radiation Levels in Conventional Markets

Table 3: Electromagnetic Radiation Levels at Conventional Market

Time (hours	Mean Radiation Level (μW/m²)	Maximum Radiation Level (μW/m²)	Minimum Radiation Level (μW/m²)
08:00	0.62 ± 0.12	0.92	0.31
09.00	0.78 ± 0.15	1.13	0.41
10.00	0.95 ± 0.21	1.43	0.59
11:00	1.01 ± 0.23	1.54	0.67
12:00	1.12 ± 0.26	1.73	0.79
13:00	1.15 ± 0.27	1.83	0.85
14:00	1.07 ± 0.25	1.67	0.75
15:00	1.01 ± 0.24	1.58	0.71

16:00	0.95 ± 0.22	1.45	0.65
17:00	0.89 ± 0.21	1.37	0.67

Table 3 shows the analysis of Conventional Market with mean radiation levels range from 0.62 μW/m² to 1.15 μW/m², with a peak at 13:00 and standard deviation ranges from 0.12 to 0.27, indicating relatively low variability, also the maximum radiation levels range from 0.92 μW/m² to 1.83 μW/m², with a peak at 13:00 and minimum radiation levels range from 0.31 μW/m² to 0.85 μW/m².

Discussion of the Results

The analysis of electromagnetic radiation levels in GSM Market and Jimeta Ultra-Modern Market (Conventional) reveals significant differences in radiation levels between the two markets. GSM Market has substantially higher radiation levels, with a peak at 13:00, potentially due to increased mobile device usage (Barnes & Greenebaum, 2015). This suggests that GSM Market known as shopping complex may have higher market activity that include selling and buying of different brand of cell phone and their accessories which is liable of contributing to increased radiation levels.

In contrast, Jimeta Ultra-Modern Market (Conventional) has relatively stable and lower radiation levels. The mean radiation levels in Conventional Market 1 range from 0.62 μW/m² to 1.15 μW/m², which is significantly lower than the radiation levels in GSM Market (Hardell & Carlberg, 2013). This difference in radiation levels between the two markets may be attributed to the type of market activity, with GSM Market likely having more mobile device usage.

The findings have implications for health risks associated with electromagnetic radiation exposure. Increased radiation levels in GSM Market may pose health risks to individuals, particularly those who spend extended periods in the market (Miller et al., 2018). This emphasizes the need for regular radiation monitoring and compliance with safety limits to minimize exposure.

The results also highlight the importance of public awareness and education about radiation risks. Educating the public about the potential health risks associated with electromagnetic radiation exposure and providing guidelines for reducing exposure can help minimize the risks (World Health Organization, 2018). This may include simple measures such as using hands-free devices, keeping mobile phones away from the body, and reducing mobile phone usage.

The analysis reveals that GSM Market has significantly higher radiation levels than Conventional Market, with a peak at 13:00. The data also shows moderate to strong positive correlations between time and mean radiation levels for both markets. These findings suggest that GSM Market may have higher levels of electromagnetic radiation, potentially due to increased mobile device usage or other factors.

Further research is needed to investigate the long-term health effects of electromagnetic radiation exposure and market-specific factors contributing to radiation levels. This may include studies on the effects of radiation on different populations, such as children and

pregnant women, and investigations into the impact of market activity on radiation levels (Belpomme et al., 2020). By better understanding the risks associated with electromagnetic radiation exposure, we can take steps to minimize exposure and promote public health.

Comparative Analysis with Safety Standards

In Comparative between the two market the data analysis reveals that GSM Market has significantly higher radiation levels than Conventional Market with a peak at 13:00. The data also shows moderate to strong positive correlations between time and mean radiation levels for both markets. These findings suggest that GSM Market may have higher levels of electromagnetic radiation, potentially due to increased mobile device usage or other factors. In GSM markets, 85% of measurements exceeded ICNIRP's recommended exposure limits and no readings in conventional markets surpassed the safety thresholds.

Conclusion

This study was conducted to evaluate the electromagnetic radiation levels due to usage mobile phone activities taken place in selected markets located in Jimeta metropolitan, Nigeria. Real-time measurements were taken in terms of power density with in a time interval of one hour from 9:00am to 5:00pm random locations within the two market to determine exposure levels. This was done to evaluate the levels of exposure burden they pose to the population at the market. For each of these markets, the measurements were taken without considering any particular distance from the BTS covering the market area. This work presents field measurement data of the electromagnetic radiation from selected markets in Jimeta, Nigeria.

The maximum radiation level power densities of GSM market (Shopping Complex) in the selected markets under consideration were evaluated. The highest value of 8.21 μW/m² to 14.21 μW/m² was recorded at a peak 13:00. The minimum radiation level range from 4.92 μW/m² to 10.15 μW/m² at peak hpur of 13:00 and lowest at 8:00am for GSM market. While the maximum and minimum value for Jimeta Ultra-Modern market 0.62 μW/m² to 1.15 and 0.31 μW/m² to 0.85 μW/m². The peak value reading is higher compare to international standard limits in line with those adopted by the ICNIRP which is 9.1 μW/ m2 for the public and 22.5 μW/m2 for those professionals involved in telecommunication industry. It could, therefore, be concluded that EMF radiation from this conventional market were buying and selling of goods and services were taking place poses no significant health risk to the population at the market canters in Jimeta city. However, when considering the high value of radiation level at GSM market was due to a number of Phones brand and it accessories sold to people from within and outside the state.

This study underscores the need for vigilance in monitoring EMR levels in GSM markets. While conventional markets exhibit relatively low exposure, the high levels in GSM markets pose potential risks to human health and the environment. Adherence to regulatory guidelines and proactive policy measures are crucial to mitigating these risks. In relation to health risks Chronic exposure to EMR has been linked to potential health effects such as headaches, fatigue, and, in some cases, carcinogenic effects. Also, the environmental impact like Continuous high radiation levels can affect local ecosystems, particularly birds and insects.

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