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Assessment of Power Density Radiation from Wi-Fi Enabled and Wi-Fi Disabled Laptops

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The introduction of Wi-Fi technology on laptops and mobile phones had tremendously solved the problems of communication in Nigeria as the acquisition and use of laptop is rapidly increasing. However, the health implications of radiation from laptop has become a great concern to the general public especially when such laptops are Wi-Fi enabled. There is therefore need to assess the radiofrequency radiation level for a both Wi-Fi enabled as well as Wi-Fi disabled laptops. In this work, 40 laptops of different brands and varying models were investigated and the power densities emanating from them were measured when the laptop were Wi-Fi disabled and when they were Wi-

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Fi enabled using hand-held Electrosmog RF meter. The RF meter was placed at a distance of 10 cm (4 inches) away from the screen of the laptop so as to capture the highest power density from the laptop. The measured power densities varied from one brand of laptop to another and for different models. The power density values recorded for all the laptops investigated when they were Wi-Fi disabled, ranged from 0.023 mW/m² to 1.369 mW/m² with a mean of 0.418 mW/m². The power density measured ranged from 0.230 mW/m² to 13.57 mW/m² with a mean of 2.593 mW/m² during Wi-Fi enabled mode. Generally, for all the laptops investigated, the values of the power densities recorded were higher during the Wi-Fi enabled mode than during the Wi-Fi disabled mode. There was no significant difference between the power density recorded during the Wi-Fi enabled mode and the Wi-Fi disabled mode. The research also revealed that newer versions of laptops presented lower power densities than older versions of laptops. All values of power density measured in this research work for both Wi-Fi enabled and Wi-Fi disabled laptops were found to lie below the permissible power density of 10 W/m2 recommended by the Federal Communication Commission, Institute of Electrical and Electronics Engineers and the International Commission on Non-Ionizing Radiation Protection for the general public. All the brands and models of laptops investigated in these work were emitting radiations at a level that are considered safe for human exposure. Exposure to electromagnetic field radiation from these laptops during Wi-Fi enabled or Wi-Fi disabled mode are within safety guidelines set by regulatory agencies.

Keywords: Laptop; Wi-Fi enabled; Wi-Fi disabled; brands; models; electromagnetic radiation; radiofrequency radiation; power density; electrosmog meter.

1. INTRODUCTION

We live in a generation that relies heavily on technology. Electromagnetic fields of all frequencies are one of the fastest growing environmental pollutants. Whether for personal use or work, wireless devices, such as cell phones, laptops, are commonly used around the world, and exposure to radio frequency radiation (RFR) is widespread, including in public spaces [1,2]. Wireless Fidelity (Wi-Fi) devices are an increasingly common technology employing radio frequency (RF) energy [3]. The pervasive use of wireless communication devices in each aspect of everyone daily life, emphasized the need for assessing the level of radio-frequency electromagnetic field (RF-EMF) exposure [4]. Wi-Fi enabled tablets such as iPads, smart phones and even laptops are commonly used and thus provide more radiation directly into human body [5]. The exposure in public spaces can even be worse than in homes as hundreds of people are simultaneously connecting to the internet.

Computer networks have played a major role in expanding boundaries in organizations today. Until now, traditional method of networking, which involved computers, wired directly to a hub or switch are the norm. Recent advances in networking technology have made it possible for device to communicate using light and wave emitting technologies. Wi-Fi is a perfect example of one of those emerging technologies. Which has enabled computers communicate with each other without the use of traditional cables. Thus, wireless fidelity devices have become an integral part of our everyday life. These devices are been used for many purposes such as internet and telecommunication. However, there are growing concerns and ongoing debates about possible health hazards related to Wi-Fi use in homes, workplace, schools and other places [6,7,8,9]. Since Wi-Fi emits radiofrequency electromagnetic fields, which can be absorbed by the body, several scientist have carried out researches to see whether there are links between radiofrequency electromagnetic fields from Wi-Fi enabled devices and the incidence of cancer, neurological effects, reproductive issues and cardiac issues among others [10,11], (Invica et al*.,* 2022).

Concerns regarding potential negative effects on health caused by RF-EMF, mainly from 100 kHz to 300 GHz, led international authorities to take decisions and establish precautionary exposure limits that are adopted by most countries, with some differences between geographic areas. There are various guidelines set by regulatory agencies where reference limits for RF-EMF are published, including international, national and regional limits [12]. Internationally respected agencies such as the International Commission on Non-Ionizing Radiation Protection [13], the Federal Communications Commission [14,15] and the International Committee on Electromagnetic Safety of the Institute of Electrical and Electronics Engineers [16] have

established guidelines for limiting human exposure to radiofrequency electromagnetic fields (RF-EMF) based on years of scientific research. These three regulatory agencies have set a reference power density level of 50 W/m^2 and 10 W/m^2 for occupational and general public exposure scenario respectively [15,16,13]. These guidelines are the reference limits to protect citizens from any possible harmful effects of the electromagnetic (EM) waves. The main objective of establishing a limit is to try to limit exposure to RF-EMF and achieve a high level of protection for all people against possible adverse health effects, both in the short and long term.

A call for more studies and the need to measure personal exposure in human epidemiological studies for a better understanding of RF-EMF and health has been initiated by the World Health Organization [17]. There exist gaps in the previous studies that assessed exposure and risk perception of people towards RF-EMF. The gaps include questionnaire-based risk perception assessment without measuring personal exposure, measurement of personal exposure without investigating risk perception among many others [18,19,20,21]. This research on RF-EMF radiation from laptops will bridge the gaps from previous studies mentioned above. Laptops, in particular, are a significant source of RF-EMF radiation, and their proximity to the user's body raises questions about the safety during prolong usage. While some studies have investigated the RF emission from laptops, there is a need for further research to understand the specific impact of Wi-Fi enablement on power density radiation. This research therefore, aim to investigate and compare the power density radiation emitted by Wi-Fi enabled laptops and Wi-Fi disabled laptops, in order to assess the potential health risk associated with RF exposure. It will also provide valuable insight for laptop users, manufacturers and regulatory agencies.

2. MATERIALS AND METHODS

2.1 Sample Collection

A total of 40 good conditioned laptops of varying brand of different brands and varying models of Acer, Asus, Dell, HP, Lenovo and Toshiba laptops of varying models were selected randomly for this research work. The brands and models of these laptops were recorded. This is to ensure variability and viability of the experimental results across a much larger population.

Plate 1. Picture of an electrosmog RF meter

2.2 Measurement

In this research study, a radiofrequency electrosmog meter of model TES-92 was used to take measurement. The electrosmog meter is a broadband device for monitoring high-frequency radiation in the range from 100 MHz to 8 GHz. It has three axis or channel sensor located with the head part of the meter. the device has high dynamic range due to three –channel digital result processing with a configurable alarm threshold and memory function and it is also easy and save to use. The unit of measurement and the measurement types have been selected to expressed in units of power density. At high frequencies, the power density is of particular significance, it provides a measure of the power absorbed by a person exposed to the field. The meter can be set to display the instantaneous value, the maximum value measured or the average value. An electrosmog meter was used to measure the power density when the laptop is Wi-Fi enabled and later when the Wi-Fi is disabled. The Wi-Fi enabled mode was achieved by connecting the laptops to the university hotspot which operate on the 2.4 GHz and the 5 GHz frequency bands. The electrosmog meter was placed at 10 cm (4 inches) away from the screen of the laptop since Wi-Fi antenna is usually located near the screen or the keyboard. The process was repeated for every other models of the laptops used and in each case, the power density was measured and recorded.

3. RESULTS AND DISCUSSION

3.1 Results

The results of the power density during Wi-Fi enabled and Wi-Fi disabled modes for each model of the laptop are presented in Table 1.

Table 1. Power density for Wi-Fi enabled and Wi-Fi disabled modes for each model of laptops

S/N	Laptop (Brand and Model	Power Density for Wi-Fi Disabled (W/m^2)	Power Density for Wi-Fi Enabled (W/m^2)
1	Acer Apsire	0.271	0.836
2	Acer Packard Bell	0.582	1.149
3	Acer Spin	0.712	2.143
4	Acer Spin	0.840	3.521
5	Acer Travelmate	0.493	1.416
6	Acer Elec	0.405	2.674
7	Asus Asuspro	0.462	1.964
8	Asus vivobook	0.324	1.238
9	Asus X515EA	0.952	4.024
10	Asus Vivobook	0.308	1.587
11	Asus X515EA	0.668	3.001
12	Asus Notebook	0.102	0.230
13	Asus Expertbook	0.208	0.994
14	Asus Asuspro	0.344	1.952
15	HP 250 G4	0.112	0.392
16	HP Elitebook	0.672	3.524
17	HP Probook	0.241	1.135
18	HP Stream	0.314	2.73
19	HP Elitebook	0.681	3.373
20	HP Stream	0.314	1.983
21	HP chromebook	0.261	0.414
22	HP Probook	0.228	0.320
23	HP Elitebook	1.325	13.57
24	Lenovo Essential	0.223	07.212
25	Lenovo Ideapad	0.255	0.367
26	Lenovo Latitude	0.129	0.821
27	Lenovo X360	0.131	2.265
28	Lenovo Latitude	0.114	0.294
29	Lenovo V15	0.063	0.305
30	Lenovo Idealpad	0.023	0.256
31	Lenovo V14	0.802	3.375
32	Dell Ispiron	0.320	1.054
33	Dell Latitude	0.172	3.184
34	Dell XPS	0.165	0.504
35	Dell Chromebook	0.357	1.945
36	Dell Probook	0.622	10.99
37	Dell XPS	1.369	12.59
38	Toshiba Protege	0.106	3.156
39	Toshiba Dynbook	0.671	0.759
40	Toshiba Protege	0.366	0.453
Mean Value		**0.418**	**2.593**

3.2 Discussion

3.2.1 Power density radiation

The measured power density radiation from laptops that are Wi-fi disabled ranged from 0.023 mW/m² to 1.369 mW/m² with a mean of 0.418 mW/m². The highest power density radiation was found in LP 23. This may be due to the fact that the model of this laptop is the oldest among the Wi-Fi disabled laptop investigated. On the other hand, the measured power density radiation recorded for the laptops that were Wi-fi enabled ranged from 0.230 mW/m² to 13.57 mW/m² with a mean of 2.593 mW/m². The lowest value of power density was found in Lenovo Idealpad probably because it was the newest version among the laptops investigated. A comparative analysis test (ANOVA) conducted between the power density recorded for laptops during Wi-Fi disabled and Wi-Fi enabled modes revealed that there is no significant difference between the two values.

All the power densities measured during the Wi-Fi disabled and Wi-Fi enabled modes for all the laptops investigated in this research work all lie below the permissible power density level of 10 W/m^2 recommended by the Federal Communication Commission, Institute of Electrical and Electronics Engineers and the International Commission on Non-Ionizing Radiation Protection [15,16,13] for the general public. The result of the power density investigated in this research work, revealed that the power density levels from these laptops were all within safety guidelines set by regulatory agencies [15,16,13]. These laptops are considered safe for human exposure and should not pose any health risk for users even during prolonged usage. The result of this research work comply with various researches that reported that RF-EMF radiation from laptops do not pose health effects on users [22,23,24,25,26]. The research also showed that the manufacturers of these laptops designed their products to comply with permissible limits set by regulatory agencies to ensure that their products operate within established safety guidelines.

5. CONCLUSION

A total of 40 of varying brands, models and versions for their power density emissions using an hand-held electrosmof RF meter during Wi-Fi enabled and Wi-Fi disabled mode. The power density radiation recorded for laptops in Wi-Fi disabled mode ranged from 0.023 mW/m² to 1.369 mW/m² with a mean of 0.418 mW/m². During the Wi-Fi enabled mode, the power density measured ranged from 0.230 mW/m² to 13.57 mW/m² with a mean of 2.593 mW/m². The value of power density radiation recorded for laptops during Wi-Fi enabled mode were higher than those recorded during Wi-Fi disabled mode. An ANOVA test carried out between the measured power density for laptops in Wi-Fi enabled mode and those in Wi-Fi disabled mode revealed that there is no significant difference between them. This research also revealed that newer version of laptops emitted lower level of power density radiation than older versions. All the power density radiation measured for all the laptops investigated in this work fell below the permissible power density level of 10 W/m² recommended by the Federal Communication Commission, Institute of Electrical and Electronics Engineers and the International Commission on Non-Ionizing Radiation Protection for the general public. The power density radiation emitted by all the laptops investigated in this research work is within the safety guidelines set by regulatory agencies. Therefore, these laptops are considered safe for human exposure and will not pose any health risk to users even during prolong usage. The data obtained in this work will serve as baseline data for further consultation on this subject.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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