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# Assessment of Radiofrequency Electromagnetic Radiation from Selected Microwave Ovens within Sokoto Metropolis.

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## Abstract

This study investigates the potential health risks posed by electromagnetic radiation emitted from microwave ovens commonly used in homes and offices for cooking and reheating food. With the widespread use of microwave ovens in modern society, concerns have arisen about the potential biological effects of prolonged exposure to the electromagnetic fields (EMFs) they generate during operation. To assess these risks, electromagnetic field measurements were conducted on selected microwave ovens located in residential areas across Sokoto Metropolis, Nigeria. Data collection involved measuring electric field strength, magnetic field intensity, and power density using a GQ EMF-390 handheld electromagnetic field meter. This instrument is capable of detecting EMF components in multiple directions and at various distances, providing a comprehensive assessment of radiation exposure levels. For each microwave oven, average values of the electric field, magnetic field, and power density were recorded during normal operation. These values were then used to compute the Specific Absorption Rate (SAR), which quantifies the amount of electromagnetic energy absorbed by human tissue. The results revealed a maximum SAR value of 3.1 W/kg, which far exceeds the maximum permissible limit of 0.08 W/kg for localized skin exposure as recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). This significant discrepancy raises concerns about the potential health implications of exposure to radiation from these appliances, particularly when users stand close to operating ovens or use them frequently over extended periods. The findings suggest that microwave ovens, if not properly shielded or used with caution, can emit radiation levels that may pose substantial health risks. This study highlights the urgent need for increased public awareness, adherence to safety guidelines, and possibly stricter regulatory enforcement regarding microwave oven design and usage. Further research is recommended to explore long-term biological effects and to evaluate radiation exposure in different settings and usage conditions.

# Keywords

Microwave oven, Non-ionizing, Radiation, Electromagnetic field

#### INTRODUCTION

form of Microwaves (MW) are ۵ radiofrequency (RF) electromagnetic radiation (EMR) in the non-ionizing region, these waves are radio waves whose wavelengths range from 1mm to 1 meter and the frequency is 300 MHz to 300GHz (ANSI, 1982). When an electromagnetic wave travels through space, the energy is transferred from the source to other objects (receivers). The rate of this energy transfer depends on the strength of electromagnetic field the components. Microwave radiation is measured as power density (Pd), which is essentially the rate of energy flow per unit area. Power density is the product of the electric field strength (E) times the magnetic field strength (H) (ICNIRP, 2010).

P = EH

Where P is the power density in W/m2. E is the electric field strength in V/m, and H is the magnetic field strength in A/m (ICNIRP, 2020).

(1)

Specific Absorption Rate (SAR) can be defined as a dosimetric quantity which is defined as the rate of RF power absorbed per unit mass by any part of the body.

$=\frac{\sigma E^2}{\sigma E^2}$	
SAR P	
	(2)

Where  $\sigma$  is the electrical conductivity of the material, and E is the electric field inside the material (Kumar, 2013).

In a microwave oven. The turntable rotates the food products through the fixed hot and cold spots inside the cooking cavity (Hadbah, 2014). The cooking cavity is a space inside which the food is heated when exposed to microwaves. Door and choke allow access of food to the cooking cavity (Jaime, 2014). n a magnetron, microwaves are produced and sent into the cooking chamber via a waveguide. Due to the steel walls of this cuboid box, it functions as a Faraday cage. Metal grids are placed over the glass front door and the light bulb chamber. Because the grids' holes are so small in relation to the microwave wavelength, they behave exactly like metal plates. Most microwaves use a spinning turntable to heat food in this chamber, but some models also have a rotating reflector that serves as a stirrer. When incident microwaves reach the metal oven walls, they behave similarly to visible light striking a silver mirror. Since the electric fields (EF) of the waves interact substantially with the almost free electrons of the metal, microwaves are successfully absorbed. In a simple model, the electron behaviors described as a forced oscillation that is dampened. The electromagnetic waves (EMW) that these accelerated electrons emit again have the same frequency and in phase, hence the microwaves are perfectly reflected. Most microwave ovens use magnetrons. The magnetrons in domestic microwave ovens emit microwaves at 2.45 GHz (repeatable, each time the magnetron is switched on, to 10 MHz) with bandwidths of only a few MHz (Meo and Rubeaan, 2013).

The rotation of water molecules would generate heat. In addition to the dipole water molecules, there is another source of heat by ionic compounds in food. As they are accelerated by an electromagnetic field (EMF), they collide with other molecules and produce heat (Priyanka *et al.*, 2013). Electromagnetic radiation can be absorbed by water-based bodies such as humans and animals. The radiation emitted by the microwave oven may affect the human body fatigue, irritability, causing cataract, aggression, hyperactivity, sleep disorder, emotional instability, and infertility in men (Thambiraj, et al., 2013). It also increases the risks of leukemia and brain/CNS cancer (WHO, 2010). Due to deep penetration of radiation, the skin may be minimally affected and shows no sign of damage while muscle, nerves, and blood vessels may be significantly damaged. Though the depth of penetration depends on the frequency of the microwave, intensity of the power, duration of exposure, and the thickness of the tissue or composition of the tissue. The effect of radiation exposure risk may increase as the oven get older of exposure (Lahham and Sharabi, 2013).

A study titled Electric and Magnetic Field Radiation Leakage from Microwave Ovens at Homes in Palestine investigated the amount of radiation leakage, the electric field, magnetic field and the specific absorption rate (SAR) from 115 microwave ovens in domestic use in Palestine. The power density of radiation leakage from microwave ovens was measured using instruments. The age of ovens were between 1 month and 13 years old including 14 ovens with unknown age, with operating power ranging from 700 W to 1350 W of different types, manufacturers, and models. The power density of radiation from ovens was measured at different distances at the height of center of door screen. Electric field, Magnetic field and SAR were calculated at distances 5 cm and 20 cm from ovens. These values were much less than the specified Electromagnetic Field levels (EMF) of International Commission on NonIonizing Radiation Protection (ICNIRP) for 2.45 GHz radiofrequency (Darawshe, 2014)

This research aims to analyze the microwave electromagnetic radiation leakage from some selected microwave ovens in residential areas within Sokoto Metropolis. This study will be of great importance to create awareness about the dangers of using micro wave ovens at home or offices. This research work is limited to the use of microwave ovens within Sokoto Metropolis.

#### 2. Methodology

#### 2.1 Study area

The study was conducted in Sokoto town located in the north-western part of Nigeria, and lies between Latitude 13.08333330, and Longitude 5.250 respectively.

#### 2.2 Data collection

A total of 23 ovens were selected at random. Measurements were obtained using GQ EMF 390 V-2 series capable of measuring power density, electric field and magnetic field in different units. Measurements were taken at 5cm distance away from the MW oven for a period of 1minute each for 1 second interval. Measurement was taken for the front, top and side of the oven for repeated period of time and the average obtained. All measurements were carried out when the oven is in use and the door is closed. First measurement was taken when the oven is not in use to serve as background. Then subsequent measurements obtained when oven is in use and the oven door is closed. Microwave oven emits MW frequency radiation of 2.4GHz. The Ovens used in this study were labeled M1 to M23. Data collected in this study were analyzed and compared with standard guidelines

# **3.Results and Discussion**

# 3.1: Results of Electromagnetic Fields, and Power Density from Microwave Ovens

The result of power density in (mWm<sup>-2</sup>) obtained at 5cm distance away from microwave ovens for 23 ovens are presented in Table 1. The value of the maximum power density was found to be 183.774 mWm<sup>-2</sup> observed for microwave oven M3 while the minimum power density was found to be 1.695 mWm<sup>-2</sup>. The

maximum power density obtained is below the ICNIRP maximum permissible limit of 10 Wm<sup>-2</sup> for 2.45 GHz frequency as indicated in the standard guidelines. The results obtained also shows that the EMF radiation obtained from the microwave ovens are high. The values fluctuate as a result of EMF obstruction from nearby objects and interference by other nearby EMF devices.

s/NO	Magnetic field	Electric field (V/m)	Power density (mW/m²)
	(mG)		
M1	297.400	55.900	2.822
M2	317.500	54.900	2.170
M3	350.200	53.100	183.774
M4	309.400	54.600	157.541
M5	239.900	55.700	2.888
M6	244.500	57.800	64.479
M7	333.400	61.000	61.567
M8	314.600	59.500	157.541
М9	324.200	55.300	12.990
M10	295.900	54.900	104.745
M11	298.900	62.600	40.933
M12	347.400	61.100	1.695
M13	355.800	55.700	4.415
M14	354.600	56.900	7.288
M15	287.600	57.100	1.874
M16	288.900	56.800	8.701
M17	242.800	56.500	42.540
M18	251.500	52.500	3.669
M19	260.300	56.600	2.025
M20	237.100	61.100	33.504

Table 1 Electromagnetic field and Power density for Microwave oven



Figure 1: Electromagnetic field from Microwave oven

Figure 1 showed that the highest value of EF was 62.6 V/m and minimum value was 52.50 V/m and for magnetic field the highest value recorded was 355.8 mG and lowest was 237.1 mG. The values fluctuate as a result of external factors like interference by other EMF around.

# 3.2: Results of SAR from Microwave Ovens

The result of specific absorption rate (SAR) in W/kg of skin tissue obtained at 5cm distance

away from microwave ovens are presented in Table 2. The Values of electromagnetic fields obtained was used to calculate the specific absorption rate.

skin	tissue f	rom m	icrowav
	Magnetic	Electri	icSAR
s/NC	) Field (mG	)field	<i></i>
	Tield (me	(V/m)	(w/ĸg)
1	297.4	55.9	2.477
2	317.5	54.9	2.389
3	350.2	531	2 2 3 5
4	200.4	55.1	2.200
4	309.4	94.0	2.303
5	239.9	55.7	2.459
6	244.5	57.8	2.648
7	333.4	61	2.949
8	314.6	59.5	2.806
9	324.2	55.3	2.424
10	295.9	54.9	2.389

Table 2: Specific absorption rate (SAR) for





Figure 2: Specific absorption rate for Microwave ovens

The result of specific absorption rate in watts per kilogram (W/kg) of skin tissue is calculated for the microwave ovens as shown in Figure 2. The Average SAR was 2.54 W/kg while the highest value of SAR was found to be 3.107 W/kg observed from oven M11, and the lowest level of SAR was found to be 1.287 W/kg. The maximum SAR obtained is higher than the ICNIRP maximum permissible limit of 0.08 W/kg of skin tissue as indicated in the standard guidelines.

The average Pd of 42.02 mWm<sup>-2</sup> obtained in this study is in agreement with the Pd obtained by Hadbah (2017) who obtained 46.12 mWm<sup>-2</sup>, and Darawshe (2014) who obtained Pd of 49.3 mWm<sup>-2</sup>, and the EF of 4.3 V/m which is within the range of EF obtained in this study. Tian (2025) obtained EF of 27.7 V/m which is lower than the value of 55.9 V/m in this study. Adding to this Tian (2025) in his work also obtained SAR of 0.0007 W/kg which is lower than average of 2.59 W/kg in this study. The small differences in RF values may be due to the age of oven, type of oven, and interference by other electromagnetic field in its vicinity.

# 4. Conclusion

ICNIRP revised guideline for 2020 does not recommend power density for radiofrequency and microwave frequency below 5GHz frequency. Therefore, the average values of electric field of 55.9 V/m, and SAR of 2.54 W/kg is above the ICNIRP recommendations. Finally, it is evident that radiation emission from the microwave oven in this study exceeds the maximum permissible limit of exposure standard set by ICNIRP.

Therefore, long-term exposure to RF and MW radiation exposure from theses microwave ovens may become harmful to those using them

as the radiation emitted is higher that safety recommended limits.

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