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Original Research Article

Analysis of Radiofrequency Radiation Exposure from Power Transmission Lines within Sokoto Metropolis

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ABSTRACT
Power transmission lines enable the efficient transfer of electricity over long distances. By transmitting electricity at high voltages, power losses due to resistance are minimized. This allows for the transport of electricity from power plants located far away to areas where it is needed, reducing the need for local power generation and promoting energy sharing and grid stability. While power transmission lines offer numerous benefits, they can also have some negative impacts on the environment. Power transmission lines generate electromagnetic fields, and there have been concerns about potential health risks associated with prolonged exposure to these fields. As such some individuals and communities express concerns and advocate for caution and further research. In this study, Radiofrequency (RF) electromagnetic radiation (EMR) was measured from power transmission lines within Sokoto metropolis. Electromagnetic field meter GQ EMF-390 was used to measure radiation in units of electric field (EF), magnetic field (MF), and power density (Pd). The maximum and minimum values of EF were found to be 97.6 V/m and 50.7 V/m. The maximum value of the magnetic field was 7.9 mG and the minimum value was 1.3 mG. The maximum power density radiation was found to be 1.533 mWm^{-2} while the minimum power density was found to be 0.001 mWm^{-2}.The highest value of specific absorption rate (SAR) was 7.88 W/kg. the SAR value obtained in this study is above the international standard limit for the general public set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) which is a limit of 0.008 W/kg of tissue. Therefore, people living close to these areas are not safe from the radiation hazard emitted by power transmission lines.

CITATION
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INTRODUCTION

Electricity in general, power lines, transformers, and electrical appliances generate low frequency (LF) electromagnetic radiation EMR). The LF electromagnetic radiation is often defined as sub-radio frequencies from 3 Hz to 30 KHz (Halpern, 2021). Power transmission lines are another important source of radiofrequency (RF) that emits Strong magnetic and electric fields. Studies show that these electromagnetic fields (EMFs) are stronger outside near the wires and extend for over a thousand feet away from the transmission lines (Neuert, 2021) Although once inside the home, the building structure provides some shielding but it is not advised able to live very close

to these transmission lines to reduce exposure to strong EMFs

Some report shows there are no health risks that have been conclusively demonstrated to be caused by living near high voltage power lines but science is unable to prove a negative including whether it is completely risk-free as there are reports that have found effects in cardiovascular, brain, hormonal, immune and behavioral changes. Therefore, power lines are not left out as the major contributors to daily environmental radiation hazards (WHO 2010).

Several countries have developed and/or adopted national or international guidelines for checking and ensuring that emissions from installed power transmission line systems conform to EMF safety levels. The adopted guidelines specify the Maximum Permissible Exposure (MPE) limits of EMF or RF energy that may be allowed into the environment for the general public. The International Commission for Non-Ionizing Radiation Protection (ICNIRP) standards and guidelines are widely used for setting national standards to restrict human bodies from EMF exposure (LEAC, 2010). Exposure standards usually referred to electric and magnetic components or power density limits. They are individually measured when it is required by the field properties related to the field regions. Nigeria, through an act of its National Assembly, is poised to adopt the ICNIRP standard (ICNIRP, 2020).

Although the amount of RF energy emitted by power lines is relatively low to constitute health hazards to humans, a poorly installed or configured power line could stray from the envisioned operating standards and function out of compliance, thus exposing humans to unsafe radiation and its attendant hazards (Bevelaqua, 2015).

Hundreds of studies worldwide have shown that living next to high-voltage power lines can cause harmful hazards to health. The closer you are the more you are bombarded with dangerous EMFs. The electrical power grid uses a "step down" system of distribution, highest near the generating station and substations, and lowest at the end. Increasingly, the medical community is recognizing the danger to health these power lines can cause. For example, a variety of studies suggests that living close to high-voltage power lines can increase the incidence of several kinds of cancer, as well as other diseases (Safe Space, 2022).

Some of the biological effects o these EMR sources are thermal effects that affect the eyes and the male testes, and non-thermal effects that may affect in vivo cell membrane structure and function. (Al-Awadi et al, 2013). The LF radiation exposure limit recommended by the 2012 Bio initiative report is 1 milligauss (mG) or 0.1 micro-Tesla. The work aims to assess EMR from power transmission lines in Sokoto state. The objective is to find the EMR in units of electric field, magnetic field, and power density emitted from these power lines and determine the specific absorption rate (SAR). The results will be used to assess the safety limits of the proximity of power lines to both residential and official residences. This work is limited to only power lines within Sokoto Metropolis, North - western Nigeria.

The awareness of the effects of EMR from power transmission lines can educate the public on the consequences of building and living close to EMR sources for a long period.

MATERIALS AND METHODS

Study Area

The study was carried out within Sokoto state. The areas lie between latitude 13.005873 North and longitude 5.247552 East as shown in Figure 1

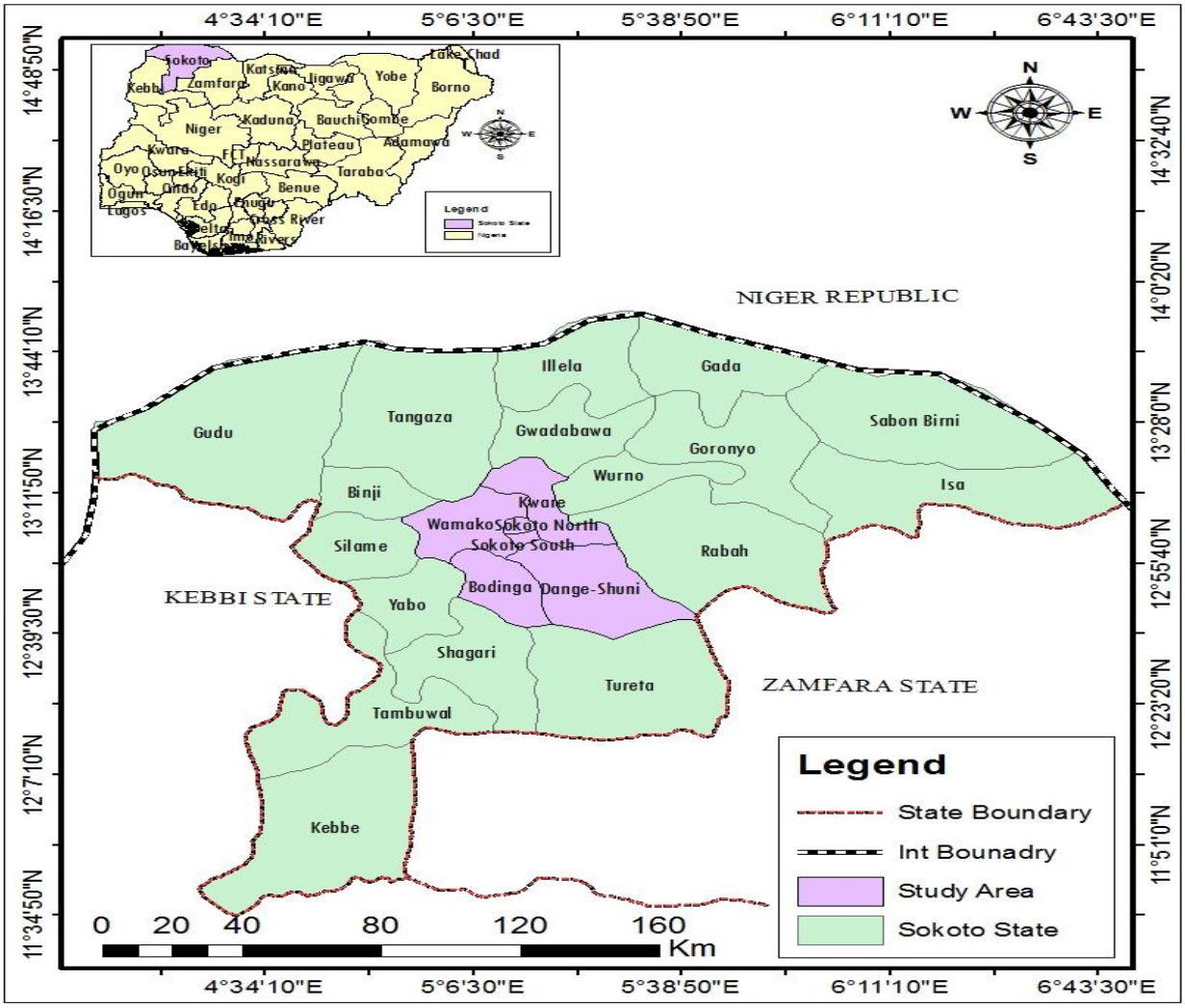

Figure 1: Map of Sokoto state showing Study Area
Source: GIS Lab Department of Geography Management A.B.U. Zaria.

Data Collection

Measurements were carried out from 19 power transmission lines selected due to proximity to living areas. GQ EMF 390 V-2 was used to measure RF and MW frequency radiation emitted from the power lines. The RF data was recorded from the foot of each power line in any convenient direction. Measurements were taken for 1 minute interval for a period of 6 minutes from each of the power lines and units of power density, electric filed and magnetic field were measured. The power lines were labeled P1 to P19. Only power lines that are accessible and close to living areas were selected. Data obtained were compared with primary data from International Commission on Non Ionizing Radiation Protection (ICNIRP) and World Health Organization (WHO) standard guidelines.

Theory:

Power density P_d at a distance R is calculated using equation (1) (Girish, 2010):

$$P_d = \frac{P \times 4\pi \times f^2}{C_0^2 \times G} \quad (1)$$

where, P = Measured power in Watts, G = 2.14 (Gain of receiving antenna), f = frequency in Hz, C_0 = Velocity of light.

Power received by an antenna at a distance R is calculated using equations (2)

$$P_r = \frac{p \times G \times Area}{4\pi R^2} (Wm^{-2}) \quad (2)$$

$$Power\ received = power\ density \times Area$$

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

$$SAR = \frac{\delta \times E^2}{\rho} \quad (3)$$

where, δ = Conductivity of human tissue, ρ = Density of human tissue, E =Electric strength

RESULTS AND DISCUSSION

Electromagnetic fields from power lines

The results of power density radiation and electromagnetic fields obtained from different power transmission lines in different locations are presented in Table 1. The maximum power density radiation was found to be 1.533 mWm^{-2} at location P8, while the minimum power density was found to be 0.001 mWm^{-2} at locations P6, P7, P10, P12, and P15, respectively.

Table 1: Average values of Electromagnetic Radiation from Power Lines

Power Lines	Magnetic field (mG)	Electric field (V/m)	Power density (mW/m^2)
P1	6.700	97.600	0.003
P2	7.700	88.800	0.005
P3	7.300	91.300	1.196
P4	7.300	99.700	0.064
P5	7.900	74.900	0.007
P6	7.000	91.900	0.001
P7	7.700	90.700	0.001
P8	3.100	51.900	1.533
P9	6.500	82.100	0.006
P10	6.100	67.400	0.001
P11	5.500	62.600	0.053
P12	7.400	72.300	0.001
P13	7.800	93.600	1.475
P14	2.900	54.600	1.375
P15	7.500	69.800	0.001
P16	1.800	52.800	1.151
P17	6.700	96.500	1.169
P18	1.300	50.700	0.013
P19	7.600	97.200	1.041

Table 2: Specific absorption rate for power lines using human skin tissue

Power Lines	Electric field(V/m)	SAR for Human Skin (W/kg)
P1	97.600	7.551
P2	88.800	6.251
P3	91.300	6.607
P4	99.700	7.879
P5	74.900	4.447
P6	91.900	6.695
P7	90.700	6.521
P8	51.900	2.135
P9	82.100	5.343
P10	67.400	3.601
P11	62.600	3.106
P12	72.300	4.143
P13	93.600	6.945
P14	54.600	2.363
P15	69.800	3.862
P16	52.800	2.209
P17	96.500	7.382
P18	50.700	2.037
P19	97.200	7.489

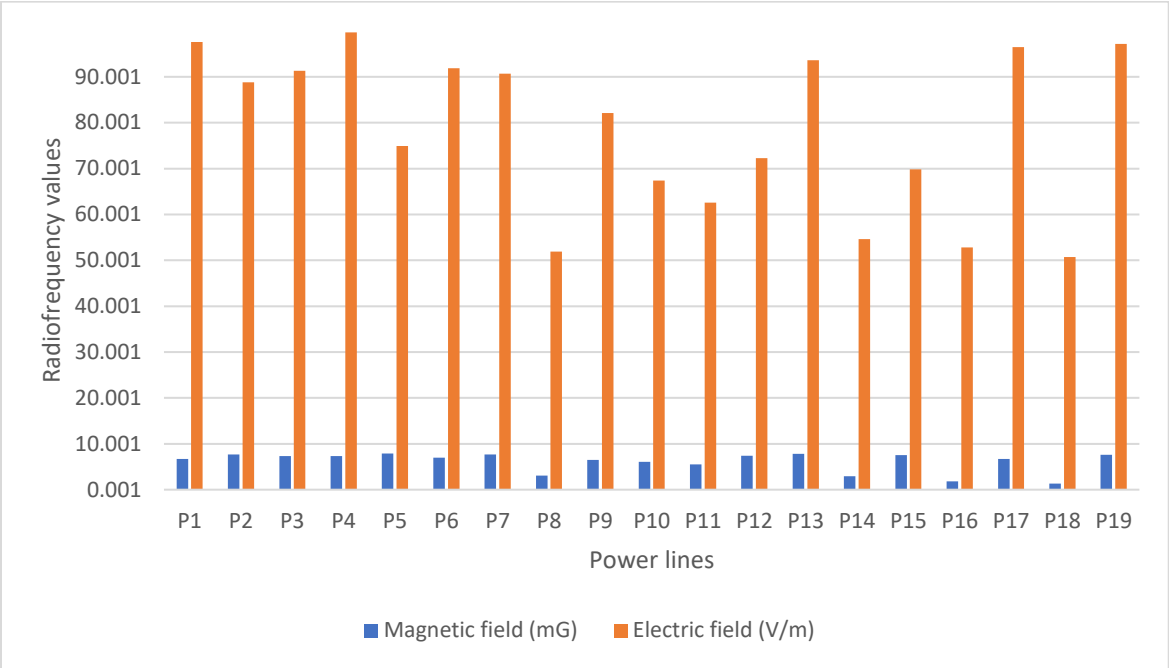

Figure 2: Electromagnetic field values for power lines

Figure 2 shows the Electric field and magnetic field value obtained for the different power transmission lines selected. The maximum and minimum values of EF were found to be 97.6 V/m at P1 and 50.7 at P18 V/m. The maximum value of the magnetic field was 7.9 mG obtained at location P5 and the minimum value was 1.3 mG at location P18. The values fluctuate as a result of EMF obstruction by nearby objects and interference by other nearby EMF devices.

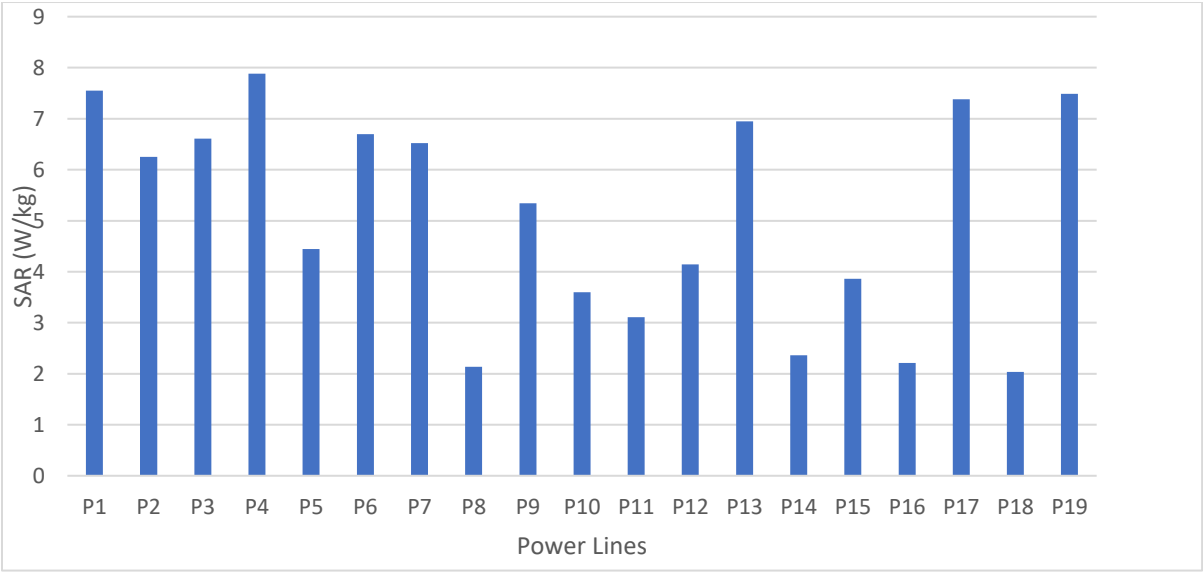

Figure 3: Specific absorption rate for power transmission lines

Figure 3 shows the result of the specific absorption rate in watts per kilogram (W/kg) of skin tissue calculated for the power transmission lines. The highest value of SAR was found to be 7.879 W/kg observed for location P4 while the lowest level of SAR was found to be 2.038 W/kg. The maximum SAR obtained is far higher than the ICNIRP maximum permissible limit of 0.08 W/kg of skin tissue as indicated in the standard guidelines.

The maximum value of the electric field obtained was 97.6 V/m is far less than the maximum value of 980 V/m obtained for power transmission line by Aregbola (2022). Adding to this Robert (2023) obtained values of 2 V/m for electric field, 0.7 mT for magnetic field, and 30 mWm-2 for

power density while Bitzas (2024) found a maximum value of 91 V/m, and 7.1 mT for magnetic fields. Hence my work is in agreement with Bitzas within a range of 97 V/m. These small differences may be due to transmitting power of the antennas, antenna type and interference by other electromagnetic field equipment.

CONCLUSION

Power transmission lines offer several benefits in the field of electrical energy distribution: They form the backbone of electrical grids, ensuring a reliable supply of electricity to homes, businesses, and industries. They also provide the infrastructure needed to deliver power from diverse sources to end-users, reducing the likelihood of blackouts and ensuring a consistent and uninterrupted power supply. The international commission on non-ionizing radiation Protection limits the general public to 0.08 W/kg of SAR for human skin tissue. To have a clearer picture, the average of the electric field, magnetic field, power density, and SAR for the entire power lines was obtained and the average value for EF was found to be 78.23 V/m, MF was 6.09 mG, Pd was 0.48 mWm^{-2} and SAR was 5.08 W/kg. ICNIRP revised guideline for 2020 does not recommend power density for low frequency radiation from power transmission lines. Therefore, the average SAR of 5.08 W/kg of tissue is above the ICNIRP maximum permissible limit of 0.008 W/kg of tissue. Hence, people living close to these power transmission lines are not safe from the hazard of exposure to electromagnetic field radiation. Although further research needs to be done on the long-term effects of this low EMF emission on human health and the environment in general. It was observed that a quiet number of people build close to these power lines which exposes them to the dangers of long-term exposure to EMR as houses are supposed to be sighted 100 m away from these structures to reduce exposure to EMR from power transmission lines.

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