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Investigation of the Health Implications of Electromagnetic Radiation Emissions from Step-Down Transformers in Akia-Effa, Calabar Municipal, Cross River State, Nigeria

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Abstract

This study was conducted to assess the intensity of electromagnetic radiation emitted from electrical transformers and its potential implications for environmental and public health safety. The research aimed to determine electric and magnetic field radiation (EMFR) levels at varying distances from selected step-down transformers in the Akia-Effa community, Calabar, Cross River State, Nigeria. Using an electromagnetic field (EMF) meter, measurements of EMFR were taken at distances of 0m - 100m from two strategically selected transformers under normal load conditions during peak and off-peak hours to assess the effect of load variation. The results revealed that the values of the electric field ranged from 0.035V/m to 0.82V/m and the magnetic field ranged from 0.29μT to 1.17μT, showing a decrease with increasing distance from the transformers, except for some flash points. Statistical (Pearson correlation and linear regression) analysis revealed a significant negative correlation between distance and EF strength ($r = -0.62$, $p = 0.041$), indicating a decrease in EF with increasing distance. However, no significant correlation was found between distance and MF strength ($r = -0.05$, $p = 0.875$). When compared with the International Commission on Non-Ionising Radiation Protection (ICNIRP) guidelines, the recorded values were significantly below the recommended exposure limits, suggesting minimal risk to residents and the environment. However, the proximity of residential buildings and shops to transformer installations indicates the need for continuous monitoring and adherence to standard setback distances. The study concludes that although the current emission levels pose no immediate health threat, proactive regulation and periodic environmental assessment are essential to ensure long-term public safety as electricity demand and transformer load capacities increase in the community.

Keywords: Emission, Electric field, Magnetic field, Transformer, Step-down, Electromagnetic radiation

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Introduction

The proliferation of electrical infrastructure in response to the increasing demand for electricity has brought about significant attention to the electromagnetic fields (EMFs) associated with such systems. One of the key components of electrical distribution networks is the step-down transformer, which reduces high transmission voltages to lower, usable levels suitable for domestic and industrial consumption. Although emission levels from step-down transformers are typically lower than those from high-voltage transmission lines or radio frequency sources, they may still contribute to long-term exposure in residential or urban settings. With the increasing installation of transformers in proximity to homes, schools, and workplaces, public concern about possible health effects associated with chronic exposure to EMFs has grown significantly (Ibrahim and Musa, 2023). Various international agencies, such as the International Commission on Non-Ionising Radiation Protection (ICNIRP), have established exposure guidelines for electromagnetic radiation to safeguard public health. However, adherence to these standards does not eliminate the need for localised investigations, especially in densely populated areas where multiple transformers are in operation. The proximity of individuals to these transformers, the duration of exposure, and the cumulative effect of electromagnetic fields from surrounding devices make it imperative to study the actual levels of electric and magnetic field emissions. This investigation seeks to evaluate the level of electric and magnetic fields emitted by step-down transformers in a given area and to compare the measured values to internationally accepted safety thresholds. The findings from this study will provide critical insights into the electromagnetic landscape of the environment, highlight potential risks, and inform strategies for mitigating exposure. Furthermore, it will contribute to the broader discourse on environmental safety, energy distribution infrastructure, and public health, particularly in rapidly urbanising regions where electrical demand and infrastructure deployment are intensifying.

The use of transformers in power distribution is indispensable. Among these, step-down transformers play a critical role in voltage reduction for end-user consumption. However, these devices emit electromagnetic fields (EMFs) that may pose environmental and health concerns. With growing urbanisation and proximity of electrical installations to residential areas, it becomes essential to investigate and assess the level of electromagnetic emissions from such equipment to ensure public safety and compliance with global standards (Abdul *et al*., 2019; Olorunfemi and Salawu, 2016). Scientific investigations into EMF exposure have focused on epidemiological studies, in vitro and in vivo experiments, and risk assessments (World Health Organisation [WHO], 2016; Adebayo *et al*., 2020). Step-down transformers are designed to reduce high voltage to a lower, usable level suitable for residential, commercial, and industrial applications. These devices are often installed in open environments or near populated areas, increasing the need for strict monitoring of their emissions. With the rising electricity demand, more transformers are being installed, often without adequate spatial buffer between equipment and human dwellings (Oladele *et al*., 2019). Multiple studies have documented concerns over the emission levels from transformers. For instance, Olowu *et al*. (2018) found that EMFs emitted from step-down transformers in urban areas often exceeded the ICNIRP-recommended exposure limits. These excessive emissions can potentially affect both biological systems and electronic equipment within their proximity (Eze, 2020). Globally, organisations such as the ICNIRP, WHO, and IEEE have developed exposure guidelines for EMFs. These frameworks set thresholds for occupational and public exposure levels to prevent adverse health effects. In Nigeria, the Nigerian Electricity Regulatory Commission (NERC) has implemented policies on transformer safety, yet implementation and monitoring remain inconsistent (NERC, 2020; Obukhov *et al*., 2015). The ICNIRP recommends a reference level of 200 μT (microtesla) for magnetic field exposure at 50 Hz for the general public. However, localised emissions near transformers have been reported to exceed these limits, especially in densely populated areas with poor zoning and infrastructural planning (Ugwoke *et al*., 2017). Studies have linked long-term EMF exposure to increased risk of childhood leukemia, neurodegenerative diseases, and alterations in cellular physiology (Kheifets *et al*., 2018; Huss *et al*., 2015). Although definitive causality has not been established, precautionary principles encourage minimizing exposure. The potential effects of electromagnetic fields on melatonin secretion, sleep patterns, and oxidative stress are among the frequently cited concerns (Okon *et al*., 2019). Besides human health, excessive EMFs can interfere with the behavior of wildlife, disrupt sensitive measuring equipment, and induce voltages in metallic structures. In urban areas, close proximity of transformers to communication installations has led to electromagnetic interference, affecting signal transmission and quality (Yahaya *et al*., 2021). Modern transformer designs now include EMF shielding, optimized coil geometry, and use of low-emission materials. Still, older installations, especially in low- and middle-income countries, continue to pose risks due to poor maintenance and aging infrastructure (Sani *et al*., 2022). Shielding, site planning, and periodic EMF assessment are recommended strategies for minimizing emissions (Alghamdi and Ismail, 2020). The lack of awareness about EMF emissions among the populace, coupled with the absence of strict enforcement mechanisms, aggravates the risk (Ibrahim and Okoro, 2020). Prior studies in Lagos, Calabar, and Kaduna have revealed varied levels of emissions, often higher in high-density neighborhoods (Onuoha et al., 2018; Yakubu *et al*., 2021).

EMF levels around distribution transformers were measured and found that PFD values decreased significantly with increasing distance from the transformer. Their results indicated a mean PFD of 1.25 μW/cm² at 0 meters, decreasing to less than 0.3 μW/cm² at 5 meters (Ushie *et al*., 2017) The standard instruments used for measuring PFD around step-down transformers include broadband electromagnetic field meters, spectrum analyzers, and frequency-specific probes. These devices capture the magnitude and distribution of emissions within a given frequency range (Ibrahim *et al*., 2022). An investigation by Chukwu *et al*. (2020) in Calabar, Nigeria, revealed that over 65% of step-down transformers were installed within 2 meters of human dwellings, often without shielding or adequate public awareness of EMF exposure. Shielding and strategic siting remain the most effective methods to mitigate EMF emissions from step-down transformers. Materials like mu-metal, copper mesh, and grounded enclosures can significantly reduce emission (Zhou *et al*., 2019). Ibrahim and Musa (2023) proposed the use of hybrid shielding enclosures and reported a 70% reduction in emission, in their pilot study involving residential transformers in Kano State. In a notable study, Ugwuanyi *et al*. (2022) measured emission levels in urban Enugu and found that EMF emissions exceeded 2 μW/cm² at distances less than 1.5 meters from transformers, breaching both ICNIRP and local guidelines. According to Ushie *et al*. (2017), low-frequency transformers typically emit magnetic fields that can propagate within a radius of several meters, potentially exposing nearby humans. They noted that emission depends on the load, transformer design, shielding, and distance from the source. The International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2010) established public exposure limits for electric field of 0.05kV/m and magnetic field strength of 0.08A/m at frequencies of 25Hz-300Hz. Though most transformer installations studied remained below this threshold, continuous exposure, especially in urban residential areas, was highlighted as potentially problematic.

Materials & Methods

This study was conducted in selected residential and institutional locations where step-down transformers are installed within Akia-Effa communities in Cross River State. Two strategically selected transformers under normal load conditions in these locations were chosen based on proximity to human settlements, accessibility, and transformer activity level. Cornet Electromagnetic Meter ED 78 Model, Global Positioning System

(GPS) Device, Measuring tape, Notebook and Pen, and Personal Protective Equipment (PPE). **Methods**: Cornet Electromagnetic Meter ED 78 Model was used vertically for proper positioning of the sensor to measure the electric field (in V/m) and magnetic field (in µT) emitted from the transformers. ED-78 Electrosmog meter is a dual mode device for quick measurement of both High frequency (RF) Electromagnetic wave field strength/power density level and Low frequency (LF) Magnetic field level (Gauss, Tesla) for living environments. It is an excellent device for individual or company with Electromagnetic wave safety concerns. It has RF bandwidth of 100MHz to 8GHz with high sensitivity (0.5uw/m² to 1.8w/m²), and LF bandwidth of 50Hz to 10KHz (or 50Hz to 1KHz) with sensitivity of 0.1uT to 60uT(1mG-600mG) or 0.01uT to 3uT (0.1mG to 30mG) with very fast response time. It was placed 1.4m above sea level indicating the average height of human beings.

Global Positioning System (GPS) Device Used to record the geographic coordinates of each transformer location for mapping and spatial analysis. Measuring tape Used for determining distances between the measurement point and the transformer to ensure standardization of data collection at specific radii and environmental conditions. Personal Protective Equipment (PPE) - Gloves, safety boots, and non-conductive wear to ensure safety near electrical installations. Ethical approval was not needed since specimens were not human tissue. A purposive sampling technique was employed to select at least 10 step-down transformer sites located in areas with varying population densities and building proximity within Aka-Effa Calabar Cross River State. EMF and EF strengths were measured at 11 points, 0-100 meters from the transformers. Each measurement was repeated three times at 5-minute intervals, and the average and standard deviation values {SD = $\sqrt{[(\Sigma(x - \text{mean})^2) / (n - 1)]}$} were used for analysis. Measurements were carried out during peak and off-peak hours to assess the effect of load variation. All readings were carefully recorded in data sheets along with corresponding GPS coordinates and environmental observations, using a calibrated meter. We analysed the data using Pearson correlation and linear regression.

Results and Discussion

From Table 1, we measured the electric field in the Akia-Effa timber market and averaged the two points. The maximum field measurement was measured at 0m (0.82V/m). The strength of the electric field decreases with distance. At a distance of 70m and 80m, the field increases; this may be caused by radiation from the mobile phone base station cited around this point and possibly due to the lowest conductor sag. This confirms Yahaya *et al*. (2021 study. The field reduces at distances of 90m and 100m. None of these points exceeds the threshold value as recommended by ICNIRP for the public.

Measurements of the magnetic field in the Akia-Effa timber market were taken, and the mean of the two points was calculated. The maximum field measurement was measured at 80m (1.17µT). The strength of the electric fields did not follow the inverse square law. However, none of these points exceeded the threshold value as recommended by ICNIRP for the public.

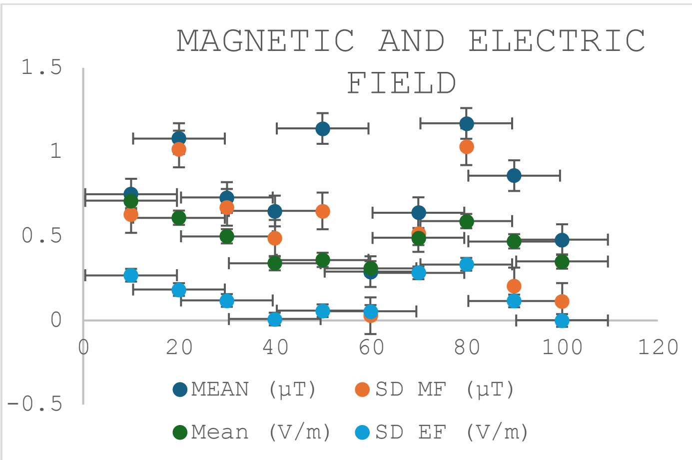

Figure 1: Comparative Plot of Electric and Magnetic Fields Showing Error Bar.

Table 1*: Measurements of the magnetic field (MF) and the electric field (EF) around the transformer in Akia-Effa timber market*

Dist. (M)	**MF (µT)**	**MF (µT)**	**Mean** (µT)	**EF (V/m)**	**EF (V/m)**	**Mean (V/m)**
0	0.40	0.36	0.380±0.0283	1.021	0.62	0.82±0.2838
10	1.20	0.31	0.75±0.6293	0.900	0.52	0.71±0.2687
20	1.80	0.36	1.08±1.0182	0.740	0.48	0.61±0.1838
30	1.20	0.25	0.73±0.6718	0.588	0.42	0.50±0.1188
40	1.00	0.31	0.65±0.4879	0.338	0.35	0.34±0.0085
50	1.60	0.68	1.14±0.6505	0.402	0.32	0.36±0.0579
60	0.31	0.27	0.29±0.0283	0.346	0.27	0.31±0.0537
70	1.00	0.27	0.64±0.5163	0.690	0.29	0.49±0.2828
80	1.90	0.44	1.17±1.0315	0.821	0.35	0.59±0.3336
90	1.00	0.71	0.86±0.2051	0.554	0.39	0.47±0.1159
100	0.40	0.56	0.48±0.1131	0.350	0.35	0.35±0.0000

The results revealed that the values of the electric field ranged from 0.035V/m to 0.82V/m and the magnetic field ranged from 0.29µT to 1.17µT, showing a decrease with increasing distance from the transformers, except for some flash points. Statistical (Pearson correlation and linear regression) analysis revealed a significant negative correlation between distance and EF strength ($r = -0.62$, $p = 0.041$), indicating a decrease in EF with increasing distance. However, no significant correlation was found between distance and MF strength ($r = -0.05$, $p = 0.875$). Fig. 1 shows that where the electric field drops, the magnetic field also drops. This shows the same strong correlation between the electric field and the magnetic field.

Conclusion

The result from the vicinity where the transformer is located shows that there is electromagnetic radiation emission. The size of the transformer is not an issue; the strength of the electromagnetic field (especially the magnetic component) where you live is what is important. For people living at a distance from the transformer, long-term exposure may be dangerous. Often it was found that secondary transmission lines in the streets are much worse polluters than the huge power line.

From the experiment carried out in Akia-Effa community in Calabar Municipal, Cross River State, Nigeria. We realise that the strength of the fields decreases with distance at certain points.

At the lowest points of conductor sag, where there is a mobile phone base station, the fields increased (Yahaya *et al*., 2021). The comparison of this result with the standard exposure limits, which is set by the International Commission on Non-Ionising Radiation Protection, shows that they don't pose any risk to human health if the exposure is for a short period. The minimum field measurement is recorded at a distance of 60 m from the transformer

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Data Availability: The data supporting the findings are contained in this article of this study and are available from the corresponding author upon reasonable request

References

Abdul Rahman, M., Hamid, N., & Huda, M. (2019). Assessment of electromagnetic field emissions from power transmission and distribution lines. *International Journal of Electrical Power & Energy Systems, 108*, 148–155.

Abidemi, A. O., & Ajayi, O. E. (2012). Assessment of electromagnetic field radiation exposure levels in the vicinity of power distribution substations in southwestern Nigeria. *Journal of Applied Science and Technology, 18*(2), 45–52.

Adebayo, F. O., & Olatunji, A. A. (2012). Investigation of electromagnetic field radiation from electric power distribution substations in Ibadan metropolis. *Nigerian Journal of Physics, 23*(1), 1–6.

Adebayo, T. A., Bello, A. A., & Salawu, S. A. (2020). Environmental assessment of power transformers in Nigerian cities. *Environmental Research Journal, 14*(2), 102–110.

Adewole, T. A., Ajayi, O. O., & Fashina, A. A. (2020). Evaluation of electromagnetic radiation around power transformers in Akure metropolis. *Nigerian Journal of Science and Environment, 18*(1), 73–82.

Ajewole, M. O., Salami, M. O., & Ogundipe, T. M. (2018). Public exposure to electromagnetic fields from distribution transformers in Lagos State. *Scientific African, 2*, 030.

Alghamdi, A., & Ismail, A. (2020). Mitigating electromagnetic emissions from electrical devices: Advances and strategies. *Journal of Applied Electromagnetics*, *18*(3), 211–219.

Bello, R. S., Olowu, T. O., & Akinyemi, S. A. (2017). Comparison of electromagnetic field levels near transformer substations using different measurement techniques. *Journal of Applied Sciences and Environmental Management, 21*(4), 625–631.

Chen, W., Li, J., & Zhao, Y. (2014). Design and evaluation of electromagnetic shielding systems for distribution transformers. *Progress in Electromagnetic Research B, 61*, 125–137.

Chukwu, C. A., Udo, A. B., & Okon, A. J. (2020). Environmental hazard assessment of power transformers in Calabar metropolis. *African University of Technology Journal of Science and Technology, 14*(9), 292–300.

Dlamini, Z., & Sibanda, M. (2021). Health perception and EMF exposure near residential transformers: A case study in Durban, South Africa. Health and Environment Journal, 12(3), 165–174.

Ekpe, A. E., Akpan, G. E., & Essien, P. J. (2017). Urban planning and the siting of electrical installations: Implications for safety in Nigerian cities. *International Journal of Urban Studies, 6*(1), 45–53.

Elliott, P., Shaddick, G., Douglass, M., & Toledano, M. B. (2010). Distance and exposure to extremely low frequency magnetic fields from power lines and transformer substations. *Bioelectromagnetics, 31*(4), 261–267.

El-Sayed, A. M., & Atya, M. A. (2011). Environmental evaluation of electromagnetic field emissions from indoor and outdoor distribution transformers. *Egyptian Journal of Engineering, 58*(3), 31–38.

Eze, C. J. (2020). Health risk assessment of electromagnetic radiation from transformers in residential areas. *Nigerian Journal of Environmental Sciences and Technology, 4*(1), 45–54.

Hardell, L., & Carlberg, M. (2015). Health risks from radiofrequency radiation, including 5G, should be assessed by experts with no conflicts of interest. *Oncology Letters, 10*(2), 1751–1756.

Huss, A., Goris, K., Vermeulen, R., & Kromhout, H. (2015). Occupational exposure to extremely low-frequency magnetic fields and the risk of ALS. *Occupational and Environmental Medicine, 72*(9), 648–653.

Ibrahim, A. R., Yusuf, M. K., & Gana, Y. M. (2022). Measurement of electromagnetic field radiation from transformers using broadband meters. *Scientific Research and Essays, 17*(5), 88–96.

Ibrahim, A., & Musa, K. (2023). Assessment and mitigation of EMF emissions from residential transformers in Northern Nigeria. *IEEE Access, 11*, 11430–11445.

Ibrahim, S., & Okoro, A. (2020). Urban planning and transformer installation standards in Nigeria: A review. *Journal of Urban and Regional Studies, 5*(4), 34–44.

ICNIRP. (2010). Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz–100 kHz). International Commission on Non-Ionizing Radiation Protection.

ICNIRP. (2020). Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). International Commission on Non-Ionizing Radiation Protection.

Kheifets, L., Swanson, J., Kandel, S., & Malloy, T. F. (2018). Risk governance and precautionary approaches related to EMF exposure. *Environmental Health Perspectives, 126*(3), 037002.

Ladan, M. A., & Musa, K. A. (2014). Mapping of electromagnetic field radiation around power transformers using GIS. *Journal of Environmental Science and Technology, 7*(2), 108–116.

Moya, A. F., Lopez, J. A., & Cortes, B. M. (2021). Modeling and assessment of EMF emissions in power distribution systems. *Energy Reports, 7,* 4521–4532.

NERC. (2020). Guidelines on the installation and maintenance of distribution transformers. Nigerian Electricity Regulatory Commission.

Nouri, H., Ghanbari, M., & Azizi, H. (2013). Measurement of power-frequency magnetic field levels around distribution transformers in Tehran. *Iranian Journal of Environmental Health, 10*(2), 74–80.

Obukhov, Y., Hehl, F. W., & Rubilar, G. F. (2015). Power density and EMF exposure: Theoretical underpinnings. *Physics Reports, 567*, 1–43.

Ogunleye, T. A., & Adeniyi, K. O. (2013). Evaluation of EMF exposure levels in schools near power transformers in Oyo State. *Nigerian Journal of Engineering and Technology, 12*(1), 34–41.

Okon, U. A., Ekong, M. B., & Ekong, C. N. (2019). Melatonin disruption by electromagnetic radiation: A review. *Nigerian Biomedical Science Journal, 15*(2), 92–100.

Oladele, J. O., Yusuf, A. T., & Musa, I. A. (2019). Step-down transformer installations in residential areas: A case study of Abuja. *Journal of Power Engineering, 19*(1), 77–85.

Olorunfemi, M. O., & Salawu, K. A. (2016). Electromagnetic field mapping of power installations in Ilorin, Nigeria. *African Journal of Physics, 8*(2), 42–49.

Olowu, A. A., Agboola, O. O., & Ogunlade, A. O. (2018). Measurement and evaluation of magnetic field emission from distribution transformers. *Journal of Physics: Conference Series, 1299*(1), 012-020.

Onuoha, M. U., Okereke, C. N., & Ndukwe, J. (2018). Magnetic field survey around electrical facilities in Lagos Metropolis. *Environmental Monitoring and Assessment, 190*(4), 228.

Sani, A. M., Yakubu, M., & Gambo, M. (2022). Comparative study of electromagnetic emissions in new and old transformer models. *Engineering and Applied Sciences Journal*, *23*(2), 101–110.

Sani, A., Abdulrahman, M., & Tanko, A. (2013). Temporal variability of power flux density from electrical transformers. *Journal of Energy and Power Engineering*, *7*(3), 104–110.

Ugwoke, E. C., Obiora, D. N., & Eze, U. A. (2017). Mapping and assessment of electromagnetic field radiation in Nsukka urban area. *Nigerian Journal of Physics*, *29*(1), 53–62.

Ugwuanyi, U. I., Nwoye, J. A., & Eze, P. O. (2022). Field evaluation of electromagnetic radiation levels around electric transformers in Enugu urban. *Journal of Environmental and Public Health*, *2*(22), 1–8.

Ushie, P. O., Pekene, D. J., Obi, E. O., & Ukhurebor, K. E. (2017). Investigation of field induced effect of high voltage transmission line in Calabar South, Nigeria. *Physical Science International Journal*, *5*(1), 1–9.

WHO. (2016). Environmental health criteria 238: Extremely low frequency fields. World Health Organization.

World Health Organization (WHO). (2016). Electromagnetic fields and public health: Exposure to extremely low frequency fields (WHO Fact Sheet No. 322).

Yahaya, A. I., Mustapha, A. A., & Adewuyi, O. (2021). Electromagnetic interference from transformers: An urban communication problem. *Nigerian Communications Journal, 9*(1), 27–33.

Yakubu, M. A., Usman, M. H., & Sulaiman, R. A. (2021). Measurement of magnetic field radiation from distribution transformers in Kaduna. *International Journal of Energy and Power Engineering*, *15*(4), 163–171.

Yusuf, I. K., & Bello, S. A. (2011). Public awareness and perception of EMF risks in Nigeria: A case study of Abuja. *International Journal of Environmental Research, 5*(4), 795–802.

Zhou, H., Li, J., & Wang, K. (2019). Design and performance analysis of electromagnetic shielding for low-frequency transformer radiation. *Progress In Electromagnetics Research, 82*, 23–35.