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Measurement of Electric Field Radiation from 11KVA High Tension Power Line and Its Environmental Effects in Calabar Metropolis, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author Inyang, Ephraim P. designed the study and performed the statistical analysis. Author Inyang, Etido P. carried out the measurements, wrote the protocol and wrote the first draft of the manuscript. Authors WES and UPO managed the analyses of the study. Author OGA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study measured the electric field from high tension 11 KVA power line by varying the distance between 5 m to 30 m respectively using electrosmog meter. The results revealed that the highest amount of radiations of 1.601 V/m, 1.568 V/m, 1.451 V/m, 1.345 V/m, 1.238 V/m, 0.996 V/m and 0.579 V/m respectively were observed at a distance of 5 m in all the locations. In all cases, the measured radiations were very far below the exposure limits set by International Commission on Non-Ionizing Radiation Protection. It is therefore recommended that one should not stay very close to high tension power line even though short term exposure may not produce immediate health effect. Nevertheless, staying close to the source of radiation, strength of the electric field generated and long term exposure can be dangerous to individual health.

Keywords: Exposure; extremely low frequency; non-ionizing radiation; electric field; power line.

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1. INTRODUCTION

Radiation is energy that moves in the form of particles or waves and humans have always been exposed to radiation from natural sources [1]. However with the development of technology, particularly in relation to work activities, this exposure has increased. Electric and magnetic field occurs during the production, transmission, distribution and use of electricity. Electricity as an electrical energy is important in so many ways such as in communication, heating, source of light and in electrical appliances. Electricity, though very useful to man has its own harmful effects from the radiations emitted from the power lines. Compliance with exposure limits recommended in international guidelines helps to control the risks of exposure [2]. This radiation of low frequency falls under non-ionizing radiation. Non-ionizing radiation refers to any type of electromagnetic radiation that does not carry enough energy to ionize atoms or molecules, that is, to completely remove an electron from an atom or molecule [3]. Instead of producing charged ions when passing through matter, the electromagnetic radiation has sufficient energy only for excitation, the movement of an electron to a higher energy state [4].

Studies by [5] and [6] described the scientific evidence suggesting that electromagnetic field exposures constitute a health risk such as cancer, leukemia, neuropsychological disorders, reproductive outcome etc.

There has been concerned over power line radiation and its effect on human health for the past decades. High-voltage overhead power lines conduct electricity from power generating stations to power source substations which are located close to where the energy is actually used. These power lines produce two types of energy: electrical energy and magnetic energy which are given of in a field that expands in all directions around the wire [7].

The health effects of exposure from extremely low frequency (ELF) will be dependent upon: The duration of exposure to the radiation, the strength of the electric field from the power line and the distance from the power line. There are European and International Commission on Non-Ionizing Radiation Protection (ICNIRP) standards. In these criteria, the frequencies of different electromagnetic fields have a reference value. Both bodies set the standard to 5 V/m for Public areas and 10 V/m for occupational areas [8].

The scientific evidence does not firmly establish that exposure to 50 Hz electric and magnetic fields found around the home, the office or near power lines is a hazard to human health. In view of the epidemiological studies, however, the possibility remains that intense and prolonged exposures to electric fields may increase the risk of leukemia in children [9]. [10] cited links between electromagnetic fields (EMFs) and the following adverse effects such as: childhood and adult leukemia, adult brain cancer, breast cancer, depression, electrical stability symptoms, certain types of heart diseases, and miscarriage.

The permittivity of biological tissues is to a large extent determined by water and electrolyte contents. Thus, tissues such as blood, muscle, liver and kidneys, which have higher water content than tissues such as fats and lungs, have higher dielectric constants and conductivities. Both the permittivity and conductivity vary with frequency and exhibit relaxation phenomena. The physical phenomenon responsible for the dispersion at low frequencies is counter ion polarization [11].

The exposure of conductors to time varying electric and magnetic field leads to current being induced in conductors. The distribution of currents in terms of its pattern induced by electric and magnetic field differ from each other. Electric field when exposed to a human body standing uprightly, the flow of field and current induced are vertical, while for a magnetic field, current flow in a perpendicular direction to form a closed loop [12]. There is perturbation of the peripheral electric field by biological bodies, due to the fact that the tissue conductivity is at low frequencies. Due to the use of wireless technologies and electricity from man-made sources, electromagnetic field has increased progressively apart from the electromagnetic fields which occur in nature. During one's lifetime, our body is exposed to a combination of electric and magnetic fields at different frequencies [13]. Health effects result from biological effects that cause deficiency in the health or wellbeing of exposed individuals when the energy of the fields is absorbed and transformed into movement of molecules [14]. Using the standard of ICNIRP classification that weighs up human, animal and laboratory evidence, ELF fields were classified as possibly carcinogenic to humans based on epidemiological studies of childhood leukemia. This classification is used to represent an agent for which there is limited evidence of carcinogenicity in humans and less than

sufficient evidence for experimental animals [15]. Children, pregnant women and those with poor health conditions are especially at risk for a lifetime of exposure [16]. The amount of "absorbed" versus. "exposed" radiation has to be considered since the absorption depends on the nature, amount and duration of radiation as well as the individual body condition. It is worth mentioning, however, that research and studies alerting from hazards are much more than those denying the effects. Studies have not been carried out in exposure of electric field radiation in this part of the world from electric power lines. Hence, this study will evaluate the health risk of exposure of electric field radiation from electric power lines.

2. MATERIALS AND METHODS

2.1 Materials

The material for this research is electrosmog meter model ED78S CORNET micro system Inc; USA having dual operation mode that is radio frequency mode and gauss meter mode. The RF meter has frequency range of 100 MHz to 8 GHz with a sensitivity of 14 mV^{-1} to 26.2 Vm^{-1} and gauss meter frequency ranges from 50 Hz to 10 KHz with a sensitivity of 0.1 mG to 600 mG respectively. The equipment has a sampling rate of 3500 per second and display update rate of 2 per second. A measuring tape of range 0-100 m was used in taking measurement from an established point.

2.2 Study Location

The study area is located in Calabar, a capital of Cross River state, Nigeria. Administratively the city is divided into Calabar `municipal and Calabar South Local Government Areas (LGA). It has an area of 406 square kilometer and had a population of 371,022 at the 2006 census. The city is adjacent to the great Kwa Rivers and creeks of the Cross River (from inland delta). The study area is located between longitude $N4^055^/$ to $N5^000^/$ and latitude $E8^018^/$ to $E8^021^/$. The location includes Palm Street, State housing estate, Ekorinim, Watt Market road, Akai Effa, Ikot Ansa and Port Harcourt Electricity Distribution (PHED) Calabar Road. All located within Calabar metropolis. The control was taken 10km away from the sample location in a forest where the effect of electric field from High tension was reduced to the barest minimum.

2.3 Methods

The electric field measurement was taken in seven locations using electrosmog meter within Calabar metropolis, Nigeria by varying the distances from 5 m, 10 m, 15 m, 20 m, 25 m and 30 m and the control was measured at a distance of 10 km away from the 11 KVA high tension in a forest were the effect was reduced. For all data, measurements were taken for a period of seven days at about 5pm in the evening every day between 8/1/18 to 14/1/18 and were repeated for at least three times and the average taken in order to ascertain the reproducibility of the results.

3. RESULTS AND DISCUSSION

Our results are as presented in Table 1, showing variation of electric field with distances at different sample locations.

At every distance, the maximum electric field emission was registered using a radio frequency meter (electrosmog meter). The electric field emitted varies with the horizontal distance away from the power line as shown in Table 1 and Fig. 1.

Palm Street recorded its maximum electric field of 1.238 V/m at a horizontal distance of 5 m from the power lines. It drops slightly to 0.785 V/m at a distance of 20 m and then it decreases sharply to 0.338 V/m at a distance of 30 m from the base of the power line. The values of the electric field at this location are high compared with the control value of 0.048 V/m at a horizontal distance of 10 km away from the source. Although the exposure level of the electric field from the power lines is below the set standard by ICNIRP of 5 V/m for the electric field. But compared to the control value, and coupled with the fact that other radio frequency gadgets such as satellite dishes, Television (TV) antennas, mast etc. capable of emitting radiations are equally present, the radiation at this location is capable of causing health risk in future.

State housing estate recorded its highest electric field of 0.579 V/m at a horizontal distance of 5 m from the base of the power line. There is a sharp downward trend of 0.097 V/m at a distance of 20 m and a decrease of 0.058 V/m at a horizontal distance of 30 m from the base of the power line. Though this increase in electric field might be influenced by other RF emission gadgets like

radio transmitters, TV antennas etc. The exposure level of the power lines is minimal below the ICNIRP set standard of 5 V/m for the electric field. State housing is highly populated it is a residential area with working class citizens. The people spent most of their time at home after work with their families which increase the use of these RF emission gadgets. Although the houses are well planned, power lines are found closed to most of the buildings. The difference between the results obtained and the control result of 0.048 V/m is high. This implies that there is a possible health risk in future from the radiations emitted from the power line.

At a horizontal distance of 5 m from the base of the power line an electric field of 1.568 V/m was recorded at Ekorinim. The value of the electric field decreases to 1.007 V/m at a distance of 20 m from the base of the power line and then to 0.639 V/m at a horizontal distance of 30 m. This high increase at a distance of 5 m might be influenced by other RF emission gadgets. But the exposure level is below the ICNIRP set standard of 5 V/m for the electric field. Ekorinim is a fast developing residential area with an increase in population. Most of the houses are situated some meters away from the power line. The control result of 0.048 V/m is small compared to the results obtained at this location. This implies that the radiations from the power line pose health risk in future.

Watt market recorded its maximum electric field of 0.996 V/m at a distance of 5 m from the power line. There is a gradual decrease in the electric field to 0.514 V/m at a horizontal distance of 20 m and then a further decrease of 0.037 V/m at a horizontal distance of 30 m. The exposure level is minimal compared to the standard set by ICNIRP of 5V/m for the electric field. Watt market is strictly for commercial purpose and not for residential. RF emission gadgets are very few so most of the radiations are from the power lines. The results at this location when compared to the control result of 0.048 V/m, obtained 10 km from a high forest is high. This implies that long term effects will be observe on those traders that stays either directly under the power lines or 20m away from the power line.

Table 1. Electric field (Vm^{-1}) variation with distances at different sample locations

S/N	Distance (m)	Palm street	State housing	Ekorinim	Watt Market	Akai Effa	Ikot Ansa	PHED
1	5	1.238	0.579	1.568	0.996	1.451	1.345	1.601
2	10	1.055	0.267	1.347	0.788	1.312	1.203	1.434
3	15	0.969	0.136	1.128	0.605	1.104	1.044	1.207
4	20	0.785	0.097	1.007	0.514	0.987	0.968	0.936
5	25	0.515	0.079	0.898	0.306	0.755	0.659	0.738
6	30	0.338	0.058	0.639	0.037	0.307	0.435	0.505

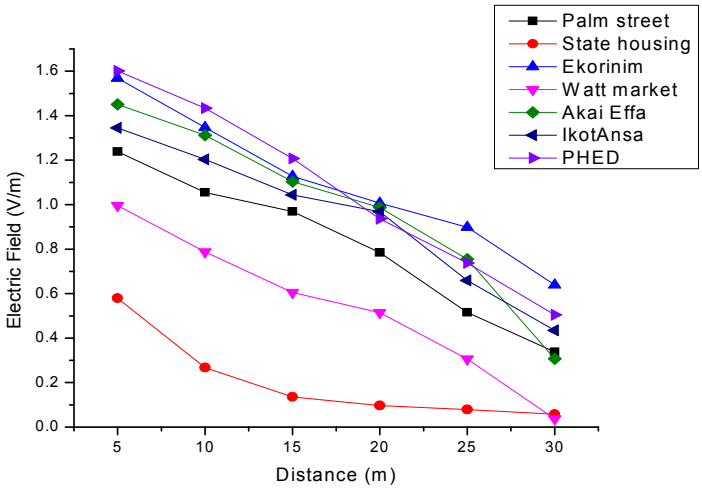

Fig. 1. Variation of electric field with distance at various sample locations

Akai Effa recorded a value of 1.451 V/m electric field at a horizontal distance of 5 m from the base of power line to 0.968 V/m at a distance of 20 m away from the base and finally 0.435 V/m at a horizontal distance of 30 m from the power line. The electric field obtained is minimal below the ICNIRP set standard of 5 V/m for electric field. Akai Effa is a fast growing area in Calabar municipal. It is a residential area with houses springing up almost on a daily basis. This will lead to an increase in population and a high demand for other RF emission gadgets such as satellite dishes, TV antennas, telephone masts etc. capable of increasing radiation. It was observed that the results obtained at this study area are higher than the control result of 0.048 V/m. This implies that the radiation from the power line is capable of causing health risk in future coupled with the radiations from other RF emission gadgets.

Ikot Ansa recorded its highest electric field of 1.345 V/m at a horizontal distance of 5m from the power lines. The electric field decreases to 0.968 V/m at a horizontal distance of 20 m from the base of the power line and with a further decrease of 0.435 V/m at a distance of 30 m. This increase might be influenced by other radio frequency gadgets such as radio transmitters, TV antennas, satellite dishes etc, due to the fact that it is a residential area and also a commercial area that is densely populated. Most People spent their time at home and the constant use of these RF gadgets will increase the amount of radiation. Though the exposure level is minimal compared to the standard set by ICNIRP of 5V/m for electric field. The results from this study area are high compared to the control result of 0.048 V/m obtained. This implies that in future, there will be a possible health risk due to the radiations from the power lines.

PHED Calabar road recorded an electric field of 1.601 V/m at a distance of 5m from the power lines. The electric field drops to 0.936 V/m at a horizontal distance of 20 m and a further decrease of 0.505 V/m at a horizontal distance of 30 m respectively. The emission level is below the set standard by ICNIRP of 5 V/m for the electric field. It is a commercial area, comprises of banks and other corporate organizations. Other RF gadgets capable of emitting radiations were observed. The result of this experiment is high compared with the control result of 0.048 V/m. These pose a health risk in the future.

4. CONCLUSIONS

Electrosmog meter (ED78S) was used for the measurement of electric field radiation from 11 KVA electric power line by varying the distance between 5 m to 30 m respectively. The results revealed that decreasing the distance increases the amount of radiation which is in agreement with the fact that electric field strength is inversely proportional to the distance.Although the radiations measured in this study were below the set standard by ICNIRP. In order to lay to rest the health concern of the general public on the effect of non-ionizing radiation, the radiation measured in this study and other studies that have been carried out over the past years in other countries reveal that there is still no persuasive evidence that the fields pose any health risk to humans. But staying close to the source of radiation, strength of the electromagnetic field radiation and long term exposure can be dangerous to individuals.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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