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Journal Name:	**Physical Science International Journal**
Manuscript Number:	**Ms_PSIJ_41825**
Title of the Manuscript:	**MEASUREMENT OF ELECTRIC FIELD RADIATION FROM HIGH TENSION (11 KVA) POWER LINE AND ITS ENVIRONMENTAL EFFECTS IN CALABAR METROPOLIS: NIGERIA**
Type of the Article	**ORIGINAL RESEARCH**

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PART 1: Review Comments

	Reviewer's comment	**Author's comment** *(if agreed with reviewer, correct the manuscript and highlight that part in the manuscript. It is mandatory that authors should write his/her feedback here)*
Compulsory REVISION comments	**MEASUREMENT OF ELECTRIC FIELD STRENGTH FROM HIGH TENSION POWER LINES (11 KVA) AND ITS ENVIRONMENTAL EFFECTS IN CALABAR METROPOLIS, CROSS RIVER STATE, NIGERIA** **ABSTRACT** *The study measured the electric field strength from high tension power lines (11 KVA) by varying the distance between 5 m to 30 m using Electrosmog meter:ED78S CORNET. The measurement was carried out within the period of [state the date and duration of the time taken]. Based from the measurement the computed mean extremum values of the mean electric field strength at the 5 m and 30 m are 0.331 ± 0.084 and 1.254 ± 0.370 V/m respectively within the sampled locations in Calabar Metropolis. In all scenario, the measured electric field strength were all below the limit of 5 kV/m for public exposure set by the International Commission on Non- Ionizing Radiation Protection (ICNIRP,2010). Result from the finding reveals that individuals living at a distance greater than 30m will experience little or no adverse health effects, while those living close to the source of high tension power lines (11 KVA) generating electric field may suffer from mild to serious health implications on the long run.* **Keywords**: Calabar Metropolis, Exposure, Non-ionizing radiation, Electric field intensity, High tension power lines **Keywords**: Calabar Metropolis, Exposure, Non-ionizing radiation, Electric field intensity, High tension power lines **1. INTRODUCTION** Radiation is a form of energy that moves in the form of particles or waves and humans have always been exposed to radiation from divers sources [1]. However with the development of technology, particularly in relation to working environment, this exposure has drastically increased. Electric and magnetic field occurs during the; production, transmission, distribution and use of electricity. Electricity as a form of energy is important in so many aspects such as; communication, source of heating, source of light and other electrical applications. Electricity, though very useful to man has its own harmful effects due to the electromagnetic field (EMF) radiation emitted from the high tension power lines. In compliance with exposure limits recommended from international guidelines, it creates an awareness to control the risks of exposure [2].The 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 the interacting 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 carried out [5;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 concern over high tension power lines radiation and its effect on human health for past decades. Especially 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 distributing high tension power lines [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. The European and International Commission on Non-Ionizing Radiation Protection (ICNIRP) standards, have a reference standard to 5kV/m for public area and 10kV/m for occupational area exposure [8]. The scientific evidence does not firmly establish that exposure to 50 Hz electric and magnetic fields found in ; home, office or near power lines is hazardous 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 leukaemia in children [9]. [10] cited the relationship between electromagnetic fields (EMFs) and adverse health 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, that 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 field 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 long time exposure [16]. The amount of "absorbed" vs. "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, that research and studies alerting from hazards are much more than those denying the effects. Studies have not been carried out due to exposure of electric field strength in Calabar metropolis from high tension power lines. Hence, this study will evaluate the measurement and the health risk of exposure to electric field strength from high tension power lines within some sample locations within the Calabar metropolis.

2. MATERIALS AND METHODS

2.1 Materials

The material used for the research is an electrosmog meter model; ED78S CORNET having dual operation mode radio frequency and gauss function. The RF meter has frequency range of 100 MHz to 8 GHz with a sensitivity of 14 V/m to 26.2 V/m and gauss meter frequency range from 50 Hz to 10 KHz with a sensitivity of 0.1 mG to 600 mG respectively. The equipment has a sampling time rate of 3500 per second and display update rate of 2 per second. A measuring tape of range 0-100 m was used in the measurement.

2.1.1 Study location

The study area is located in Calabar, the capital of Cross River State, Nigeria. Administratively the city is divided into Calabar municipal and Calabar South Local Government Areas (LGAs). It has an area of 406 square kilometer and 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^{0}55/ to N5000/ and latitude E8018/ to E8021/. The sampled locations include; 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.

2.2 METHODS

The electric field measurement was taken within the seven locations using electrosmog meter within Calabar metropolis, 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 completely null. For all data, measurements were repeated for at least three times and the average taken in order to ascertain the accuracy of results.

3. RESULTS AND DISCUSSION

The results showing variation of the electric field strength with distances at the different sampled locations and the mean values are presented in Table 1.

Table 1: Electric field (V/m) variation with distances at different sample locations

S/N	Distance (m)	Palm street	State housing	Ekorinim	Watt Market	Akai Effa	Ikot Ansa	PHED	Mean value of electric field strength (V/m)
1	5	1.238	0.579	1.568	0.996	1.451	1.345	1.601	1.254 ± 0.370
2	10	1.055	0.267	1.347	0.788	1.312	1.203	1.434	1.058 ± 0.155
3	15	0.969	0.136	1.128	0.605	1.104	1.044	1.207	0.885 ± 0.145
4	20	0.785	0.097	1.007	0.514	0.987	0.968	0.936	0.756 ± 0.128
5	25	0.515	0.079	0.898	0.306	0.755	0.659	0.738	0.578 ± 0.111
6	30	0.338	0.058	0.639	0.037	0.307	0.435	0.505	0.331 ± 0.084

At every distance, the maximum electric field strength was measured using the 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 Figure 1.

Figure 1: Variation of electric field intensity with distance at various sampled locations

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 kV/m [8],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 high tension power lines. There is a sharp downward decrease 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 kV/m [8]. 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 electric field strength emitted from the power lines.

At a horizontal distance of 5 m from the base of the high tension power lines, the electric field intensity of 1.568 V/m was recorded at Ekorinim. The value of the electric field intensity 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 neighbouring RF emission gadgets.
But the exposure level is below the ICNIRP set standard of 5 kV/m[8], for the electric field.
Ekorinim is a fast developing residential area with an increase population. Most of the
houses are situated some meters away from the high tension power lines. 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 high tension power lines. There is a gradual decrease in the electric field intensity 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[8].
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 high tension power lines or 20m away from it.
Akai Effa recorded a value of 1.451 V/m electric field intensity 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 [8]. 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 electric field strength. 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 electric field strength from the high tension power lines is capable of causing health risk in future coupled with the electric fields from nearby RF emission gadgets. Ikot Ansa recorded its highest electric field intensity of 1.345 V/m at a horizontal distance of 5m from the high tension 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 30m. 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 exposed rate of electric field. Though the exposure level is minimal compared to the standard set by ICNIRP of 5kV/m for electric field[8].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 high tension 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 5kV/m for the electric field [8]. 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

The results revealed that decrease in distance results to increase to the amount of electric field strength exposure which conforms to the fact that electric force field strength is inversely proportional to the square of its distance. Although the electric field strength measured in this study were all below the set standard by the ICNIRP of 5kV/m for electric field [8]. The measurements from this study and other studies carried out over the past years in other countries, have revealed that there is still no persuasive evidence that the electric field exposure posed no health risk to humans. But staying close to the source of high tension power lines generating electromagnetic radiation can be dangerous to an individual on the long term.

REFERENCES

[8] International Commission on Non-ionizing Radiation Protection, (ICNIRP Guidelines) for limiting exposure to time- varying electric, magnetic fields and electromagnetic fields (1Hz - 100kHz), Health Physics ; 2010:(99)6:818 - 836

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Minor REVISION comments		
Optional/General comments	Try and add the coordinates of the sampled locations (optional)	

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