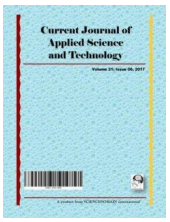

Current Journal of Applied Science and Technology

23(4): 1-9, 2017; Article no.CJAST.35298
Previously known as British Journal of Applied Science & Technology
ISSN: 2231-0843, NLM ID: 101664541

Measurement and Determination of Emission Levels of Ionizing Radiation from High Tension Lines around Kaduna Metropolis, North West, Nigeria

J. E. Nwoke[1*], M. Y. Onimisi[1], S. A. Jonah[2] and R. A. Tafida[1]

[1]Department of Physics, Nigerian Defence Academy, Kaduna, Nigeria.
[2]Center for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria.

Authors' contributions

All the authors collaborated to carry out this work. Author MYO designed the study. Author JEN undertook the experimental work, performed the statistical analysis, wrote the protocol, wrote the first draft and manage the literature searches. Author SAJ managed the analysis of the study and literature searches. Author RAT managed literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2017/35298
Editor(s):
(1) Luigi Maxmilian Caligiuri, Faculty of Science, University of Calabria, Italy and Foundation of Physics Research Center (Director)- FoPRC, Italy.
Reviewers:
(1) A. Ayeshamariam, Khadir Mohideen College, India.
(2) Adlina Suleiman, National Defence University of Malaysia, Malaysia.
Complete Peer review History: http://www.sciencedomain.org/review-history/20897

Original Research Article

Received 5th July 2017
Accepted 28th July 2017
Published 9th September 2017

ABSTRACT

Gamma radiation dose rate was measured at the base of 11 KV, 33 KV, 132 KV and 330 KV high tension lines (power lines) from different locations in Kaduna including Mando transmission sub-station using Radex 1503+ model. A total of about 187 measurements were taken and calculated. Radiation dose rate was also measured from a control site, an area that has no power line for comparison. Results show that the highest radiation dose rate from power lines within the city and the control site were about 1.46 mSv and 1.52 mSv respectively, which are greater than the ICRP guideline of 1mSv for public exposure by about 46% and 52% respectively. The results also show inconsistent relationship between the radiation dose rate and distance from the base of the power line. Results from the power sub-station was a little above that from the control site, about 0.84 mSv which comparing to ICRP guideline of 20 mSv for occupational exposure, the measured data is about 4.2% of ICRP guideline. Though the power lines show no significant evidence of emitting

**Corresponding author: E-mail: julietebele66@gmail.com;*

ionizing radiation, the high radiation dose rate (above the guidance level for the public), including the control site may probably result from beta radiation from ^{40}K, a known beta radiation emitter constituent of fertilizer use in farming that is very common in the area, since Radex radiation meter also measures beta radiation.

Keywords: Power lines; ionizing radiation; gamma rays; ICRP guideline; public exposure; occupational exposure; radiation dose rate.

1. INTRODUCTION

Electric power is, transmitted and distributed through high voltage cables. These high voltage cablesalso known as high tension cables or power lines are the cheapest means of transmitting and distributing electric power. Transmission lines carry 3-phase electric current from one point to another in an electric power system. The voltages vary from 11 KV to 330 KV in Nigeria [1]. These are transported over long distance via high tension grid.

When current goes through a wire, it generates magnetic field, and the field travels far from the line compared to the electric field produced. The field virtually passes through all materials and affects us more compared to electric field [2,1]. Transmission lines are therefore the dominant source of magnetic field in our environment. It has been confirmed that life is not safe under this high HV power lines [3,1].

Apart from the consequence of electric shock that can happen, the magnetic field created around the wire by the flowing current can have adverse biological effects on human like neurological, cardiovascular disorders and low sperm count in the workers who regularly service the line [3].

The danger associated with living near high-voltage power lines was first raised in 1979 in a study by Wertheimer and Leeper, which associated increased risk of childhood leukemia with residential proximity to power lines [4]. More recent studies by Draper and his group confirmed a reported association between elevated risks of childhood leukemia and proximity to residential power lines [5,6,7].

Some scientists have argued the physical impossibility of any health effects due to weak ambient levels of electromagnetic fields, while others maintained that the potential health risks should not be dismissed even though the evidence remains equivocal and contradictory.

While these arguments about health effects of emission from electromagnetic fields go on, in 2001 and 2011 the World Health Organization (WHO) entered extremely low frequency (ELF), which is the frequency range of electric and magnetic fields; and radio frequency (RF) respectively into the list of possible carcinogenic in human [8]. It has also been suggested on the internet and in transmission line hearings that corona_discharge produce by high voltage (HV) power lines emit ionizing radiation, and that this could explain the association between power line and cancer [9]. Others argue that corona discharge produce heat, light (in form of sparks), audible noise, radio interference and a small amount of ozone, and that there is no evident that these discharges produce ionizing radiation [9]. If power line emits ionizing radiation, it may be gamma radiation.

Although there are no known health risks that has been conclusively demonstrated to be caused by living near high-voltage power line, however science is unable to prove that the low-level magnetic and electric fields are completely risk free [10]. The research on safety or otherwise in living near power lines is continuous.

A Magnetic field exerts a force on a charge particle, such as electrons, accelerated in it which causes the particle to emit radiation that is in the gamma ray region of the electromagnetic spectrum [11]. This radiation can also be bremsstrahlung x-ray if the electron is accelerated in the electrostatic field around a nucleus [11].

To mitigate the effect of electromagnetic (EM) radiation from power line on human beings living/working close to the lines, the authority, Power Holding Company of Nigeria (PHCN) makes it clear that any building constructed along the HV lines must give a right-of-way (RoW) of 10 m, 15 m and 25 m for 11 KV and 33 KV, 132 KV and 330 KV lines respectively [12].

Based on these guide lines, an attempt was made in this research, to measure ionizing

radiation (gamma rays) from high tension cables around houses, schools, work places that are close to the lines, around Kaduna metropolis to determine emission levels of this radiation and the consequences on those living around the areas.

2. AREA OF THE RESEARCH

The area of the research is Kaduna metropolis, which consists of many communities. It is located at latitude 10.52° North and longitude 7.44° East, with elevation of 614 m, covering an area of 3,080 square kilometer. It has a population of about 6 million (www.Kadunastate.gov.ng). Kaduna is also close to the Nigerian capital Abuja, as such attract a lot of settlers all the time. The map of Kaduna metropolis is shown in Fig. 1.

2.1 Measurement of Gamma Radiation

Radex radiation monitor was used for measuring gamma radiation dose rate. The meter was held at 1 m above the ground, switched on and μSv/h unit was selected. The stop clock was switched on to time 40 seconds and the value on the screen at the end of 40 seconds was recorded as the gamma radiation for the particular distance from the power line base. The gamma radiation was measured at the base of each power line and at 10 m distances from the base up to about 100 m. Each measurement was taken twice and the average calculated. The Radex radiation meter measures gamma radiation in μSv/h [13]. The measured values were each multiplied by 16 hours in a day (because of average 8 working hours in a day) by 365 days in a year to obtain the annual gamma radiation dose in mSv for public exposure. For occupational exposure, the measured values were each multiplied by 9 hours in a day by 6 days in a week by 52 weeks in a year to obtain the annual dose for the workers in mSv. The capacities of the power lines from which measurements were made in this research were 11 KV, 33 KV, 132 KV and 330 KV power lines.

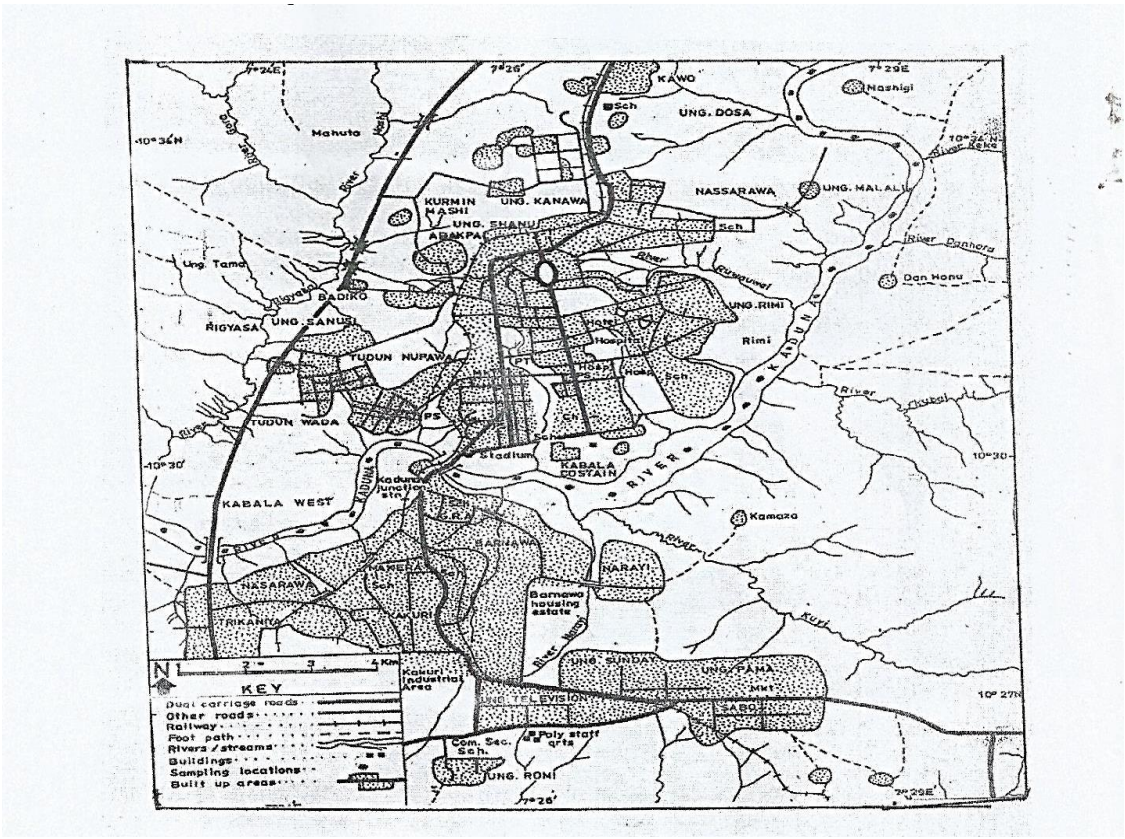

Fig. 1. Topographic map of Kaduna Metropolis
(Kaduna SE sheet 123 SE and Kakuri NE sheet 144 NE

3. RESULTS AND DISCUSSION

Measured data are presented for the locations in Tables 1 and 2.

Results in the Tables 1 and 2 show that gamma radiation dose rate has no consistent relationship with distance from the base of the power line.

3.1 Analysis of Measured Data by Bar Chart

From Fig. 2, the highest value of gamma radiation for 11 KV power line is from Goningora with 0.22 µSv/h, followed closely by Badiko, Kakuri and Afaka with 0.21 µSv/h each and the lowest is 0.20 µSv/h from Sabo.

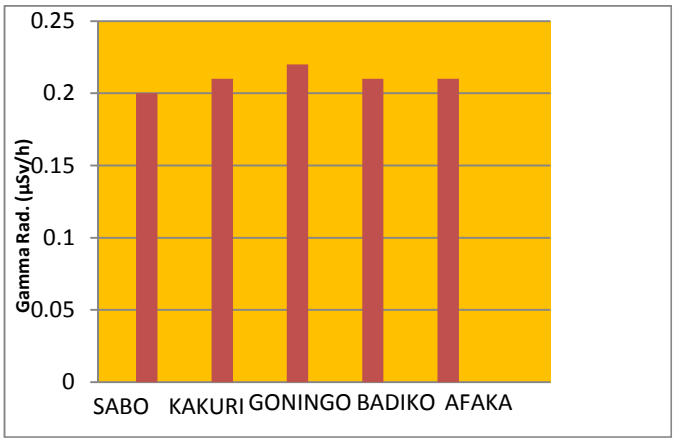

Fig. 2. Variation of Gamma Rad. from different locations for 11 KV power line

Table 1. Measured data from Afaka, Kabala West, Kigo Road and Mando community

Distance (m)	Gamma radiation (µSv/h)			
	Afaka	Kabala West	Kigo Road	Mando Comm
	(33 KV)	(132 KV)	(33 KV)	(330 KV)
0 (Base)	0.25 ± 0.03	0.21± 0.03	0.21± 0.03	0.25± 0.03
10	0.22 ± 0.03	0.19± 0.03	0.18± 0.03	0.23± 0.03
20	0.24 ± 0.03	0.18± 0.03	0.22± 0.03	0.20± 0.03
30	0.22 ± 0.03	0.22± 0.03	0.23± 0.03	0.21± 0.03
40	0.21 ± 0.03	0.20± 0.03	0.20± 0.03	0.23± 0.03
50	0.18 ± 0.03	0.20± 0.03	0.16± 0.03	0.22± 0.03
60	0.17 ± 0.03	0.22± 0.03	0.21± 0.03	0.21± 0.03
70	0.19 ± 0.03	0.18± 0.03	0.20± 0.03	0.19± 0.03
80	0.20 ± 0.03	0.20± 0.03	0.18± 0.03	0.17± 0.03
90	0.18 ± 0.03	0.18± 0.03	0.18± 0.03	0.20± 0.03
100	0.16 ± 0.03	0.18± 0.03	0.15± 0.03	0.18± 0.03

Table 2. Measured data from Badiko and Mando sub-station

Distance (m)	Gamma radiation (µSv/h)			
	Badiko	Mando SS	Mando SS	Mando SS
	(11 KV)	(330 KV)	(132 KV)	(33 KV)
0 (Base)	0.21 ± 0.03	0.30± 0.03	0.28± 0.03	0.26± 0.03
10	0.22 ± 0.03	0.26± 0.03	0.28± 0.03	0.24± 0.03
20	0.22 ± 0.03	0.24± 0.03	0.26± 0.03	0.20± 0.03
30	0.21 ± 0.03	0.23± 0.03	0.23± 0.03	0.18± 0.03
40	0.20 ± 0.03	0.24± 0.03	0.25± 0.03	0.20± 0.03
50	0.18 ± 0.03	0.26± 0.03	0.22± 0.03	0.22± 0.03
60	0.17 ± 0.03	0.23± 0.03	0.22± 0.03	0.20± 0.03
70	0.16 ± 0.03	0.21± 0.03	0.23± 0.03	0.22± 0.03
80	0.18 ± 0.03	0.20± 0.03	0.21± 0.03	0.18± 0.03
90	0.20 ± 0.03	0.20± 0.03	0.18± 0.03	0.14± 0.03
100	0.18 ± 0.03	0.18± 0.03	0.14± 0.03	0.14± 0.03

The highest value of gamma for 33 KV power line, as shown in Fig. 3 is from Afaka with 0.25 µSv/h and the lowest are Kigo Road and Mando with 0.21 µSv/h each.

From Fig. 4, the highest value of gamma is from 330 KV at Mando with 0.25 µSv/h followed by the 132 KV of Afaka with 0.23 µSv/hand the least is from the 132 KV of Kabala West with 0.22 µSv/h. The higher values of gamma radiation from lower capacity power lines compared to higher capacity power linessuggests that gamma radiation does not depend on the power line capacity. It can result from other sources of the radiation such as communication masks and environmental cosmic rays or even beta radiation from fertilizersin farm lands since Radex meter also measures beta radiation.

From Fig. 5, the highest and lowest values for gamma radiation from Mando sub-station are from 330 KV and 33 KV units with 0.30 µSv/h and 0.26 µSv/h respectively.

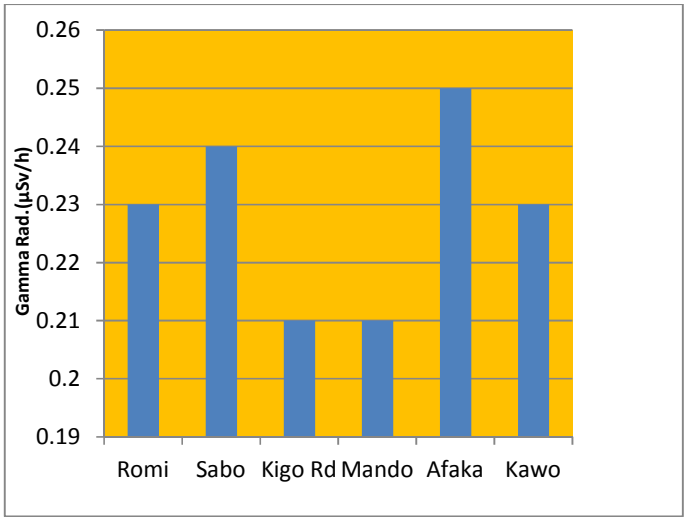

Fig. 3. Variation of Gamma Rad. from different locations for 33 KV power line

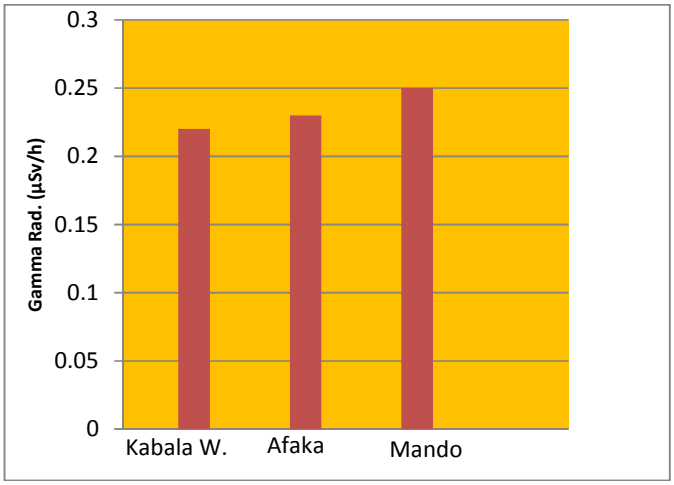

Fig. 4. Variation of Gamma Rad. from different locations for 132 and 330 KV power line

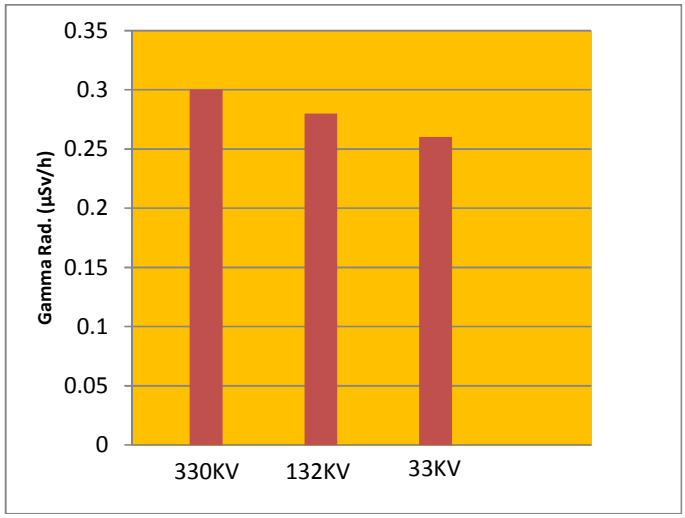

Fig. 5. Gamma Rad. from different units of Mando sub-station

3.2 Comparison of Measured Data with ICRP Data

3.2.1 Public exposure

The results of Table 3 shows that the highest measuredgamma radiation from 330 KV, 132 KV, 33 KV and 11 KV are greater than ICRP data [14], by about 46% at the base of the power line, 34%, 46% and 28% respectively with various percentages that fluctuate up to the 100 m distance, thus the power line poses radiological hazard to the public at various distances from the base of the power line. The measured gamma radiation is greater than the ICRP data at other distances except at 80 m from 330 KV, 70 m and 90 m for 132 KV.60 m and 100 m for 33KV and 60m and 70 m distances for 11KV power lines. Results from the Table 3 shows that gamma radiation does not depend on the capacity of the power line.

3.2.2 Occupational exposure

From Table 4, the measured gamma radiation at the base and 100 m are about 95.8% and 97.4% respectively less than the ICRP data for the 330 KV, about 96% at the base and 98% at 100 mless than ICRP data for 132 KV and between 96.3% and 98% less than ICRP data for 33 KV. This means that ionizing radiations atthe sub-station are by far less than the guidance levels and so pose no occupational hazard even at the base of the power lines. Again the comparisons from the tables for occupational exposure shows inconsistent relationship between gamma radiation and distance from the base of the power lines.

Table 3. Comparison of measured data with ICRP data

Distance (m)	Gamma radiation (mSv)				
	Measured data				ICRP
	330 KV	132 KV	33 KV	11 KV	
Base	1.46	1.28	1.46	1.23	1
10	1.34	1.17	1.28	1.28	1
20	1.17	1.34	1.40	1.28	1
30	1.23	1.28	1.28	1.23	1
40	1.34	1.17	1.23	1.16	1
50	1.28	1.05	1.05	1.05	1
60	1.23	1.05	0.99	0.99	1
70	1.11	0.99	1.11	0.93	1
80	0.99	1.11	1.17	1.05	1
90	1.17	0.99	1.05	1.16	1
100	1.05	1.17	0.93	1.05	1

Table 4. Comparison of measured data with ICRP data

Distance (m)	Measured data (mSv)			ICRP (mSv)
	330 KV	132 KV	33 KV	
Base	0.84	0.79	0.73	20
10	0.73	0.79	0.67	20
20	0.67	0.73	0.56	20
30	0.65	0.65	0.51	20
40	0.67	0.70	0.56	20
50	0.73	0.62	0.62	20
60	0.67	0.62	0.56	20
70	0.59	0.65	0.62	20
80	0.56	0.59	0.51	20
90	0.56	0.59	0.39	20
100	0.51	0.39	0.39	20

3.3 Comparison of Measured Gamma Radiation from Power Lines with Radiation from Control Site

Base on the fact that measured gamma radiation from the power lines were greater than the ICRP data for public exposure, and also show no consistent relationship with distance from the base of the power lines, further measurements of gamma radiation from control site were made. This was done at Juji, a new settlement at the out sketch of Kaduna metropolis. The placehas no electricity and so power lines are not available there, with very scanty buildings and majorly farm lands. The results are presented in the Tables 5 and 6.

From Table 5, the highest measured gamma radiation from power line is 0.25 μSv/h from 33KV and 330 KV and the lowest is 0.16 μSv/h from 11 KV and 33 KV power lines while the highest measured gamma radiation from control site is 0.26 μSv and the lowest is 0.17 μSv/h. Also the table shows there is no consistency in the relationship between gamma radiation values and distance for both from the power lines and the control site. This suggests that the power lines may not have reasonable effect on gamma radiation values.

Examining Table 6 shows that the highest gamma values from the 330 KV, 132 KV and 33 KV units are 30 μSv/h, 28 μSv/h and 26 μSv/h respectively. The values for the 330 and 132 KV are a little above the radiation from the control site whose highest value is 0.26 μSv/h. Also the gamma radiation values from the power lines shows decrease with increasing distance between the base of the power lines and 30m distances after which the relationship shows inconsistency up to 100 m distance. This suggests that the increase gamma radiation at the base of the power line units may be due to corona discharge which was evidently present at the power line base with its audible noise. But the radiation dies down within 30 m distance.

Table 5. Comparison of measured gamma radiation with control site

	Gamma radiation (μSv/h)				
Distance (m)	Control site	330 KV	132 KV	33 KV	11 KV
0	0.18	0.25	0.22	0.25	0.21
10	0.20	0.23	0.20	0.22	0.22
20	0.20	0.20	0.23	0.24	0.22
30	0.17	0.21	0.22	0.22	0.21
40	0.19	0.23	0.20	0.21	0.20
50	0.25	0.22	0.18	0.18	0.18
60	0.19	0.21	0.18	0.17	0.17
70	0.26	0.19	0.17	0.19	0.16
80	0.22	0.17	0.19	0.20	0.18
90	0.21	0.20	0.17	0.18	0.20
100	0.24	0.18	0.20	0.16	0.18

Table 6. Comparison of measured gamma radiation from Mando sub-station with control site

	Gamma radiation (μSv/h)			
Distance (m)	**Control site**	**330 KV**	**132 KV**	**33 KV**
0	0.18	0.30	0.28	0.26
10	0.20	0.26	0.28	0.24
20	0.20	0.24	0.26	0.20
30	0.17	0.23	0.23	0.18
40	0.19	0.24	0.25	0.20
50	0.25	0.26	0.22	0.22
60	0.19	0.24	0.22	0.20
70	0.26	0.21	0.23	0.22
80	0.22	0.20	0.21	0.18
90	0.21	0.20	0.18	0.14
100	0.24	0.18	0.14	0.14

4. CONCLUSION

Comparison of the measured data for gamma radiation (ionizing radiation) showed that the highest measured values from power lines and control site are about 46% and 52% respectively greater than the ICRP data for the general public. These ionizing radiation levels higher than the guidance level can constitute radiological hazard for the public even in the absence of power line as these can increase the stochastic effect of ionizing radiation to the public which can lead to genetic mutation and all forms of cancer. For occupational exposure, the measured gamma dose rate from the power line units of the power sub-station are by far less than (about 95.8%) the ICRP data, showing no radiological hazard for occupational exposure. The high ionizing radiation dose rate could be as a result of other sources of radiation like beta radiation from potassium - 40 constituent of the fertilizer use in farming in the area rather than from power lines. Also the power lines outside the power sub-station show no significant evidence of producing ionizing radiation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ibrahim M. Analysis of magnetic field pollution due to 330 KV and 132 KV transmission lines around Bauchi and Gombe. JOTTER. 2011;4(2):87-89.
2. Hal J. The negative effects of electromagnetic fields. Consumer Health. 1997;20(9). Alan Smale, Babra Mattson, Myers JD. Process that creates Cosmic Gamma rays. High Energy Astrophysics Science Archive Research Centre (HEASARC); 2014.
3. Siaka M. Highlighting the dangers of living under high tension cables 2010. Business Day Newspaper. 1 July; 2010.
4. Wertheimer, Leeper. Risk of childhood leukemia in association with proximity to power line; 1979.
5. Draper G, Vincent T, Kroll ME, Swanson J. Childhood cancer in relation to distance from high voltage power lines in England and Wale. British Medical Journal. 3 June; 2005.
6. Draper G, Vincent T, Kroll ME, Swanson J. The magnetic field result paper. British Journal of Cancer; 2010.
7. Draper G, Vincent T, Kroll ME, Swanson J. Follow – on – Study 2014.
8. UNSCEAR 2001 Report to the General Assembly, with Scientific Annex “Health Effects of Radiation”.
9. Clover M. Power system analysis (5th Edition), Cen Gage Learning Connection; 2012.
10. Human Radiation Effects Group (HREG). H.H. Wills Physics Laboratory, Tyndall Avenue United Kingdom; 2010.
11. Alan Smale, Babra Mattson, Myers JD, Process that creates Cosmic Gamma

rays. High Energy Astrophysics Science Archive Research Centre (HEASARC); 2014.

12. National Electric Power Authority NEPA News. Health and Safety Guidline, October to November 2000.

13. General Electromagnetics (GENE 2013); RADEX RD1503- Radiation Detector. Available:http:/www.RADEX1503+ …… (01 February 2014)

14. International commission on radiological protection. ICRP Publication. 2007;103.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/20897