International Journal of Advanced Research in Physical Science (IJARPS)
Volume 2, Issue 4, April 2015, PP 15-20
ISSN 2349-7874 (Print) & ISSN 2349-7882 (Online)
www.arcjournals.org

Radioactivity Measurement around Electrical Installations in Akure, Ondo State

Ibikunle S.B., Ajayi O.S., Kolawole O.O.

Departmet of Physics
Federal University of Technology
Akure, Ondo State.
tuncom7084@yahoo.co.uk

Abstract: *Radioactivity measurement was carried out around Electrical Installations and Power Lines. The 132 kV Transformer Station, (Transmission Division) Akure was the chief point of focus. Other areas are 11kV, 33kV, 132kV and 330kV lines at Oba Adeshida road and Federal University of Technology road, Akure. The measurement was carried out using 500 VBR Rad*Scanner. The values obtained in count per minute (CPM) was used to estimate the outdoor absorbed dose rate in air and the risk of incurring cancer to the people living in the study area. Moderate radioactivity was detected around 330 kV Power Lines and low radioactivity around the 15 MVA Transformer (33/11) kV and Feeder Panels (132/33)kV. The mean outdoor absorbed dose rate in air from the electrical installations is 0.1299 ± 0.0322 μGyh^{-1}. This value represents about 236% of the world average value 0.055μGyh^{-1}. The mean outdoor effective dose equivalent is 265.566 ± 65.84μSvy^{-1}.*

Keywords: *Electrical Installation, Power Line, Radioactivity, Absorbed dose, Effective Dose.*

1. INTRODUCTION

Radioactivity measurement is a popular topic around the world today. The purpose is to access the concentration of ionizing radiation being emitted by a material. Ionizing radiation over the years has been a threat to human health and survival. The presence of nuclear radiation has been identified in many media ranging from soil (UNSCEAR, 1988) to water, solid minerals (Ezekwesili2005), food stuff (Ajayi, 2006), and electrical power line Bamidele (2009).

Knowledge of the distribution pattern of natural and anthropogenic radionuclides is essential in maintaining some sense of control of prevailing radiation levels (Siotis and Wrixon, 1984). The reported radio toxicity of the radionuclides varies from moderate (^{222}Rn) through high (^{234}Th, ^{228}Ac, ^{137}Cs) to very high (^{226}Ra, ^{228}Th) (IAEA, 1973).

The presence of an industry or factory can contribute to the elevation of the background radiation of the immediate environment. The effect/impact of industrial production on its host environment essentially depends on the nature of the input raw materials, effluents from the production process and the output products. Ebeniro and Avwiri (1998), studied the external environmental radiation in the Trans-Amadi industrial area and other sub-industrial areas of Port Harcourt and reported an average value of 0.014mRh^{-1}. This result indicated some level of impactation of the environment and a significant elevation from the standard background radiation level for similar environments.

Bamidele (2009) measured the radiation levels around electrical power lines. The result obtained shows that the average radiation levels around the power lines of 330kV, 132kV and 11kV range from 13.85 x 10^{-8}Gy/h to 18.14 x 10^{-8}Gy/h. This range is less than 20 x 10^{-8}Gy/h which according to IAEA is the minimum standard for background ionizing radiation that can cause health hazard.

2. AIM AND OBJECTIVE OF THE STUDY

The research work is aimed at studying the concentration of nuclear radiation in the areas where electrical installations and power lines were sited. The purpose of the research is to detect the level of human exposure to nuclear radiation and to compare it with the Maximum Permissible Level (MPL) so as to disclose the possible effect on Humans and suggest measures to minimize the effect.

3. METHODOLOGY

Nuclear Radiation was measured around electrical installations, which include Feeder Panels, Power Transformers, Circuit Breakers and Power Transmission Lines. The measuring instrument used "500 VBR Radiation*Scanner" was held very close to the equipments (0 meter) whose nuclear radiation was to be measured and readings were recorded per minute for five minutes. This Procedure was repeated at 1 metre (m) intervals for 5 metres. The measured value was recorded in count per minute (CPM).

4. CHOICE OF SITES

The Power Holding Company of Nigeria 132 kV Transformer Station, (Transmission Division) Akure was the chief point of focus. Other areas include Oba Adeshida and FUTA road where the measurements of nuclear radiation emitted from 11 kV, 33 kV, 132 kV and 330 kV lines were taken.

5. INSTRUMENT USED FOR TAKING THE MEASUREMENT

The Rad*Scanner Model 500 VBR is easy to operate and almost maintenance free. All the switches are mounted on the top panel. The Rad*Scanner model 500 battery power off/on switch is located to the right when viewed facing the front label. The green light emitting diode (LED) flashes on for a moment at power up time if the battery voltage is adequate. The threshold, CPM-µR/h, sound on and update/total switches are located on the left side of the top panel.

The threshold switch is set to give individual clicks for each particle detected. The red LED also flashes for every individual nuclear particle detected, this is the Pulse mode. When the threshold switch is set toward the back side of the case, the Model 500 give a continuous tone sound when the average number of nuclear particles exceeds 1095 counts per minute (10µGy/h or 1.0 mR/h rate). This corresponds to the Nuclear Regulatory Commission's suggested Maximum Safe Working Level. This is the threshold mode. Bursts of random background radiation will occasionally trigger a brief tone while in the threshold mode. Special threshold settings can be requested from the factory.(www.antirad.com/operate.htm, 2012).

6. RADIATION QUANTITIES AND THEIR UNITS

6.1. Absorbed Dose

Radiation effects depend on the amount of the energy of the radiation deposited in the human tissue. A measure of this amount of energy is called the Absorbed Dose D, which is used in Dosimetry to assess the risk of any health effects. This dosimetric quantity is defined as:

$$D = \frac{d_E}{d_m} \text{ (Gy)} \qquad (1)$$

Where d_E is the mean energy imparted on a volume element by an ionizing radiation and d_m is the mass of the volume element. The average dose is the total energy over the volume divided by the mass in the volume. The SI unit is the Gray (Gy) defined as 1 Joule/Kilogram (ICRP, 1990).

6.2. Dose Equivalent

Because the same dose of different types of radiation will cause biological effects, each radiation type is weighed on a reference scale. The radiation-weighing factor W_R expresses the ability of the radiation type to cause biological damage. Once the radiation type is weighed, the dose equivalent H_T to a tissue T due to an absorbed dose D_T is given by

$$H_T = D_T W_T \qquad (2)$$

The unit of H_T is Sievert (SV) (ICRP, 1990).

6.3. Effective Dose

The radiation quantity that takes into account the radio sensitivity of individual organ is called the Effective Dose (ICRP, 1990). A measure of the radio sensitivity for the different tissues is called the tissue-weighing factor W_T given in the Table 1 below.

Table1. *The weighing and risk factors for different tissues (ICRP, 1990)*

Organ	Weighing factor (W_T)	Risk factor x (10^{-3}) Sv^{-1}
Gonad	0.25	4.00
Breast	0.15	2.50
Red bone marrow	0.12	2.00
Lung	0.12	2.00
Thyroid	0.03	0.50
Bone	0.03	0.50
Remainder	0.30	5.00
Total	1.00	16.50

It is defined as the proportion of the detriment to the tissue from stochastic effects to the total detriment when the whole body is uniformly irradiated. The effective dose H_E to the whole body is the sum total of the weighed equivalent doses for all the exposed tissues in an individual given as:

$$H_E = \sum_T W_T H_T \tag{3}$$

The unit is also Sievert (Sv)

6.4. Collective Effective Dose

The total impact of the radiation exposure due to a given practice or source depends on the number of individuals that are exposed as well as the dose received.

The collective effective dose S_E to any group is the summation of the products of the mean effective dose H_E in the various sub-groups of the exposed people and the number N_i of individual given as:

$$S_E = \sum_i N_i H_{E_i} \tag{4}$$

The linear no threshold relationship between dose equivalent and health effects has been assumed in this work and this implies that there is a risk associated with the exposure of an individual member of the sub-group to ionizing radiation. This risk of having different health effects on an individual within a given population is given as:

$$R = \sum_i P_i \tag{5}$$

Where P_i is the probability that the individual will have an effect i

The Collective Health Detriment (G), on a population of N people can be written in terms of the collective dose S_E given as:

$$G = R_T S_E \text{ (Man)} \tag{6}$$

Where R_T is a constant of proportionality called the Total Risk Factor (ICRP, 1990). The Risk Factor for different tissues is given in Table 1 above.

7. RESULT

7.1. Absorbed Dose Rate

The Absorbed Dose Rate in air at about 1.4m above the ground have been calculated by converting the measurement values gotten from the Rad*Scanner in count per minute (CPM) to μGyh^{-1}. This was achieved by using the equation below:

$$\text{Absorbed Dose rate in Air } (\mu Gyh^{-1}) = \frac{Average\ CPMx\ \ 10\ \mu Gyh^{-1}}{1095\ CPM} \tag{7}$$

The results presented in Table 1 shows that the 330 kV power lines have the highest absorbed dose rate value (195.43±31.42 $nGyh^{-1}$) at 0 m. This could be as a result of the high voltage passing through the power lines. The 15 MVA transformer (33/11)kV has the lowest absorbed dose rate value (96.80±21.28 $nGyh^{-1}$) at 5 m from it. This could also be attributed to the attenuation or weakened diffusion of nuclear radiation through air asa result of increased distance from the Transformer.

The Feeder Panel (132/33) kV also has the lowest absorbed dose rate at 2 m from it sharing the same value with 15 MVA transformer (33/11) kV (96.80±27.49 $nGyh^{-1}$). This may be as a result of the type of material used to construct the panel. Figure 1 shows the trend of nuclear radiation concentration in air around different electrical equipments.

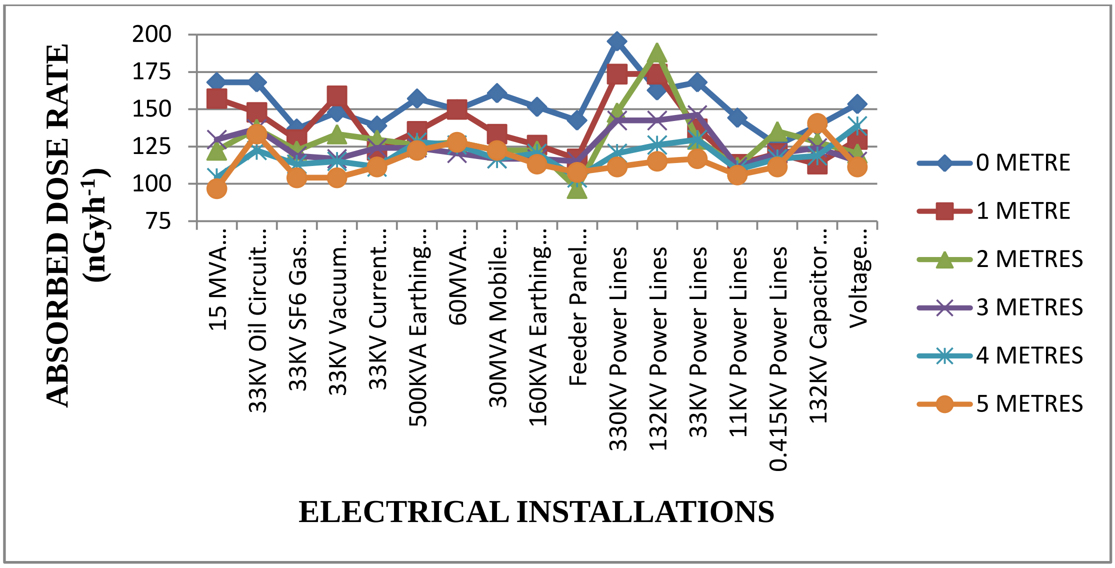

Fig1. *Graph of Various Contributions of Absorbed Dose Rate in Air for each of the Electrical Installations at Different Distances*

Table2. *Absorbed Dose Rate Values for each of the Electrical Installations at Different Distances*

MEASUREMENT DISTANCE (M) **ELECTRICAL INSTALLATIONS**	0.00	1.00	2.00	3.00	4.00	5.00	Mean Absorbed Dose (nGyh^{-1})
15MVA Transformer (33/11)KV	168.04 ±24.20	157.08±17.72	122.37±34.43	129.68±33.88	104.11±20.46	96.80±21.28	129.680± 25.33
33KV Oil Circuit Breaker	168.04 ±45.66	147.95±22.83	136.99±42.01	136.99±33.15	122.37±28.04	133.33±33.52	140.945± 34.20
33KV SF$_6$ Gas Circuit Breaker	136.99 ±22.37	129.68±25.48	122.37±34.98	118.72±20.82	113.24±34.98	104.11±30.87	121.352± 28.25
33KV Vacuum Circuit Breaker	147.95 ±30.23	158.90±27.49	133.33±28.04	116.89±37.17	115.07±38.17	104.11±22.10	129.375± 30.53
33KV Current Transformer	138.81 ±34.34	122.37±39.45	129.68±37.63	124.20±31.96	111.42±22.65	111.42±30.23	122.983± 32.71
500KVA Earthing Transformer	157.08 ±23.38	135.16±29.13	126.03±38.90	124.20±31.96	127.85±38.72	122.37±32.97	132.115± 32.51
60MVA Transformer (132/33)KV	149.77 ±31.96	149.77±38.17	127.85±38.72	120.55±31.32	126.03±35.34	127.85±42.83	133.637± 36.39
30MVA Mobile Transformer (132/33)KV	160.73 ±37.72	133.33±47.12	122.37±36.35	116.89±32.33	116.89±34.34	122.37±48.49	128.763± 39.39
160KVA Earthing Transformer	151.60 ±45.66	126.03±36.26	122.37±24.20	116.89±28.49	120.55±25.48	113.24±32.97	125.113± 32.18
(132/33)KV Feeder Panel	142.47 ±21.28	116.89±30.23	96.80±27.49	115.07±27.49	104.11±22.10	107.76±30.78	113.850± 26.56
330KV Power Line	195.43 ±31.42	173.52±22.37	147.95±31.32	142.47±37.72	120.55±33.88	111.42±38.90	148.557± 32.60
132KV Power Line	162.56 ±29.13	173.52±28.86	188.13±24.93	142.47±28.68	126.03±27.31	115.07±29.77	151.297± 28.11
33KV Power Line	168.04 ±34.98	136.99±28.86	129.68±41.37	146.12±31.14	129.68±27.95	116.89±41.37	137.900± 34.27
11KV PowerLine	144.29 ±23.38	113.24±28.68	111.42±22.65	111.42±29.68	109.59±28.86	105.94±39.45	115.983± 28.78
0.415KV PowerLine	126.03 ±50.77	120.55±48.13	135.16±38.90	120.55±33.88	116.89±41.37	111.42±22.65	121.767± 39.28
132KV Capacitor Voltage Transformer	138.81 ±31.87	113.24±32.97	127.85±41.64	124.20±27.49	118.72±34.16	140.64±47.12	127.243± 35.88
132KV Voltage Transformer	153.42 ±30.23	129.68±22.65	120.55±30.23	115.07±26.21	138.81±42.19	111.42±31.87	128.158± 30.56

7.2. Outdoor Effective Dose Equivalent

In estimating the outdoors effective dose equivalent in any environment, the two factors of importance are the conversion factor from Gyh^{-1} to Svh^{-1} and the Occupancy factor. The former gives the human dose equivalent (Svy^{-1}) from the absorbed dose rate in air (Gyh^{-1}) while the latter gives the fraction of the time that an individual is exposed to outdoor radiation. The first factor has been recommended by the United Nation Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 1988) as 0.7 $SvGy^{-1}$ and the second factor as 0.2, which suggest that an average individual stays about 4.8 hours outdoor daily.

In this work, the first factor of 0.7 $SvGy^{-1}$ has been retained while the second factor of 0.2 was modified to suit the reality of the environment we are studying. PHCN staffs, Mechanics and commercial Traders in the study environment spend an average of 8 hours outdoor daily. Hence the second factor has been modified to 0.33.

The mean Outdoor Effective Dose Equivalent (OEDE) for Akure area is calculated thus:

OEDE (Svy^{-1}) = Conversion factor (0.7Sv/Gy) x Occupancy factor (8 hrs/day) x 365 days (1year) x Mean Absorbed Dose Rate in Air ($nGyh^{-1}$) (8)

The Mean Absorbed Dose Rate in air can be obtained from Table 2. The result of the mean Outdoor Effective Dose Equivalent (OEDE) for the Electrical Installations in the Akure area considered was obtained to be 265.566 ± 65.84 μSvy^{-1} as shown in Table 3.

Table3. *Mean Outdoor Absorbed Dose Rate in Air and Mean Outdoor Effective Dose Equivalent.*

ELECTRICAL INSTALLATIONS	Mean Outdoor Absorbed Dose rate in Air($nGyh^{-1}$)	Mean Outdoor Effective Dose Equivalent(μSvy^{-1})
15 MVA Transformer (33/11)KV	129.680±25.33	265.066±51.77
33KV Oil Circuit Breaker	140.945±34.20	288.092±69.90
33KV SF_6 Gas Circuit Breaker	121.352±28.25	248.043±57.74
33KV Vacuum Circuit Breaker	129.375±30.53	264.443±62.40
33KV Current Transformer	122.983±32.71	251.377±66.86
500KVA Earthing Transformer	132.115±32.51	270.043±66.45
60MVA Transformer (132/33)KV	133.637±36.39	273.154±74.38
30MVA Mobile Transformer (132/33)KV	128.763±39.39	263.192±80.51
160KVA Earthing Transformer	125.113±32.18	255.731±65.78
(132/33)KV FeederPanel	113.850±26.56	232.709±54.29
330KV PowerLine	148.557±32.60	303.651±66.63
132KV PowerLine	151.297±28.11	309.251±57.46
33KV PowerLine	137.900±34.27	281.868±70.05
11KV PowerLine	115.983±28.78	237.069±58.83
0.415KV PowerLine	121.767±39.28	248.892±80.29
132KV Capacitor Voltage Transformer	127.243±35.88	260.085±73.34
132KV Voltage Transformer	128.158±30.56	261.955±62.46
Mean (Result)	129.925±32.21	265.566±65.84

7.3. Calculation of Collective Effective Dose Equivalent

The Collective Effective Dose Equivalent to N population is a measure of the collective detrimental effects and the percentage of people at risk of incurring radiation induced diseases. This was calculated for the whole of Akure Area using equation 4 given by ICRP (1990). This equation 4 shows a direct proportionality between the average annual effective dose equivalent and the exposed population. The collective dose equivalents S_E for Akure area have been calculated using the mean annual effective dose equivalent shown in Table 3 and the projected population figure for Akure in the year 2012 387,087 (Wikipedia, 2012). The collective effective dose (S_E) for Akure area is calculated thus:

S_E (Man-Svy^{-1}) = OEDE (Svy^{-1}) x Total Population

S_E (Man-Svy^{-1}) = OEDE (Svy^{-1}) x 387,087 (9)

The result obtained for the collective effective dose equivalent is 103 ± 25.49 Man-Svy^{-1}

7.4. Collective Health Detriment

The linear no threshold relationship between dose equivalent and health risk has been employed in this work to relate the absorbed dose from the Electrical Installations to the risk of incurring detrimental health effects in Akure. This risk, G, to the people of Akure was estimated using equation 6. The number of individuals at risk of incurring fatal cancer as a result of nuclear radiation emitted from Electrical Installations in Akure is 2 Man-y^{-1}.

8. CONCLUSION

The nuclear radiation emitted from electrical installations have been measured in Akure using the Nuclear Rad*Scanner. The measurement values obtained in count per minute (CPM) have been used to estimate the outdoor absorbed dose rate in air and the resulting radiological implications to the inhabitants of the city. It has been concluded that there is moderate radioactive emissions in areas around 330 KV Power Lines and low radioactive emissions in areas around 15 MVA Transformers (33/11)KV and Feeder Panels (132/33)KV. It was observed that the type of materials used to construct electrical installations, their power ratings, their voltage ratings and the distance from the electrical equipment constituted to the rate of exposure to nuclear radiation emitted from them.

The mean outdoor absorbed dose rate in air from electrical installations in Akure is 0.1299 ± 0.0322 μGyh^{-1}. This value represents about 236% of the world average value of 0.055 μGyh^{-1} (UNSCEAR, 1988). The mean outdoor effective dose equivalent is 265.566 ± 65.84 μSvy^{-1}. This made the expected number of people at risk of radiation induced cancer per year as a result of nuclear emissions from electrical installations in Akure to be 2.

REFERENCES

Ajayi, O.S. (2006): A Study of the Effects of Ionizing Radiations on Germination and Growth of Okro (AbelmoschusEsculentus), Maize (Zea Mays) and Bean (VignaUnguiculata) Seedlings, p. 1-8

Bamidele, L. (2009): Influence of Electricity Power Lines on Environmental Radiation Level. International Journal of Physics, (1).

Ebeniro, J. O. and Avwiri, G.O. (1998): ‘External Environmental Radiation in an Industrial Area of Rivers State’ ‘Nig Jour. Of Phy., Vol. 10, 105 -107.

Ezekwesilli, O. (2005): Nigeria: Promoting Wealth through solid minerals, Africa files, Toronto, www. Africafiles.org (05/01/2010).

IAEA (1973).Safe Handling of radionuclides. Safety Series, No 1 Vienna.

ICRP (1990), Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Ann ICRP 21, 1-3.

Siotis I. and Wrixon A.D. (1984).Radiological Consequences of the Use of Fly Ash in Building Materials in Greece. Radiation Protection Dosimetry.**7** (1): 101 – 105.

United Nations Scientific Committee on Effects of Atomic Radiations (UNSCEAR), (1988) Sources, Effects and Risks of Ionizing Radiations, UN, New York.

Wikipedia, the Free Encyclopedia, en.wikipedia.org/wiki/Akure (Accessed on 5th September, 2012) www.antirad.com/operate.htm (Accessed on 20th August, 2012)