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Measurement of Outdoor and Indoor Background Ionizing Radiation of O.B. Lulu Briggs Health Center, University of Port Harcourt, Choba, Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Measurement of outdoor and indoor background ionizing radiation (BIR) of O.B. Lulu Briggs Health Centre in the University of Port Harcourt, Rivers State, Nigeria was carried out using a well-calibrated Radalert-100 (Radiation meter) and Digilert-200 meters and Global Positioning System (Garmin 765). 30 selected locations were considered. The outdoor and indoor results are as follows respectively, average exposure rates are 0.012±0.001 and 0.013±0.001 mR/h, mean absorbed dose rate (ADR) are 105.6 and 96.28 nGy/h, estimated value of the annual effective dose equivalent (AEDE) are 0.17 and 0.27 mSv/y and mean excess lifetime cancer risk (ELCR) are (0.60

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and 0.92) x 10^{-3}. The obtained values for BIR in O.B. Lulu Briggs Health Centre are not above the recommended standard limit of 0.013mR/h by International Commission on Radiological protection (ICRP). AEDE that was calculated in the entire O.B. Lulu Briggs Health Centre is within safe values, the ELCR and the ADR estimated were higher than the world permissible values of 0.29 x 10^{-3} and 84.0 nGy/h respectively. The calculated dose to organs for O.B. Lulu Briggs showed that the testes have the highest organ dose of (0.140667 and 0.218053) mSv/y for outdoor and indoor respectively.

Keywords: Annual effective dose equivalent; Digilert 200; excess lifetime cancer risk; absorbed dose rates; background ionization radiation.

1. INTRODUCTION

The environment is an intricate ecological system, consisting of many different and connected parts. Undesirable or harmful impact on any part of the environment invariably affects other parts [1]. The environment is very critical for the survival of humans as such the environment is very important to human existence.

"Ionizing radiation is a form of energy that acts by removing electrons from atoms and molecules thereby ionizing them" [2]. The absorption of such energy from the environment over a very long-time which results to tissue damage and disruption of cellular function at the molecular levels is of great interest. Chronic exposure might lead to radiation related sicknesses such as sterility, cancer, atrophy of kidney etc [3]. Various products in O.B. Lulu Briggs Health Centre have nuclides in them that might emit radiation of varying levels. This might enhance the background radiation status of the hospital.

Abubakar et al. [4] measured and obtained "the indoor ionizing radiation profile placed at 22 selected presumable hotspots within the Radiology department of Federal Medical Centre (FMC) Asaba. The calculated mean indoor post exposure dose value was in the range of 0.09 – 0.20 µSv/hr (0.60-2.01 mSv/yr). The highest point with increased radiation dose was found to being the diagnostic x-ray room (2.01±4.11 mSv/yr), while the lowest point was detected at the intern's common room with a value of 0.60±0.3 mSv/yr. The overall mean of the Mean Indoor Post Exposure (MIPE) was arrived at 0.88±0.28mSv/yr".

Ononugbo et al. [5] also evaluated "the effective dose and excess lifetime cancer risk from indoor and outdoor gamma rate of the University of Port Harcourt Teaching Hospital, Rivers State. The average values for indoor and outdoor gamma doses were found to be greater than the world population weighted average for indoor gamma dose rate of 89 nGyh^{-1}. The result shows that ELCR for both indoor and outdoor exposure were higher than the world acceptable value of 0.29 × 10^{-3}, though the annual effective dose levels in all of the locations (indoor and outdoor) were below the 1mSvy^{-1} maximum permissible limit for the public set by International Commission on Radiological protection" [6].

Behzad Fouladi Dehaghi et al. [7] investigated "on the background ionization radiation in radiography centres in Ahvaz, Iran. The measured locations included behind the door of the X-ray room, outdoor, waiting room for the people, and the reception section in each center. The indoor radiation levels were 0.13 ± 0.004, 0.11 ± 0.004, 0.13 ± 0.004, 0.16 ± 0.007, and 0.16 ± 0.006 µSv/h for centres *a*, *b*, *c*, *d*, and *e*, respectively, and the outdoor radiation levels were 0.12 ± 0.02, 0.11 ± 0.01, 0.10 ± 0.00, 0.12 ± 0.01, and 0.13 ± 0.00 µSv/h, respectively. The mean equivalent dose in this study was lower than the standard level (1 mSv/y)".

Monitoring radiological parameters in the environment especially areas where man's activities tend to pose more risks is very essential to maintain the radiation within the average limit as recommended by International Commission on Radiological Protection (ICRP) and United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR). The aim of this work is to measure the Background Ionizing Radiation level of O.B. Lulu Briggs Health Centre in University of Port Harcourt.

2. MATERIALS AND METHODS

2.1 Study Area

O.B. Lulu Briggs Health Centre is a Health Centre in the University of Port Harcourt, Rivers State, Nigeria. It is situated along East/West Road located at Choba Community in the University of Port Harcourt. Its coordinates are 04°54.126°N and 006°54.537°E.

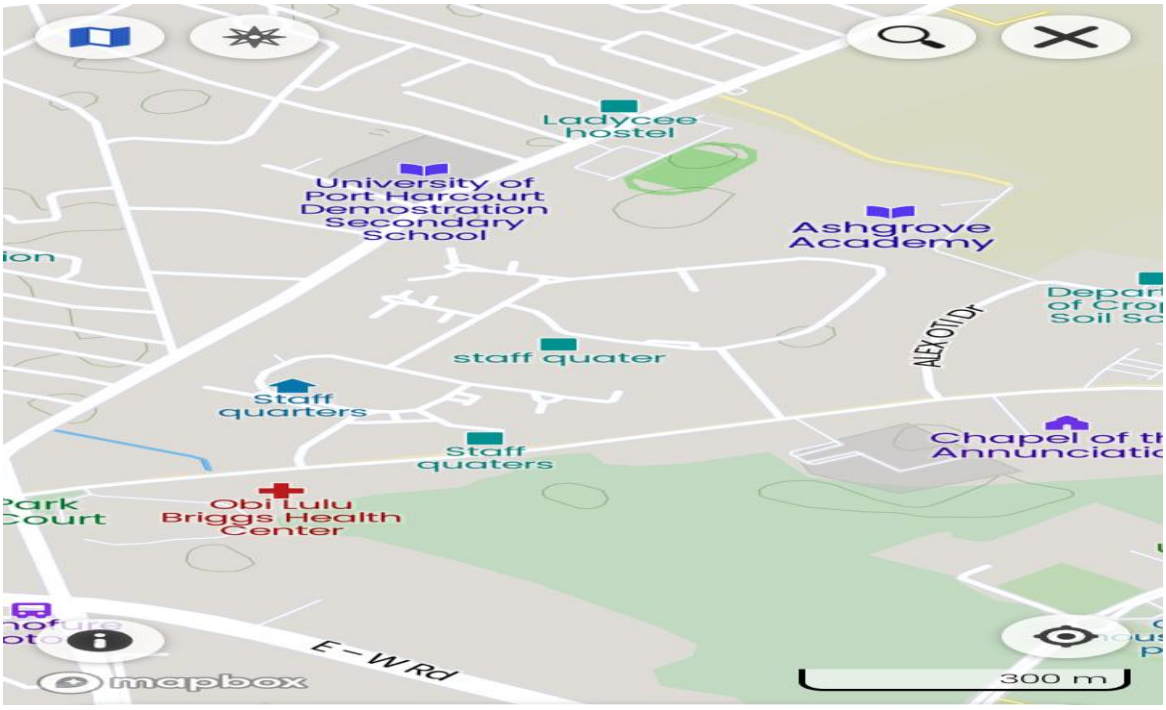

Fig. 1. Map of study area
Source: Mapbox

The Background Ionizing Radiation was measured both indoor and outdoor of the O.B Lulu Briggs Health Centre, University of Port Harcourt. An *in-situ* approach was adopted using a well calibrated Rad-monitor, Radalert-100 nuclear radiation monitoring meter (S.E. International Incorporation, Summer Town, USA), containing a Geiger-Muller tube capable of detecting alpha particles, beta particles, gamma rays and X-rays was used within the temperature range of -10^{o}C to 50^{o}C [8] and a global positioning system (GPS) was used to measure the precise sampling location of outside O.B. Lulu Briggs Health Centre in University of Port Harcourt, Choba. While randomly selected locations inside Lulu Briggs Health Centre in University of Port Harcourt, Choba were used for indoor sampling. “The Geiger-Muller tube generates a pulse current each time radiation passes through the tube and causes ionization. Each pulse is electronically detected and registered as a count. The radiation meters were calibrated with a Cs-137 source of specific energy and set to measure exposures rate in milli-Roentgen per hour (mR/h). The meter has an accuracy of ±15%. The tube of the radiation monitoring meter was raised to a standard height of 1.0m above where the GPS reading was taken at that spot. Measurements were taken within the hours necessary since exposure rate meter has a peak response to environmental radiation within these hours, then the background radiation level was recorded. The switch (knob) was turned to return the meter to zero after each measurement. The generated data were converted to absorbed dose rate nGy/h using the relation for the external exposure rate” by [9].

$$1\mu Rh^{-1} = 8.7nGyh^{-1} = 8.7 \times 10^{-3}\mu Gy/(\frac{1}{8760y}) \quad (1.1)$$

3. RESULTS AND DISCUSSION

3.1 Equivalent Dose Rate (EDR)

To estimate the whole-body equivalent dose rate over a period of one year, we used the National Council on Radiation Protection and Measurement’s recommendation [9].

$$1mRh^{-1} = \frac{0.96\times24\times365}{100} mSvy^{-1} \quad (1.2)$$

3.2 Absorbed Dose Rate (ADR)

It is the energy imparted to matter (human body) from any type of radiation for a given period. The data obtained for the external exposure rate in mRh^{-1} were converted into absorbed dose rates $nGyh^{-1}$ using the conversion factor [10].

$$1\mu Rh^{-1} = 8.7nGyh^{-1}\frac{8.7\times10^{-3}}{(\frac{1}{8760y})} = 76.212\mu Gyy^{-1} \quad (1.3)$$

3.3 Annual Effective Dose Equivalent (AEDE)

The annual effective dose equivalent received by patients and staff of the three hospitals were estimated from the absorbed dose rate, a dose conversion factor of 0.7 Sv/Gy the occupancy factor indoor and outdoor was 0.75 and 0.25 respectively. It has been estimated that people spend approximately 6 hours outdoors. The annual effective dose equivalent is determined using the following equations [2,11].

AEDE (indoor) (mSv/y) = Absorbed dose rate (nGy/h) x 8760 h x 0.7 Sv/Gy x 0.75

AEDE (outdoor) (mSv/y) = Absorbed dose rate (nGy/h) x 8760 h x 0.7Sv/Gy x 0.25 (1.4)

3.4 Excess Lifetime Cancer Risk (ELCR)

Excess lifetime cancer risk measures the stochastic effects produced by low dose background radiation. It is the additional cancer risk induced by exposure to ionizing radiation. Based on the calculated values of lifetime cancer risk is calculated values of lifetime cancer risk is calculated using the equation [12,13].

ELCR = AEDE x Average duration of life (DL) x risk factor (RF) (1.5)

Where AEDE = Annual Effective Dose Equivalent

DL = Duration of life (70 years)

RF = Risk factor 0.05 (fatal cancer risk per Sievert)

3.5 Effective Dose Rate

"D_{organ} in $mSvy^{-1}$ to different organs and tissues estimates the amount of radiation dose intake to various body organs and tissues. The effective dose rate delivered to a particular organ can be calculated using the following relation" [14].

$$D_{organ}(mSvy^{-1} = O \times AEDE \times F \quad [15] \quad (1.6)$$

Where O (occupancy factor) = 0.8

F (conversion factor for organ dose from ingestion = 0.64(lungs), 0.58(ovaries), 0.69(bone marrow), 0.82(testes), 0.62(kidneys), 0.46(liver), 0.68(whole body).
The model of the annual effective dose to organs estimates the amount of radiation intake by a person [16].

Table 1. Outdoor BIR and radiological parameters of O.B. Lulu Briggs Health Centre

Sampling Point	BIR (mR/hr)	Equivalent Dose (mSv/y)	Absorbed dose (nGy/hr)	AEDE (mSv/y)	ELCR x 10^{-3}
LU1	0.010	0.841	87.0	0.14	0.49
LU2	0.013	1.093	113.10	0.19	0.67
LU3	0.017	1.429	147.9	0.23	0.81
LU4	0.013	1.093	113.10	0.19	0.67
LU5	0.010	0.841	87.0	0.14	0.49
LU6	0.015	1.261	130.5	0.21	0.74
LU7	0.012	1.009	104.4	0.17	0.60
LU8	0.010	0.841	87.0	0.14	0.49
LU9	0.010	0.841	87.0	0.14	0.49
LU10	0.011	0.925	95.7	0.16	0.57
LU11	0.010	0.841	87.0	0.14	0.49
LU12	0.010	0.841	87.0	0.14	0.49
LU13	0.015	1.261	130.5	0.21	0.74
LU14	0.014	1.177	121.8	0.20	0.70
LU15	0.012	1.009	104.4	0.17	0.60
Mean	0.012±0.001	1.02±0.001	105.6±0.001	0.17±0.001	0.60±0.001
World Average	0.013	1.093	84.00	0.48	0.29

Table 2. Indoor BIR and radiological parameters of O.B. Lulu Briggs Health Centre

Sampling Point	BIR (μR/hr)	Equivalent Dose (mSv/y)	Absorbed dose (nGy/hr)	AEDE (mSv/y)	ELCR x 10^{-3}
DFR Pharmacy	0.014	1.177	104.4	0.48	1.68
Laboratory	0.014	1.177	104.4	0.48	1.68
TSIP Pharmacy	0.010	0.841	87.0	0.14	0.49
File Record Office	0.013	1.093	69.60	0.11	0.37
Waiting Room Ground floor	0.013	1.093	69.60	0.11	0.37
Mini Bed Area 1	0.013	1.093	69.60	0.11	0.37
Eye section	0.010	0.841	87.0	0.14	0.49
Stair Case Left	0.010	0.841	87.0	0.14	0.49
Stair Case Right	0.011	0.925	95.7	0.44	1.54
Mini Bed Area 2	0.016	1.346	156.6	0.29	0.96
Waiting Area First Floor	0.014	1.177	104.4	0.48	1.68
Finance Office	0.013	1.093	69.60	0.11	0.37
General Office	0.013	1.093	69.60	0.11	0.37
Upstairs Left	0.012	1.009	139.2	0.25	0.77
Upstairs Right	0.015	1.261	130.5	0.60	2.10
Mean	0.013±0.001	1.071±0.001	96.28±0.001	0.27±0.001	0.92±0.001
World Average	0.013	1.093	84.00	0.48	0.29

Table 3. Dose to different organ of outdoor of O.B. Lulu Briggs Health Centre

Sampling Point	D_{organ} (mSv/y)						
	Lungs	Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole Body
LU1	0.0896	0.0812	0.0966	0.1148	0.0868	0.0644	0.0952
LU2	0.1216	0.1102	0.1311	0.1558	0.1178	0.0874	0.1292
LU3	0.1472	0.1334	0.1587	0.1886	0.1426	0.1058	0.1564
LU4	0.1216	0.1102	0.1311	0.1558	0.1178	0.0874	0.1292
LU5	0.0896	0.0812	0.0966	0.1148	0.0868	0.0644	0.0952
LU6	0.134	0.122	0.145	0.172	0.130	0.097	0.143
LU7	0.109	0.099	0.118	0.140	0.106	0.079	0.116
LU8	0.0896	0.0812	0.0966	0.1148	0.0868	0.0644	0.0952
LU9	0.0896	0.0812	0.0966	0.1148	0.0868	0.0644	0.0952
LU10	0.102	0.093	0.110	0.131	0.099	0.073	0.109
LU11	0.0896	0.0812	0.0966	0.1148	0.0868	0.0644	0.0952
LU12	0.0896	0.0812	0.0966	0.1148	0.0868	0.0644	0.0952
LU13	0.134	0.122	0.145	0.172	0.130	0.097	0.143
LU14	0.130	0.118	0.140	0.166	0.126	0.094	0.138
LU15	0.109	0.099	0.118	0.140	0.106	0.079	0.116
Mean	0.109733	0.0996	0.118433	0.140667	0.1064	0.079067	0.116733

Table 4. Dose to different organ of indoor of O.B. Lulu Briggs Health Centre

Sampling Point	D_{organ} (mSv/y)						
	Lungs	Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole Body
DFR Pharmacy	0.3072	0.2784	0.3312	0.3936	0.2976	0.2208	0.3264
Laboratory	0.3072	0.2784	0.3312	0.3936	0.2976	0.2208	0.3264
TSIP Pharmacy	0.0896	0.0812	0.0966	0.1148	0.0868	0.0644	0.0952
File Record Office	0.070	0.064	0.076	0.090	0.068	0.051	0.075
Waiting Room Ground floor	0.070	0.064	0.076	0.090	0.068	0.051	0.075
Mini Bed Area 1	0.070	0.064	0.076	0.090	0.068	0.051	0.075
Eye section	0.0896	0.0812	0.0966	0.1148	0.0868	0.0644	0.0952
Stair Case Left	0.0896	0.0812	0.0966	0.1148	0.0868	0.0644	0.0952
Stair Case Right	0.2816	0.2552	0.3036	0.3608	0.2728	0.2024	0.2992
Mini Bed Area 2	0.1856	0.145	0.2001	0.2378	0.1798	0.1334	0.1972
Waiting Area First Floor	0.3072	0.2784	0.3312	0.3936	0.2976	0.2208	0.3264
Finance Office	0.070	0.064	0.076	0.090	0.068	0.051	0.075
General Office	0.070	0.064	0.076	0.090	0.068	0.051	0.075
Upstairs Left	0.160	0.145	0.173	0.205	0.155	0.115	0.170
Upstairs Right	0.344	0.348	0.414	0.492	0.372	0.276	0.4692
Mean	0.16744	0.1528	0.183607	0.218053	0.164853	0.164853	0.185027

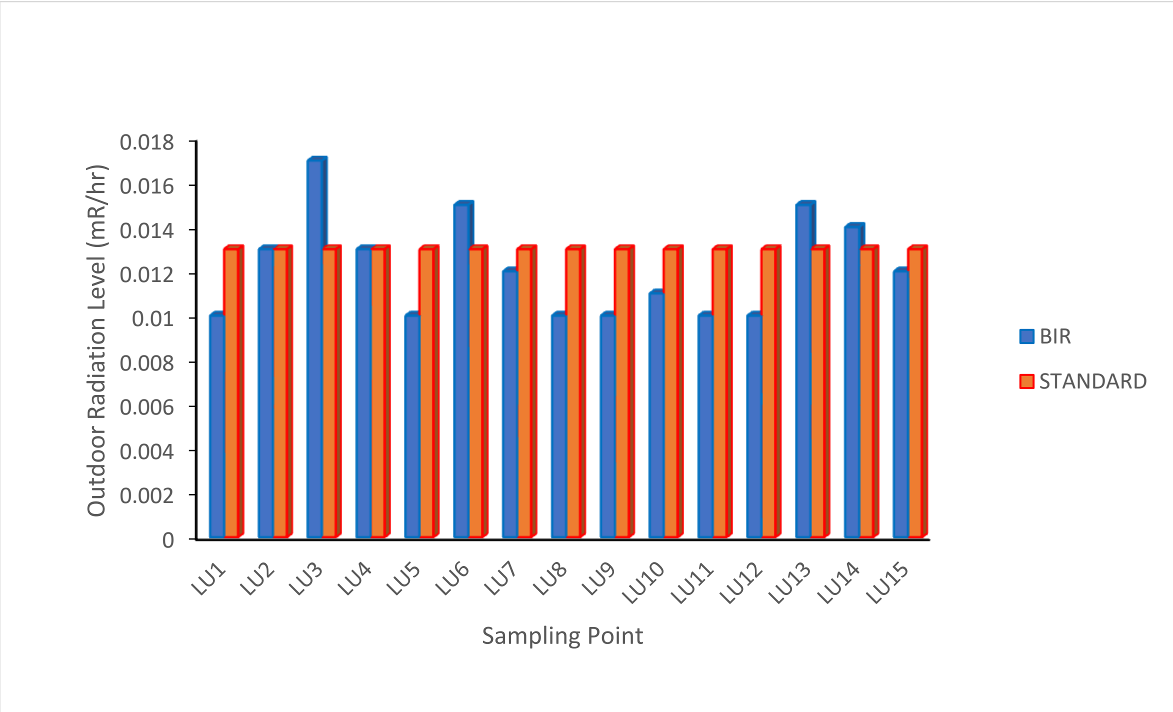

Fig. 2. Comparison of Outdoor Radiation level of O.B. Lulu Briggs Health Centre with the Standard Radiation Level

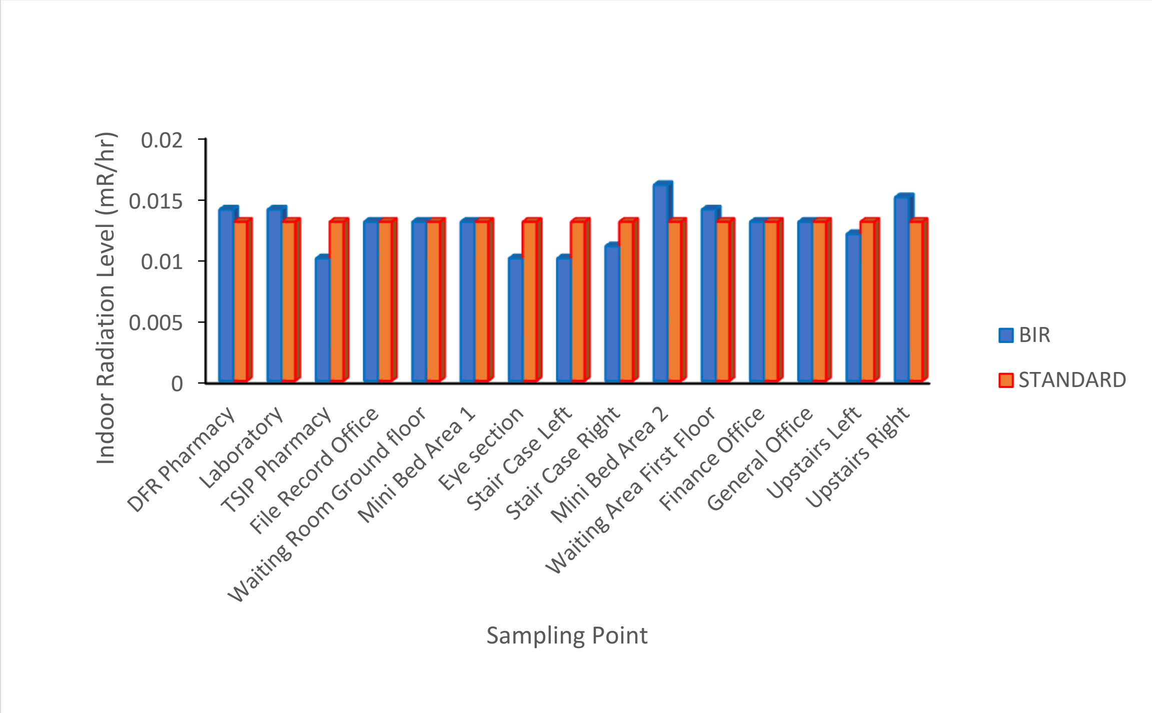

Fig. 3. Comparison of Indoor Radiation level of O.B. Lulu Briggs Health Centre with the Standard Radiation Level

The results obtained are presented in Tables 1 to 2 showing the average exposure rate, absorbed dose rate, equivalent dose rate, annual effective dose equivalent, excess lifetime cancer risk and organ dose of the thirty locations. Figs. 2 and 3 shows the result compared with standard. The average exposure rate (mR/hr) of O.B. Lulu Briggs Health Centre for both outdoor and indoor range from 0.010mR/hr to 0.017mR/hr and 0.010mR/hr to 0.016mR/hr with total mean values 0.012 ± 0.001mR/hr and 0.013 ± 0.001mR/hr respectively. About four sampling points for outdoor (LU3 (0.017), LU6 (0.015), LU13 (0.015), LU14 (0.014)) and six sampling points for that of the indoor (DRF Pharmacy (0.014), Laboratory (0.014), Staircases (0.016), Staircase Right (0.014), General Office (0.015), Upstairs left (0.014)) where higher than ICRP standard value of 0.013mR/hr. These high values might be as a result of presence of products that emits radionuclides and due to poor waste management system. The mean absorbed dose rate of outdoor and indoor from the study area are 105.6 nGy/hr and 96.28nGy/h respectively is lesser than the values obtained by Agbalagba et al. [17]. The mean value for both outdoor and indoor were higher than the standard value of 84nGy/h but lower than Ononugbo et al. [5]. For the AEDE, the calculated values ranging from 0.14mSv/y to 0.23mSv/y and 0.11mSv/y to 0.60mSv/y for outdoor and indoor respectively with mean values of 0.17mSv/y and 0.27mSv/y were lower than the standard value of ICRP and the value (1.60mSv/y) obtained by Nwankwo et al. [18] in pharmaceutical facilities in Ilorin, Nigeria. The mean values of ELCR are high when compared with the value obtained Bension I.D. and Ugbede F.O [19]. The values show that the chances of contracting cancer for the workers of the study area does not show immediate effect but have future cancer implication. The calculated effective dose delivered to the adult body for O.B. Lulu Briggs Health Centre are shown in Tables 3 and 4. The testes recorded the highest dose (0.140667mSv/y and 0.218053mSv/y) for both outdoor and indoor respectively. This is because the testes happen to be the most radiosensitive tissue [20], while the liver records the least values. The obtained results show that the estimated dose to different organs are all below the international tolerance limits on dose to body organs of 1.0mSv/y [21].

4. CONCLUSION

The study reveals that the BIR maintains the standard limit of 0.013mR/hr. these results however do not indicate that BIR monitoring and evaluation should stop but it should be carried out from time to time. There should be improvement on waste management system in order to maintain or reduce ionizing radiation emission from waste.

DISCLAIMER

The product used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and the producers of the products because we do not intend to use these products as an avenue for any litigation but for advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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