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Research Article

Radiological Health Risk of Exposure to Gamma Radiation in Private Diagnostic Center in Khana Local Government Area Rivers State, Nigeria

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Abstract

The *In-situ* measurement of background ionizing radiation of Centre of Life hospital Bori in Khana Local Government Area of Rivers state of Nigeria has been carried out. Digilert-200 Radiation meters was utilized in measurement of background ionizing radiation and Global Positioning System (Garmin 765) was used in measuring coordinates of the sampling points. Fifteen (15) sampling points were arbitrarily selected within the diagnostics centre. The results of the BIR outdoor and indoor varies from 0.010 - 0.015 with mean of 0.013 $mRhr^{-1}$. Absorbed Dose rate varies from 87.0 -130.5 nGy/yr with mean of 114.3 nGy/yr and 116.0 nGy/yr for outdoor and indoor. AEDE varies from 0.107 – 0.160 with mean of 0.140 mSv/yr and 0.142 mSv/yr and Excess life cancer risk varies from 0.37×10^{-3} – 0.56×10^{-3} with mean of 0.50×10^{-3} and 0.50×10^{-3} for outdoor and indoor respectively. The obtained values for BIR of Centre of Life Hospital Ltd was within recommended standard limit of 0.013mR/h. The obtained result for AEDE was within the recommended safe limit. The obtained results of ELCR and the ADR are all higher than the recommended standard of 0.29×10^{-3} and 84.0 nGy/h respectively. The result of radiation dose to different body organ shows that the testes have the highest radiation percentage for outdoor and indoor respectively.

Keywords

Ionizing Radiation, Radiation Monitor, Absorbed Dose Rate (ADR), X-ray, Utilization and Radioactivity

1. Introduction

The excessive exposure of patients and medical staff to ionizing radiation sources during working hours or examination is of great concern, due to its health effects. [1]. The risks of radiation to human health cannot be overstated, because the exposure to radiation can occur from a variety of sources such as; human manufacturing processes, research in sciences, therapeutic radiation sources, X-ray usage, and other associated operations. Ionizing radiation, has been used in medicine services, and it is now widely acknowledged as a vital diagnostic and therapeutic technique [2]. Patients and health worker receive ionizing radiation from well executed operations, medical radiography has been widely practiced, and as a result, medical radiation exposures now account for a significant portion of the population's overall exposure to radiation. The vast majority of wealthy countries with sophisticated healthcare systems currently rely mostly on medical expo-

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sures as their primary source of ionizing radiation. [3]. Since high radiation doses are known to have harmful consequences, ionizing radiation from hospitals and medical research facilities has raised significant concerns. Ionizing radiation exposure may end up in injury and clinical manifestations, such as radiation catractogenesis, chromosomal change, cancer induction, free radical generation, and bone necrosis. Both acute and chronic dosage exposure may be the source of the damage and clinical symptoms [10]. Ionizing radiation are radiation that has enough energy to knock off electros from any material they interact with, such interact has effects on the body or the immediate environment [13]. The radiation exposure to patients during the radioisotope procedures, radiographic examination and radiation therapy has contributed immensely to the increase of background ionizing radiation likewise to the radiation levels of patients and health workers [4]. Radiation that originates on earth are called terrestrial radiation. Primordial radionuclides that were present when the earth was formed are found around the globe in igneous and sedimentary from rock and these radionuclides migrated into soil, water, and even air [5]. Radiation from primordial radionuclides is the major components of the total radiation dose to human population for both indoor and outdoor environments. The contribution of cosmic rays to environmental dose at sea level, depends on altitude, and the solar cycle, which is insignificant when compared to the terrestrial radiation [7]. The natural radioactivity has greater effects of ionizing radiation on world populace due to its presence in our environment at different amounts. The populace is exposed to variable amount of radiation within the immediate environment and the ambient radiation comprises of both natural and artificial radioactivity sources [6]. The exposure to background radiation over the years has raise a serious public health concern due to its effects. Therefore, ascertaining its level becomes imperative within strategic areas in radiological facilities for monitoring and compliance with international standards [5]. The health effects of background ionizing radiation arises from different anthropogenic activities here on earth such as oil exploration, mining, fertilizer production, scientific research work the application of radioactive sources in nuclear medicine, regular application of x-ray in medicine and the application of other materials containing enhanced sources of naturally occurring radioactive materials (NORM) which are present within the environment might lead individuals to occupational and public exposure of ionizing radiations [8].

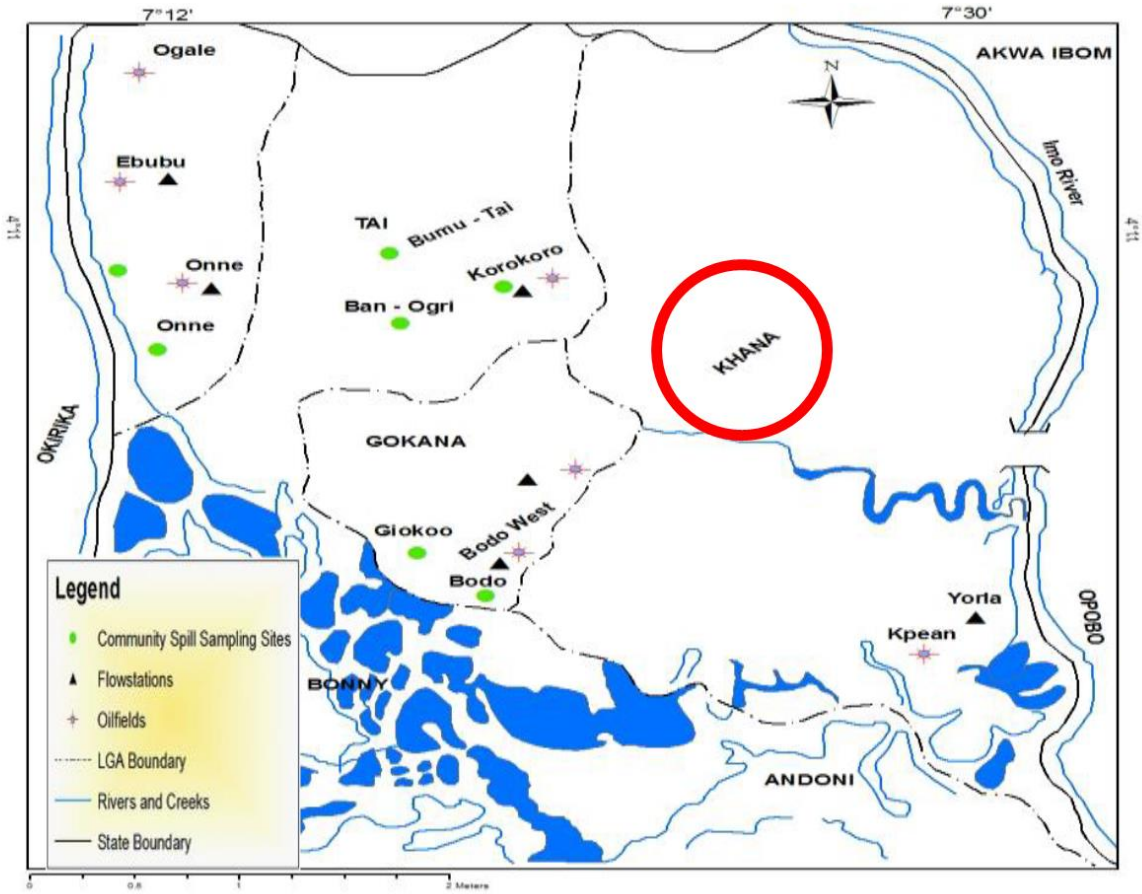

Figure 1. *Map of the Study Area.*

2. Study Area

The study is carried out in private diagnostic centre in Bori city, which is the traditional headquarters of Ogoni and also the headquarters of Khana local Government Area of Rivers State. Bori lies between 4°67°North latitude 7°36° east, longitude and 201metres elevation above the sea level. Bori is among the small cities in Rivers State and Nigeria with a total population of 11,693 people [9]. It serves as commercial center for the Ogoni's, Opobo and Andoni as shown in Figure 1.

Centre of life hospital Ltd is located at no. 13 market road Bori, and started its operation in the year 2009. Centre of life hospital has special ward for female and male and three (3) private wards. Centre of life hospital Ltd has the following department: Surgery, pharmacy, radiology, laboratory unit and emergency unit.

3. Materials and Methods

3.1. Materials

Radiation meter (Digilert 200) was utilized in carrying out In-situ measurement of the indoor and outdoor ionizing radiation exposure level of the study area. The Radiation monitoring meter, (Digilert 200) contains a Geiger-Muller tube which is capable of detecting alpha, beta and gamma radiation was used in recording the background ionizing radiation within the study area. The radiation meter was well calibrated for accurate results. Global Positioning System (GPS Map76 Garmin product) was used to estimate the geographical coordinates of the selected sample points within the study area.

3.2. Methods

The in-situ measurement was carried out in Centre of life hospital Bori in Khana Local Government Area. Fifteen (15) sampling points were arbitrarily selected within the selected diagnostics centre, with the use of codes for proper differentiation and identification of the sampling points. The outdoor background ionizing radiation (BIR) were taken around the premises of the selected diagnostics center by placing the Radiation meter at a height of one meter (1m) above the selected sampling points (Ground level). Three different readings were taken within the sampling points and the average was calculated to represent the BIR of the selected sampling points and the radiation meters was set to measure the exposure dose rate in milli-Roetgen per hour (mR/hr). The geographical positioning system (GPS) was used to measure the precise coordinates of each of the sampling points within the selected diagnostic center.

A) The Absorbed Dose Rate.

Absorbed dose rate is a physical dose quantity (D) representing the mean energy conveyed to matter per unit mass by ionizing radiation. The unit of measurement is joules per kilogram (J/Kg), and its special name is gray (Gy) [12].

B) *Absorbed Dose Rate* = Exposure Dose Rate x 8.7 (nGy/hr).

Annual Effective Dose Equivalent.

The annual effective dose equivalent (AEDE) received through the consumption of the agricultural produce from the study area was calculated using the absorb dose. Dose conversion factor of 0.7Sv/Gy and the occupancy factor for indoor and outdoor was 0.70 (18/24), and 0.2 (6/24) respectively. It is assumed that the people spend 6 hours indoors and outdoors. The annual effective dose is determined using the following equation [11].

$$\text{AEDE (outdoor) (mSv/yr)} = \text{Dose rate (nGy/h)} \times 8760\text{h} \times 0.75\text{Sv/Gy} \times 0.25.$$

C) Excess Life Cancer Risk (ELCR).

Excess Lifetime Cancer Risk (ELCR) is a carcinogenic potential effects that are characterized by assessing the probability of cancer occurrence in a population of individuals for a specific lifetime from projected intakes (and exposures) and chemical specific dose-response data [12]. Excess lifetime cancer risk deals with the possibility of developing cancer over a lifetime at a given exposure level.

$$ELCR = \text{AEDE} \times \text{Average Duration of Life (DL)} \times \text{RISK factor (RF)}.$$

The Average duration of life is 70years while Risk factor for public exposure is 0.05 [12].

D) Effective Dose to Body Organs (Dorgan).

The radiation effective dose to organs (Dorgan), estimates the quantity of radiation dose in take to the various human's organs and tissues [14].

$$\text{Effective dose to organs (mSv/yr)} = \text{AEDE} \times \text{F}.$$

Where F is the conversion factor of organ dose and the conversion factor (F) values for lungs, ovaries, bone marrow, testes, kidney, liver, and whole body are 0.64, 0.58, 0.69, 0.82, 0.62, 0.46, and 0.68, respectively [15].

4. Result

The obtained results outdoor and indoor background ionizing radiation of the selected private diagnostic centre are presented in Table 1 and Table 2 with its health risk parameters.

Table 1. *Outdoor Background Ionizing Radiation of Centre of life hospital Ltd.*

Locations Code	**GPS Reading**	**Exposure Level (mRhr^{-1})**	**Absorbed Dose (nGy/hr)**	**AEDE Outdoor (mSv/y)**	**ELCR × 10^{-3}**
CLH$_1$ Outdoor	N04^{O}40’57.4” E007^{0}21’59.1”	0.014	121.8	0.149	0.523
CLH$_2$ Outdoor	N04^{O}40’37.1” E007^{0}21’60.2”	0.014	121.8	0.149	0.523
CLH$_3$ Outdoor	N04 º40’37.7” E007^{0}21’61.5”	0.013	113.1	0.139	0.485
CLH$_4$ Outdoor	N04 º40’36.5” E007^{0}21’61.9”	0.014	121.8	0.149	0.523
CLH$_5$ Outdoor	N04 º40’35.0” E007^{0}21’59.6”	0.013	113.1	0.139	0.485
CLH$_6$ Outdoor	N04 º40’37.9” E007^{0}21’60.9”	0.015	130.5	0.160	0.560
CLH$_7$ Outdoor	N04 º40’36.8” E007^{0}21’60.8”	0.013	113.1	0.139	0.485
CLH$_8$ Outdoor	N04 º40’37.7” E007^{0}21’61.8”	0.015	130.5	0.160	0.560
CLH$_9$ Outdoor	N04 º40’36.7 E007^{0}21’62.5”	0.014	121.8	0.149	0.523
CLH$_{10}$ Outdoor	N04 º40’49.8 E007^{0}21’63.1”	0.015	130.5	0.160	0.560
CLH$_{11}$Outdoor	N04 º40’55.8 E007^{0}21’62.5”	0.010	87.0	0.107	0.373
CLH$_{12}$ Outdoor	N04 º40’52.8 E007^{0}21’61.4”	0.013	113.1	0.139	0.485
CLH$_{13}$ Outdoor	N04 º41’39.8 E007^{0}24’61.5”	0.014	121.8	0.149	0.523
CLH$_{14}$ Outdoor	N04 º45’40.8 E007^{0}32’61.9”	0.010	87.0	0.107	0.373
CLH$_{15}$ Outdoor	N04 º45’41.8 E007^{0}32’62.9”	0.010	87.0	0.107	0.373
Mean		0.013	114.3	0.140	0.50
UNSCEAR (2002)		0.013	84	1.00	0.29

Table 2. *Indoor Background Ionizing Radiation of Centre of life hospital Ltd.*

Locations Code	**GPS Reading**	**Exposure Level (mRhr^{-1})**	**Absorbed Dose (nGy/hr)**	**AEDE Outdoor (mSv/y)**	**ELCR × 10^{-3}**
CLH$_1$ Indoor	N04 º40’57.4” E007^{0}21’59.1”	0.015	130.5	0.160	0.560
CLH$_2$ Indoor	N04 º40’37.1” E007^{0}21’60.2”	0.015	130.5	0.160	0.560
CLH$_3$ Indoor	N04 º40’37.7” E007^{0}21’61.5”	0.015	130.5	0.160	0.560
CLH$_4$ Indoor	N04 º40’36.5” E007^{0}21’61.9”	0.010	87.0	0.107	0.373
CLH$_5$ Indoor	N04 º40’35.0” E007^{0}21’59.6”	0.013	113.1	0.139	0.485
CLH$_6$ Indoor	N04 º40’37.9” E007^{0}21’60.9”	0.014	121.8	0.149	0.523
CLH$_7$ Indoor	N04 º40’36.8” E007^{0}21’60.8”	0.010	87.0	0.107	0.373
CLH$_8$ Indoor	N04 º40’37.7” E007^{0}21’61.8”	0.013	113.1	0.139	0.485
CLH$_9$ Indoor	N04 º40’36.7 E007^{0}21’62.5”	0.015	130.5	0.160	0.560
CLH$_{10}$ Indoor	N04 º40’49.8 E007^{0}21’63.1”	0.013	113.1	0.139	0.485
CLH$_{11}$ Indoor	N04 º40’55.8 E007^{0}21’62.5”	0.010	87.0	0.107	0.373
CLH$_{12}$ Indoor	N04 º40’52.8 E007^{0}21’61.4”	0.015	130.5	0.160	0.560
CLH$_{13}$ Indoor	N04 º41’39.8 E007^{0}24’61.5”	0.014	121.8	0.149	0.523
CLH$_{14}$ Indoor	N04 º45’40.8 E007^{0}32’61.9”	0.014	121.8	0.149	0.523
CLH$_{15}$ Indoor	N04 º45’41.8 E007^{0}32’62.9”	0.014	121.8	0.149	0.523

Locations Code	GPS Reading	Exposure Level ($mRhr^{-1}$)	Absorbed Dose (nGy/hr)	AEDE Outdoor (mSv/y)	ELCR $\times 10^{-3}$
Mean		0.013	116.0	0.142	0.50
UNSCEAR (2002)		0.013	84.00	1.00	0.29

5. Discussion

The *In-situ* measurement of background ionizing radiation of Centre of Life hospital Bori in Khana Local Government Area of Rivers state of Nigeria has been carried out. The results for indoor and outdoor background ionizing radiation are presented in Table 1 and Table 2. The radiation dose to different body organ outdoor and indoor are presented in Table 3 and Table 4. Figure 2 and Figure 5 shows the BIR of outdoor and indoor, Figure 3 and Figure 6 shows Absorbed dose outdoor and indoor and Figure 4 and Figure 7 shows ELCR of outdoor and indoor. The obtained results for outdoor background ionizing radiation varies from 0.010 - 0.015 with mean of 0.013 $mRhr^{-1}$ for outdoor and indoor respectively. The obtained mean value for outdoor and indoor are within the tolerable limit of 0.013 $mRhr^{-1}$ though higher values was recorded within the sampling points and these high values, might be due to the presence of radionuclide within the environment or due to the leakage of the x-ray machine. The obtained mean for the background ionizing radiation outdoor and indoor are within the reported work of Bubu and Ononugbo [17]. The Absorbed Dose rate varies from 87.0 -130.5 nGy/yr with mean of 114.3 nGy/yr and 116.0 nGy/yr for outdoor and indoor respectively. The obtained mean for absorbed rate for indoor and outdoor are higher than the stipulated value of 84 nGy/yr and lower than the reported work of Agbalagba et al. [18]. The Annual effective dose equivalent varies from 0.107 – 0.160 with mean of 0.140 mSv/yr and 0.142 mSv/yr for outdoor and indoor respectively. The obtained mean value of AEDE for outdoor and indoor are within the permissible limit of 84 mSv/yr [16] and lower than the report value of Bubu and Ononugbo [17]. The excess life cancer risk varies from 0.37 $x10^{-3}$ – 0.56 $x10^{-3}$ with mean of 0.50 $x10^{-3}$ and 0.50 $x10^{-3}$ for outdoor and indoor respectively. The obtained mean values for outdoor and indoor are higher than the stipulated value of 0.29 $x10^{-3}$ [16] and low when compared with the reported work of Bubu and Ononugbo [17]. These higher mean values of ELCR for outdoor and indoor of the study area implied, that workers and resident who may spent their life time within the study area might developed cancer in the future.

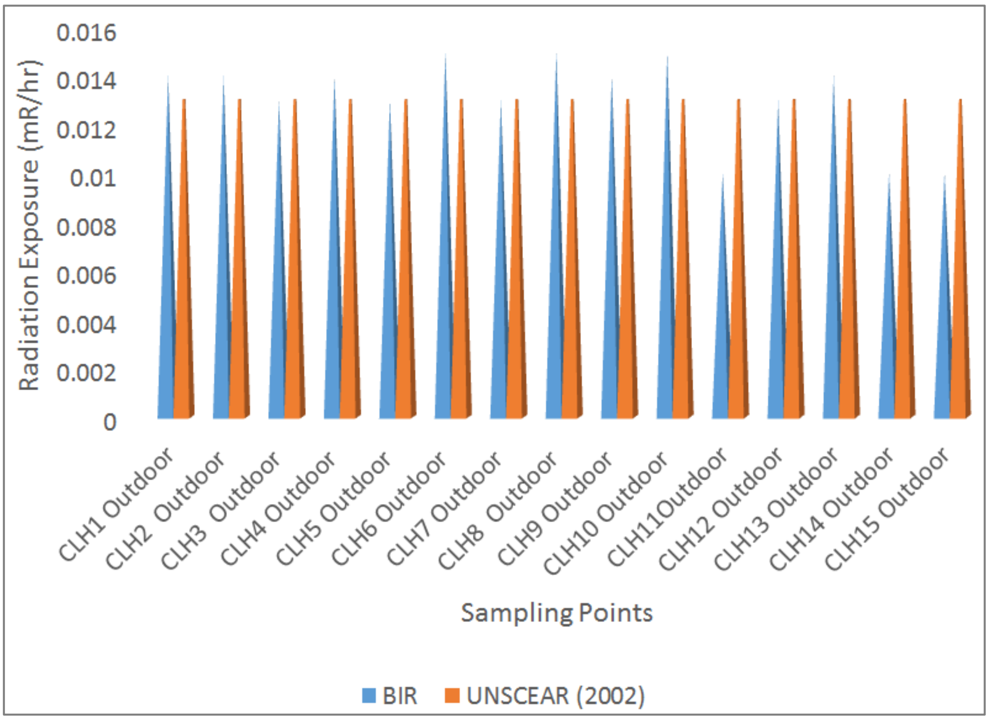

***Figure 2.** Comparison of Background Ionizing Radiation outdoor with Standard.*

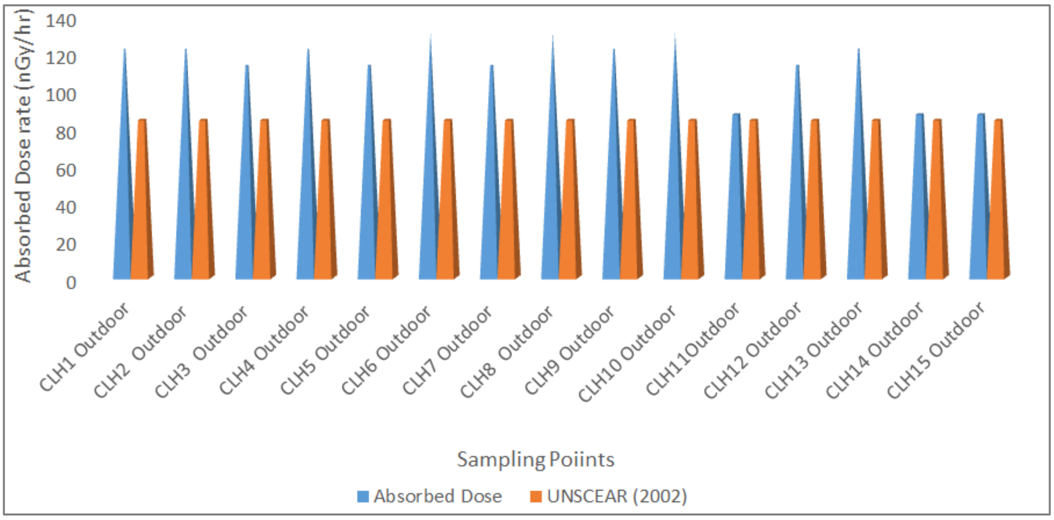

Figure 3. *Comparison of Absorbed Dose rate outdoor with Standard.*

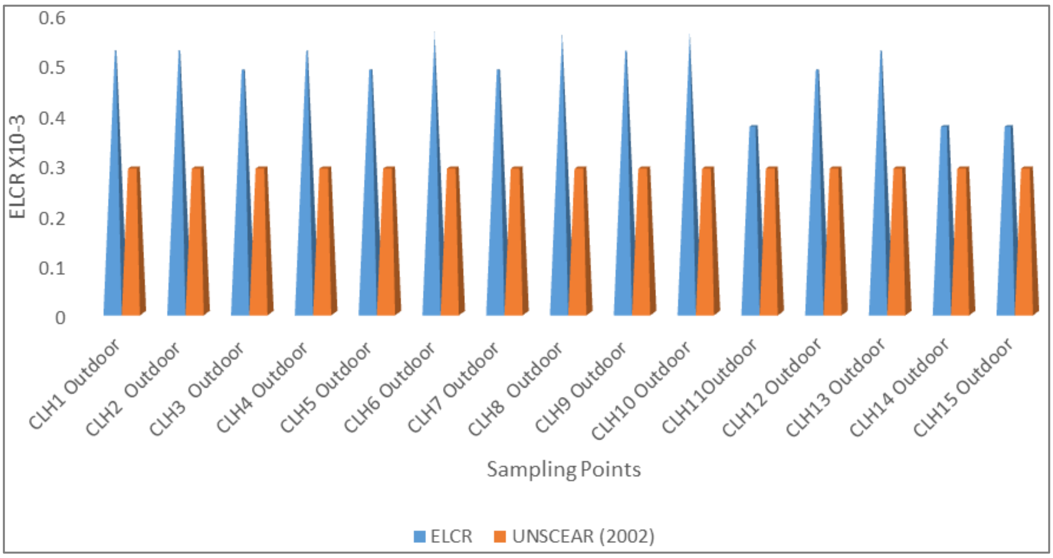

Figure 4. *Comparison of ELCR outdoor with Standard.*

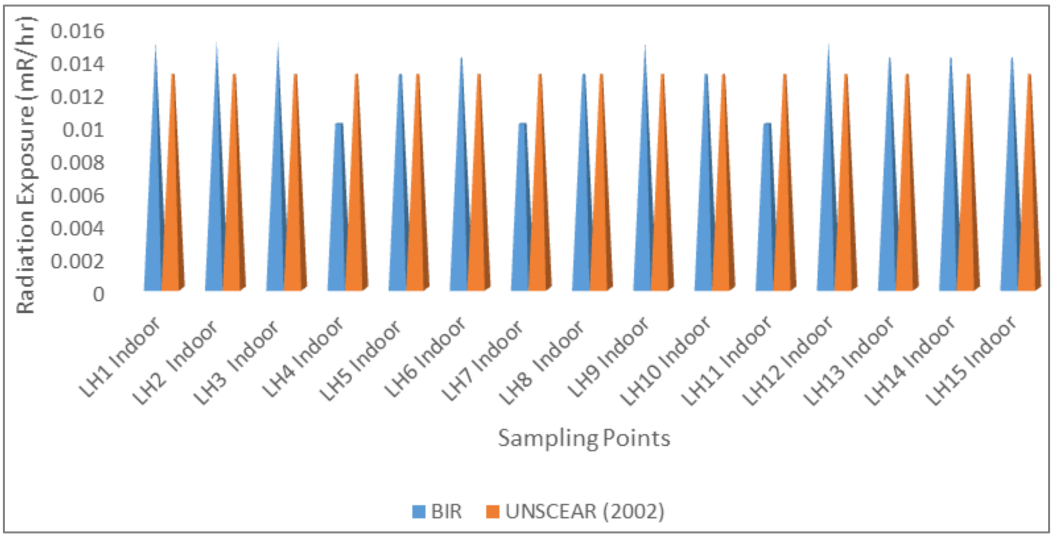

Figure 5. *Comparison of Background Ionizing Radiation indoor with Standard.*

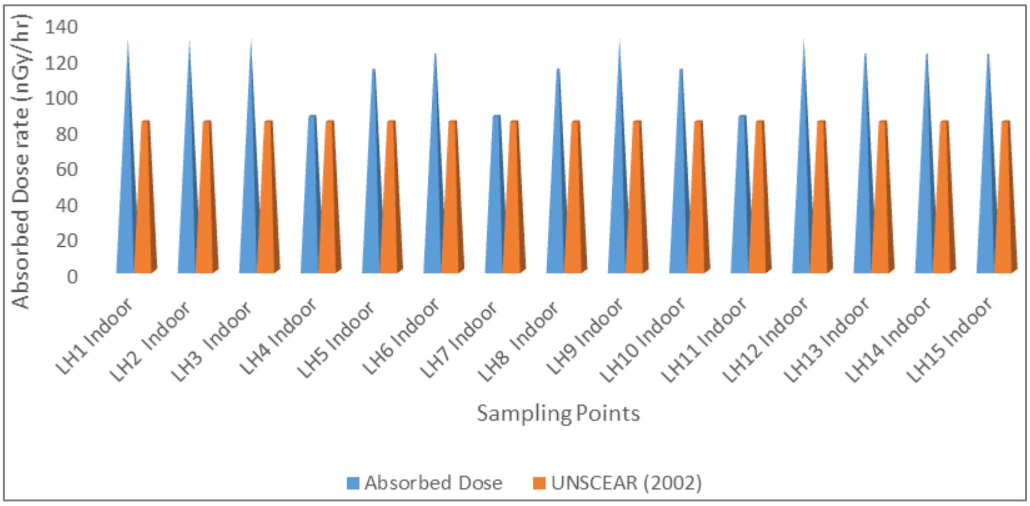

Figure 6. *Comparison of Absorbed Dose Rate for indoor with Standard.*

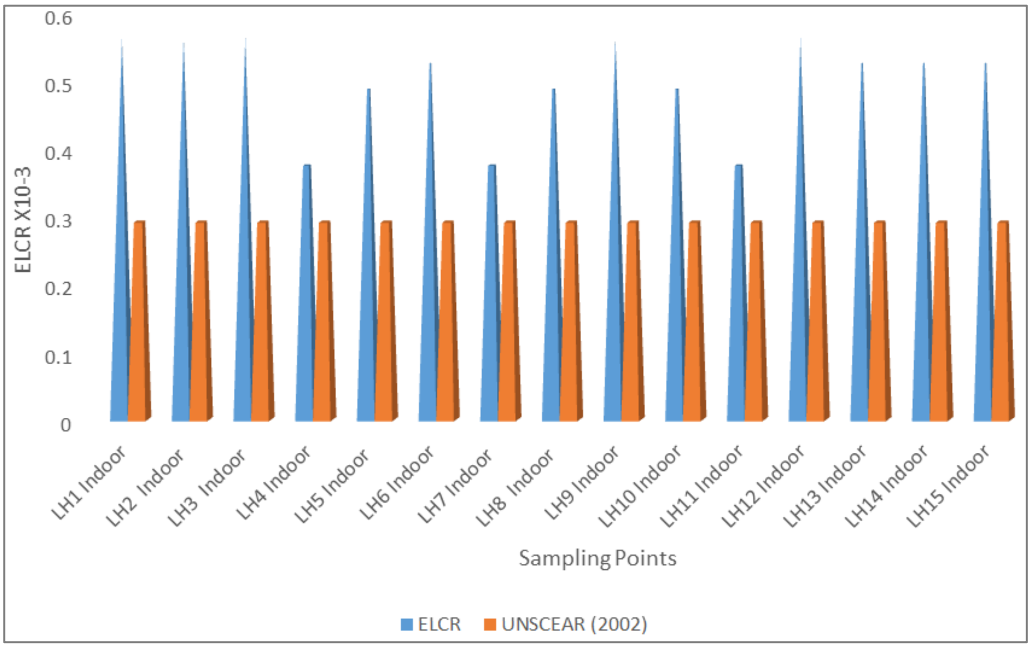

Figure 7. *Comparison of ELCR outdoor with Standard.*

Table 3. *Dose to Different Organ of Centre of life hospital Ltd (Outdoor).*

Sampling point code	**Dorgan ($mSvy^{-1}$)**						
	Lungs	**Ovaries**	**Bone marrow**	**Testes**	**kidney**	**liver**	**Whole body**
CLH_1 Outdoor	0.1024	0.0928	0.1104	0.1312	0.0992	0.0736	0.1088
CLH_1 Indoor	0.1024	0.0928	0.1104	0.1312	0.0992	0.0736	0.1088
CLH_2 Indoor	0.1024	0.0928	0.1104	0.1312	0.0992	0.0736	0.1088
CLH_3 Indoor	0.0685	0.0621	0.0738	0.0877	0.0663	0.0492	0.0728
CLH_4 Indoor	0.0889	0.0806	0.0959	0.1139	0.0862	0.0639	0.0945
CLH_5 Indoor	0.0953	0.0864	0.1028	0.1222	0.0924	0.0685	0.1013

Sampling point code	Dorgan ($mSvy^{-1}$)						
	Lungs	Ovaries	Bone marrow	Testes	kidney	liver	Whole body
CLH_6 Indoor	0.0685	0.0621	0.0738	0.0877	0.0663	0.0492	0.0728
CLH_7 Indoor	0.0889	0.0806	0.0959	0.1139	0.0862	0.0639	0.0945
CLH_8 Indoor	0.1024	0.0928	0.1104	0.1312	0.0992	0.0736	0.1088
CLH_9 Indoor	0.0889	0.0806	0.0959	0.1139	0.0862	0.0639	0.0945
CLH_{10} Indoor	0.0685	0.0621	0.0738	0.0877	0.0663	0.0492	0.0728
CLH_{11} Indoor	0.1024	0.0928	0.1104	0.1312	0.0992	0.0736	0.1088
CLH_{12} Indoor	0.0954	0.0864	0.1028	0.1222	0.0924	0.0685	0.1013
CLH_{13} Indoor	0.0954	0.0864	0.1028	0.1222	0.0924	0.0685	0.1013
CLH_{14} Indoor	0.0954	0.0864	0.1028	0.1222	0.0924	0.0685	0.1013
Mean	0.0910	0.0825	0.0982	0.1167	0.0882	0.0654	0.0967

***Table 4**. Dose to Different Organ of Centre of life hospital Ltd (Indoor).*

Sampling point code	Dorgan ($mSvy^{-1}$)						
	Lungs	Ovaries	Bone marrow	Testes	kidney	liver	Whole body
CLH_1 Outdoor	0.0954	0.0864	0.1028	0.1222	0.0924	0.0685	0.1013
CLH_2 Outdoor	0.0954	0.0864	0.1028	0.1222	0.0924	0.0685	0.1013
CLH_3 Outdoor	0.0889	0.0806	0.0959	0.1139	0.0862	0.0639	0.0945
CLH_4 Outdoor	0.0954	0.0864	0.1028	0.1221	0.0924	0.0685	0.1013
CLH_5 Outdoor	0.0889	0.0806	0.0959	0.1139	0.0862	0.0639	0.0945
CLH_6 Outdoor	0.1024	0.0928	0.1104	0.1312	0.0992	0.0736	0.1088
CLH_7 Outdoor	0.0889	0.0806	0.0959	0.1139	0.0862	0.0639	0.0945
CLH_8 Outdoor	0.1024	0.0928	0.1104	0.1312	0.0992	0.0736	0.1088
CLH_9 Outdoor	0.0954	0.0864	0.1028	0.1221	0.0924	0.0685	0.1013
CLH_{10} Outdoor	0.1024	0.0928	0.1104	0.1312	0.0992	0.0736	0.1088
CLH_{11}Outdoor	0.0685	0.0620	0.0738	0.0877	0.0663	0.0492	0.0728
CLH_{12} Outdoor	0.0889	0.0806	0.0959	0.1139	0.0862	0.0639	0.0945
CLH_{13} Outdoor	0.0954	0.0864	0.1028	0.1221	0.0924	0.0685	0.1013
CLH_{14} Outdoor	0.0685	0.0621	0.0738	0.0877	0.0663	0.0492	0.0728
CLH_{15} Outdoor	0.0685	0.0621	0.0738	0.0877	0.0663	0.0492	0.0728
Mean	0.0897	0.0812	0.0967	0.1149	0.0869	0.0645	0.0953

The human testes have the highest percentage of the radiation dose to the different body organs for both outdoor and indoor respectively and the lowest percentage was recorded in the liver and ovaries as shown in Figure 8 and Figure 9. This high percentage of radiation dose in testes shows that testes is one of the most radiosensitive body organ [19]. The obtained result of radiation dose to different body organs agreed with the reported work of Darwish et al. [14]. The obtained results of radiation dose to different human body organs are all below the recommended limits of 1.0mSv/y [20].

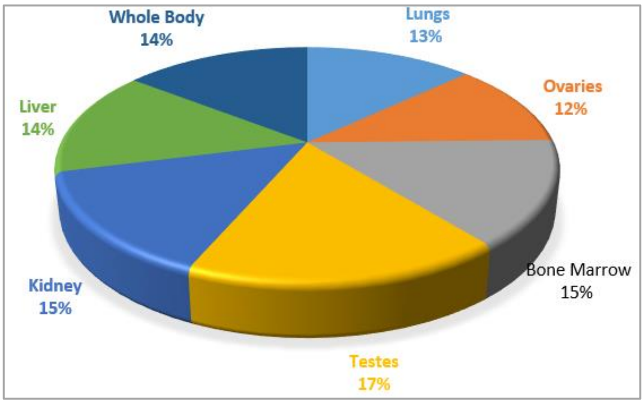

Figure 8. *Percentage of Outdoor Radiation Dose to different Body Organ.*

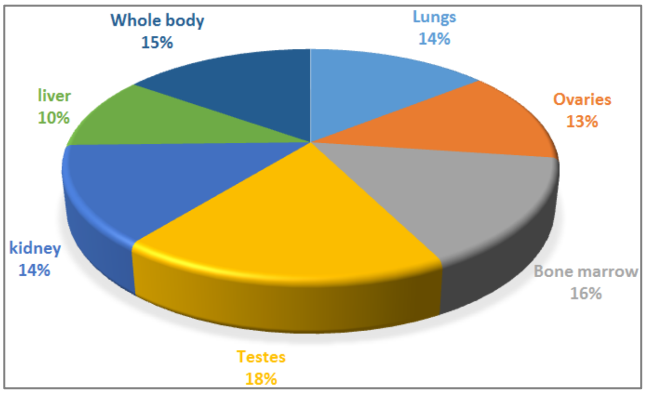

Figure 9. *Percentage of Indoor Radiation Dose to different Body Organ.*

6. Conclusion

The obtained mean value of the BIR for both indoor and outdoor are within the recommend safe limit of 0.013 mRyr^{-1}. Thought the variation within the sampling points might be due to the presence of gamma emitting material or due to the leakage of the x-rays machine. The result of absorbed dose rate for indoor and outdoor are higher than the recommended standard value of 84.0 nGyhr. The result of the ELCR for both outdoor and indoor and higher than the stipulated standard of 0.29x10^{-3} this higher value of ELCR may not pose any immediately health risk but an individual who may spent his/her life time with in the study area may develop cancer in due time.

Abbreviations

AEDE	Annual Effective Dose Equivalent
BIR	Background Ionizing Radiation
ELCR	Excess Lifetime Cancer Risk
CLH	Centre of Life Hospital

Author Contributions

Nwii Abayiga Abel: Formal Analysis
Biibalo Livinus Legborsi: Data curation

Conflicts of Interest

The authors declare no conflicts of interest.

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