Applied Science, Computing and Energy, 2025, 3(2), 344-355

Level of Radiological Hazards at the Information Computer Technology (ICT) Complex, Federal University Otuoke, Nigeria

Uzochukwu Leonard Anekwe

Received: 17 July 2025/Accepted: 29 August 2025/Published online: 16 September 2025

Abstract: *Background ionizing radiation (BIR) is the largest source of human exposure to ionizing radiation and elevated levels of natural radionuclides and their decay products may increase long-term health risks, particularly in high-occupancy environments such as university complexes. This study assessed radiation levels and associated risks in and around the Information Communication Technology (ICT) Complex of Federal University Otuoke, Bayelsa State, Nigeria. Forty (40) sampling points were monitored using portable radiation survey meter, the Alert monitor 200. Results of the study showed that the BIR values ranged from 0.010 to 0.018 mR/h. These BIR values were used to compute corresponding values of absorbed dose rates, and radiological risk parameters such as equivalent dose (ED), annual effective dose equivalent (AEDE), and excess lifetime cancer risk (ELCR). Absorbed dose rates ranged from 87.0 to 156.6 nGy/h with mean value of 113.1 nGy/h. The equivalent dose varied from 0.53 to 0.96 mSv/y, with 0.72 mSv/y mean value. Indoor AEDE values ranged between 0.40 and 0.72 mSv/y (mean: 0.54 mSv/y), while outdoor AEDE ranged from 0.13 to 0.24 mSv/y with mean of 0.18 mSv/y. The estimated ELCR values ranged from 1.0 to 1.8) × 10^{-3} for indoors and 0.33 to 0.60 × 10^{-3} for outdoors, both exceeding the global average of 0.29 × 10^{-3}. Generally, these values are not at alert levels though prolonged occupancy of the ICT Complex may therefore pose non-negligible long-term stochastic health risks, continuous monitoring is therefore advised.*

Keywords*: Adsorbed dose, Background radiation, Electronic equipment, Excess lifetime cancer risk, ICT complex*

Uzochukwu Leonard Anekwe Department of Physics, Federal University Otuoke, Nigeria
Email: anekweul@fuotuoke.edu.ng
https://orcid.org/0000-0003-0554-8617

1.0 Introduction

Ionizing radiation is an inescapable component of the natural environment. Human beings are continuously exposed to varying levels of natural and artificial radiation originating from terrestrial, cosmic, and anthropogenic sources (Eddy *et al.*, 2025a). Naturally occurring radioactive materials (NORMs), such as uranium (^{238}U), thorium (^{232}Th), and potassium (^{40}K), are widely distributed in soil, rocks, and construction materials (Eddy *et al.*, 2025b. Their decay products contribute to background ionizing radiation, which differs significantly depending on geology, geography, and human activities in a given location (Dawidall *et al.*, 2004; Farai & Vincent, 2006). Where human interventions—such as mining, oil exploration, industrial activities, and building construction—elevate concentrations of these radionuclides, the sources are classified as technologically enhanced naturally occurring radioactive materials (TENORMs) (Avwiri & Agbalagba, 2007). Such elevated levels can result in enhanced exposure of populations living, studying, or working near these sources. Globally, natural background radiation accounts for the largest share of human exposure. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2008) estimates that the average annual effective dose to humans is about 2.4 mSv, of which approximately 40% arises from internal exposure to radon gas and its progeny. Radon (^222Rn), a colorless, odorless radioactive gas, is a decay product of uranium-

238. When inhaled, radon decays inside the lungs, emitting alpha particles (^218Po and ^214Po) with energies as high as 7.69 MeV, which deposit energy in sensitive tissues, thereby increasing the risk of lung cancer (Schnelzer *et al*., 2010). The International Commission on Radiological Protection (ICRP, 2007) has identified indoor radon exposure as one of the most significant contributors to the radiation dose received by the public.

In Nigeria, studies have reported elevated background radiation levels in oil-bearing regions, urban centers, and even within public institutions due to a combination of geological composition and human activities (Okoye & Avwiri, 2013; Arogunjo *et al*., 2004). The Niger Delta, in particular, has attracted considerable attention because oil and gas exploration activities often release NORMs to the surface environment, contributing to terrestrial and atmospheric radioactivity (Ononugbo *et al*., 2011). At the same time, poorly regulated urbanization and the use of locally sourced building materials—many of which contain trace amounts of radioactive isotopes—may further elevate radiation exposure indoors (Ononugbo & Efere, 2016). These circumstances make localized assessments essential in order to establish baseline data and quantify potential health risks to the population.

The significance of conducting radiation risk assessments within an academic setting such as the Federal University Otuoke cannot be overstated. Universities and ICT complexes are high-occupancy environments where students, staff, and visitors spend considerable amounts of time, both indoors and outdoors. Given that exposure time is a critical determinant of cumulative radiation dose, the radiation risk to occupants of such facilities must be carefully evaluated (Cember & Thomas, 2009). For example, ICRP guidelines assume that people spend roughly 80% of their time indoors and 20% outdoors (ICRP, 2007). In densely used facilities such as ICT complexes, where indoor occupancy may be even higher due to the long study and working hours, the indoor component of the annual effective dose could dominate the total radiation burden.

Several health risks are associated with prolonged exposure to ionizing radiation. Beyond the well-established association with lung cancer, exposure may induce other stochastic effects such as genetic mutations, leukemia, and solid tumors. Deterministic effects, which occur above a threshold dose, include skin burns, radiation cataracts, and impairment of organ functions (Norm, 2008). Though background radiation levels are generally low compared to occupational or accidental exposures, chronic exposure—even at low doses—can accumulate over time, posing a long-term risk to public health (UNSCEAR, 2000). For this reason, the principle of keeping exposure “as low as reasonably achievable” (ALARA) has been universally adopted in radiation protection practice (NCRP, 1993).

The Federal University Otuoke is located in Bayelsa State, within the Niger Delta region of Nigeria. This area is geologically characterized by sedimentary alluvium, sandy loam, silt, and clayey soils, which may contain radionuclides of natural origin. Coupled with ongoing oil exploration activities in the wider region, there exists a real possibility of elevated background ionizing radiation (Ononugbo *et al*., 2011). Previous studies in similar Niger Delta communities have reported absorbed dose rates and annual effective dose equivalents higher than global averages, raising concerns about long-term radiological health risks (Taskin *et al*., 2009; Huyumbu *et al*., 1995). Yet, few studies have systematically assessed radiation exposure within institutional environments, particularly university ICT complexes where sensitive electronic equipment, staff, and large populations of students converge daily.

Therefore, this study aims to estimate ionizing radiation risks in and around the ICT Complex of Federal University Otuoke. By conducting in-situ measurements of background ionizing radiation, converting exposure rates to absorbed dose, and calculating the annual effective dose equivalent (AEDE) and excess lifetime cancer risk (ELCR), the research seeks to provide baseline radiological data for the institution. These results will not only serve to compare with internationally recommended limits but will also inform policymakers, campus administrators, and environmental regulators on the safety status of academic environments in oil-bearing regions. Ultimately, the study contributes to ongoing national and global discussions on radiation protection, environmental monitoring, and public health.

2.0 Materials and Methods

2.1 Study Area

The study was conducted in and around the Information Communication Technology (ICT) Complex of the Federal University Otuoke, located in Ogbia Local Government Area of Bayelsa State, Nigeria. The University lies within the lower Niger Delta region at latitude approximately 4°47′N and longitude 6°19′E. The region is characterized by sedimentary alluvium soils comprising sandy loam, clay, and silt, with a generally flat topography and high annual rainfall. These geological and hydrological conditions favor the presence of naturally occurring radionuclides such as ^{238}U, ^{232}Th, and ^40K in soils and building materials (Mustapha *et al*., 1999). The ICT Complex serves as a hub for academic and administrative activities, hosting large numbers of students, staff, and visitors daily. Because of its centrality within the campus and high population density, the ICT Complex was selected for radiation risk assessment to establish baseline data and to determine whether radiation levels in and around the facility fall within internationally accepted limits.

2.2 Instrumentation

Background ionizing radiation levels were measured *in situ* using portable radiation survey meters—Radalert-100 and Digilert-200 (S.E. International Inc., USA). These detectors employ Geiger–Müller (GM) tubes sensitive to alpha, beta, gamma, and X-ray radiations. Both instruments were factory calibrated and operated within a temperature range of –10 to 50 °C. Each instrument was set to measure exposure rate in milli-Roentgen per hour (mR/h). A handheld Global Positioning System (GPS) receiver was used to record the precise latitude and longitude of each sampling point to ensure accurate spatial referencing of the measurements (Mahmoud & El Saman, 2014).

2.3 Sampling Procedure

Measurements were carried out at forty (40) designated points in and around the ICT Complex, including indoor halls, offices, corridors, open grounds, and surrounding areas. At each location, the radiation detector was positioned at a height of approximately 1.0 m above the ground to simulate the breathing zone of humans, consistent with established protocols (Ajayi & Achuka, 2009). Three independent readings were taken per point, each lasting for about 5 minutes to allow for statistical averaging and minimize the effect of fluctuations. The mean value of the readings was computed and recorded as the background ionizing radiation (BIR) level at that location.

2.4 Conversion to Absorbed Dose

The absorbed dose rate (D, in nGy/h) was calculated from the measured exposure rate using the conversion factor established by the United Nations Scientific Committee on the Effects of Atomic Radiation as shown in equation 1 (UNSCEAR, 2000)

$$1\mu R/h = nGy/h \qquad (1)$$

The obtained absorbed dose values were subsequently used in further risk assessments.

2.5 Annual Effective Dose Equivalent (AEDE)

The annual effective dose equivalent (AEDE) was estimated from the absorbed dose rates using a dose conversion factor of 0.7 Sv/Gy and occupancy factors of 0.75 for indoor and 0.25 for outdoor exposure, consistent with International Commission on Radiological Protection (ICRP, 2007) recommendations. The equations applied were equations 2 and 3

$$AEDE_{indoor}(Sv/y) = D \times 8760 \times 0.7 \times 0.75 \times 10^{-6} \quad (2)$$

$$AEDE_{outdoor}(Sv/y) = D \times 8760 \times 0.7 \times 0.25 \times 10^{-6} \quad (3)$$

where D is the absorbed dose rate (nGy/h), 8760 is the number of hours in a year, and 10^{-6} converts nano- to milli-Sieverts.

2.6 Equivalent Dose Rate (EDR)

The whole-body equivalent dose rate (EDR) was derived to represent the annualized radiation burden without occupancy factors. It was obtained using the relation expressed in equation 4 (Aliyu & Ramli, 2015)

$$EDR(mSv/y) = \frac{D \times 8760 \times 0.7}{10^6} \quad (4)$$

EDR is a parameter that serves as a reference for comparison with international dose limits for the general public.

2.7 Excess Lifetime Cancer Risk (ELCR)

The Excess Lifetime Cancer Risk (ELCR) was calculated to estimate the probability of developing cancer attributable to lifetime exposure to the measured radiation levels. ELCR was computed based on equation 5 (Anekwe & Ibe, 2017)

$$ELCR = AEDE \times DL \times RF \quad (5)$$

where AEDE is the annual effective dose equivalent (mSv/y), DL is the average duration of life (assumed as 50 years), and RF is the fatal cancer risk factor per Sievert (0.05 Sv^{-1} for the public, as recommended by ICRP).

2.8 Data Analysis

The results obtained for each sampling point were tabulated, and statistical parameters such as mean, minimum, and maximum values were computed. These values were compared with internationally recommended limits, including the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) global average absorbed dose rate of 84 nGy/h (UNSCEAR, 2000) and the International Commission on Radiological Protection (ICRP) annual effective dose limits of 1.0 mSv for the general public and 20 mSv for occupationally exposed workers (ICRP, 2007). The dataset for the ICT Complex includes background ionizing radiation (BIR), absorbed dose, equivalent dose, annual effective dose equivalent (AEDE; indoor and outdoor), and excess lifetime cancer risk (ELCR; indoor and outdoor) for all forty (40) sampling points.

3.0 Results and Discussion

The in-situ measurements of background ionizing radiation in and around the ICT Complex of the Federal University Otuoke and the corresponding radiological risk parameters are presented in Table X. A total of forty (40) sampling points were assessed, covering both indoor and outdoor environments. For each point, the background ionizing radiation (BIR), absorbed dose rate (nGy/h), equivalent dose (mSv/y), annual effective dose equivalent (AEDE) for indoor and outdoor scenarios, and excess lifetime cancer risk (ELCR) were calculated.

3.1 Background Ionizing Radiation and Absorbed Dose

The measured BIR values ranged from 0.010 ± 0.003 mR/h (lowest, at Sampling Point 5) to 0.018 ± 0.006 mR/h (highest, at Sampling Points 9, 19, 23, and 34). The mean exposure rate across all points was approximately 0.014 mR/h. Using the UNSCEAR conversion factor, these values correspond to absorbed dose rates between 87.0 nGy/h and 156.6 nGy/h, with a mean value of 113.1 nGy/h. This mean absorbed dose exceeds the world average absorbed dose rate of 84 nGy/h reported by UNSCEAR (2000).

3.2 Equivalent Dose

The equivalent dose, derived from absorbed dose, varied from 0.533 mSv/y (lowest, Sampling Point 5) to 0.960 mSv/y (highest, at

Sampling Points 9, 19, 23, and 34). The overall mean equivalent dose was 0.72 mSv/y, which is below the limit of 1.0 mSv/y recommended by the International Commission on Radiological Protection (ICRP, 2007) for the general public, but still indicates relatively elevated exposure compared to global background averages.

3.3 Annual Effective Dose Equivalent (AEDE)

For indoor exposure scenarios, AEDE values ranged from 0.400 mSv/y to 0.720 mSv/y, with a mean of 0.54 mSv/y. For outdoor exposure, AEDE values ranged from 0.133 mSv/y to 0.240 mSv/y, with a mean of 0.18 mSv/y. While these values are well below the occupational dose limit of 20 mSv/y (ICRP, 2007), some indoor AEDE values approach the 1.0 mSv/y public exposure limit, suggesting that prolonged occupancy in the ICT Complex could lead to non-negligible long-term risks.

3.4 Excess Lifetime Cancer Risk (ELCR)

The estimated ELCR values for indoor exposure ranged from 1.0×10^{-3} to 1.8×10^{-3}, with a mean of 1.35×10^{-3}. Outdoor ELCR values ranged between 0.33×10^{-3} and 0.60×10^{-3}, with a mean of 0.45×10^{-3}. These values exceed the acceptable global average of 0.29×10^{-3} for environmental radiation (UNSCEAR, 2000; Taskin *et al*., 2009), indicating an elevated risk of stochastic effects such as cancer within the ICT Complex environment.

3.5 Spatial Variability

Spatial analysis revealed that higher exposure values were generally associated with outdoor sampling points located closer to open grounds, while relatively lower values were recorded in enclosed indoor spaces. Sampling Points 9, 19, 23, and 34 consistently recorded the highest absorbed doses (156.6 nGy/h), equivalent doses (0.960 mSv/y), and corresponding AEDE and ELCR values. By contrast, Sampling Point 5 (87.0 nGy/h) recorded the lowest dose and associated risk parameters.

Table 1 presents the results of in-situ background ionizing radiation (BIR) measurements and corresponding radiological risk parameters in and around the ICT Complex of the Federal University Otuoke. A total of forty (40) sampling points were assessed, covering both indoor and outdoor environments. Parameters determined include exposure rate (BIR), absorbed dose rate (nGy/h), equivalent dose (mSv/y), annual effective dose equivalent (AEDE) for indoor and outdoor scenarios, and excess lifetime cancer risk (ELCR). These indicators provide a comprehensive overview of the radiological environment in a high-occupancy institutional facility where staff, students, and visitors spend extended periods.

Table 1: Background ionizing radiation, absorbed dose, AEDE, and ELCR in and around ICT Complex, Federal University Otuoke.

S/N	Latitude	Longitude	BIR (mR/hr)	Absorbed Dose (nGy/h)	Equivalent Dose (mSv/y)	AEDE Indoor (mSv/y)	AEDE Outdoor (mSv/y)	ELCR Indoor ($x10^{-3}$)	ELCR Outdoor ($x10^{3}$)
1	N4°47'50"	E6°19'28"	0.015±0.003	130.5	0.800	0.600	0.200	1.500	0.500
2	N4°47'43"	E6°19'21"	0.012±0.001	104.4	0.640	0.480	0.160	1.200	0.400
3	N4°47'49"	E6°19'28"	0.017±0.002	147.9	0.907	0.680	0.227	1.700	0.567
4	N4°47'49"	E6°19'27"	0.015±0.004	130.5	0.800	0.600	0.200	1.500	0.500
5	N4°47'48"	E6°19'26"	0.010±0.003	87.0	0.533	0.400	0.133	1.000	0.333
6	N4°47'48"	E6°19'25"	0.014±0.004	121.8	0.747	0.560	0.187	1.401	0.467
7	N4°47'48"	E6°19'24"	0.012±0.002	104.4	0.640	0.480	0.160	1.200	0.400
8	N4°47'47"	E6°19'24"	0.013±0.001	113.1	0.694	0.521	0.174	1.302	0.434

9	N4°47'46"	E6°19'23"	0.018±0.003	156.6	0.960	0.720	0.240	1.800	0.600
10	N4°47'43"	E6°19'23"	0.017±0.003	147.9	0.907	0.680	0.227	1.700	0.567
11	N4°47'44"	E6°19'21"	0.015±0.002	130.5	0.800	0.600	0.200	1.500	0.500
12	N4°47'45"	E6°19'21"	0.012±0.001	104.4	0.640	0.480	0.160	1.200	0.400
13	N4°47'45"	E6°19'23"	0.014±0.003	121.8	0.747	0.560	0.187	1.401	0.467
14	N4°47'43"	E6°19'22"	0.012±0.004	104.4	0.640	0.480	0.160	1.200	0.400
15	N4°47'44"	E6°19'20"	0.014±0.005	121.8	0.747	0.560	0.187	1.401	0.467
16	N4°47'43"	E6°19'22"	0.016±0.002	139.2	0.854	0.641	0.214	1.603	0.401
17	N4°47'43"	E6°19'22"	0.012±0.002	104.4	0.640	0.480	0.160	1.200	0.400
18	N4°47'43"	E6°19'21"	0.011±0.005	95.7	0.587	0.440	0.147	1.101	0.367
19	N4°47'43"	E6°19'19"	0.018±0.006	156.6	0.960	0.720	0.240	1.800	0.600
20	N4°47'44"	E6°19'19"	0.016±0.007	139.2	0.854	0.641	0.214	1.603	0.401
21	N4°47'44"	E6°19'20"	0.012±0.006	104.4	0.640	0.480	0.160	1.200	0.400
22	N4°47'42"	E6°19'20"	0.014±0.007	121.8	0.747	0.560	0.187	1.401	0.467
23	N4°47'41"	E6°19'19"	0.018±0.003	156.6	0.960	0.720	0.240	1.800	0.600
24	N4°47'43"	E6°19'18"	0.016±0.006	139.2	0.854	0.641	0.214	1.603	0.401
25	N4°47'42"	E6°19'18"	0.013±0.005	113.1	0.694	0.521	0.174	1.302	0.434
26	N4°47'41"	E6°19'18"	0.016±0.003	139.2	0.854	0.641	0.214	1.603	0.401
27	N4°47'44"	E6°19'19"	0.012±0.001	104.4	0.640	0.480	0.160	1.200	0.400
28	N4°47'45"	E6°19'19"	0.015±0.003	130.5	0.800	0.600	0.200	1.500	0.500
29	N4°47'46"	E6°19'20"	0.011±0.004	95.7	0.587	0.440	0.147	1.101	0.367
30	N4°47'45"	E6°19'20"	0.017±0.002	147.9	0.907	0.680	0.227	1.700	0.567
31	N4°47'46"	E6°19'19"	0.013±0.005	113.1	0.694	0.521	0.174	1.302	0.434
32	N4°47'45"	E6°19'18"	0.011±0.001	95.7	0.587	0.440	0.147	1.101	0.367
33	N4°47'40"	E6°19'19"	0.013±0.005	113.1	0.694	0.521	0.174	1.302	0.434
34	N4°47'40"	E6°19'18"	0.018±0.007	156.6	0.960	0.720	0.240	1.800	0.600
35	N4°47'39"	E6°19'19"	0.014±0.002	121.8	0.747	0.560	0.187	1.401	0.467
36	N4°47'39"	E6°19'19"	0.013±0.003	113.1	0.694	0.521	0.174	1.302	0.434
37	N4°47'38"	E6°19'18"	0.011±0.007	95.7	0.587	0.440	0.147	1.101	0.367
38	N4°47'37"	E6°19'17"	0.015±0.002	130.5	0.800	0.600	0.200	1.500	0.500
39	N4°47'36"	E6°19'17"	0.014±0.003	121.8	0.747	0.560	0.187	1.401	0.467
40	N4°47'35"	E6°19'18"	0.013±0.001	113.1	0.694	0.521	0.174	1.302	0.434

The measured BIR values ranged between 0.010 ± 0.003 mR/h (Sampling Point 5) and 0.018 ± 0.006 mR/h (Sampling Points 9, 19, 23, and 34). These correspond to absorbed dose rates between 87.0 nGy/h and 156.6 nGy/h, with a mean of 113.1 nGy/h (Table 1). This average value is notably higher than the UNSCEAR (2000) global population-weighted average of 84 nGy/h, suggesting that local geological factors and possibly radionuclide-bearing construction materials contribute to elevated radiation levels (Jibiri & Agomuo, 2007).

Fig. 1 further illustrates the variability in absorbed dose rates across sampling points. Peaks at Sampling Points 9, 19, 23, and 34 indicate localized hotspots, while the lowest dose rate was observed at Sampling Point 5. Such variability reflects spatial heterogeneity influenced by soil composition, building design, or proximity to open grounds (Avwiri & Ononugbo, 2012).

The equivalent dose values ranged from 0.533 mSv/y to 0.960 mSv/y, with a mean of 0.72 mSv/y (Table 1). These results remain below the ICRP's public exposure limit of 1.0 mSv/y (ICRP, 2007), but exceed global background averages, such as the worldwide estimate of 0.48 mSv/y reported in similar studies (Arogunjo, 2007). This indicates relatively elevated exposure levels, though still within acceptable international safety standards.

The AEDE values revealed distinct differences between indoor and outdoor environments. Indoor AEDE values ranged from 0.400–0.720 mSv/y (mean 0.54 mSv/y), while outdoor AEDE values ranged from 0.133–0.240 mSv/y (mean 0.18 mSv/y) (Table 1). Fig. 3 demonstrates this disparity, with indoor exposures consistently higher due to longer occupancy factors, consistent with ICRP assumptions (ICRP, 2007). Although these values are below the occupational exposure limit of 20 mSv/y, some indoor AEDE values approach the public limit of 1.0 mSv/y, underscoring the importance of indoor exposure in long-term radiation risk assessments.

The ELCR values ranged from 1.0×10^{-3} to 1.8×10^{-3} for indoor exposure and 0.33×10^{-3} to 0.60×10^{-3} for outdoor exposure (Table 1). Both sets of values exceed the global average of 0.29×10^{-3} proposed by Taskin *et al*. (2009). Fig. 2 highlights this distribution, showing that indoor ELCR values consistently exceeded outdoor values.

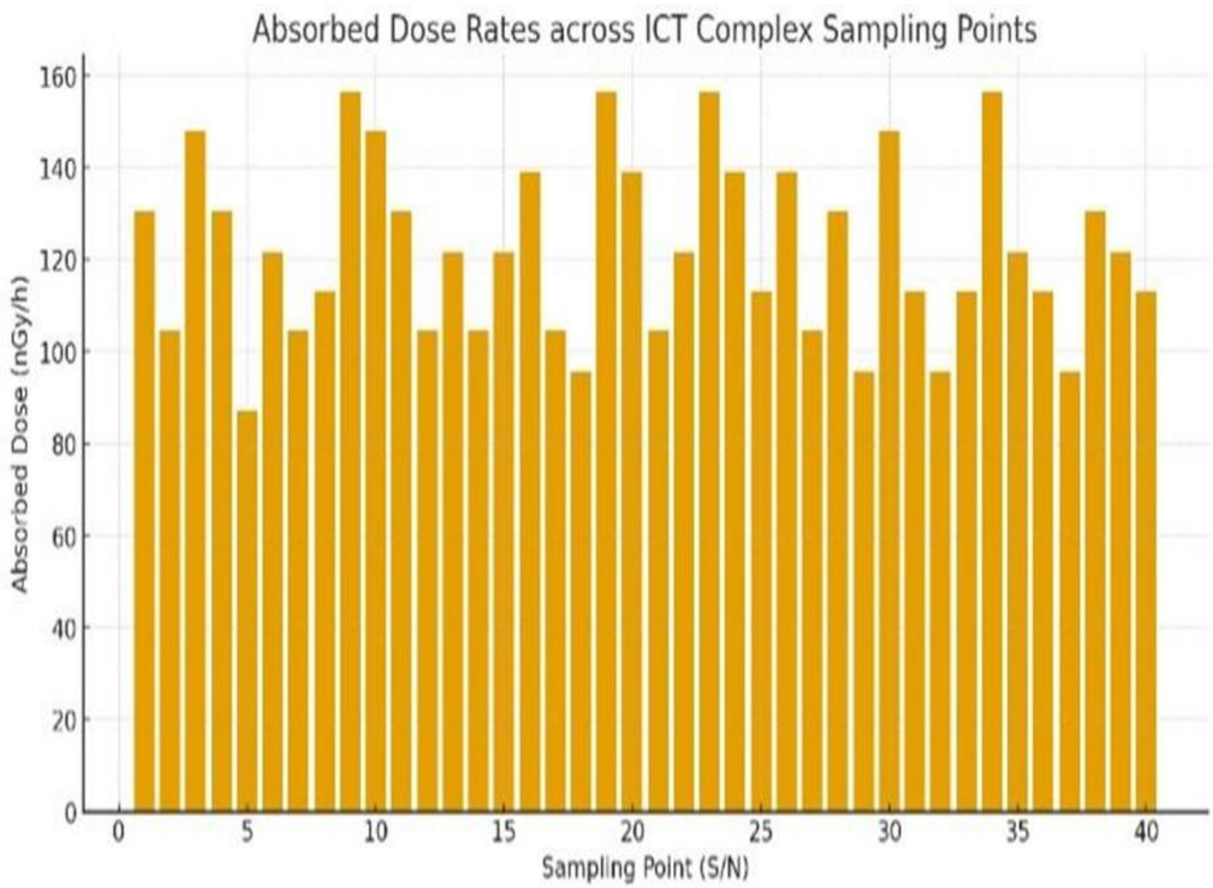

Fig. 1:Absorbed Dose Rates across ICT Complex Sampling Points

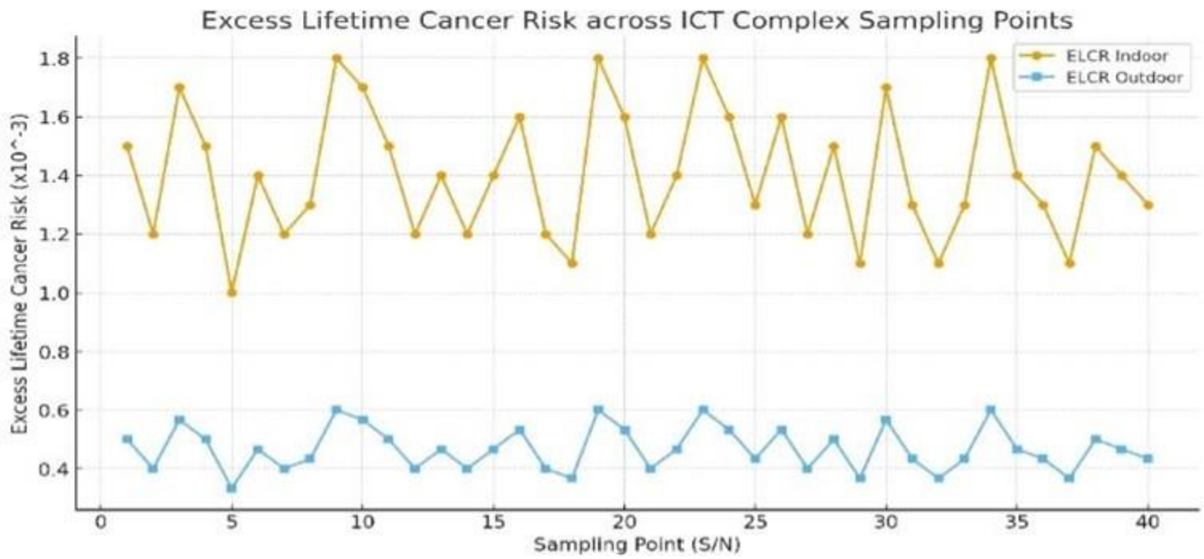

Fig. 2:Excess Lifetime Cancer Risk across ICT Complex Sampling Points

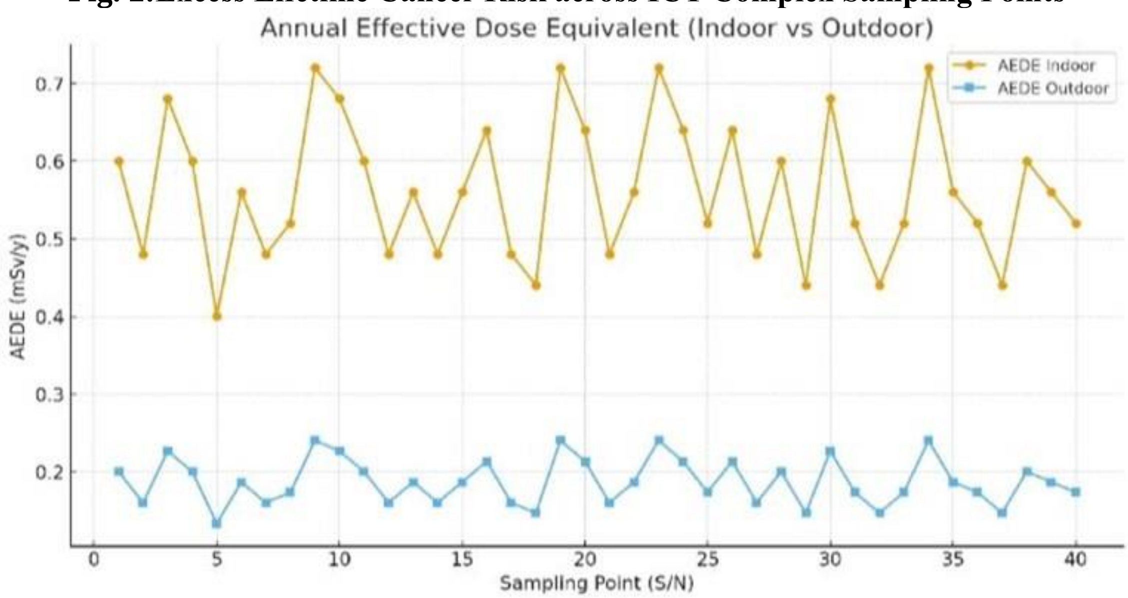

Fig. 3: Annual Effective Dose Equivalent (Indoor vs. Outdoor) across ICT Complex Sampling Points

These findings suggest that individuals who spend significant time indoors within the ICT Complex may face a higher-than-normal probability of stochastic health effects such as cancer. Although the absolute risks are small compared to occupational exposures, they are non-negligible in the context of continuous public occupancy.

When compared to similar research in Nigeria, the ELCR values reported here are consistent with studies conducted in Port Harcourt (Avwiri & Ononugbo, 2012), Bayelsa industrial sites (Avwiri *et al*., 2014), and Ogba/Egbema/Ndoni communities (Agbalagba, 2017), where elevated background ionizing radiation was also recorded. Comparable results have also been reported in other geologically similar regions, such as Kirklareli, Turkey (Taskin *et al*., 2009) and Zambia (Hayumbu *et al*., 1995).

The findings from Table 1 and Figs. 1–3 demonstrate that radiation levels in and around the ICT Complex exceed global averages reported by UNSCEAR (2000), though they remain below ICRP's annual effective dose limit of 1.0 mSv/y for the general public. The elevated absorbed doses, higher-than-average equivalent doses, and ELCR values above global reference levels raise concerns regarding long-term radiological health risks in a high-density academic environment.

These results call for (i) Regular radiological monitoring to track changes in exposure over time, (ii) awareness programs for staff and students to promote safe occupancy practices and (iii) consideration of construction materials and environmental factors in future infrastructural development to minimize exposure. Ultimately, while the ICT Complex is not an immediate radiation hazard, its elevated exposure parameters underscore the need for sustained surveillance to ensure radiological safety for all campus occupants.

4.0 Conclusion

The study evaluated the background ionizing radiation levels and associated radiological health risks in and around the ICT Complex of the Federal University Otuoke. The results showed that the absorbed dose rates ranged between 87.0 and 156.6 nGy/h, with a mean value of 113.1 nGy/h, which is higher than the global average of 84 nGy/h reported by UNSCEAR (2000). Equivalent dose values ranged from 0.533 to 0.960 mSv/y, with an average of 0.72 mSv/y, indicating exposure levels below the ICRP's recommended limit of 1.0 mSv/y for the public but relatively elevated compared to global averages. The annual effective dose equivalent (AEDE) revealed that indoor values, ranging from 0.400 to 0.720 mSv/y, were consistently higher than outdoor values, which ranged between 0.133 and 0.240 mSv/y, reflecting longer indoor occupancy factors. The excess lifetime cancer risk (ELCR) values were higher than the global average of 0.29×10^{-3} (Taskin et al., 2009), with indoor risks ranging from 1.0×10^{-3} to 1.8×10^{-3} and outdoor risks from 0.33×10^{-3} to 0.60×10^{-3}, suggesting a non-negligible cancer risk for individuals spending extended time within the complex. Overall, the findings indicate that while radiation levels remain within international safety thresholds, they are elevated compared to global averages and may pose long-term health implications for frequent occupants. Based on these observations, it is concluded that regular monitoring of radiation levels in the university environment is essential, and awareness programs should be introduced for staff and students on safe occupancy practices. In addition, future infrastructural developments should consider the radiological impact of building materials and the environmental setting to minimize radiation exposure risks.

5.0 References

Ajayi, O. S., & Achuka, J. A. (2009). Natural radioactivity in sediments and health risk assessment from Ogun River, Nigeria. *Radiation Protection Dosimetry, 135*(1), 54–63. https://doi.org/10.1093/rpd/ncp233

Ajayi, O. S., & Ibikunle, S. B. (2013). Assessment of radiation hazard indices from natural radioactivity of soils in Ibadan, Southwestern Nigeria. *Radiation Protection and Environment, 36*(2), 77–82. https://doi.org/10.4103/0972-0464.123856.

Aliyu, A. S., & Ramli, A. T. (2015). The world's high background natural radiation areas revisited: Sources, doses and risk. *Radiation Measurements, 73*, 1–17. https://doi.org/10.1016/j.radmeas.2015.01.002.

Al-Hamarneh, I. F., & Awadallah, M. I. (2009). Soil radioactivity levels and radiation hazard assessment in Jordan. *Radiation Protection Dosimetry, 134*(1), 30–37. https://doi.org/10.1093/rpd/ncp082.

Anekwe, U. L., & Ibe, S. O. (2017). Estimation of radiation risk due to exposure to terrestrial radiation. *Archives of Current Research International, 9*(4), 1–10. https://doi.org/10.9734/ACRI/2017/34454.

Arogunjo, M. A., Farai, I. P., & Fuwape, I. A. (2004). Impact of oil and gas industry on natural radioactivity distribution in the Delta Region of Nigeria. *Nigerian Journal of Physics*, *16*, 131–136.

Avwiri, G. O., Agbalagba, E. O. (2007). Survey of gross alpha and beta radionuclide activity in Okpare Creek, Delta State, Nigeria. *Journal of Applied Sciences*, *7*, 3542–3546. https://doi.org/10.3923/jas.2007.3542.3546.

Avwiri, G. O., Agbalagba, E. O., & Enyinna, P. I. (2007). Terrestrial radiation around oil and gas facilities in Ughelli, Nigeria. *Journal of Applied Sciences and Environmental Management*, *11*(2), 57–60. https://doi.org/10.4314/jasem.v11i2.55002.

Avwiri, G. O., Ononugbo, C. P., & Nwokeoji, I. E. (2014). Radiological impact of oil spilled soil from Gokana, Rivers State, Nigeria. *International Journal of Science and Technology*, *4*(1), 1–7.

Avwiri, G. O., Osimobi, J. C., & Agbalagba, E. O. (2013). Evaluation of radiation hazard indices and excess lifetime cancer risk in soil samples from coastal areas of Nigeria. *Journal of Environmental Health Science & Engineering*, *11*(1), 3–11. https://doi.org/10.1186/2052-336X-11-3.

Bamidele, J. O., Ayedun, H., & Ibitoye, A. (2015). Assessment of radiological hazards in selected building materials in Nigeria. *Journal of Environmental Health Science*, *9*, 91–100.

Cember, H., & Thomas, E. J. (2009). *Introduction to health physics* (4th ed.). McGraw-Hill.

Chinyere, P. O., Avwiri, G. O., & Chad-Umoren, Y. E. (2011). Impact of gas exploitation on environmental radioactivity of Ogba/Egbema/Ndoni Area, Nigeria. *Energy & Environment*, *22*(8), 1017–1027. https://doi.org/10.1260/0958-305X.22.8.1017.

Dar, M. A., & El Saman, M. I. (2014). Interaction of radioelements activity with hydrographic parameters in petroleum regions, Red Sea. *Journal of Radiation Research and Applied Sciences*, *7*, 293–304. https://doi.org/10.1016/j.jrras.2014.03.001.

Dawdall, M., Vicat, K., Frearson, I., Geland, S., Linda, B., & Shaw, G. (2004). Assessment of the radiological impacts of historical coal mining operations in Ny-Ålesund, Svalbard. *Journal of Environmental Radioactivity*, *71*(1), 101–114. https://doi.org/10.1016/S0265-931X(03)00188-0.

Eddy, N. O., Eze, I. S., Garg, R., Akpomie, K., Udoekpote, G., Timothy, C. L., Ucheana, I. A., & Paktin, H. (2025). Exploration of health effects, economic impacts, and regulatory challenges for ionizing radiation: A case study in Nigeria. *Discover Applied Sciences*. https://doi.org/10.1007/s42452-025-07069-z

Eddy, N. O., Igwe, O., Eze, I. S., Garg, R., Akpomie, K., Timothy, C., Udeokpote, G., Ucheana, I., & Paktin, H. (2025). Environmental and public health risk management, remediation and rehabilitation options for impacts of radionuclide mining. *Discover Sustainability* 6(209). https://doi.org/10.1007/s43621-025-01047-6

El-Taher, A., Alharbi, A., & Al Zahrani, J. H. (2016). Environmental radioactivity measurements in Qassim, Saudi Arabia. *Radiation Physics and Chemistry*, *118*, 83–88. https://doi.org/10.1016/j.radphyschem.2015.09.007.

Farai, I. P., & Vincent, U. E. (2006). Outdoor radiation level measurement in Abeokuta, Nigeria. *Nigerian Journal of Physics*, *18*(1), 121–126.

Huyumbu, P., Zaman, M. B., Lababa, N. H. C., et al. (1995). Natural radioactivity in Zambian building materials. *Journal of Radioanalytical and Nuclear Chemistry*

Letters, 11, 299–306. https://doi.org/10.1007/BF02164809.

International Atomic Energy Agency. (2014). *Radiation protection and safety of radiation sources: International basic safety standards* (IAEA Safety Standards Series No. GSR Part 3). IAEA.

International Commission on Radiological Protection. (2007). *The 2007 recommendations of the International Commission on Radiological Protection* (ICRP Publication 103, Annals of the ICRP 37(2–4)). Elsevier.

Maria, S., Gael, P. H., Kreuzer, M., et al. (2010). Radon-related lung cancer risk among German uranium miners. *Health Physics, 98*(2), 274–283. https://doi.org/10.1097/HP.0b013e3181b49cad.

Mustapha, A. O., Patel, J. P., & Rathore, I. V. S. (1999). Assessment of human exposures to natural sources of radiation in Kenya. *Radiation Protection Dosimetry, 82*(4), 285–292. https://doi.org/10.1093/oxfordjournals.rpd.a032639.

National Council on Radiation Protection and Measurements. (1993). *Limitation of exposure to ionizing radiation* (NCRP Report No. 116). NCRP.

Norm, E. B. (2008). Review of occupational hazards and safety concerns for nuclear medicine technologists. *Journal of Nuclear Medicine Technology*, *36*(2), 11–17. https://doi.org/10.2967/jnmt.107.049346.

Okedeyi, O., & Akinlua, A. (2012). Assessment of radiological risk from selected granite rocks in Southwest Nigeria. *Journal of Radiation Protection and Environment, 35*, 181–187.

Okoye, P. C., & Avwiri, G. O. (2013). Evaluation of background ionizing radiation levels of Braithwaite Memorial Specialist Hospital, Port Harcourt. *American Journal of Science and Industrial Research, 4*(4), 359–365.

Okoye, P. C., Avwiri, G. O., & Chad-Umoren, Y. E. (2008). Environmental radioactivity distribution in River State University campus. *Journal of Applied Sciences and Environmental Management, 12*(4), 73–77. https://doi.org/10.4314/jasem.v12i4.55590

Ononugbo, C. P., & Efere, J. (2016). Evaluation of excess lifetime cancer risk from gamma dose rates of industrial sites around Bayelsa State, Nigeria. *World Academy Research Journal, 7*(2), 112–117.

Saleh, M. A., & Hussain, H. M. (2013). Gamma radiation dose measurements and health hazard parameters in Basrah, Iraq. *Journal of Radiation Research and Applied Sciences, 6*, 37–42. https://doi.org/10.1016/j.jrras.2013.02.004.

Taskin, H. M., Karavus, P., Ay, A., et al. (2009). Radionuclide concentrations in soil and lifetime cancer risk due to gamma radioactivity in Kirklareli, Turkey. *Journal of Environmental Radioactivity, 100*, 49–53. https://doi.org/10.1016/j.jenvrad.2008.10.012.

United Nations Scientific Committee on the Effects of Atomic Radiation. (2000). *Sources and effects of ionizing radiation: Report to the General Assembly, with scientific annexes* (Vol. I & II). United Nations.

United Nations Scientific Committee on the Effects of Atomic Radiation. (2008). *Sources and effects of ionizing radiation: 2008 report to the General Assembly, with scientific annexes* (Vol. II). United Nations.

United Nations Scientific Committee on the Effects of Atomic Radiation. (2010). *Sources and effects of ionizing radiation: 2010 report to the General Assembly, with scientific annexes*. United Nations.

World Health Organization. (2009). *Handbook on indoor radon: A public health perspective*. WHO.

Declaration

Competing interests

There are no known financial competing interests to disclose

Ethical Consideration

This study adhered to ethical standards by ensuring non-invasive environmental measurements, safeguarding human health, and avoiding harm to participants, staff, or the university community. Data collection and reporting were conducted with integrity, accuracy, and transparency, while results were presented objectively to inform policy, protect public safety, and promote environmental sustainability..

Funding:

There was no external financial sponsorship for this study

Availability of data and materials:

The data supporting the findings of this study can be obtained from the corresponding author upon request

Authors' Contributions

The entire work was carried out by the author.