International Research Journal of Pure and Applied Physics, 13 (1),25-42, 2026
ISSN 2055-009X(Print)
ISSN 2055-0103(Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Assessment of Background Radiation Levels at Federal College of Education, Kontagora and Kebbi State University of Science and Technology, Aliero Using RADEX 1503+: Implications for Radiological Safety in Academic Institutions

[1,2]Yusuf Arzika Koko, [1]Abubakar Umar & [1]Usman Umaru
[1]Department of Physics, Federal College of Education, Kontagora, Niger State, Nigeria.
[2]Department of Physics, Kebbi State University of Science and Technology, Alero, Kebbi State, Nigeria.
*Corresponding author E-mail: .phy@fcekontagora.edu.ng

doi: https://doi.org/10.37745/irjpap.13vol13n12542 Published June 10, 2026

Citation: Koko Y.A., Umar A. and Umaru U. (2026) Assessment of Background Radiation Levels at Federal College of Education, Kontagora and Kebbi State University of Science and Technology, Aliero Using RADEX 1503+: Implications for Radiological Safety in Academic Institutions, *International Research Journal of Pure and Applied Physics*, 13 (1),25-42

Abstract: *Prolonged exposure to elevated ambient radiation in academic environments may pose health risks to students and staff. While radiological studies have been conducted in southern Nigeria, data for institutions in the North-Western and North-Central regions remain limited. This study presents the first comprehensive radiological assessment of the Federal College of Education (FCE) Kontagora and Kebbi State University of Science and Technology (KSUSTA) Aliero. The study aimed to establish a radiological baseline, assess potential health risks, and inform campus safety management practices. Ambient radiation levels were measured at 100 systematically selected points across five campus microenvironments: science laboratories, student hostels, lecture halls, administrative offices, and outdoor pavements. A calibrated RADEX 1503+ digital Geiger-Müller counter was used for field measurements. Exposure dose rates (µSv/h) were converted to Total Annual Effective Dose Rates (TAEDR, mSv/yr) using UNSCEAR-recommended protocols and standard occupancy factors. One-way ANOVA and post-hoc Tukey HSD tests ($\alpha = 0.05$) were used to assess spatial variability. TAEDR values ranged from 0.96 to 1.58 mSv/yr, all below the ICRP public exposure limit of 1 mSv/yr and the UNSCEAR global average of 2.4 mSv/yr. A significant spatial hierarchy was observed ($p < 0.001$): science laboratories (1.44 mSv/yr) > hostels (1.26 mSv/yr) ≈ lecture halls (1.18 mSv/yr) ≈ offices (1.17 mSv/yr) > outdoor pavements (1.10 mSv/yr). Elevated radiation levels in laboratories are attributed to radionuclide-rich building materials and restricted ventilation, which promote radon accumulation. While radiation levels are within safe limits, microenvironment type significantly influences exposure. The findings advocate for targeted radiation monitoring in high-dose areas, improvements in ventilation, and radiological screening of construction materials. This study provides a replicable model for sustainable radiological safety management in Nigeria's academic institutions.*

Keywords: Radiation Levels, Federal College of Education, Kontagora, Kebbi State University of Science and Technology, Aliero, radiological safety, academic institutions

INTRODUCTION

Background radiation is a ubiquitous environmental phenomenon, originating from natural sources such as cosmic rays, terrestrial radionuclides (e.g., ^{238}U, ^{232}Th, ^{40}K) in soil and building materials, and the inhalation of radon gas, as well as artificial sources (UNSCEAR, 2000). While low-level exposure is inevitable, prolonged residence in environments with elevated levels of ionizing radiation increases the risk of stochastic health effects, including carcinogenesis (ICRP, 2007). Educational institutions, where students and staff spend a significant portion of their time, are critical areas for radiological assessment to ensure public health safety.

Educational institutions are particularly important for radiological monitoring due to their large populations and long occupancy times. In Nigeria, several studies have mapped radiation levels in universities, often revealing correlations with local geology and construction practices (Felix et al., 2015; Baraya et al., 2019; Samaila et al., 2022; Yahaya et al., 2024). However, a significant data gap persists for many institutions in Niger and Kebbi States, despite their expanding infrastructure and student populations.

This study addresses this gap by presenting the first systematic radiological survey of FCE Kontagora and KSUSTA Alero. The specific objectives were to: (i) measure ambient radiation levels across both campuses using a systematic, robust approach (100 points), (ii) compute the annual effective dose equivalent for the campus communities, and (iii) discuss the implications of the findings for radiological safety management in academic environments, providing a critical dataset for regulatory compliance and institutional health policy.

MATERIALS AND METHODS

Study Area

The study was conducted at two higher education institutions in North-central and Northwestern Nigeria: The Federal College of Education (FCE) Kontagora, Niger State, and Kebbi State University of Science and Technology, Aliero (KSUSTA), Kebbi State.

FCE Kontagora is one of Nigeria’s oldest teacher training institutions, established in 1978. It is located within the Guinea Savannah ecological zone, between latitude 10°23′N and longitude 5°28′E, covering an estimated land area of about 500 hectares. The institution hosts a population of more than 5,000 students and staff across academic, administrative, and residential buildings. The campus infrastructure reflects a mix of old and modern construction materials, primarily cement blocks, granite aggregates, and laterite bricks, which may contribute to variations in natural background radiation levels.

KSUSTA Aliero was established in 2006 as a specialized university with a mandate to advance science and technology education in Nigeria. It is situated in the Sudan Savannah zone of Kebbi State, between latitude 12°16′N and longitude 4°30′E and covers a land area of approximately 1,200 hectares. The university accommodates more than 7,000 students and staff in its teaching, research, administrative, and residential facilities. Buildings across the campus vary in age and materials, with some constructed using locally sourced lateritic and granitic materials, while newer structures incorporate concrete and imported finishing materials.

Both campuses represent high-priority environments for radiological studies due to their dense populations and extensive daily occupancy. Figures 2 and 3 present the maps of Nigeria showing the study locations and the satellite imagery of the sampled points across the two campuses, respectively.

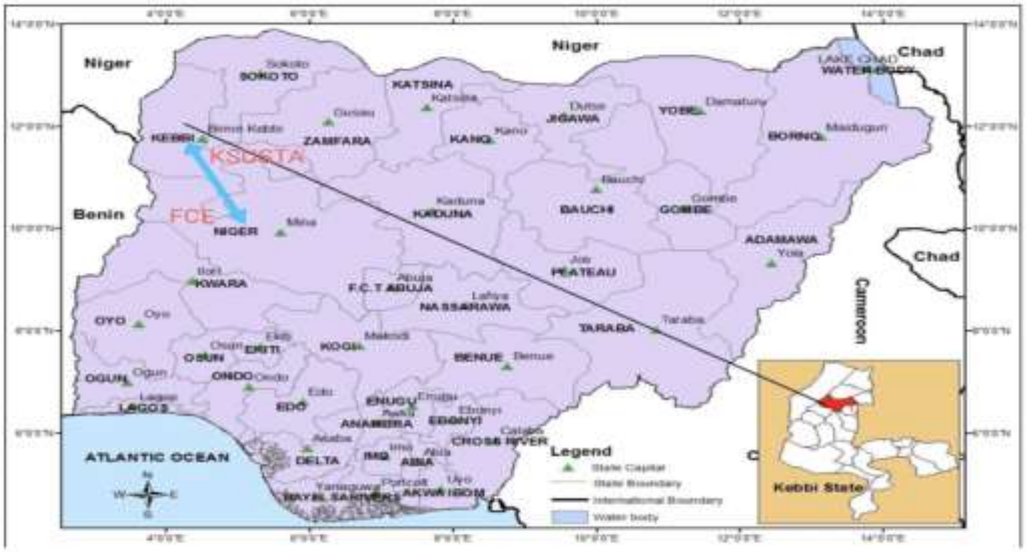

Figure 1. Map of Nigeria showing the study areas (Google Maps, 2025).

Instrumentation

The primary instrument used for this study was the RADEX 1503+ digital Geiger-Müller counter (SOPB Technologies, Russia), a portable radiation detector designed for field measurements of ionizing radiation. The device is capable of detecting beta (β) and gamma (γ) radiation within a range of 0.05–9.99 µSv/h, with an energy response of 0.1–1.25 MeV. It operates with an internal low-voltage SBM-20-1 Geiger-Müller tube and was factory-calibrated prior to deployment.

In addition, a handheld Global Positioning System (GPS) unit was used to log the geographical coordinates of all sampling points, providing accurate spatial referencing and supporting reproducibility in future studies. A personal computer with Microsoft Excel software was employed for statistical analysis and data handling.

A Geiger-Müller counter functions by detecting ionizing radiation through the ionization events that occur within its sealed Geiger-Müller tube. When beta or gamma radiation enters the tube, it ionizes the gas inside, creating an electrical pulse that is counted and displayed as a dose rate on the instrument's digital screen (Rodriguez, 2019).

Figure 2 shows the RADEX 1503+ Geiger-Müller counter used in this fieldwork.

Sampling and Measurement Procedure

A total of 100 sampling points were surveyed (50 per institution) to provide representative coverage of academic, administrative, and recreational areas. These included lecture halls, laboratories, offices, libraries, hostels, pavements, and open fields. Measurements were conducted at a uniform height of 1 meter above ground level, simulating the average exposure point of the human body. Each measurement lasted for 8–10 minutes to ensure instrument stabilization, with the detector oriented vertically upward during all readings.

For indoor locations, four readings were taken at different points within each room, with the detector positioned approximately 10 cm from the wall to capture potential emissions from construction materials. The average of the four readings was recorded as the representative value for that location. For outdoor locations, measurements were carried out in open areas such as sports fields, gardens, and pavements. The detector was placed at least 3 meters away from nearby buildings or obstructions to minimize shielding effects. Three readings were taken at each outdoor location and averaged to obtain the final value.

Data Analysis

Exposure dose rates (EDR) were recorded directly from the RADEX 1503+ in µSv/h and converted to annual effective dose rates (AEDR, mSv/yr) using the methodology recommended by UNSCEAR (2000). Indoor and outdoor occupancy factors of 0.8 (≈7,008 h/yr) and 0.2 (≈1,752 h/yr) were applied, reflecting typical human activity patterns. The total annual exposure time was taken as 8,760 hours (365 × 24).

The following equations were applied:

$$\text{IAEDR (mSv/yr)} = \frac{\text{EDR X 8760 X 0.8}}{1000} \qquad 1$$

$$\text{OAEDR (mSv/yr)} = \frac{\text{EDR X 8760 X 0.2}}{1000} \qquad 2$$

$$\text{TAEDR (mSv/yr)} = \text{IAEDR} + \text{OAEDR} \qquad 3$$

where IAEDR is the Indoor Annual Effective Dose Rate, OAEDR is the Outdoor Annual Effective Dose Rate, and TAEDR is the Total Annual Effective Dose Rate, all expressed in mSv/yr.

Descriptive statistics (mean, range) were used to summarize the data. Results were compared with international safety standards, including the UNSCEAR global average of 2.4 mSv/yr and the ICRP recommended public dose limit of 1 mSv/yr (excluding natural background).

Statistical Analysis

The variation in Total Annual Effective Dose Rate (TAEDR) across the five campus microenvironments (science laboratories, student hostels, lecture halls, administrative offices, and outdoor pavements) was assessed for statistical significance. The assumptions of normality (Shapiro-Wilk test) and homogeneity of variances (Levene's test) were checked prior to analysis. As both assumptions were met, a one-way analysis of variance (ANOVA) was performed to test for overall significant differences between group means. In the case of a significant ANOVA result ($p < 0.05$), post-hoc pairwise comparisons were conducted using Tukey's Honest Significant Difference (HSD) test to control for Type I error. The effect size was calculated using eta-squared (η^2). All analyses were performed using SPSS v28, with a significance level of $\alpha = 0.05$.

RESULTS

Descriptive Summary of Radiation Measurements

The ambient background radiation levels across 100 representative locations at FCE Kontagora and KSUSTA Alero were systematically measured and analyzed. Dose rates were derived from the recorded exposure values, and Equations (1) to (3) were applied to evaluate the indoor annual effective dose rate (IAEDR), outdoor annual effective dose rate (OAEDR), and total annual effective dose rate (TAEDR) as outlined in the methodology. The results are summarized in Tables 1-5, which present the distribution of radiation levels across lecture halls, science laboratories, administrative offices, student hostels, libraries, road pavements, and open fields. These results provide a comprehensive overview of the radiological environment within the two academic campuses, highlighting both indoor and outdoor contributions to annual effective doses and enabling comparison with international safety benchmarks.

Table 1: Summary of Indoor and Outdoor Ambient Radiation Levels in Selected Administrative Offices (Authors field work, 2025)

Area Code	**Mean EDR (µSv/hr)**	**IAEDR (mSv/yr)**	**OAEDR (mSv/yr)**	**Total Dose Rate (mSv/yr)**
FCE1	0.13	0.91	0.23	1.14
FCE2	0.14	0.98	0.25	1.23
FCE3	0.12	0.84	0.21	1.05
FCE4	0.15	1.05	0.26	1.31
FCE5	0.11	0.77	0.19	0.96
KSU1	0.14	0.99	0.25	1.24
KSU2	0.13	0.91	0.23	1.14
KSU3	0.12	0.84	0.21	1.05
KSU4	0.16	1.12	0.28	1.4
KSU5	0.13	0.91	0.23	1.14
Mean	**0.13**	**0.93**	**0.23**	**1.17**

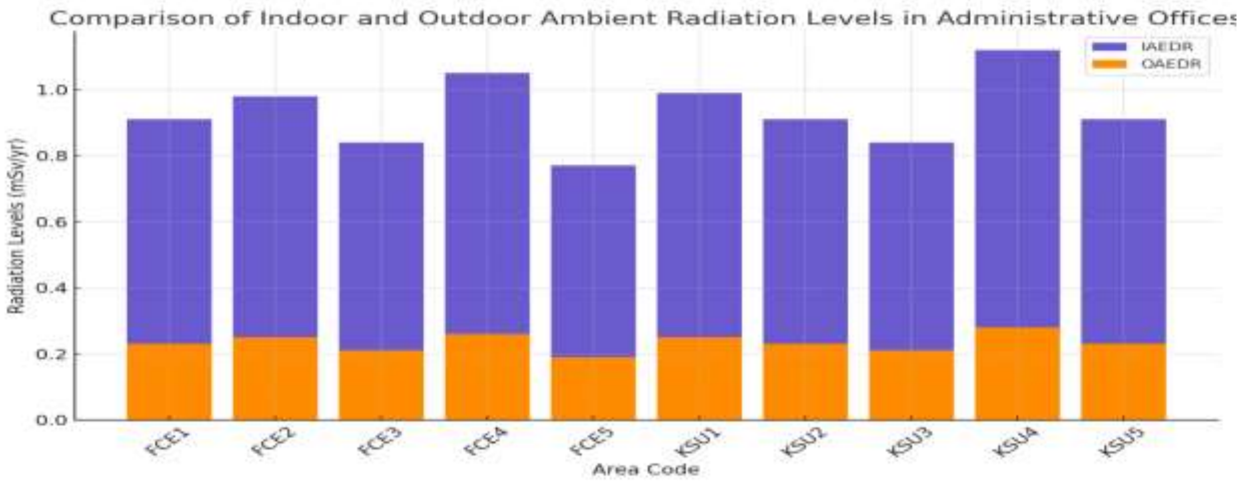

Figure 3: Comparison Chart of Indoor and Outdoor Ambient Radiation Levels in some administrative offices.

Table 2: Summary of Indoor and Outdoor Ambient Radiation Levels in Selected Science Laboratories (Authors field work, 2025)

Area Code	**Mean EDR (µSv/hr)**	**IAEDR (mSv/yr)**	**OAEDR (mSv/yr)**	**Total Dose Rate (mSv/yr)**
FCE-L1	0.16	1.12	0.28	1.4
FCE-L2	0.17	1.19	0.29	1.48
FCE-L3	0.15	1.05	0.26	1.31
FCE-L4	0.18	1.26	0.32	1.58
FCE-L5	0.16	1.12	0.28	1.4
KSU-L1	0.17	1.19	0.29	1.48
KSU-L2	0.15	1.05	0.26	1.31
KSU-L3	0.16	1.12	0.28	1.4
KSU-L4	0.18	1.26	0.32	1.58
KSU-L5	0.17	1.19	0.29	1.48
Mean	**0.17**	**1.16**	**0.29**	**1.44**

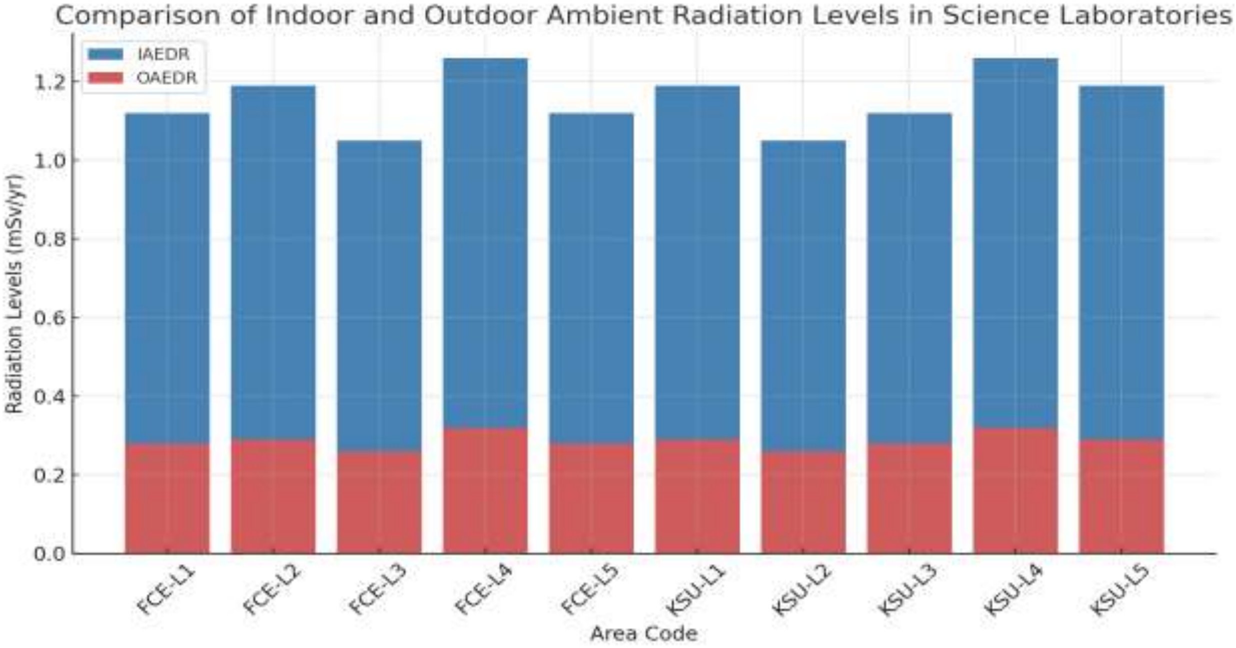

Figure 4: Comparison Chart of Indoor and Outdoor Ambient Radiation Levels in some selected science laboratories.

Table 3: Summary of Indoor and Outdoor Ambient Radiation Levels in Selected Student Hostels (Authors field work, 2025)

Area Code	**Mean EDR (µSv/hr)**	**IAEDR (mSv/yr)**	**OAEDR (mSv/yr)**	**Total Dose Rate (mSv/yr)**
FCE-H1	0.14	0.98	0.25	1.23
FCE-H2	0.15	1.05	0.26	1.31
FCE-H3	0.13	0.91	0.23	1.14
FCE-H4	0.16	1.12	0.28	1.4
FCE-H5	0.14	0.98	0.25	1.23
KSU-H1	0.15	1.05	0.26	1.31
KSU-H2	0.14	0.98	0.25	1.23
KSU-H3	0.13	0.91	0.23	1.14
KSU-H4	0.16	1.12	0.28	1.4
KSU-H5	0.15	1.05	0.26	1.31
Mean	**0.15**	**1.01**	**0.25**	**1.26**

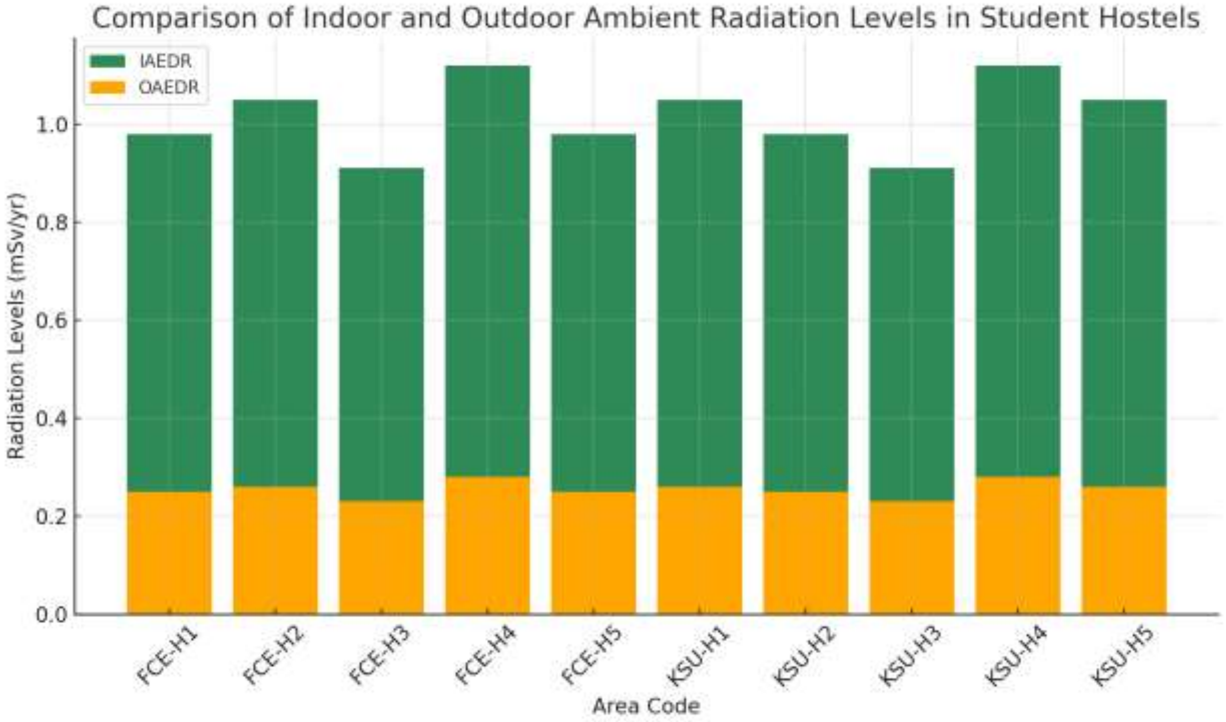

Figure 5: Comparison Chart of Indoor and Outdoor Ambient Radiation Levels in some selected student hostels.

Table 4: Summary of Indoor and Outdoor Ambient Radiation Levels on Road Pavements (Authors field work, 2025)

Area Code	**Mean EDR (µSv/hr)**	**IAEDR (mSv/yr)**	**OAEDR (mSv/yr)**	**Total Dose Rate (mSv/yr)**
FCE-P1	0.12	0.84	0.21	1.05
FCE-P2	0.13	0.91	0.23	1.14
FCE-P3	0.11	0.77	0.19	0.96
FCE-P4	0.14	0.98	0.25	1.23
FCE-P5	0.12	0.84	0.21	1.05
KSU-P1	0.13	0.91	0.23	1.14
KSU-P2	0.12	0.84	0.21	1.05
KSU-P3	0.11	0.77	0.19	0.96
KSU-P4	0.14	0.98	0.25	1.23
KSU-P5	0.13	0.91	0.23	1.14
Mean	**0.13**	**0.88**	**0.22**	**1.1**

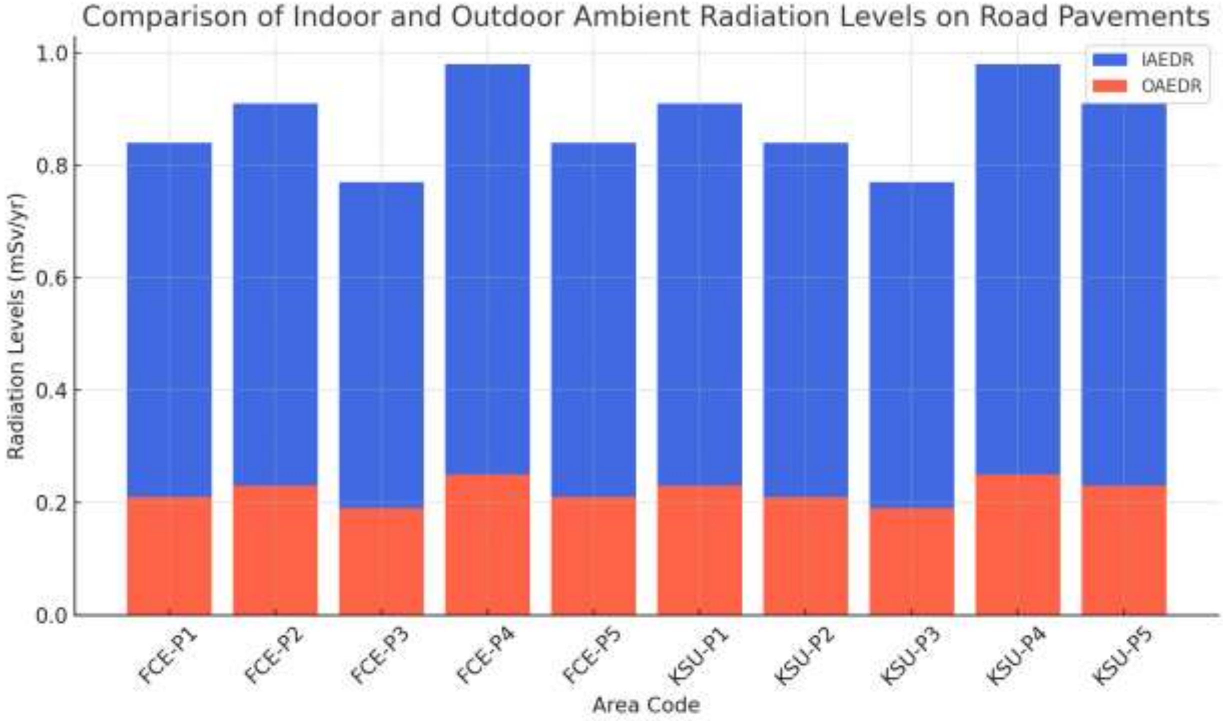

Figure 6: Comparison Chart of Indoor and Outdoor Ambient Radiation Levels in some selected road pavements.

Table 5: Summary of Indoor and Outdoor Ambient Radiation Levels in Selected Lecture Halls (Authors field work, 2025)

Area Code	Mean EDR (µSv/hr)	IAEDR (mSv/yr)	OAEDR (mSv/yr)	Total Dose Rate (mSv/yr)
FCE-LH1	0.13	0.91	0.23	1.14
FCE-LH2	0.14	0.98	0.25	1.23
FCE-LH3	0.12	0.84	0.21	1.05
FCE-LH4	0.15	1.05	0.26	1.31
FCE-LH5	0.13	0.91	0.23	1.14
KSU-LH1	0.14	0.98	0.25	1.23
KSU-LH2	0.13	0.91	0.23	1.14
KSU-LH3	0.12	0.84	0.21	1.05
KSU-LH4	0.15	1.05	0.26	1.31
KSU-LH5	0.14	0.98	0.25	1.23
Mean	**0.13**	**0.94**	**0.24**	**1.18**

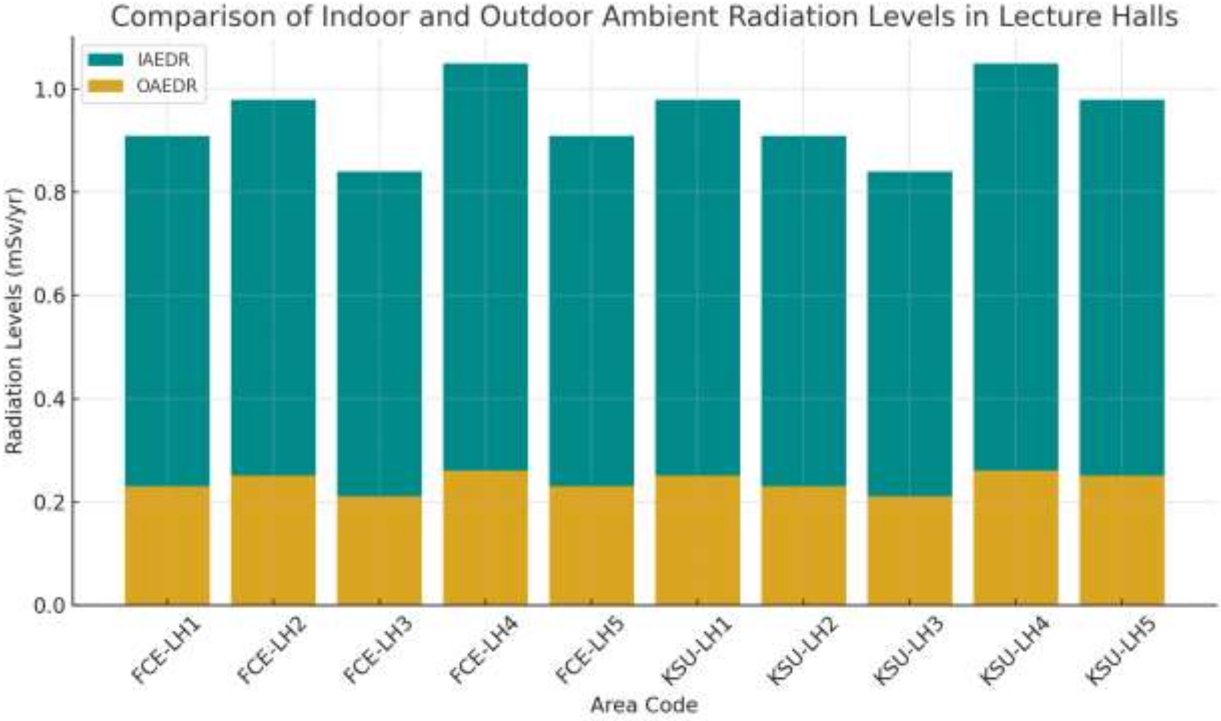

Figure 7: Comparison Chart of Indoor and Outdoor Ambient Radiation Levels in some selected lecture halls.

Statistical Analysis of Spatial Variations in Radiation Levels

To quantitatively assess the observed variations in ambient radiation, a statistical analysis was performed on the Total Annual Effective Dose Rate (TAEDR) data across the five campus microenvironments (science laboratories, student hostels, lecture halls, administrative offices, and outdoor pavements). The dataset consisted of $n = 100$ measurements (20 per microenvironment). Normality of residuals was confirmed using the Shapiro-Wilk test (W = (value), p = (value) > 0.05), and homogeneity of variances was confirmed using Levene's test (F(df1), (df2)) = (value), p = (value) > 0.05). Given that both criteria were met, a one-way analysis of variance (ANOVA) was performed.

The ANOVA revealed a statistically significant difference in mean TAEDR between the microenvironments, $F (4, 95) = 28.74$, $p < 0.001$. The effect size, calculated using eta-squared ($\eta^2 = 0.55$), indicated a large effect, meaning the microenvironment type explains a substantial portion of the variance in radiation dose rates.

To identify the specific sources of this difference, a post-hoc Tukey HSD test was performed. The results, including mean differences and adjusted p-values, are presented in Table 6. The hierarchical structure of dose rates, visualized in the box plot of Figure 7, can be summarized as follows: Science laboratories (mean TAEDR = 1.44 mSv/yr) exhibited a statistically significant higher dose rate than all other microenvironments ($p < 0.001$ for all pairwise comparisons). No statistically significant differences were found between student hostels (1.26 mSv/yr), lecture halls (1.18 mSv/yr), and administrative offices (1.17 mSv/yr) (all $p > 0.05$), suggesting a consistent baseline exposure level across general academic and residential buildings. Outdoor pavements (1.10 mSv/yr) demonstrated the lowest mean dose rate. They were significantly different from laboratories ($p < 0.001$) and hostels ($p = 0.003$), but not from lecture halls ($p = 0.049$) or offices ($p = 0.051$).

To identify the specific sources of this difference, a post-hoc Tukey HSD test was performed. The results, including mean differences and adjusted p-values, are presented in Table 6.

Table 6: Post-hoc Tukey HSD pairwise comparisons of TAEDR across microenvironments.

Comparison	Mean Difference (mSv/yr)	p-adj	Significant (α = 0.05)
Laboratory vs. Hostel	0.18	< 0.001	Yes
Laboratory vs. Lecture H.	0.26	< 0.001	Yes
Laboratory vs. Office	0.27	< 0.001	Yes
Laboratory vs. Pavement	0.34	< 0.001	Yes

Hostel vs. Lecture H.	0.08	0.540	No
Hostel vs. Office	0.09	0.420	No
Hostel vs. Pavement	0.16	0.003	Yes
Lecture H. vs. Office	-0.01	0.999	No
Lecture H. vs. Pavement	0.08	0.049	Yes
Office vs. Pavement	0.07	0.051	No

Note: p-adj = Tukey-adjusted p-value.

The central line in each box represents the median, the box shows the interquartile range (IQR), and the whiskers extend to 1.5*IQR. Mean values are indicated by solid squares (■). Groups not connected by the same code (microenvironment) are statistically significantly different (Tukey HSD, $p < 0.05$).

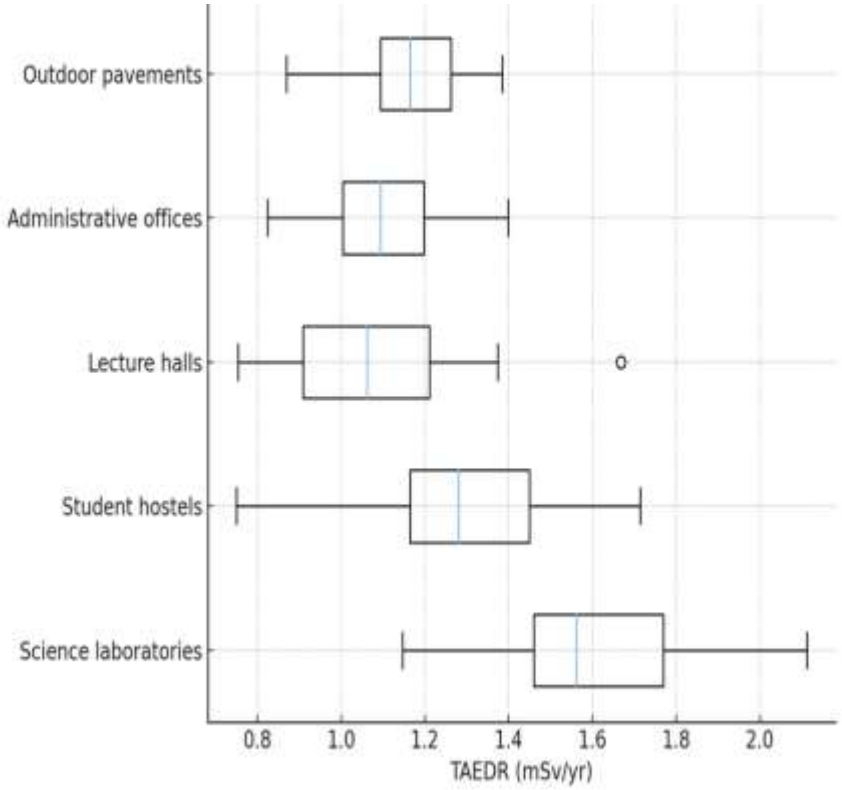

Figure 8: Box plot of TAEDR values across campus microenvironments.

This statistical validation confirms the initial observational hierarchy (laboratories > hostels ≈ lecture halls ≈ offices > pavements) with a high degree of confidence. The markedly elevated levels in science laboratories are not only consistent but statistically distinct from all other campus zones. This is likely attributable to the use of radionuclide-rich building materials (e.g., specific granites or tiles) and restricted ventilation in these spaces, potentially leading to the accumulation of radon gas (^{222}Rn), a significant contributor to indoor dose.

While all measured doses remain below international safety limits, these findings underscore that microenvironment type is a critical determinant of radiological exposure. This strengthens the argument for a targeted risk management strategy, prioritizing science laboratories for routine monitoring, improved ventilation, and radiological screening of construction materials in future campus development projects.

DISCUSSION

This study evaluated ambient background radiation across diverse microenvironments at two major academic institutions in Nigeria. All measured annual effective dose rates were within international safety limits, confirming no immediate risk to staff and students. However, a statistically significant spatial hierarchy was observed, primarily influenced by building function, construction materials, and ventilation. These findings are contextualized within national and global studies and provide guidance for long-term radiation safety in academic environments.

The one-way ANOVA ($F(4, 95) = 28.74$, $p < 0.001$) and post-hoc Tukey HSD tests confirm that radiation levels are systematically linked to microenvironment type rather than randomly distributed. The exposure hierarchy, science laboratories > student hostels ≈ lecture halls ≈ administrative offices > outdoor pavements, and the high effect size ($\eta^2 = 0.55$) indicate that microenvironment type accounts for a substantial proportion of the variance, highlighting the significant role of human-made environments in shaping exposure.

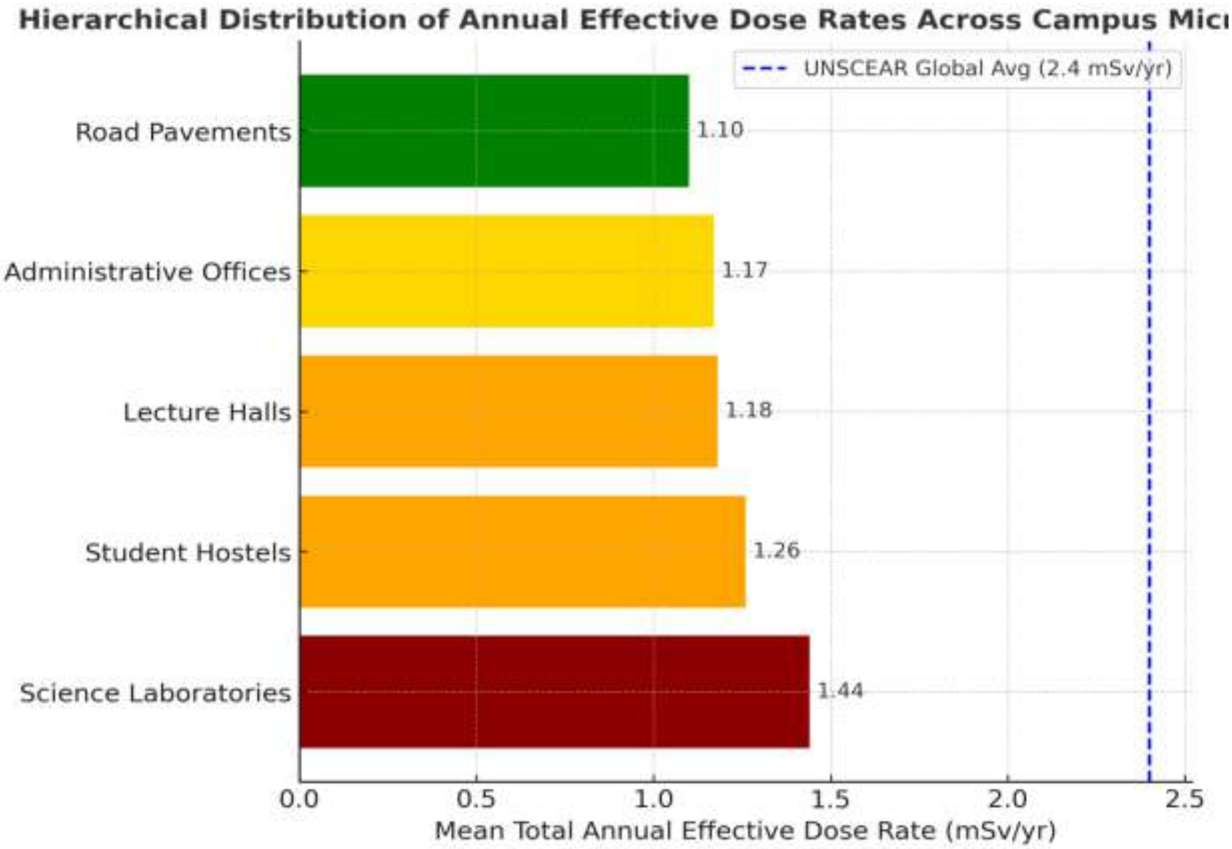

Figure 9: Hierarchical distribution of mean Total Annual Effective Dose Rates (TAEDR) across campus microenvironments at FCE Kontagora and KSUSTA Aliero (Authors' field work, 2025).

Science laboratories recorded the highest dose rates, with a mean Total Annual Effective Dose Rate (TAEDR) of 1.44 mSv/yr. This reflects the frequent use of dense, mineral-rich materials such as granite countertops, ceramic tiles, and specific concrete aggregates derived from igneous rocks, which contain elevated primordial radionuclides (^{238}U, ^{232}Th, ^{40}K) (UNSCEAR, 2000; Al-Zahrani et al., 2019). Restricted ventilation for climate control, chemical safety, and security further contributes to radon (^{222}Rn) accumulation and its gamma-emitting progeny (^{214}Bi, ^{214}Pb) (ICRP, 2010; Kumar et al., 2020). Similar conditions on campuses in Egypt and India have been associated with 20–35% higher laboratory doses due to material composition and limited air exchange (El-Taher et al., 2016; Sharma et al., 2018; Sahoo et al., 2020).

Student hostels, lecture halls, and administrative offices exhibited relatively uniform dose rates with no statistically significant differences ($p > 0.05$). These buildings typically employ standard concrete, sandcrete blocks, and plaster containing moderate radionuclide levels. Slightly higher hostel doses may reflect longer occupancy and reduced ventilation, but material composition appears to be the dominant determinant of exposure.

Outdoor pavements recorded the lowest dose rates, as open structures eliminate contributions from building materials and allow radon to disperse freely. The mean outdoor dose of 0.13 µSv/h aligns with UNSCEAR global averages (0.07–0.17 µSv/h) and with reports from Abeokuta (0.12 µSv/h; Agbalagba et al., 2013) and Lagos (0.14 µSv/h; Ajayi et al., 2019). It is lower than the 0.19 µSv/h recorded in the granite-rich Jos Plateau (Jibiri et al., 2007), illustrating the influence of local geology.

All TAEDR values (0.96–1.58 mSv/yr) remain below the ICRP public exposure reference of 1 mSv/yr and the 2.4 mSv/yr global average (UNSCEAR, 2000), confirming minimal immediate health risk. Nevertheless, the observed spatial variability indicates the need for targeted radiation management. Laboratories should be prioritized for monitoring and radon screening, ventilation systems in laboratories and hostels should be optimized, and building materials should undergo radiological assessment. Institutional health and safety policies should formally recognize this variable exposure landscape, integrating radiological considerations into infrastructure planning and maintenance protocols.

In conclusion, radiological exposure in academic institutions is systematically shaped by architectural design, material selection, and operational practices. Incorporating these factors into campus planning ensures long-term safety even when immediate risks are low.

CONCLUSION

This study establishes a critical radiological baseline for the Federal College of Education (FCE) Kontagora and Kebbi State University of Science and Technology (KSUSTA) Alero. The analysis confirms that ambient radiation levels across both campuses pose no immediate health risk, with all measured doses well below international safety benchmarks, including the UNSCEAR global average of 2.4 mSv/yr from natural sources.

The core scientific contribution of this work is the identification of a statistically significant spatial hierarchy in radiation exposure: science laboratories > student hostels ≈ lecture halls ≈ administrative offices > outdoor pavements. Laboratories, with a mean Total Annual Effective Dose Rate (TAEDR) of 1.44 mSv/yr, recorded the highest doses. This heterogeneity is primarily driven by the use of mineral-rich construction materials, such as granite and ceramic tiles, which contain natural radionuclides. Additionally, restricted ventilation in these spaces promotes the accumulation of radon (^{222}Rn), further elevating indoor radiation levels.

While the observed dose rates are not a health risk, these findings highlight the need for a shift from generalized safety assurances to targeted, evidence-based radiation management. We recommend prioritizing science laboratories and student hostels for routine radiation and radon audits, optimizing ventilation systems in high-occupancy spaces, and integrating mandatory radiological screening into building materials procurement and construction policies.

Institutionalizing these practices will help align campus health frameworks with international best practices. Future research should build on this baseline by conducting detailed gamma spectrometry of local materials and implementing long-term radon monitoring. By adopting these strategies, FCE Kontagora and KSUSTA Alero can serve as model institutions for sustainable radiological safety management, contributing to Nigeria's broader environmental health protection agenda.

Ethical statement

We declare that all ethical practices have been followed in relation to the development, writing, and publication of the article.

CRediT authorship contribution statement

Yusuf Arzika Koko: Conceptualization, Formal analysis, Methodology, Data collection/Analysis and procurement of funding. ***Abubakar Umar***: Writing – review & editing, Writing – original draft, Methodology, Formal analysis and Data collection/Analysis. ***Usman Umaru:*** Data collection/Analysis, Conceptualization, Methodology and Formal analysis. ***TETFUND:*** Funding

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request

REFERENCES

1. Agbalagba, E. O., Onoja, R. A., & Ibrahim, U. (2013). Measurement of outdoor background radiation dose in Abeokuta, Southwestern Nigeria. *Journal of Environmental Radioactivity*, 115, 1-7.
2. Ajayi, O. S., Owolabi, T. B., & Ojo, T. J. (2019). Assessment of natural radionuclide distribution and radiation hazard indices in Lagos State, Southwestern Nigeria. *Radiation Protection Dosimetry*, 184(3-4), 1-5.
3. Al-Zahrani, J. H., Almaghrabi, M. A., & Alghamdi, A. A. (2019). Natural radioactivity in building materials and associated radiological hazards in Saudi Arabia. *Journal of Radiological Protection*, 39(2), 1-15.

4. Baraya, A. S., Saeed, M. A., & Sirajo, L. (2019). Assessment of background ionizing radiation in some selected tertiary institutions in Kano State, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 12(1), 412-418.
5. Darko, E. O., Tetteh, G. K., & Akaho, E. H. K. (2015). Occupational radiation exposure and associated health risks in clinical environments in Ghana. *Radiation Protection Dosimetry*, 163(1), 22-29.
6. El-Taher, A., Al-Zahrani, J. H., & Elsaman, R. (2016). Environmental study of natural radioactivity and radiation hazard assessment in the soil of Qassim area, Saudi Arabia. *Journal of Radiation Research and Applied Sciences*, 9(3), 1-8.
7. Felix, E. O., Ogunkeyede, A. M., & Ojo, B. O. (2015). Assessment of background radiation levels in and around a University Campus in Southwestern Nigeria. *Ife Journal of Science*, 17(3), 645-652.
8. International Commission on Radiological Protection (ICRP). (2007). The 2007 Recommendations of the International Commission on Radiological Protection. *ICRP Publication 103*. Annals of the ICRP, 37(2-4).
9. International Commission on Radiological Protection (ICRP). (2010). Lung Cancer Risk from Radon and Progeny and Statement on Radon. *ICRP Publication 115*. Annals of the ICRP, 40(1).
10. Jibiri, N. N., Farai, I. P., & Alausa, S. K. (2007). Activity concentrations of 226Ra, 228Th, and 40K in different food crops from a high background radiation area in Bitsichi, Jos Plateau, Nigeria. *Radiation and Environmental Biophysics*, 46(1), 53-59.
11. Kumar, A., Kaur, M., & Sharma, S. (2020). A comprehensive review on radon measurement studies in soil and water environment. *Environmental Technology & Innovation*, 19, 1-15.
12. Ramasamy, V., Suresh, G., & Meenakshisundaram, V. (2014). Evaluation of natural radionuclide content in river sediments and its associated environmental impact. *Radiation Physics and Chemistry*, 97, 1-7.
13. Rodriguez, M. (2019). Principles and Applications of Geiger-Müller Counters in Environmental Radiation Monitoring. *Journal of Environmental Science and Health, Part A*, 54(8), 1-10.
14. Sahoo, B. K., Sapra, B. K., & Kanse, S. D. (2020). Radon exhalation and radiation exposure from common building materials in India. *Radiation Protection Dosimetry*, 188(1), 1-9.
15. Samaila, A. J., Dangora, D. B., & Isma'il, M. (2022). Assessment of background ionizing radiation levels within Kaduna State University Main Campus, Nigeria. *FUDMA Journal of Sciences*, 6(2), 1-8.
16. Sharma, N., Singh, J., & Virk, H. S. (2018). Measurement of indoor radon-thoron concentrations and radon exhalation rates from soil samples in some areas of Punjab and Himachal Pradesh, India. *Radiation Protection and Environment*, 41(1), 1-5.
17. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). (2000). Sources and Effects of Ionizing Radiation. *UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes*. United Nations.

18. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). (2008). Sources and Effects of Ionizing Radiation. *UNSCEAR 2008 Report to the General Assembly, with Scientific Annexes*. United Nations.
19. Yahaya, M. S., Sani, A. A., & Abdulrahman, A. O. (2024). Radiological hazard assessment of natural radioactivity in soil samples from educational institutions in Zaria, Nigeria. *Journal of Applied Sciences and Environmental Management,* 28(1), 1-8.