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Measurement of Background Ionizing Radiation at Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria

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ABSTRACT

Background ionizing radiation (BIR) is a significant contributor to human radiation exposure, with levels influenced by geological, environmental, and anthropogenic factors. Continuous assessment of BIR in learning environments is essential for safeguarding public health, as students and staff spend considerable time indoors, particularly in hostels, classrooms, and offices. Against this backdrop, an in-situ measurement of background ionizing radiation was carried out in twelve (12) sections of Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University (ABU), Zaria, Kaduna State, Nigeria. The study assessed indoor and outdoor background ionizing radiation (BIR) levels using a calibrated portable handheld gamma survey meter. The indoor BIR ranged from 0.119 to 0.186 µSv/hr, with an average value of 0.155 ± 0.06 µSv/hr and outdoor BIR ranged from 0.114 to 0.204 µSv/hr, with an average value of 0.144 ± 0.04 µSv/hr. Both indoor and outdoor average values exceeded the global indoor and outdoor averages of 0.013 µSv/hr and 0.015 µSv/hr, respectively (ICRP, 2007). The total annual effective dose for indoor measurements was 0.739 mSv/yr, and for outdoor measurements given as 0.190 mSv/yr, which were all below the maximum permissible limit of 1 mSv/yr (UNSCEAR, 2000). The average ELCR for indoor and outdoor measurement was 0.002 and 0.0038 respectively. These values were lower than the world recommended threshold of 0.29×10^{-3} (UNSCEAR, 2000). Although the observed radiation levels were generally within global safety limits, slightly elevated ELCR values in residential zones indicate a potential long-term health concern. These findings provide baseline data for radiological monitoring and contribute to environmental health risk assessments in academic institutions.

Keywords:
Background ionizing radiation,
Annual effective dose,
Excess lifetime cancer risk,
Samaru,
Environmental radiation,
Nigeria.

INTRODUCTION

Background ionizing radiation (BIR) is a natural and ever-present phenomenon in the environment, originating from cosmic rays, terrestrial radionuclides, and anthropogenic activities. It contributes significantly to the total radiation dose received by individuals and can pose long-term health risks if levels exceed international safety standards (Rafique et al., 2014). It is essential to consider the specific factors that may influence background radiation levels. These factors could include the geographical location, building materials used in construction, proximity to sources of terrestrial radiation from naturally occurring terrestrial radiation, ^{238}U, ^{232}Th, and ^{40}K radionuclides with half-lives similar to Earth's age contribute the most to natural radiation (Isa et al., 2024), as well as any unique environmental characteristics that might impact radiation levels such as soil composition and mineral deposits, atmospheric conditions affecting cosmic radiation levels, nearby industrial activities emitting radioactive materials, and the presence of naturally occurring radon gas in the vicinity (Taskin et al., 2009). Additionally, the presence of certain equipment or materials within office spaces, laboratories, and hostel such as electronic devices or radioactive substances could also contribute to elevate background radiation levels (James et al., 2015).

During working hours, employees and students in the school environment are exposed to background radiation for extended periods of time (Mubarak et al., 2017). Even while background radiation is usually thought to be at low levels, prolonged exposure can nevertheless have negative health effects, such as a higher chance of cancer

(Kurnaz, 2023). Thus, Monitoring BIR levels is essential for assessing environmental safety, especially in Division of Agricultural College in Zaria (DAC) with high human activity.

This study aims to measure and assess the background ionizing radiation levels at the Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria. The data obtained will help in evaluating radiological risks and ensuring a safe environment for staff, students, and visitors.

MATERIALS AND METHODS

Study Area Description

The study was conducted at Samaru College of Agriculture, Division of Agricultural Colleges, located in Zaria, Kaduna State, Nigeria. Positioned at latitude 11.1650° N and longitude 7.6355° E, it is the second oldest College of Agriculture in Nigeria and plays a significant role in agricultural research and education.

Materials

Handheld Radiation Detector, survey map, notebook and pen, personal protective equipment (PPE).

Methods

Permission to carry out the study was obtained from the relevant authorities within the College. The study area was divided into systematically selected segments, each representing distinct functional zones—classrooms, laboratories, offices, hostel areas, and open outdoor environments. Measurements were conducted using a handheld radiation monitor capable of detecting ambient background ionizing radiation levels in (µSv/h**)**. The detector was operated at a consistent height of one (1) meter above the ground level in accordance with in-situ radiological survey standards, to minimize influence from ground radiation or nearby objects (Ugbede et al., 2018).

A total of twelve (12) distinct locations were selected for measurement, with each location spaced approximately 2 meters apart to ensure comprehensive spatial coverage. At each sampling point, three (3) measurements were recorded at ten (10) minute intervals, and the average value was taken as the final reading to account for fluctuations in environmental radiation. The exact coordinates of each location were logged using a GPS device for accuracy and reproducibility.

Measurements were taken between 13:00 and 16:00 hours, as recommended by the National Council on Radiation Protection and Measurements (NCRP, 1993). This time window was selected to optimize detector sensitivity and reduce atmospheric variability. Both indoor and outdoor readings were recorded at each site.

Data from all sampled locations were entered into a spreadsheet and processed to estimate the Annual Effective Dose Equivalent (AEDE) and Excess Lifetime Cancer Risk (ELCR) for individuals exposed to background radiation within the study area.

Radiological Risk Assessment

Annual Effective Dose Equivalent (AEDE)

$$\text{AEDE (mSv/y)} = DR \times T \times OF \times 10^{-3} \quad (1)$$

Where: DR = Dose rate in µSv/hr, T = Time (8760 hrs/year), OF = Occupancy Factor (0.2 for outdoors; 0.8 for indoors), 10^{-3} = conversion factor from µSv to mSv (Ramli et al., 2014)

Excess Lifetime Cancer Risk (ELCR)

$$ELCR = AEDE \times DL \times RF \quad (2)$$

Where: DL = Duration of Life (70 years), RF = Risk Factor (0.05 Sv^{-1}) (ICRP, 2007)

RESULTS AND DISCUSSION

Background Ionizing Radiation Levels (BIR)

The measured indoor and outdoor background ionizing radiation (BIR) dose rates at twelve (12) different locations within Samaru College of Agriculture are presented in Table 1. The readings are expressed in micro-Sieverts per hour (µSv/h) and represent the mean of three independent measurements at each site.

Table 1: Indoor and Outdoor Background Radiation Dose In µsv/Hr

S/N	Location	BIR (µSv/hr) Indoor	BIR (µSv/hr) Outdoor
1	SLT Lab	0.167 ± 0.01	0.140 ± 0.02
2	HRE Classrooms	0.143 ± 0.12	0.114 ± 0.05
3	Library	0.147 ± 0.01	0.156 ± 0.03
4	PRM Section	0.180 ± 0.12	0.137 ± 0.07
5	PMT Section	0.182 ± 0.11	0.142 ± 0.01
6	Agric Tech S.	0.148 ± 0.01	0.131 ± 0.06
7	Agric Engineering S.	0.119 ± 0.05	0.129 ± 0.05
8	LIVESTOCK SECTION	0.145 ± 0.06	0.126 ± 0.05
9	SCA Admin Block	0.119 ± 0.10	0.172 ± 0.05
10	Boys Hostel	0.186 ± 0.14	0.204 ± 0.01
11	DOWN HOSTEL	0.185 ± 0.07	0.115 ± 0.07
12	QUARTER II STAFF QTRS	0.142 ± 0.02	0.165 ± 0.02

S/N Location	BIR (µSv/hr) Indoor	BIR (µSv/hr) Outdoor
Mean	**0.155 ± 0.06**	**0.144 ± 0.04**
Range	**0.119 – 0.18**	**0.114 – 0.20**
Minimum	**0.119 ± 0.05**	**0.114 ± 0.05**
Maximum	**0.186 ± 0.14**	**0.204 ± 0.01**
World Average BIR value	**0.057 (ICRP, 1999)**	**0.075 (ICRP, 1999)**

From table 1, the indoor BIR ranged from 0.119 µSv/h (Admin Block and Agric Engineering Section) to 0.186 µSv/h (Boys Hostel), while outdoor BIR ranged from 0.114 µSv/h (HRE Classrooms) to 0.204 µSv/h (Boys Hostel). The Boys Hostel exhibited the highest dose rates for both indoor and outdoor environments, indicating a potential accumulation of radioactive materials or less effective shielding from cosmic and terrestrial radiation. Conversely, relatively lower dose rates were observed at the Admin Block, Agric Engineering Section, and Down Hostel, possibly due to building materials with lower natural radioactivity or better architectural shielding.

Comparison with Global Safety Standards

According to UNSCEAR (2000), the global average outdoor BIR level is approximately 0.057 µSv/h, and the indoor level is typically 0.075 µSv/h. The measured values in this study are significantly higher than the global averages, with some locations exceeding them by more than 100%. However, they remain within the permissible safety limit of 0.416 µSv/h recommended by the International Commission on Radiological Protection (ICRP, 2007) for public exposure.

Annual Effective Dose Rate (AEDR) and Excess Lifetime Cancer Risk (ELCR)

The computed Annual Effective Dose Rate (AEDR) and Excess Lifetime Cancer Risk (ELCR) for indoor and outdoor exposure at all sampling locations are presented in Table 2. The AEDR values were derived using dose conversion and occupancy factors based on UNSCEAR (2000) recommendations.

Table 2: Indoor and Outdoor AEDR (mSv/yr) and ELCR at Sampled Locations

S/N	Sample Location	AEDR(mSv/yr) Indoor	AEDR(mSv/yr) Outdoor	Total AEDR (mSv/yr)	ELCR
1	SLT Lab	0.815	0.172	0.987	0.0027
2	HRE Section	0.703	0.416	0.843	0.0023
3	Library	0.717	0.191	0.908	0.0024
4	PRM Section	0.881	0.168	1.049	0.0028
5	PMT Section	0.089	0.142	0.234	0.0063
6	AgricTech Section	0.721	0.161	0.882	0.0024
7	Agric Eng. Section	0.058	0.158	0.216	0.0059
8	Livestock Section	0.710	0.155	0.865	0.0037
9	SCA admin Block	0.875	0.211	1.087	0.0029
10	Boys Hostel	0.912	0.204	1.116	0.0030
11	Down Hostel	0.908	0.141	1.049	0.0088
12	Staff Qtrs. II	0.697	0.166	0.863	0.0027
Mean		**0.739**	**0.190**	**0.777**	**0.0038**
Maximum		**0.912**	**0.416**	**1.116**	**0.0088**
Minimum		**0.058**	**0.141**	**0.216**	**0.0023**
Recommended limit		**0.460**	**0.460**	**1.000**	**0.2900**

The total AEDR across the sampling locations ranged from 0.216 mSv/yr (Agric Engineering Section) to 1.116 mSv/yr (Boys Hostel). Notably, four locations (Boys Hostel, PRM Section, Down Hostel, and SCA Admin Block) recorded total AEDR values above the public exposure limit of 1.0 mSv/yr recommended by the International Commission on Radiological Protection (ICRP, 2007). This suggests the potential need for radiation risk mitigation in those specific locations.

Excess Lifetime Cancer Risk (ELCR) Evaluation

ELCR estimates the probability of developing cancer over a lifetime due to prolonged radiation exposure (Agbalagba et al., 2017). The values ranged from 0.0023 to 0.0088 across the study area. The Down Hostel recorded the highest ELCR value (0.0088), suggesting an elevated potential for long-term radiological health effects. This is likely attributable to the combination of high indoor dose and prolonged indoor occupancy (typically 80%, as assumed in UNSCEAR models). Similarly, the Agric Engineering Section and PMT Section showed lower total AEDR values but notably high ELCR, possibly due to unaccounted exposure contribution. Despite most values being within the acceptable ELCR threshold of 0.29×10^{-3} recommended by UNSCEAR (2000), the elevated readings in some locations indicate a potential long-term cancer risk that should not be ignored, especially in a learning environment.

CONCLUSION

This study revealed spatial variations in background ionizing radiation across the Samaru College of Agriculture, with residential and administrative buildings exceeding ICRP's recommended exposure limits. The elevated levels are likely attributable to construction materials, radon accumulation, poor ventilation, and geogenic contributions. These findings indicate localized radiological health risks, underscoring the need for continuous radiation surveillance, radon monitoring and mitigation, stricter regulation of construction materials, and awareness programs to promote safe practices among students and staff.

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