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Dosimetric Evaluation of Terrestrial Gamma Radiation and Associated Cancer Risk in Federal University Dutsin-Ma, Nigeria

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ABSTRACT

This study evaluates natural radioactivity on FUDMA campuses to ensure radiological safety. Since natural radionuclides are always present in the environment, exposure to terrestrial gamma radiation is unavoidable. The research aimed to measure terrestrial gamma radiation dose rates (TGDR), calculate the annual effective dose (AED), and assess the excess lifetime cancer risk (ELCR). A digital radiation meter was used for measurements, while Microsoft Excel was used for data analysis.At the take-off campus, The highest AED was recorded at the school clinic (TOC-A5) with a value of 2.76 mSv/y, while the lowest was at the school gate (TOC-A1) at 1.02 mSv/y. The average AED across the campus was 1.75 mSv/y. At the main campus, the highest AED was 2.64 mSv/y at the school clinic (MC-A4), and the lowest was 1.14 mSv/y at the Senate Building (MC-A2), with an average of 1.64 mSv/y. These values exceed the ICRP (2007) recommended limit of 1 mSv/y for the general public, indicating potential health risks.For ELCR, the take-off campus recorded the highest value at the school clinic (TOC-A5) with 8.68, while the lowest was at the school gate (TOC-A1) with 3.21, averaging 5.49. At the main campus, the highest ELCR was 8.30 at the school clinic (MC-A4), and the lowest was 3.59 at the Senate Building (MC-A2), with an average of 4.99. These results suggest an increased radiological risk compared to standard safety limits.

Keywords:
AED,
ELCR,
FUDMA,
TGRD.

INTRODUCTION

Radionuclides are present naturally in the earth's crust (Pöschl and Nollet, 2007). They are found on the earth's surface, in the soil, the atmosphere, water, building materials, and in plant and animal tissue (UNSCEAR, 2000). All living organisms including human beings are exposed to different radioactive sources that is subject to the surroundings thereof (Ochiai, 2014; Jaishankar, *et al.*, 2014). Due to natural evolution, all living organisms have adapted to certain amounts of radioactivity without suffering any harmful effects (Kovalchuk *et al.*, 2001). A major concern arises when certain human activities such as testing of nuclear weapons, mineral exploration, and agriculture significantly enhance exposures of humans and the environment to alarming levels of radioactivity (Ahmed and El-Arabi 2005). Terrestrial gamma radiation dose is a measure of the level ofionizing radiationpresent in the environment at a particular location which is not due to deliberate introduction of radiation sources. Terrestrial gamma radiation originates from both natural and artificial sources, (IAEA, 2007). Radiation in the environment originates from a number ofnaturally occurring and human made sources while exposurefrom it can occur via ingestion, inhalation, injection, orabsorption of radioactive materials (Abba, 2022). The effects of terrestrial gamma radiation dose on human health depend on the level of exposure. Prolonged exposure to elevated levels of ionizing radiation can have health effects, including: increased cancer risk, genetic damage, acute radiation sickness and cataracts. Terrestrial gamma radiation dose can affect plant growth and cause genetic mutations, population dynamics, radiosensitivity, bioaccumulation and behavioural changes. The aim of this work is to measure and statistically analyse excess life cancer risk due to terrestrial gamma radiation doses (TGRD) and compute the resultant effective doses in the Federal University Dutsin-Ma campuses, Katsina state, Nigeria. In addition, it will be of great importance to assess the safety levels by comparing the obtained

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results with the permissible limits set by (WHO,2003), (USEPA, 2011), (ICRP, 2007) and (UNSCEAR, 2000) ensuring compliance with international safety standards.We live in an environment where we are being exposed to certain amounts of ambient radiation every day, this ambient radiation may be from natural sources (e.g. radon gas, soil, granite rocks) or artificial sources (e.g. x-ray machines, building materials, radioactive wastes from reactors, etc.) in the environment and the level of radiation varies from one place to another (Tikyaa *et al*., 2017; Ewansiha et al. 2024; Farai and Vincent, 2006). Aliyu et al. (2023) analyzed uranium and thorium contamination in baobab leaves consumedin Katsina State, Nigeria, and found that the activity concentrations were within safe limits.Radon gas from the earth crust is the most abundant source of natural radiation in the environment. The radioactive disintegration of uranium-238 produces 222Rn which in turn decays with a half-life of 3.82 days (Tikyaa *et al*., 2017; Masok *et al.*, 2015). As it is inhaled, it penetrates into the lungs and the continuous deposition and penetration of such high energy particles through the lungs leads totissue damage and mutation which leads to incidence of lung cancer (Tikyaa *et al*., 2017; Chad-Umoren *et al.*, 2007). Other natural radiation sources include radionuclides in the soil, cosmic radiation due to ionization of gases in the atmosphere and natural radioactivity due to radionuclides in the body (Tikyaa *et al*., 2017; Osiga, 2014 and James *et al.*, 2015). The materials used in constructing buildings are also major sources of indoor radiation exposure to humans while in the soil, natural radioactivity is mainly due to 238U, 40K, 226Ra which causes external and internal radiological hazard from consumption of crops grown on such (UNSCEAR, 2021). Generally, ionizing radiation when absorbed at higher doses poses health challenges to humans, leading to certain ailments like cancers, tumors, organ and tissue damage, sterility/infertility, genetic mutation, etc. (Jwanbot *et al.*, 2014).It is crucial to have a comprehensive database of the level of terrestrial gamma radiation dose, AED and ELCR to weigh their long-term implications in the two campuses of the University. This investigation e provides essential radiological information. Understanding terrestrial gamma radiation dose levels of the campuses helps in setting safety standards for protecting the university community from excessive exposure. Monitoring radiation levels helps in assessing health risks and develop strategies to protect against radiation exposure. Also, the statistical analyses in this research enhanced and rigor the reliability of the investigation. The statistical parameters provided a concise summary of the dataset and the obtained results has given a quick overview of the range and central tendency of the results. It is also of interest to the University authorities to ensure that both the students and staff operate in areas that are radiologically safe.The research was unable to cover the entire Dutsin-ma town or Katsina state.The research was limited to analysis of the TGRD, AED and ELCR. The research was only limited to one (1) statistical software which are Microsoft excel.

MATERIALS AND METHODS

Study Area

Dutsin-Ma is a Local Government Area in Katsina State, North-Western Nigeria. It lies on latitude 12°26'N and longitude 07°29'E. It is bounded by Kurfi and Charanchi LGAs to the north, Kankia LGA to the East, Safana and Dan-Musa LGAs to the West, and Matazu LGA to the Southeast (Abaje *et al.*, 2014).The Federal University Dutsin-Ma was established on 7th February, 2011 with the take-off site located in Dustin-Ma town while the main campus was later located at Kilometer-Sixty Katsina-Kankara road in Dutsin-Ma Local Government Area of Katsina State (FUDMA, 2015). Tables1 and 2 show the key to the coding of the sampled points in this work while plates 1 and 2 show the satellite view in FUDMA take-off and FUDMA main campus respectively.

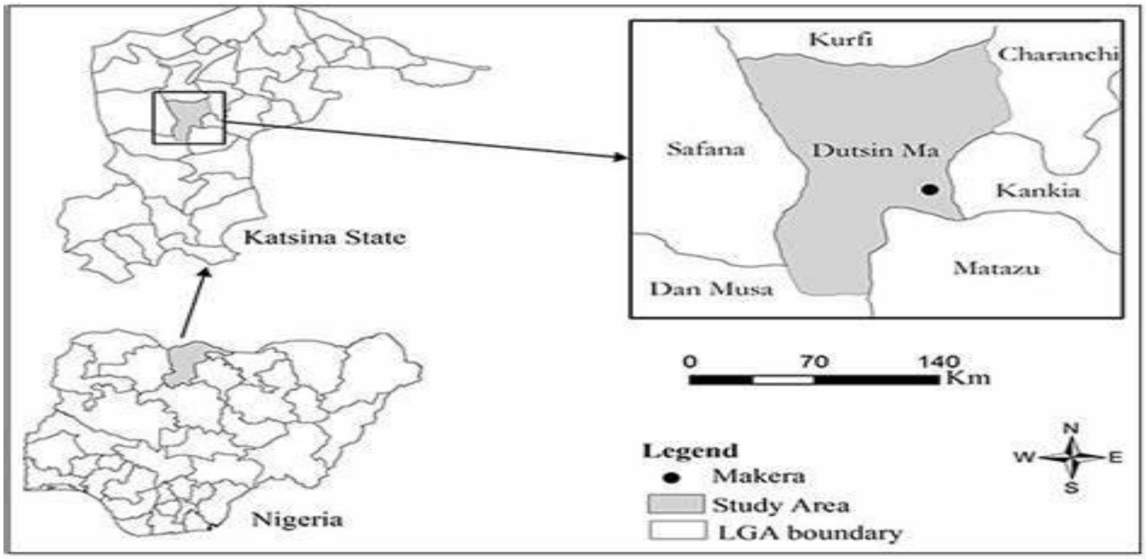

Figure 1: Geographical of Map of Nigeria, indicating Katsina state and Dutin-Ma (Oyebamiji *et al*., 2019)

Plate 1: Satellite View of Federal University Dutsin-Ma take-off Campus (Google maps, 2017; modified)

Plate 2: Satellite View of Federal University Dutsin-Ma main Campus (Google maps, 2024; modified)

Method of measuring terrestrial gamma radiation dose

The indoor and outdoor ambient terrestrial gamma radiation dose levels at the Federal University Dutsin-Ma take-off and main campuses were measured using a nuclear radiation meter (alert Inspector). 20 locations from each campus were identified where students and staff spend most of their times. For each location, six readings were taken, three indoors and three outdoors. Also, the geographical coordinates of each location monitored were taken with the use of geographical positioning system (GPS).

Prior to the measurements, the radiation meter was calibrated and checked to ensure that it was functioning correctly. The measurement probe wasplaced at the designated location for a specified time during which the data logger recorded the readings obtained.

From the readings obtained, the annual effective dose (AED), which is the summation of Indoor annual effective dose rate (IAEDR) and Outdoor annual effective dose rate (OAEDR), was calculated as follows (Abba, 2022)

Annual Effective Dose Equivalent

$$Indoor\ (IAEDR): X(mSv/yr) = Y(\mu Sv/hr)\ X\ 8760\ (hr/yr)\ X\ 0.8\ X\ 0.001 \quad (1)$$

$$Outdoor\ (OAEDR): X(mSv/yr) = Z\ (\mu Sv/hr)\ X\ 8760\ (hr/yr)\ X\ 0.2\ X\ 0.001 \quad (2)$$

$$AED = IAEDR + OAIDR \quad (3)$$

Ineqn. (1) and eqn. (2), above, we converted the indoor and outdoor equivalent doses from micro – Sievert per hour (μSv/h) to milliSievert per year (mSv/y). The annual effective dose equivalent (AED) to the population due to the TGDR was calculated by summing up the IAEDR and OAEDR to the population obtained using eqn. 1 and eqn. 2 above.

Excess Life Cancer Risk (ELCR) due to TGRD

The resultant excess life cancer risk due to annual effective dose received estimates the probability of cancer incidence in a population of individuals for a specific lifetime. This was calculated using eqn. (4).(Bello, 2019; Abba, 2022; ICRP, 2007).

$$ELCR = AED \times LE \times RF \quad (4)$$

where LEis the life expectancy and RF the risk factor. In this work, we used the LE value of 55.12 reported by UNPD, 2021 and RF value of 0.057 reported by ICRP, 2007.

RESULTS AND DISCUSSION

Results of Terrestrial Gamma Radiation Dose

Table 1: Take-off campus Area Code, Area locations and geographical coordinates

S-No	Area Code	Area Location	Geographical Coordinates	
			Latitude	Longitude
1.	TOC-A1	School Gate	N12^{0}28’20.2”	E007°29’14.0”
2.	TOC-A2	Central Mosque	N12°28'23.2”	E007°29'15.2"
3.	TOC-A3	Senate Building	N12°28'20.9"	E007°29'09.6"
4.	TOC-A4	School Library	N12°28'18.3"	E007°29'09.1"
5.	TOC-A5	School Clinic	N12°28'14.8"	E007°29'11.2"
6.	TOC-A6	New ICT complex	N12°28'20.6"	E007°29'06.9"
7.	TOC-A7	New Physics Lab	N12°28'24.5"	E007°29'10.2"
8.	TOC-A8	New Chemistry Lab	N12°28'24.7"	E007°29'10.9"
9.	TOC-A9	New Biology Lab	N12°28'24.7"	E007°29'10.5"
10.	TOC-A10	Biochemistry Lab	N12°28'22.9"	E007°29'13.1"
11.	TOC-A11	Microbiology	N12°28'24.3"	E007°29'14.5"
12.	TOC-A12	CBT Lab	N12°28'24.6"	E007°29'07.4"
13.	TOC-A13	Students’ Centre	N12°28'16.8"	E007°29'05.3"
14.	TOC-A14	Staff School	N12°28'16.2"	E007°29'06.1"
15.	TOC-A15	Auditorium	N12°28'19.6"	E007°29'12.4"
16.	TOC-A16	Biological Garden	N12°28'25.5"	E007°29'09.7"
17.	TOC-A17	Language Lab	N12°28'21.5"	E007°29'15.7"
18.	TOC-A18	Girl’s Hostel	N12°28'12.4"	E007°29'03.5"
19.	TOC-A19	Soil and Water Lab	N12°28'20.9",	E007°29'11.9"
20.	TOC-A20	GIS laboratory	N12°28'21.8"	E007°29'12.8"

In Table 1 above, we present the Area Codes (unique identifiers), area locations (specific facilities or landmarks), and their corresponding Geographical coordinates (latitude and longitude). The table serves to pinpoint the exact geographical positions of locations on the campus where radiation measurements were conducted. These coordinates are vital for replicating the study, assessing potential environmental or geographical factors influencing radiation levels and integrating radiation data into Geographic information systems (GIS) for spatial analysis. Unique identifiers for each site, labeled as TOC-A1 to TOC-A20, "TOC" stands for Take-off Campus, "A" represents the campus area or location group and numbers indicate specific locations within the campus.

Table 2: Main campus Area Code, Area locations and geographical coordinates

S-No	Area Code	Area Location	Geographical Coordinates	
			Latitude	Longitude
1.	MC-A1	School Gate	N12°17'43.1"	E7°27'.42.0"
2.	MC-A2	Senate Building	N12°17'43.3"	E7°27'32.2"
3.	MC-A3	ICT Centre	N12°17'40.2"	E7°27'29.4"
4.	MC-A4	School Clinic	N12°17'38.7"	E7°27'18.8"
5.	MC-A5	University Main Library	N12°17'44.8"	E7°27'25.6"
6.	MC-A6	Faculty of Physical Sciences	N12°17'40.9"	E7°27'26.4"
7.	MC-A7	Faculty of Life Sciences	N12°17'43.7"	E7°27'25.9"
8.	MC-A8	Faculty of Agricultural Sciences	N12°17'37.5"	E7°27'25.7"
9.	MC-A9	Faculty of Management Sciences	N12°17'43.3"	E7°27'20.5"
10.	MC-A10	Faculty of Nursing Sciences	N12°17'59.8"	E7°27'17.1"
11.	MC-A11	Faculty of Health Science	N12°18'01.6"	E7°27'08.3"
12.	MC-A12	Faculty of Engineering Sciences	N12°17'54.2"	E7°27'25.2"
13.	MC-A13	Faculty of Law	N12°17'41.3"	E7°27'20.4"
14.	MC-A14	Entrepreneurship Centre	N12°17'41.0"	E7°27'20.8"
15.	MC-A15	Security Unit	N12°17'56.5"	E7°27'43.3"

16.	MC-A16	Professorial Building	N12°17'40.2"	E7°27'10.9"
17.	MC-A17	Skill G Building	N12°17'44.7"	E7°27'28.2"
18.	MC-A18	Female Hostel	N12°17'40.3"	E7°27'02.0"
19.	MC-A19	Female Hostel new block	N12°17'42.9"	E7°27'06.1"
20.	MC-A20	Male Hostel	N12°17'51.4"	E7°26'55.7"

Table 2 above provides a comprehensive mapping of 20 identified locations within the main campus, with their corresponding geographical coordinates. These include area codes, area locations, and their precise latitude and longitude values. This table complements the Take-off Campus table (Table1) by providing geospatial data for key locations on the main campus.

Table 3: Descriptive statistical analysis of Take-off and Main campuses result of Indoor and outdoor terrestrial gamma radiation dose.

Area Code	Area Name	INDOOR Average & S. D (µSv/h)	OUTDOOR Average & S. D (µSv/h)	Area Code	Area Name	INDOOR Average & S. D (µSv/h)	OUTDOOR Average & S. D (µSv/h)
TOC-A1	School Gate	0.113±0.01	0.13±0.01	MC-A1	Gate	0.173±0.01	0.147±0.01
TOC-A2	Central Mosque	0.12±0.01	0.147±0.01	MC-A2	Senate Building	0.133±0.03	0.117±0.01
TOC-A3	Senate Building	0.227±0.1	0.143±0.02	MC-A3	ICT Centre	0.15±0.03	0.127±0.01
TOC-A4	School Library	0.233±0.14	0.153±0.04	MC-A4	School Clinic	0.34±0.07	0.157±0.02
TOC-A5	School Clinic	0.35±0.07	0.16±0.04	MC-A5	University Main Library	0.21±0.01	0.177±0.04
TOC-A6	New ICT complex	0.23±0.13	0.147±0.02	MC-A6	Faculty of Physical Sci	0.157±0.02	0.117±0.01
TOC-A7	New Physics Lab	0.13±0.01	0.133±0.01	MC-A7	Faculty of Life Sciences	0.243±0.03	0.14±0.03
TOC-A8	New Chem Lab	0.14±0.02	0.157±0.01	MC-A8	Faculty of Agriculture	0.187±0.01	0.147±0.01
TOC-A9	New Biology Lab	0.183±0.08	0.157±0.02	MC-A9	Faculty of Management	0.17±0.02	0.177±0.01
TOC-A10	Biochemistry Lab	0.237±0.04	0.123±0.02	MC-A10	Faculty of Nursing	0.18±0.05	0.16±0.02
TOC-A11	Microbiology	0.29±0.02	0.137±0.03	MC-A11	Faculty of Health Sc	0.163±0.02	0.15±0.02
TOC-A12	CBT Lab	0.243±0.02	0.23±0.01	MC-A12	Faculty of Engineering	0.143±0.01	0.17±0.02
TOC-A13	Students' Centre	0.29±0.02	0.253±0.03	MC-A13	Faculty of Law	0.173±0.01	0.123±0.01
TOC-A14	Staff School	0.257±0.01	0.137±0.02	MC-A14	Entrepreneurship Centre	0.193±0.02	0.19±0.03
TOC-A15	Auditorium	0.34±0.06	0.143±0.04	MC-A15	Security Unit	0.21±0.01	0.173±0.04
TOC-A16	Biological Garden	0.143±0.01	0.133±0.01	MC-A16	Professorial Building	0.16±0.02	0.12±0.01
TOC-A17	Language Lab	0.157±0.02	0.13±0.01	MC-A17	Skill G Building	0.237±0.01	0.19±0.02
TOC-A18	Girl's Hostel	0.227±0.01	0.22±0.06	MC-A18	Female Hostel	0.237±0.03	0.127±0.01
TOC-A19	Soil & Water Lab	0.113±0.01	0.147±0.01	MC-A19	Female Hostel new block	0.27±0.04	0.123±0.02
TOC-A20	GIS laboratory	0.12±0.08	0.34±0.09	MC-A20	Male Hostel	0.203±0.01	0.143±0.02
	MINIMUM	0.113	0.123		**MINIMUM**	0.133	0.117
	MAXIMUM	0.35	0.34		**MAXIMUM**	0.34	0.19
	RANGE	0.24	0.217		**RANGE**	0.204	0.073
	AVERAGE	0.211	0.174		**AVERAGE**	0.200	0.146
	S. D	0.076	0.0541		**S. D**	0.049	0.024
	VARIANCE	0.007	0.004		**VARIANCE**	0.004	0.001
	SKEWNESS	0.0146	0.813		**SKEWNESS**	-0.170	-1.495
	KURTOSIS	-0.88	4.967		**KURTOSIS**	2.13	-1.183
	PEARSON	-0.01			**PEARSON**	0.18	
	STD ERROR	0.0784			**STD ERROR**	0.0498	

Table 3 above compares indoor and outdoor terrestrial gamma radiation dose levels across the Take-off campus (TOC) and main campus (MC). The table presents measurements of indoor and outdoor terrestrial gamma radiation dose at specific locations within two university campuses. The data includes: Average radiation levels (in micro-sieverts per hour, µSv/hr), Standard deviation (S.D.) representing the variability in measurements for each location. Additionally, the statistical summaries are provided for each campus, including: minimum, maximum, range, average, variance, standard deviation, skewness, kurtosis, Pearson correlation, and standard error. The Area Name describes the specific facilities or regions where radiation measurements were taken. These include: educational facilities (e.g., school library, students' centre, language lab), administrative or public areas (e.g., gate, senate building, ICT centre), Research and health-related facilities (e.g., Biochemistry lab, New Physics Lab, Clinic), Residential buildings (e.g., Girl's Hostel, Male Hostel). We observed that the Take-off Campus average indoor level was 0.257 µSv/hr, while the outdoor average was 0.154 µSv/hr. The Indoor radiation levels are consistently higher than outdoor levels. The Skewness (0.014) is near-symmetrical distribution, suggesting balanced values. The Kurtosis has a value of -0.88 showing a flatter distribution with fewer extreme values. The Main campus indoor average was 0.203 µSv/hr while the Outdoor average was 0.148 µSv/hr. The Indoor radiation levels are slightly higher than outdoor levels. The Skewness which was obtained as -0.71 shows negative skewness indicating a concentration of higher indoor values. The Kurtosis (2.13) shows a slightly peaked distribution.Terrestrial gamma radiation levels are influenced by several environmental factors. Soil composition plays a key role since soils rich in uranium-238, thorium-232, and potassium-40 naturally emit more radiation, with variations depending on the local geology. Cosmic radiation also contributes, especially at higher altitudes where the thinner atmosphere offers less protection from high-energy cosmic rays. Additionally, building materials like granite, bricks, and concrete can contain natural radionuclides, increasing indoor radiation exposure. The combination of these factors determines the overall radiation levels in a given area.

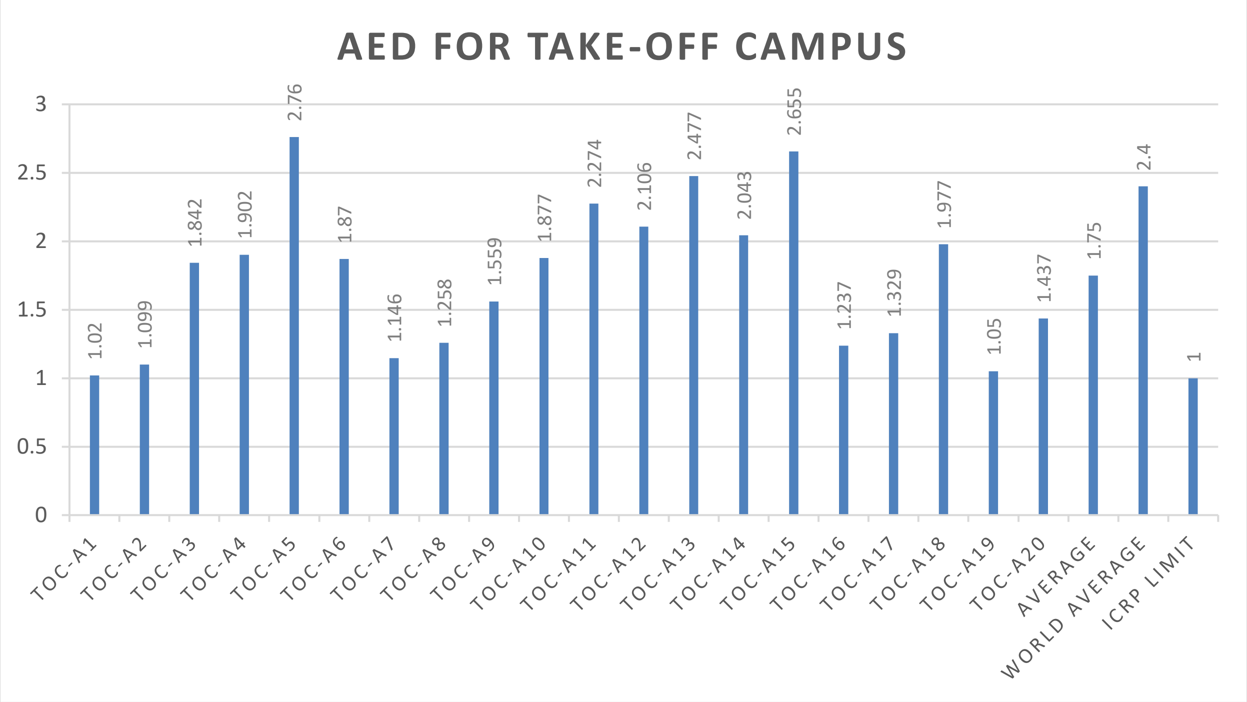

Figure 2: Chart of annual effective dose due to terrestrial gamma radiation in take-off campus

The chart in Figure 2, shows the annual effective dose (AED) from terrestrial gamma radiation at various locations in the take-off campus, labeled TOC-A1 to TOC-A20. Values range from 1.02 to 2.76 mSv/year, with TOC-A5 having the highest dose. The average dose (1.75 mSv/year) falls below the world average (2.4 mSv/year) but exceeds the ICRP recommended limit of 1.0 mSv/year. The data highlights localized variations in gamma radiation, emphasizing the need for regular monitoring to ensure safety.

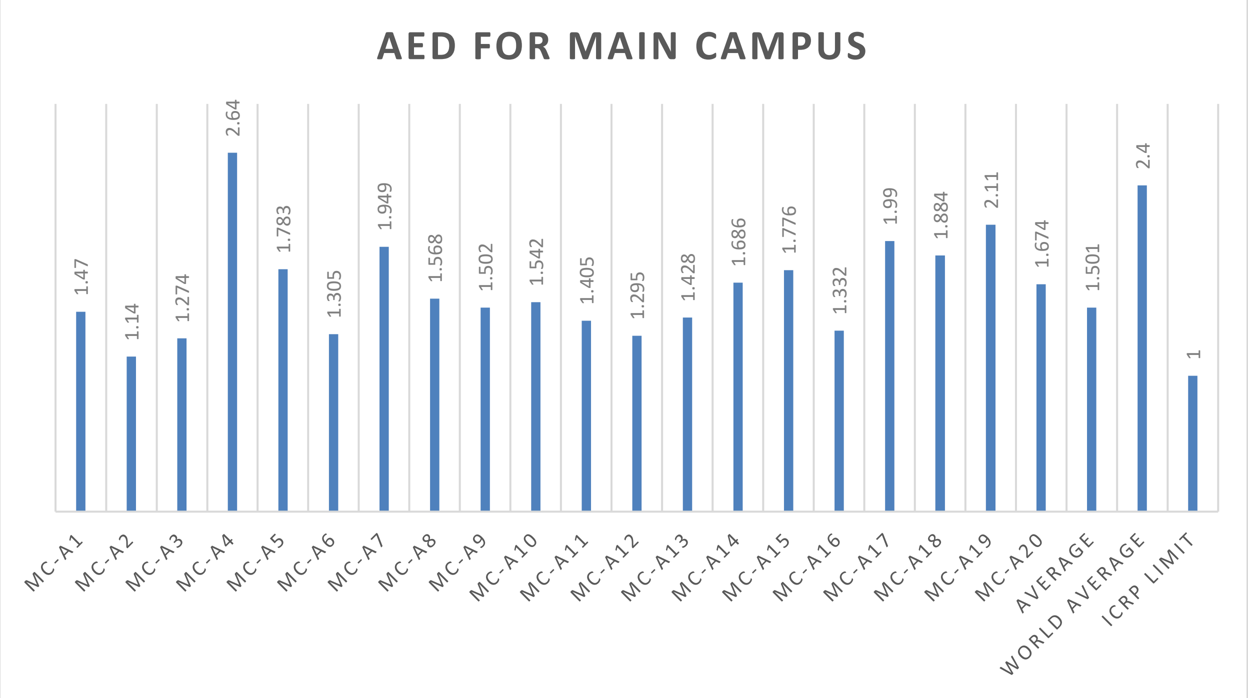

Figure 3: Chart of annual effective dose due to terrestrial gamma radiation in main campus

Figure 3 above, illustrates the annual effective dose (AED) from terrestrial gamma radiation across locations in the main campus, labeled MC-A1 to MC-A20. The values range from 1.14 to 2.64 mSv/year, with MC-A4 recording the highest dose. The average dose (1.67 mSv/y) falls below the world average (2.4 mSv/year) but exceeds the ICRP recommended limit of 1.0 mSv/year. These findings highlight moderate radiation levels, with localized variations across the sites. Continuous monitoring is essential to maintain radiation safety.Reducing exposure to terrestrial gamma radiation requires a mix of practical strategies. Using shielding materials like low-radon concrete, lead-lined walls, and radiation-resistant coatings can help minimize indoor radiation levels. Raising awareness through educational programs ensures people understand the risks and make informed choices about building materials and safe practices. Regular radiation monitoring helps detect any rising levels early, allowing for timely action to protect public health. Combining these efforts can significantly reduce long-term exposure and associated health risks.

Table 4: AED and ELC for both Take-off and Main Campus

Area Code	AED (TOC) (mSv/y)	ELCR (TOC)	Area code	AED (MC) (mSv/y)	ELCR (MC)
TOC-A1	1.02	3.21	MC-A1	1.47	4.62
TOC-A2	1.09	3.46	MC-A2	1.14	3.59
TOC-A3	1.84	5.79	MC-A3	1.27	4.01
TOC-A4	1.90	5.98	MC-A4	2.64	8.3
TOC-A5	2.76	8.68	MC-A5	1.78	5.61
TOC-A6	1.87	5.88	MC-A6	1.31	4.11
TOC-A7	1.14	3.61	MC-A7	1.95	6.13
TOC-A8	1.25	3.96	MC-A8	1.57	4.93
TOC-A9	1.55	4.9	MC-A9	1.50	4.72
TOC-A10	1.87	5.9	MC-A10	1.54	4.85
TOC-A11	2.27	7.15	MC-A11	1.41	4.42

TOC-A12	2.10	6.62	MC-A12	1.29	4.07
TOC-A13	2.47	7.79	MC-A13	1.42	4.49
TOC-A14	2.04	6.42	MC-A14	1.68	5.3
TOC-A15	2.65	8.35	MC-A15	1.77	5.58
TOC-A16	1.23	3.89	MC-A16	1.33	4.19
TOC-A17	1.32	4.18	MC-A17	1.99	6.26
TOC-A18	1.97	6.22	MC-A18	1.88	5.92
TOC-A19	1.05	3.3	MC-A19	2.11	6.63
TOC-A20	1.43	4.52	MC-A20	1.67	5.26
MINIMUM	1.02	3.21	**MINIMUM**	1.14	3.59
MAXIMUM	2.76	8.68	**MAXIMUM**	2.64	8.3
RANGE	1.73	5.47	**RANGE**	1.50	4.72
AVERAGE	1.75	5.49	**AVERAGE**	1.64	5.15
WORLD AVERAGE	2.40	2.80	**WORLD AVERAGE**	2.40	2.80

Table 5: Correlationbetween Take-off and Main Campus AED

	AED TOC (mSv/y)	*AED MC (mSv/y)*
AED TOC (mSv/y)	1	
AED MC (mSv/y)	0.325070332	1

Table 6: Correlationbetween Take-off and Main Campus ELCR

	ELCR (MC)	*ELCR (TOC)*
ELCR (MC)	1	
ELCR (TOC)	0.347731885	1

The correlation between AED TOC and AED MC in Table 6 is 0.3251, which means there's a weak positive relationship. In simple terms, when AED increases at one campus, there's a slight tendency for it to increase at the other but not always. This suggests that while both locations might share some common environmental influences, like natural background radiation, local factors play a bigger role in determining the actual dose levels.

Similarly, the correlation between ELCR TOC and ELCR MC in Table 6 is 0.3477, which is also a weak positive correlation. Since ELCR is calculated from AED, it makes sense that the two would have a somewhat similar pattern. But again, the relationship isn't strong, meaning other factors like variations in water consumption, shielding effects, or local geological differences could be affecting cancer risk estimates at each campus independently. So overall, while there's a bit of a connection between radiation exposure and risk levels at TOC and MC, they're mostly shaped by their own unique environmental conditions.

The statistical analysis reveals a weak positive correlation between the Annual Effective Dose (AED) and Excess Lifetime Cancer Risk (ELCR) at the Take-off Campus (TOC) and Main Campus (MC). The correlation coefficients (0.3251 for AED and 0.3477 for ELCR) suggest a weak positive relationship, indicating that while radiation exposure levels and associated cancer risks at both campuses share some similarities, they are largely influenced by independent environmental factors.

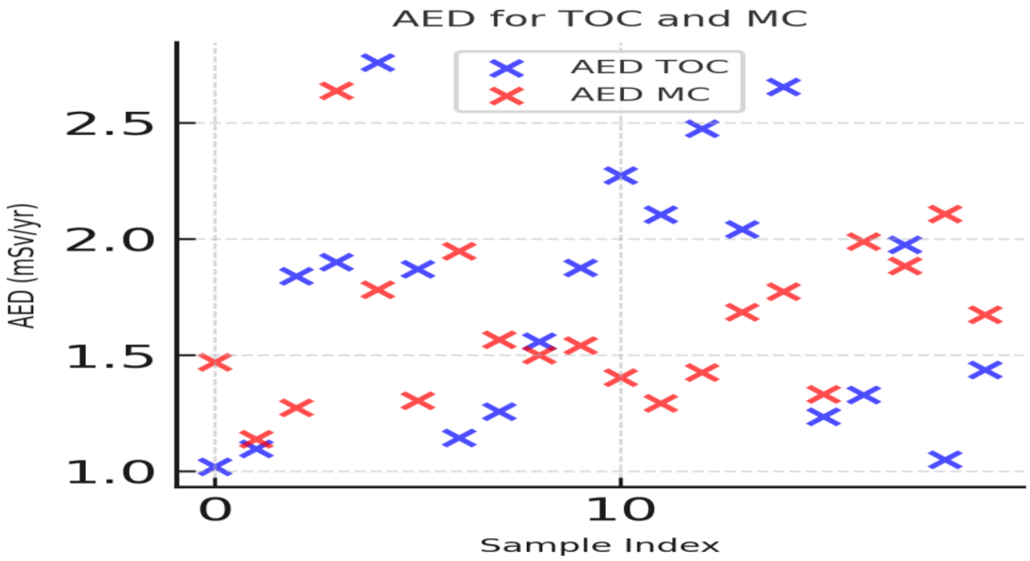

Figure 4: Scatted plots correlation for annual effective dose (AES) in take-off and main campus

The scatter plot comparing AED for TOC and MC shows a weak positive correlation, suggesting slight similarities in radiation exposure at both campuses. However, variations indicate local environmental differences. The spread of points confirms that AED levels are not strongly dependent on each other, requiring site-specific radiological assessments.

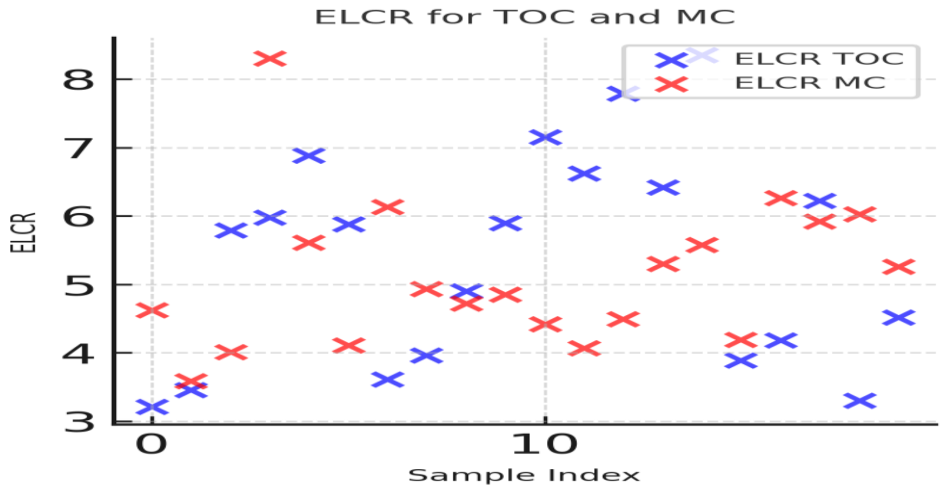

Figure 5: Scatted plots correlation for excess lifetime cancer risk (ELCR) in take-off and main campus

The ELCR scatter plot reveals a weak correlation between TOC and MC, meaning lifetime cancer risk estimates slightly relate but vary independently. Differences in local exposure conditions likely influence ELCR values. This suggests that risk assessments should be conducted separately for each campus, considering unique environmental and radiological factors.

CONCLUSION

This work investigates the radiological nature of Federal University Dutsin-Ma take-off and Main campuses. Digital Radiation Meter was used to measure terrestrial gamma radiation and corresponding annual effective dose was numerically computed along with excess life cancer risk (ELCR). Annual effective dose (AED) which is the total annual effective dose combining both indoor and outdoor exposures,highest AED was the school clinic (TOC-A5) with a value of 2.76 mSv/y, due to higher indoor and outdoor dose rates compared to other locations.Lowest AED was the school gate (TOC-A1) with 1.02 mSv/y, attributed to lower dose rates indoors and outdoors.Average AED of take-off campus was 1.75 mSv/y, which provides a baseline for exposure levels across all sampled areas.A minimum of 1.02 mSv/y and a maximum of 2.76 mSv/y. In the main campus, the school clinic (MC-A4) has the highest AED of 2.64 mSv/y, indicating significantly elevated radiation levels compared to other locations.Lowest AED was the senate building which was 1.14 mSv/y, attributed to lower indoor and outdoor dose rates.The campus-wide average AED is 1.64 mSv/y, slightly lower than the take-off campus average.The statistical analysis reveals a weak positive correlation between the Annual Effective Dose (AED) and Excess Lifetime Cancer Risk (ELCR) at the Take-off Campus (TOC) and Main Campus (MC). The correlation coefficients (0.3251 for AED and 0.3477 for ELCR) suggest that while the radiation exposure levels and associated cancer risks at both campuses are somewhat related, they are not strongly dependent on each other.Radiation exposure thresholds are set to minimize health risks, with the ICRP-recommended public dose limit of 1 mSv/year and higher occupational limits for radiation workers. Long-term exposure above these thresholds increases the likelihood of biological effects, including DNA damage, cell mutations, and a heightened risk of cancer. Studies like those from UNSCEAR (2021) report have shown a direct correlation between increased radiation dose and cancer risk, even at low doses. Epidemiological research on atomic bomb survivors and occupational radiation workers further supports these findings, emphasizing the importance of keeping exposure as low as reasonably achievable (ALARA).Several studies have assessed terrestrial gamma radiation exposure in university environments, highlighting variations in dose levels and potential health risks. A survey at the University of Port Harcourt, Nigeria, found that most indoor radiation levels were below the 1 mSv/year safety limit, except for a pharmaceutical laboratory with slightly elevated levels (Ononugbo and Ishiekwene, 2017). Similarly, a study in Minna, Nigeria, reported gamma dose rates between 0.125 and 0.184 µSv/hr, with an average annual dose of 0.189 mSv/year, well below the ICRP recommended limit (Ajayi & Ajayi, 2010). In Dhaka, Bangladesh, research at the Atomic Energy Centre Dhaka (AECD) recorded an average annual effective dose of 0.472 mSv/year, aligning with global averages (Hossain *et al*., 2017). However, a follow-up study found indoor dose rates ranging from 0.373 to 0.646 µGy/hr, with annual effective doses reaching up to 3.17 mSv/year, suggesting the need for monitoring and mitigation (International Journal of Scientific Research and Management, 2017). These findings emphasize the importance of regular radiation assessments in university environments to ensure safe exposure levels for students and staff.

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