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Assessment of Background Ionizing Radiation and Radiological Health Risks in Federal Government Girls' College, Imiringi, Nigeria.

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Abstract: *Ionizing radiation poses health risks when exposure surpasses certain thresholds for humans. In the vicinity of Federal Government College Imiringi, crude oil activities potentially impact levels of naturally occurring radioactive materials. Thus, it's essential to evaluate potential impacts on students. Consequently, an assessment was conducted involving in-situ measurement of terrestrial gamma radiation and calculation of radiological health risks. This assessment utilized a well-calibrated RadMonitor-200 and established radiological equations. The study area was partitioned into three zones (Zone A, Zone B, and Zone C). Thirty sampling points were selected, with ten in each zone. Background ionizing radiation (BIR) results across the zones ranged from 0.011 to 0.015 mRhr-1, 0.008 to 0.21 mRhr-1, and 0.011 to 0.19 mRhr-1. Mean values were 0.015±0.002 mRhr-1, 0.017±0.003 mRhr-1, and 0.015±0.002 mRhr-1 for Zone A, Zone B, and Zone C respectively, with an overall mean of 0.017 mRhr-1. This suggests a slight exceedance of the recommended safe BIR value of 0.013 mRhr-1.The mean absorbed dose in Zones A, B, and C were 126.15±0.003, 147.03±0.002, and 126.15±0.002 nGyhr-1 respectively. The annual effective dose equivalent (AEDE) remained below the permissible safe limit of 1.0 mSvyr-1. Excess lifetime cancer risk (ELCR) ranged from 0.57 x10-3 to 0.89 x10-3, 0.49x10-3 to 0.94x10-3, and 0.57x10-3 to 0.85 x10-3 with mean values of 0.70 x10-3±0.001, 0.78 x10-3±0.001, and 0.71 x10-3 ±0.001 in Zones A, B, and C respectively, which were above 0.29x10-3. However, these elevations do not warrant the classification of the area as radiologically unsafe. Nevertheless, regular monitoring is advisable, particularly due to the observation of a potential methane gas emission within the college premises. The findings of this research should serve as baseline data for future spectrometry analyses of soil, borehole, and surface waters in the college's vicinity.*

Keywords*: Absorbed dose; background radiation; cancer risk; effective dose*

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1.0 Introduction

As innovations are being made, old scientific discoveries are constantly being studied in other to provide information wherever such information is needed. Radioactivity has been known for so many years but the need to conduct studies on it is increasing daily. Background ionizing radiations (BIR) in virtually all human environments are mainly due to radiations from naturally occurring radioactive material (NORMs) and manmade sources, technologically naturally occurring radioactive materials (TENORMs). These materials can cause harm to the immediate environment either as NORMs or as a combination of both NORMS and TENORMs. In most cases, human beings are unconsciously exposed to several doses of these radiations. This happens because background ionizing radiations constantly interact with the terrestrial environment hosting living and nonliving things. Internal exposure to radioisotopes can occur through irradiation and inadvertent ingestion.

Continuous exposure could lead to excess accumulation of radionuclides within human internal body organs (Ugbede and Benson, 2018).

Soil and rock are also some of the sources of radiation exposure to human population and also a means of migration for the transfer of radionuclides into the environment. Natural radioactivity in the soil is mainly due to ^{238}U, ^{40}K, and ^{226}Ra which cause external and internal radiological hazards due to emission of gamma rays and inhalation of radon and its daughters (UNSCEAR, 2000).

Ionizing radiation includes all particulate radiations mainly alpha/beta particles and the energetic x-rays and gamma rays which are injurious to human health. A significant part of the total dose contribution in the form of natural sources comes from terrestrial gamma radionuclides (Anekwe, 2020). Non-ionizing radiation on the other hand includes ultraviolet rays, visible light, infrared, microwaves and radio waves which may have only thermal effects or no severe health effects. The Cosmic rays from the Sun and galaxy, terrestrial radiation from the Earth's crust, and incorporation of radioisotopes from the biosphere summarize the undesirable exposure all over the world (Kostoff et al).

Oil and gas activities abound in the local community of Imiringi with oil wells and crisscross of oil pipelines quite close to the study. Radiation level increases in the immediate environment when crude oil in its natural concentration with NORMs are drilled from underneath to the top. Overexposure to thorium is dangerous to humans and it can damage the lung, pancreas, hepatic, bone, and kidney cancers and leukaemia (Taskin *et al*., 2009). Radon, a decay product of radium (226Ra) which is also a measure of uranium (238U) decay series is another major root cause of lung cancer. One of the progenies of the naturally occurring radionuclides is radon gas which contributes high amounts of potentially lethal doses and it has been reported to be the leading cause of lung cancer death (NRC, 2006; Drek et al., 2010; Atipo et al., 2020). In recent times, research work in high background radiation areas in the world has been of great importance for risk estimation due to extensive periods of low-level exposure to the public (Suresh Gandhi *et al*., 2014). Radioisotopes during radioactive decay, have sufficient energy to knock off electrons from the atoms in the materials it interacts with, hence are dangerous to health as they pass through human tissue and biological systems at different doses of stochastic or deterministic conditions. Exposure to ionizing radiation at elevated doses can initiate the induction of cancer in organs and tissues of the body. New cases of cancer have been observed to be the major cause of transience in recent times, therefore, it is necessary to evaluate the radiological health risk associated with exposure to background ionizing radiation within the terrestrial environment, Farai I. J. (2014). The presence of radionuclides in the soil, food and water poses numerous numbers of health hazards, especially when these radionuclides are deposited in the human body through food consumption or drinking waters from the contaminated area. FGGC Imiringi has a rice farm and borehole water supply and of course if the environment is seriously contaminated adverse effects may be on human beings in and around the College. Dissolved radionuclides in foods and water emit alpha particles, beta particles and photons (gamma) which gradually are exposed to human tissues, Gruber *et al.* (2009). Evaluation of ionized dose rate at FGGC Imiringi became necessary as the nation places emphasis on environmental standard requirements. In this regard, the Millennium Development Goal 7 which has been replaced sought to explain the importance of environmental sustainability. This is in a view to minimize the perturbation of the natural ecosystem by natural occurrences and human activities. This led to the declaration by the Niger Delta Survey (2000) that for rural and urban populations, environmental sustainability is fundamental to human development and well-being. Therefore it is also important that the level of background ionizing radiation in Federal Government Girls' College Imiringi is known to provide acceptable data or opinion concerning human exposure to these dangerous electromagnetic energies emanating from radionucleides. Apart from the natural existence of radionucleides, manmade sources exist in the area too. The study area, Imiringi, has a flare boom or ground flare nearby. In the coastal region, mangrove which was a good source of fuel wood and habitat for biodiversity have been destroyed (UNSCEAR, 2000), such as in another part of Imiringi through gas flaring. Gas flaring is another destructive effect of the oil and gas industry because toxic components are released into the environment, which includes methane majorly and other greenhouse gases like carbon monoxide (Jibiri, 2009). The level of natural background radiation is generally between 1 and 2mSv/year (Hunt, 1987). A World Bank Study showed that Nigeria flares about 76% of all natural gas from petroleum production, this is in contrast to 0.6% in the United States, 4.5 in the United Kingdom, 21%, 20% and 19% in Libya, Saudi Arabia and Iran respectively (Taskin et al., 2009). In 1994, the Nigerian Conservation Foundation revealed that Nigeria released 34 million tons of methane to the atmosphere, that year alone with 15% of it being radon gas. This implied that Nigerian oil fields contribute more to global warming than the rest of the world (Aghalino et al., 2001). The flow of energy in the form of atoms and sub-atomic particles frees electromagnetic waves that are capable of freeing electrons from an atom causing the atom to become charged or ionized. People are therefore exposed to natural sources of ionizing radiation such as in the soil, water, air and vegetation.

2.0 Materials and Methods

The materials used were a Digilert 200 radiation meter and a Global Positioning System (GPS).

An *in-situ* approach was adopted in measuring the outdoor background ionizing radiation in the federal government college Imiringi. This meter has a Geiger Muller tube and employing the Tube principle could detect alpha, beta, gamma and X-rays at -10^{o}C to 50^{o}C temperature range. The mode/unit of measurement was then chosen and the meter was set to the chosen unit which was milli-Roetgen per hour. The well-calibrated Digilert-200 nuclear radiation meter (S.E. International INC. Summer Town, USA) at each point of measurement was raised 1 m above the ground level. Readings were taken and recorded at thirty different sampling points. The exact points of measurement were recorded using the global positioning system (GPS) Map76 Garmin product. The average value was used in known standard equations for the computation of hazard indices.

2.3 Hazard Indices Computation.

2.3.1 Absorbed dose

According to Mahmoud *et al*, (2014), the absorbed dose rate (nGy/h) denoted with D, was obtained from the exposure dose in (μR/h) together with a conversion factor.

D = Exposure dose rate x 8.7 (nGy/hr)

1μR/hr = 8.7 nGy/hr (1)

2.3.2 Equivalent Dose

The equivalent Dose was calculated from equation 2 as recorded by Avwiri *et al*, 2013; NCRP, 1990. This is the product of the absorbed dose of radiation and radiation weighting factor to tissue.

$$1\text{mR/hr} = \frac{0.96x24x365}{100}\ (\text{mSv/yr}) \quad (2)$$

2.3.3 Annual Effective Dose Equivalent (AEDE)

As previously recorded by Muhmoud *et al* (2014), the annual effective dose equivalent (AEDE) was computed from the relation in equation 3 below. Dose conversion factor of 0.7Sv/Gy and the occupancy factor for outdoor of 0.2(6/24) were used.

AEDE (outdoor) (mSv/yr) =Dose rate (nGy/h)×8760h×0.75Sv/Gy×0.25 (3)

2.3.4 Excess Lifetime Cancer Risk (ELCR)

The excess lifetime cancer risk (ELCR) in a community such as FGGC Imiringi is a carcinogenic potential effect that is characterized by assessing the probability of cancer occurrence. This is for a specific lifetime from projected exposures and chemical-specific dose-response using the relation in equation 4.

ELCR = AEDE x Average duration of life (DL) x Risk Factor (RF) 4

where, AEDE, DL and RF are the annual effective dose equivalent, duration of life (50 yrs) and the risk factor (Sv^{-1}) fatal risk per Sievert. Usually, stochastic effects are associated with low-dose background radiations and in this case, ICRP 60 uses values of 0.05 for the public Taskin *et al*, (2009).

2.4 Study area

Federal Government Girls' College Imiringi is in Ogbia Local Government Area of Bayelsa State, South-South Zone of Nigeria. Imiringi, apart from hosting the FGGC hosts several oil and gas facilities which include but are not limited to forty-six (46) oil wells, five planning sites, a manifold flow station, field logistic base (Anekwe and Onoja, 2020). The population of Imiringi was about eight thousand three hundred and fifty-one (Olokoya, 2015) and it is one of the first few communities in Nigeria where oil and gas exploration started. Lately, residents are complaining and alluding certain unconfirmed sicknesses to continual gas flaring and oil pollution. The Federal Government Girls College Imiringi is located near the Imiringi oil field. It is located between latitude 4^{o}51'6.66'' N and longitude 6^{o}22'28.09''E.

4.0 Results and Discussion

An in-situ measurement of background ionizing radiation was carried out within Federal Government Girls College in the Imiringi community and other radiological parameters were calculated such as Absorbed Dose, equivalent dose, Annual effective dose equivalent (AEDE) and Excess life cancer risk., The study area was arranged into zones (Zone A, Zone B and Zone C) and the obtained results are presented in Tables 1 to 4.

Table 1: Exposure and Radiological Indices in Zone A

S/N	Latitude	Longitude	Exposure (mR/hr)	Equivalent Dose (mSv/yr)	Absorbed Dose (nGy/hr)	AEDE Outdoor (mSv/yr)	ELCR $\times 10^{-3}$
1	04^{o} 51'436''	06^{o}22'2560'	0.011	0.925	95.7	0.16	0.57
2	04^{o}51'367''	06^{o}22'233''	0.013	1.093	113.1	0.19	0.67
3	04^{o} 51'3530''	06^{o} 22'225''	0.013	1.093	113.1	0.19	0.67
4	04^{o} 51'3862''	06^{o} 22'186''	0.019	1.598	165.3	0.27	0.85
5	04^{o}51'5155''	06^{o} 22'196''	0.020	1.682	174.0	0.33	0.89
6	04^{o} 51'4052''	06^{o} 22'191''	0.017	1.429	147.9	0.23	0.81
7	04^{o} 51'4134''	06^{o}22'196''	0.011	0.925	95.7	0.16	0.57
8	04^{o}.51'3920''	06^{o}22'224''	0.011	0.925	95.7	0.16	0.57

9	04º51'4029''	06º 22'225''	0.019	1.598	165.3	0.27	0.85
10	04º 51'4177''	06º22'196''	0.011	0.925	95.7	0.16	0.57
	Mean		**0.015±0.002**	**1.22±0.001**	**126.15±0.003**	**0.212±0.002**	**0.70±0.001**

Table 2: Exposure and Radiological Indices in Zone B

S/N	Latitude	Longitude	Exposure (mR/hr)	Equivalent Dose (mSv/yr)	Absorbed Dose (nGy/hr)	AEDE Outdoor (mSv/yr)	ELCR $\times 10^{-3}$
1	04º51'4378''	06º 22'222''	0.010	0.841	87.0	0.14	0.49
2	04º 51'4456''	06º22'245''	0.017	1.429	147.9	0.23	0.81
3	04º51'4671''	06º22'245''	0.013	1.093	113.1	0.19	0.67
4	04º51'4662''	06º22'233''	0.008	0.673	69.6	0.11	0.37
5	04º51.41167''	06º22'532''	0.021	1.766	182.7	0.35	0.94
6	04º51'4178''	06º 22'2518''	0.019	1.598	165.3	0.27	0.85
7	04º51'4177''	06º 22'2318''	0.020	1.682	174.0	0.33	0.89
8	04º51'4167''	06º 22'2519''	0.019	1.598	165.3	0.27	0.85
9	04º51'4167''	06º 22'2348''	0.021	1.766	182.7	0.35	0.94
10	04º51'4178''	06º 22'2618''	0.021	1.766	182.7	0.35	0.94
	Mean		**0.017±0.003**	**1.380 ±0.001**	**147.03±0.002**	**0.259±0.001**	**0.775±0.001**

Table 3: Exposure and Radiological Indices in Zone C

S/N	Latitude	Longitude	Exposure (mR/hr)	Equivalent Dose (mSv/yr)	Absorbed Dose (nGy/hr)	AEDE Outdoor (mSv/yr)	ELCR $\times 10^{-3}$
1	04º51'4177''	06º 22'2518''	0.019	1.598	165.3	0.27	0.85
2	04º51'4177''	06º 22'2318''	0.011	0.925	95.7	0.16	0.57
3	04º51'4178''	06º 22'2518''	0.019	1.598	165.3	0.27	0.85
4	04º51'3530''	022º'2450''	0.013	1.093	113.1	0.19	0.67
5	04º51'3862''	06º22'1862''	0.015	1.261	130.5	0.21	0.74

6	04°51'515 5''	06° 22'1956''	0.015	1.261	130.5	0.21	0.74
7	04°51'405 2''	06°22'191 4''	0.015	1.261	130.5	0.21	0.74
8	04°51'436 0''	06°22'256 0''	0.011	0.925	95.7	0.16	0.57
9	04°51'367 0''	06°22'232 9''	0.013	1.093	113.1	0.19	0.67
10	04°51'351 7''	06°22'224 5	0.014	1.177	121.8	0.20	0.70
	Mean		**0.015±0.0 02**	**1.22±0.0 01**	**126.15±0. 002**	**0.21±0.0 01**	**0.71±0.0 01**

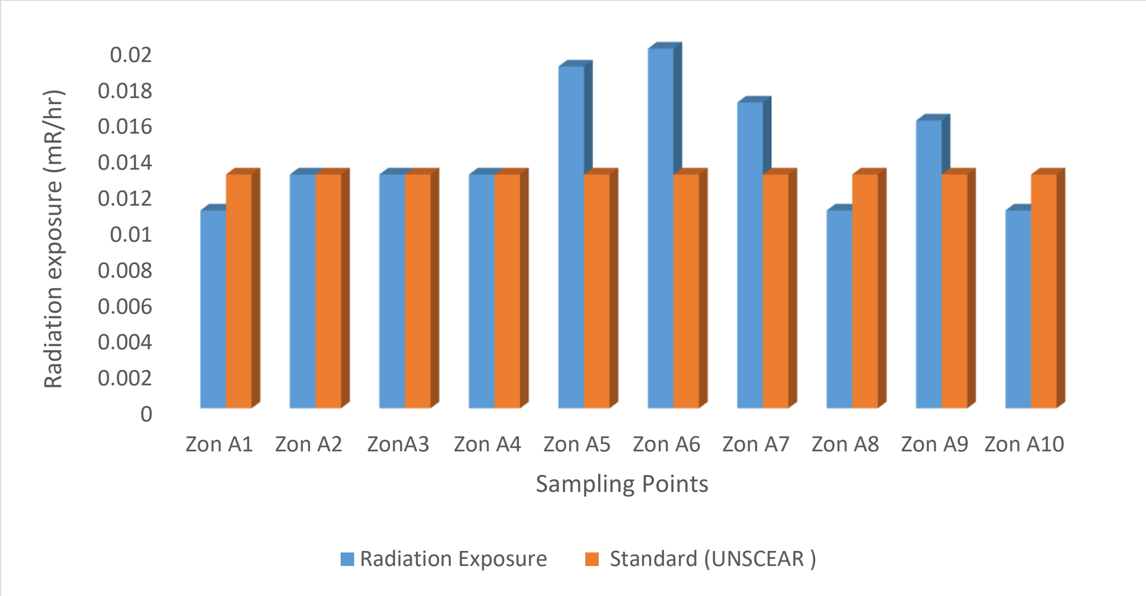

Fig.1: Comparison of exposure with permissible level in Zone A

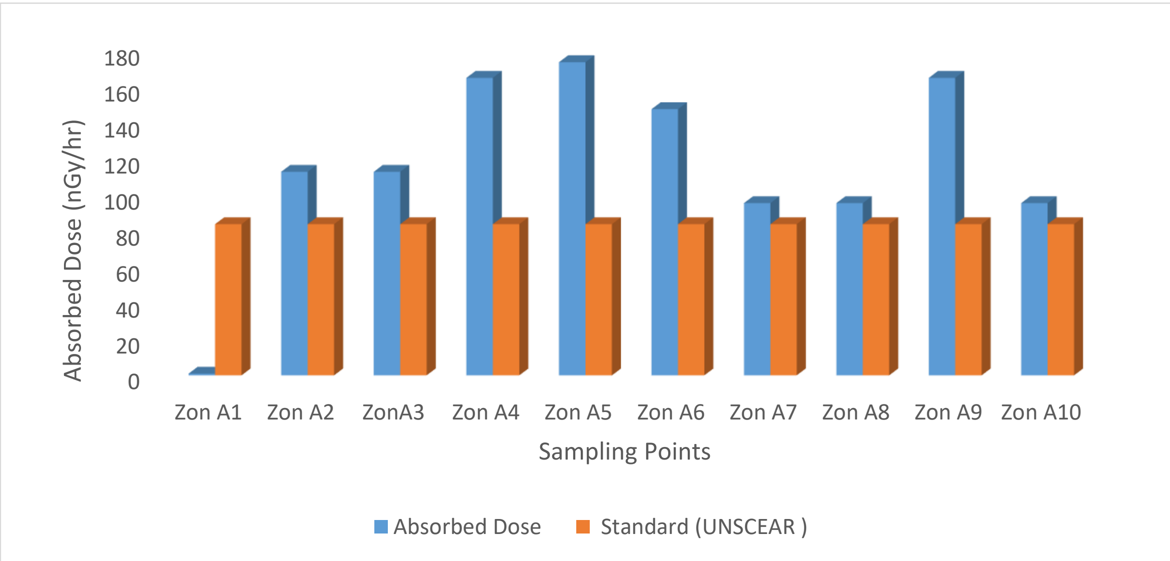

Fig.2: Comparison of Exposure with Absorbed Dose Rate in Zone A

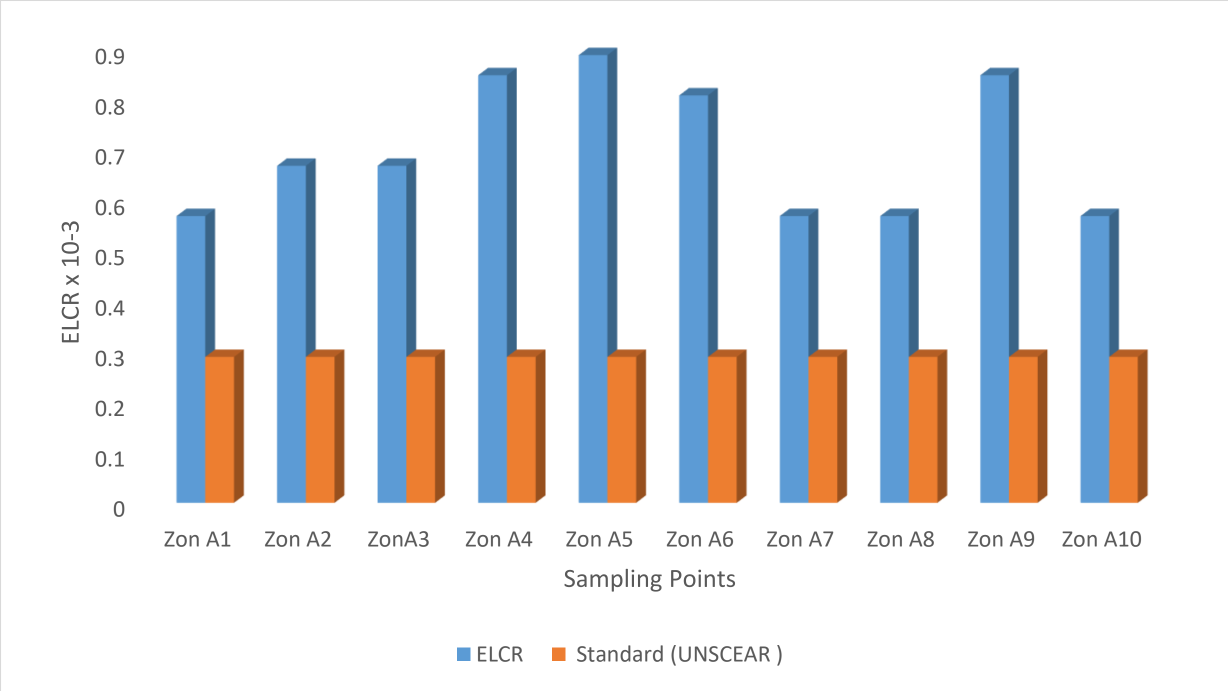

Fig.3: Comparison of Excess Life Cancer Risk with permissible level in Zone A

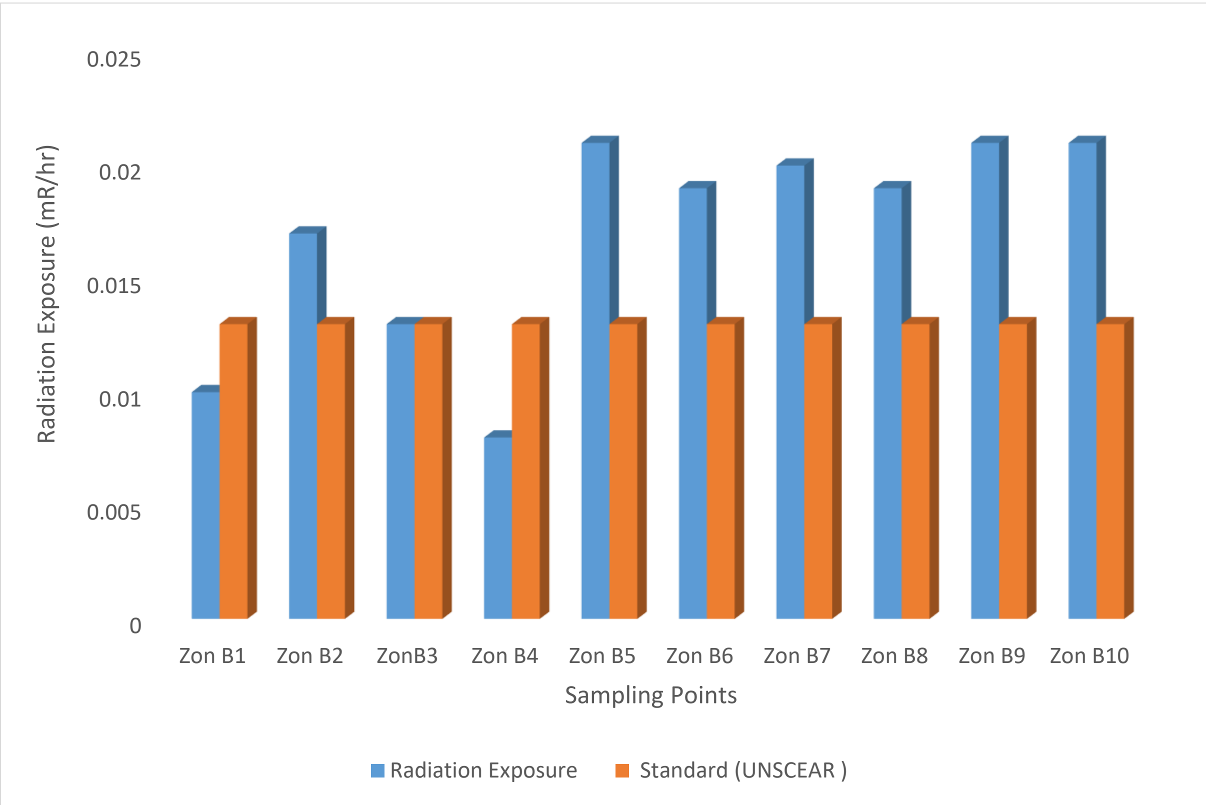

Fig.4: Comparison of Exposure with permissible level in Zone B

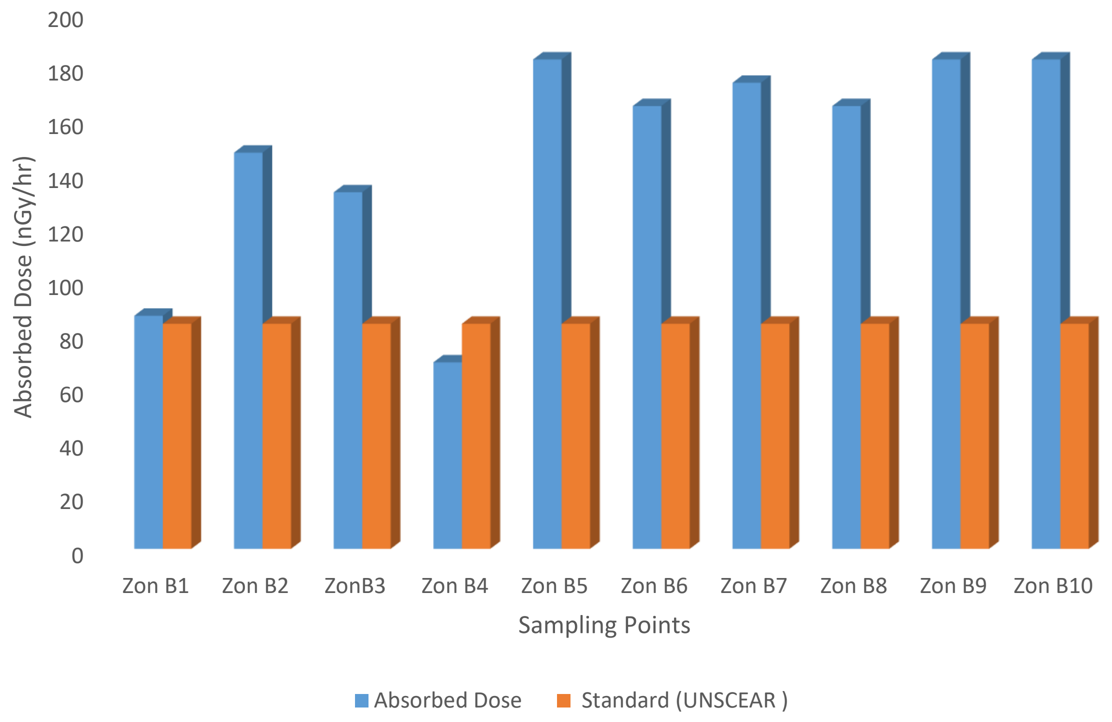

Fig.5: Comparison of Absorbed Dose Rate with permissible level in Zone B

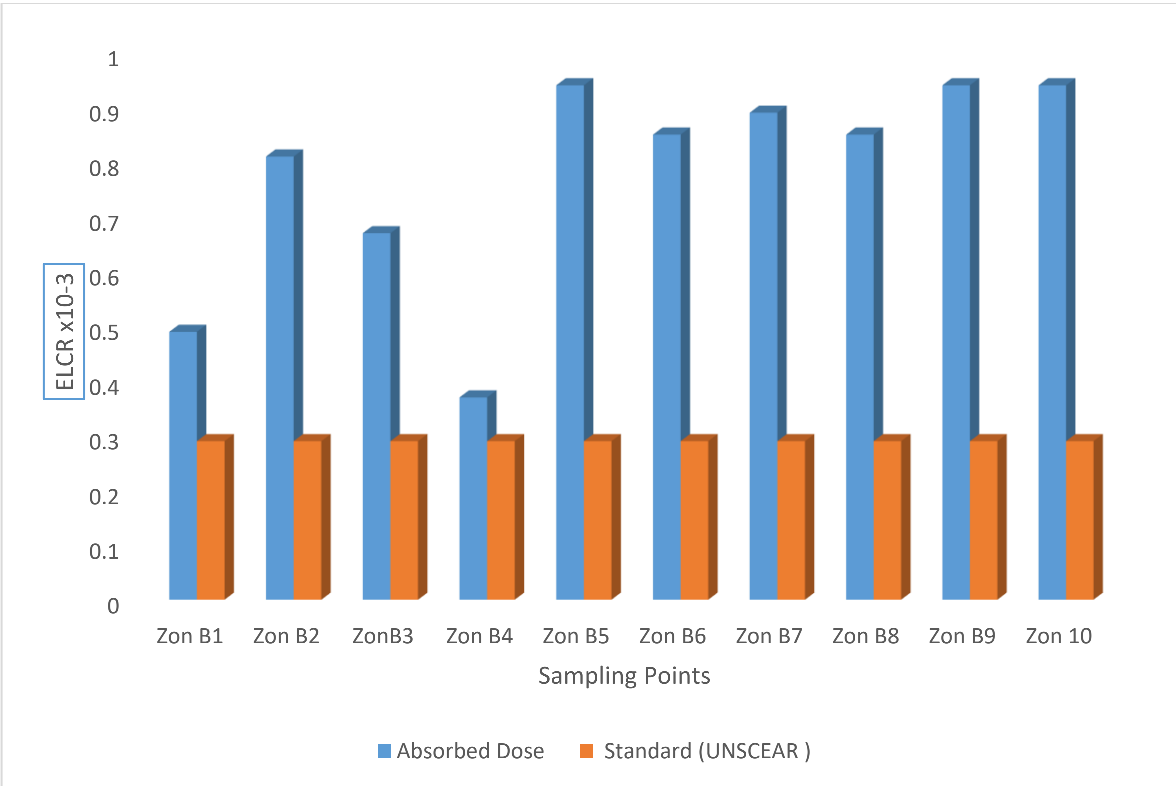

Fig.6: Comparison of Excess Life Cancer Risk with permissible level in Zone B

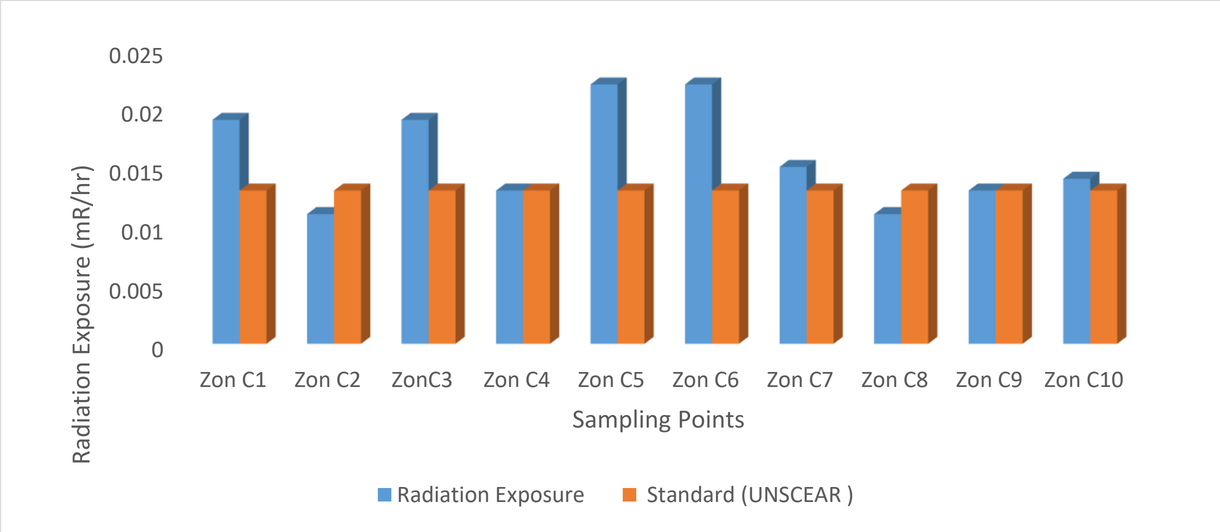

Fig.7: Comparison of Exposure with permissible level in Zone C

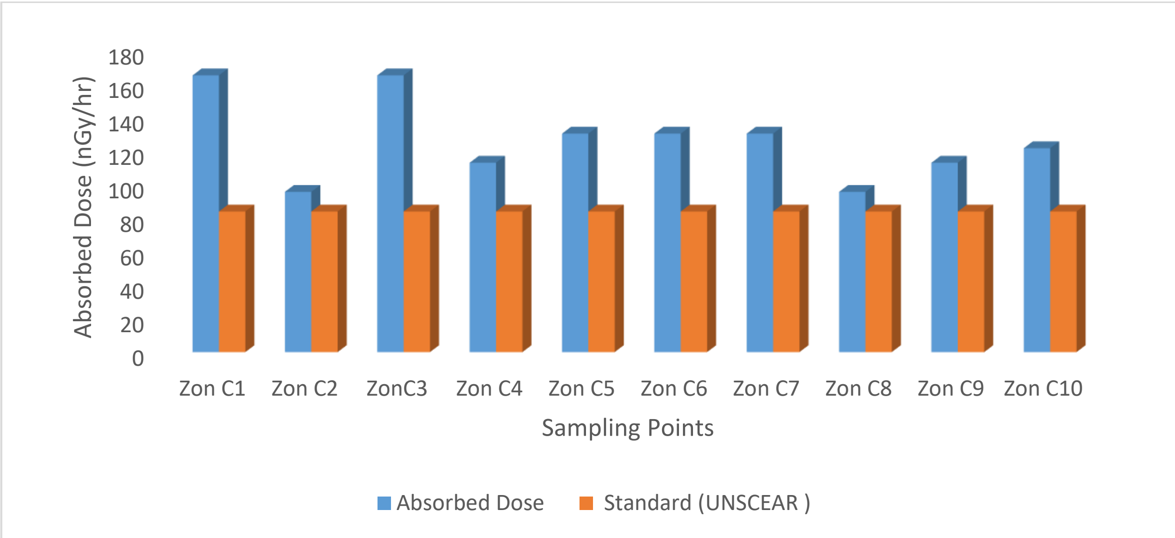

Fig.8: Comparison of Absorbed Dose Rate with permissible level in Zone C

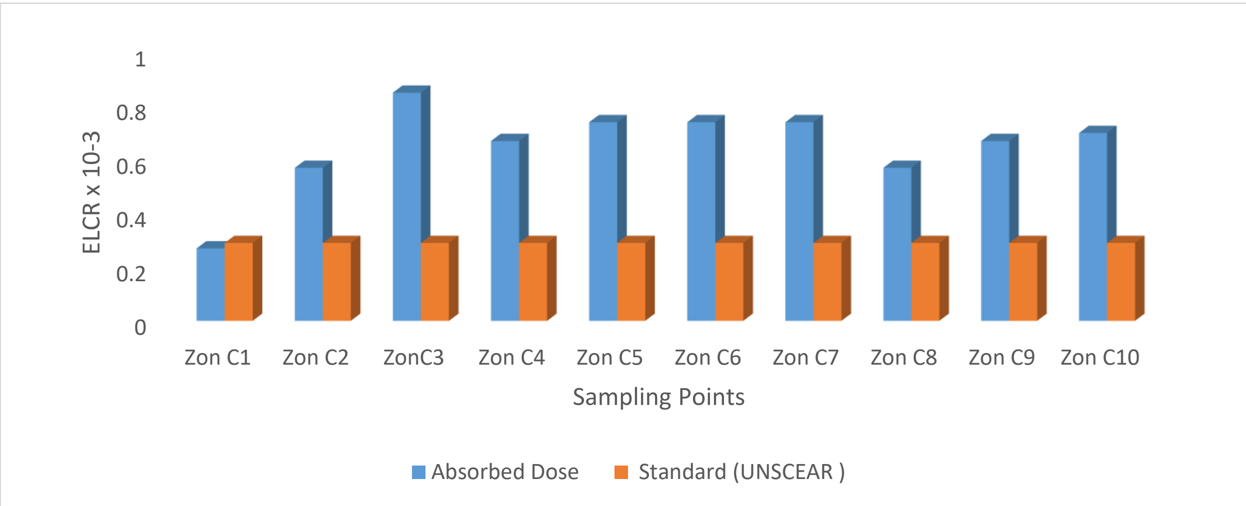

Fig.9: Comparison of Excess Life Cancer Risk with permissible level in Zone C

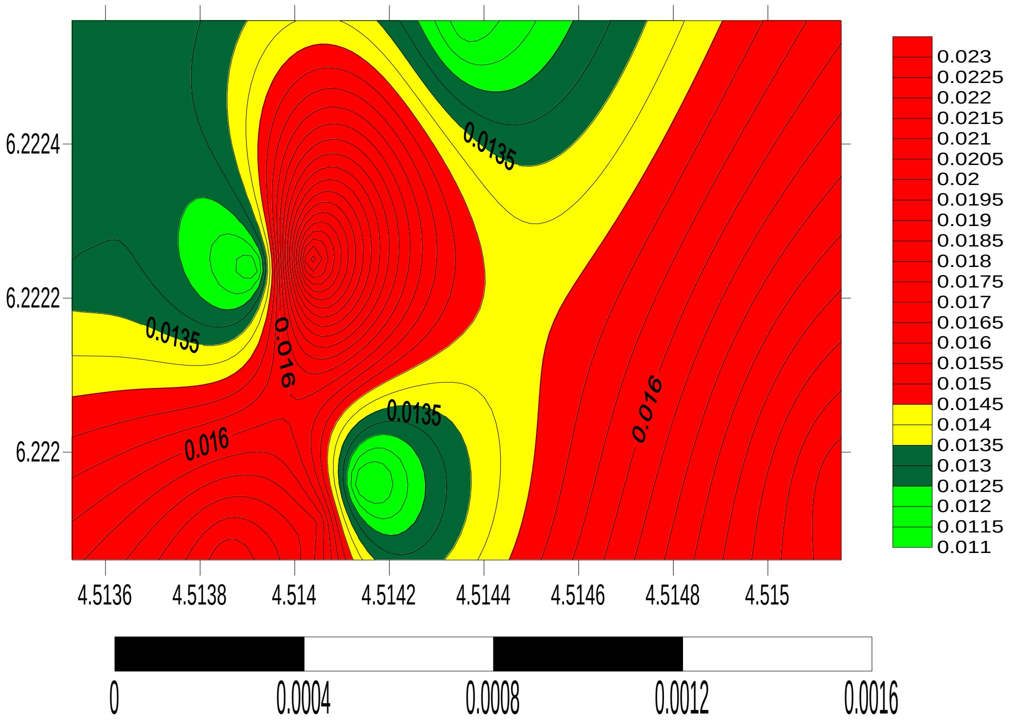

Fig.10: Contour Map of Zone A

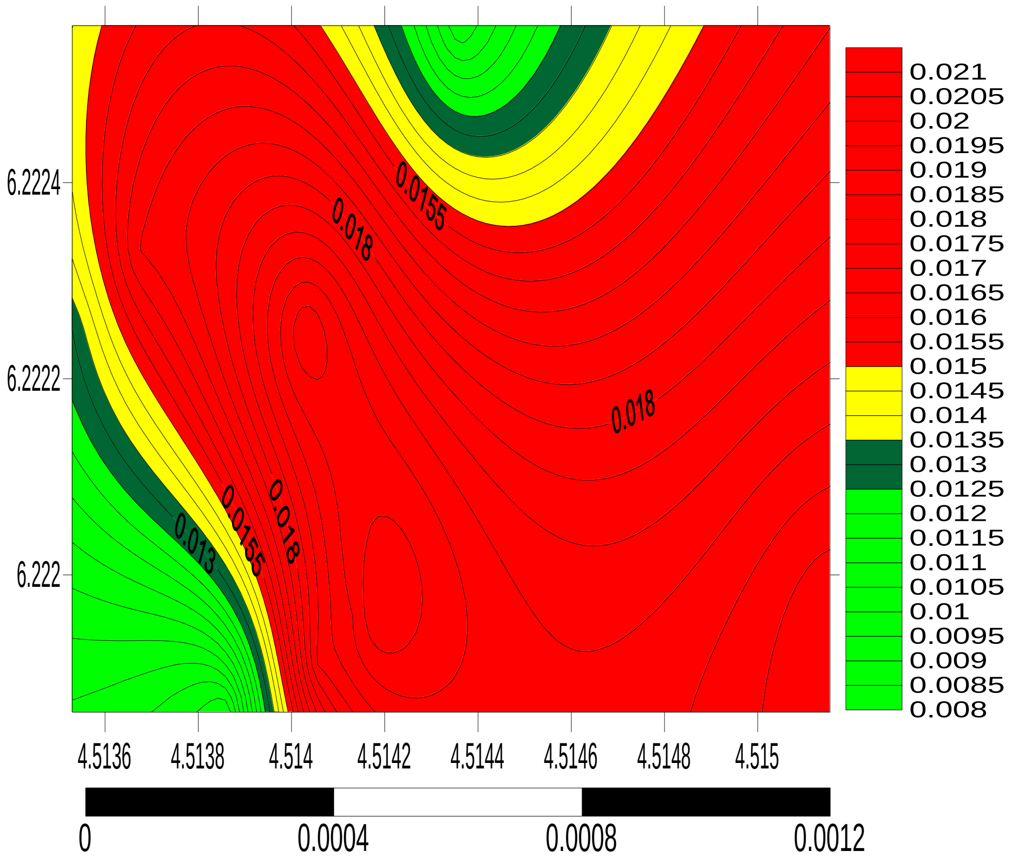

Fig.11: Contour Map of Zone B

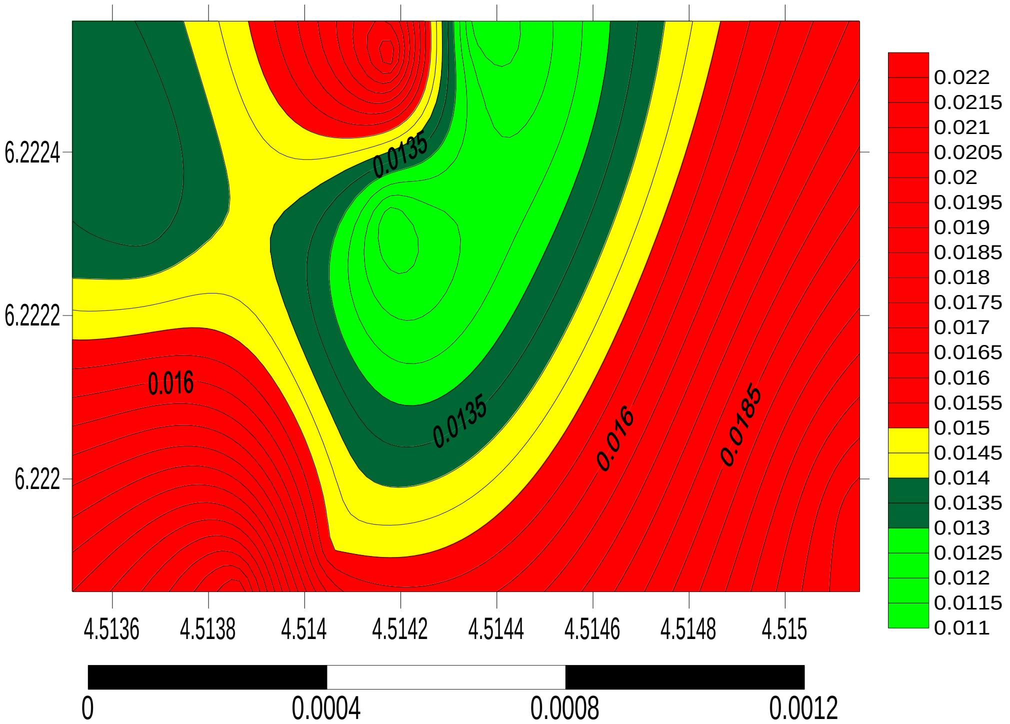

Fig.12: Contour Map of Zone C

An *in-situ* measurement of background ionizing radiation in Federal Government Girls' College Imiringi has been assessed. The results are presented in Tables 1 to 3. The obtained results of the background ionizing radiation varied from 0.011-0.015, 0.008 - 0.21 and 0.011- 0.19 mRhr^{-1} with mean values of 0.015, 0.021 and 0.016 mRhr^{-1} for Zones A, B, and C respectively. The obtained results were compared as shown in Figs. 2, 5, and 8. These values are higher than the results recorded by Echewozo and Ugede (2023). The obtained mean value of the BIR of the three Zones was higher than the recommended standard value of 0.013 mRhr^{-1}. This high value of radiation within the three zones might be due to the alteration of the concentration of gamma-emitting material within Federal Government Girls College. The results of absorbed dose obtained from the three zones are with mean values of 138.45, 147.03 and 126.15 nGyhr^{-1} for Zones A, Zones B, and Zones C respectively. Figs 2, 5 and 8 show the absorbed doses compared with the permissible. The obtained mean value was higher than that reported by Nwii A. *et al*, (2021) except that of Zone C which in turn exceeded the UNSCEAR (2000) recommended value of 84.0 nGyhr^{-1}. The annual effective dose equivalent (AEDE) of the Federal Government Girls College is below the recommended safe limit of 1.0 mSvyr^{-1}. The result of Excess lifetime cancer risk (ELCR) of the three Zones varied from 0.57 x10^{-3}- 0.89 x10^{-3}, 0.49x10^{-3} - 0.94x10^{-3}and 0.57x10^{-3}- 0.85 x10^{-3} with mean value of 0.75 x10^{-3} 0.78 x10^{-3} and 0.71 x10^{-3} for Zone A, Zone B and Zone C respectively. The results of the Excess lifetime cancer risk (ELCR) were compared with the standard value in Fig.3, Fig.6 and Fig.9. The obtained result ELCR are slightly higher than the standard value of 0.29x10^{-3} as recommended by ICRP (2007), and also higher than the value obtained by Taskin *et al*, (2009). The radiation contour map of the study area is shown in Figs 10 to 12 for the three Zones. The area with red shows a higher radiation level 0.015 mRhr^{-1} and above, light green shows a lower radiation level, dark green shows a radiation level within 0.014 - 0.015 $mRhr^{-1}$ while yellow shows a radiation level within 0.013-0.014 $mRhr^{-1}$.

4.0 Conclusion

The aim of this study was to assess the potential impact of crude oil activities on levels of naturally occurring radioactive materials and associated health risks around Federal Government College Imiringi. Through in-situ measurements of terrestrial gamma radiation and rigorous computation of radiological parameters, we found that while there was a slight exceedance of the recommended safe level of background ionizing radiation (BIR), the overall radiological hazards remained within permissible limits. Despite observing elevated levels of excess lifetime cancer risk (ELCR) in some zones, these values did not reach levels indicative of radiological unsafety. Nonetheless, given the observation of potential methane gas emissions within the college premises, regular monitoring is warranted to ensure ongoing safety. The findings of this study provide valuable baseline data for future analyses, serving as a foundation for spectrometry investigations of soil, borehole, and surface waters in the college's vicinity. By continuing to monitor and evaluate radiological conditions, we can ensure the ongoing safety and well-being of the college community.

5.0 References

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Compliance with Ethical Standards Declarations

The authors declare that they have no conflict of interest.

Data availability

All data used in this study will be readily available to the public.

Consent for publication

Not Applicable

Availability of data and materials

The publisher has the right to make the data public.

Competing interests

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