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Annual Effective Dose Due to Background Gamma Radiation in Buni Gari, Yobe State

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Abstract: *In this study, we aimed to assess the levels of gamma radiation both outdoors and indoors in Buni Gari, Yobe State. Our goal was to determine the annual effective dose associated with gamma radiation and to investigate whether the presence of active quarrying companies around the town has had any notable impact on the background radiation levels. Geiger Muller (G. M) detector known as X5C plus, was used to carry out the measurement. To ensure the accuracy of our readings, the G.M detector was positioned one meter above ground level to minimize ground-related effects. During outdoor measurements, we maintained a distance of at least six meters from nearby building walls to avoid any interference from the building materials. Our findings indicated that the average gamma dose rates for outdoor and indoor measurements were 55.8 ± 8.2 nSv/h and 62 ± 6.4 nSv/h, respectively. We calculated the average annual effective dose resulting from background gamma radiation to be 0.372 mSv, which was found to be lower than the global average value of 0.48 mSv. In conclusion, the average annual effective dose from background gamma radiation in Buni Gari was below the global average. When we compared our results with a previous study conducted in 2019 to determine the effective dose of environmental gamma radiation in the same town, we found that the presence of quarrying activities around the town over four years did not significantly change the annual effective dose of Buni Gari.*

Keywords: Effective dose, Outdoor, Indoor, Background gamma radiation, Quarrying.

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1.0 Introduction

Life on Earth inevitably involves exposure to ionizing radiation, assessing health risks associated with background gamma radiation is crucial in the field of radiation and health physics. The initial step toward achieving this objective involves measuring the levels of background gamma radiation in a particular region. The results of this measurement can serve as a benchmark for evaluating the impacts of human-generated radiation. The primary sources of background radiation encompass cosmic radiation and terrestrial radiation. Cosmic radiation consists of energetic particles resulting from spallation reactions in the outer space of the atmosphere. These particles penetrate the Earth's atmosphere and contribute significantly to the overall background radiation.

The interaction of certain particles with atmospheric molecules can lead to the formation of cosmogenic radionuclides. These long-lived cosmogenic radionuclides have given rise to terrestrial radionuclides that can be found in the air, soil, rocks, water, and building materials. Among these terrestrial radionuclides, the ones that have the most significant impact on human exposure to radiation are ^{232}Th, ^{238}U, and ^{40}K. ^{232}Th and ^{238}U are the parent radionuclides in the decay series, with their radioactive progeny contributing to human radiation exposure and increasing the overall radiation levels on Earth (UNSCEAR, 2000). The natural environmental radiation levels are greatly influenced by the geological and geographical characteristics of a particular region, as well as the materials used in construction within that region. Consequently, background radiation levels can vary significantly from one geographic location to another (Arogunjo, A.M., 2003). Due to its primary role in human radiation exposure, background radiation has been extensively researched on a global scale. In pursuit of this, numerous studies have been conducted in various regions across the globe [Arogunjo, 2003, Ibianu, 1999, Ibrahim *et al*., 1993, Benabar, *et al*., 1997, Baretka and Mathew, 1985). The findings of these studies indicate that the levels of background gamma radiation exhibit substantial variation among different geographical locations. In some places, the average dose rate exceeds the mean value reported by the United Nations Scientific Commission on Effects of Atomic Radiation, (UNSCEAR, 2000).

In 2019, a study was conducted in Buni Gari by Abba and Yusuf (Abba and Yusuf, 2020) to measure environmental gamma radiation levels from soil samples. The absorbed dose rate from background gamma radiation was found to range from 0.33 μSv/h to 41.1 μSv/h, with a corresponding average annual effective dose rate ranging from 3×10^{-5} mSv to 4×10^{-4} mSv with a mean value of 0.481 mSv. Given concerns about the potential impact of the quarry's activities in Buni Gari on environmental background radiation, it is essential to monitor background gamma radiation levels to better understand the current situation and provide a scientific response to these concerns. Therefore, in this study, we assessed the background gamma radiation in Buni Gari using a G.M detector (X5plus) following standard procedures.

2.0 Materials and Method

Buni Gari is an agrarian town located between the latitudes 11° 11' 40" − 11° 13' 38" N and the longitude 12° 03' 50" − 12° 87' 52" E (Fig. 1) in the southeastern part of Yobe state sharing its border with Borno state on the south and Gulani L.G.A to the west.

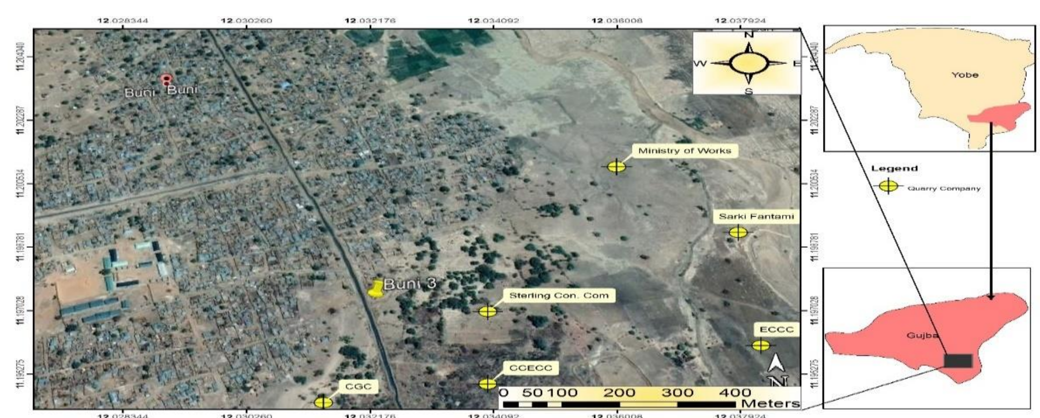

Fig. 1: Map of Buni Gari showing the locations of some quarrying companies

It is characterized by two distinct seasons: the wet season starting from the beginning of May to the end of October, and the dry season between November and April. Activities of quarries have been ongoing for many years around this community.

The town was divided into five parts, including the north, east, west, south, and centre, with the centre serving as the reference point for measurements maintaining a reasonable distance from each other.

To ensure accurate measurements, buildings made from similar and commonly used masonry materials were selected. Background gamma radiation measurements were conducted using a G.M detector (X5C plus) that had been calibrated. To minimize the influence of ground and buildings on outdoor measurements, the detector was positioned one meter above ground level and at least six meters away from nearby building walls.

Similarly, for indoor measurements, the detector was placed one meter above ground level to meet indoor measurement criteria. Each measurement had a total exposure time of one hour. The average of all measurements at each station and building was computed to represent the absorbed dose rate for that location. Using the results of the absorbed doses, the annual effective dose from background gamma radiation was estimated as follows (UNSCEAR, 2000).

$$E\ (nSv) = (D_{out} \times OF_{out} + D_{in} \times OF_{in}) \times T \times CC \times 10^{-6} \quad (1)$$

where E (nSv) represents the annual effective dose, D_{out} and D_{in} (nSv/h) stand for the average absorbed dose rates outdoors and indoors, T (hr) indicates the time used to convert from a year to an hour (which is 8760 hours), OF_{out} and OF_{in} represent the occupancy factors for outdoor and indoor areas (20% for outdoor and 80% for indoor), and CC is the conversion coefficient (0.7 for adults) provided by UNSCEAR to transform the absorbed dose in the air into the effective dose in humans (UNSCEAR, 2000), 10^{-6} is to convert nSv to mSv.

3.0 Results and Discussion

In Table 1, you can find data on gamma dose rates in both indoor and outdoor environments for the five selected areas within the town. The table also includes the mean values and standard deviations (SD) calculated for each of these measurements. The maximum and minimum gamma dose rates for outdoor measurements were 61 ± 11 nSv/h and 48 ± 7 nSv/h, respectively. For indoor measurements, the maximum and minimum values were 55 ± 4 nSv/h and 70 ± 9 nSv/h.

Table 1: Average outdoor and indoor gamma dose rates and resulted in effective dose in selected areas of Buni Gari

Area	MIDR (nSv/h)±SD	Range	MODR (nSv/h)±SD	Range	EDR (mSv/h)
North	59 ± 6	40-68	48 ± 7	39-77	0.33 ± 0.03
East	55 ± 4	40-80	60 ± 9	36-97	0.37 ± 0.06
West	70 ± 9	53-88	61 ± 11	32-81	0.51 ± 0.06
South	60 ± 5	35-73	57 ± 6	45-65	0.37 ± 0.05
Center	66 ± 8	51-91	53 ± 8	31-70	0.43 ± 0.07

Key: MIDR = Mean indoor dose rate, MODR = Mean outdoor dose rate, EDR = effective dose rate

The average gamma dose rates for indoor and outdoor settings were found to be 62 ± 6.4 nSv/h and 55.8 ± 8.2 nSv/h, respectively. The ratio of indoor gamma dose rates to outdoor gamma dose rates was determined to be 1.12. Using the average outdoor and indoor gamma dose rates as a basis, the annual effective dose for adults resulting from background gamma radiation in Buni Gari was calculated.

$$E\ (nSv) = (62\ \times 0.8 + 55.8\ \times 0.2) \times 8760 \times 0.7 \times 10^{-6} \quad = \ 0.372\, mSV$$

The study conducted in Buni Gari measured background gamma dose rates, both indoors and outdoors, and calculated the annual effective dose. The results, obtained using a G.M detector, showed that the effective dose from natural background gamma radiation Buni Gari was below the global average. In contrast, an adult living in Buni Gari receives an annual effective dose of 0.372 mSv from environmental gamma radiation, which is lower than the 0.48 mSv reported by UNSCEAR [2]. The lower radiation level in this study could primarily be due to its geographical characteristics, which place it among regions with low background radiation levels. One noteworthy aspect of this study is the relatively small variation in our measurements compared to similar studies across various regions of the world. In contrast, other researchers have reported significant variations in gamma dose rates across different locations (Ibianu, 1999, Ibrahim *et al*., 1993). The primary reason for this disparity can be attributed to the diverse geographical features of various areas. In the case of Buni Gari, the limited variation in altitude and latitude across the specified sampling sites resulted in a narrow range of measurements, ranging from 48 to 61 nSv/h for outdoor measurements and 55 to 70 nSv/h for indoor measurements.

Altitude and latitude play crucial roles in determining the level of background radiation (Bahreyni *et al*., 2009, gholami and Mirza, 2011, Shahbazi, 2003, Shahbazi, 2003). Research findings indicate a direct relationship between altitude and the annual effective dose resulting from background gamma radiation (Bahreyni *et al*.,). In regions at high altitudes, such as Azarbayjan (above 1000 meters), Khorasan South, Khorasan Razavi, Khorasan North, Kordestan, and Lorestan, the effective dose from background gamma radiation is higher, ranging from 0.68 mSv to 0.88 mSv (Arogunjo, 2003, Ibianu, 1999, Bahreyni *et al.*, 2000, Bahreyni and Jomehzadeh, 2005). In contrast, low-altitude areas like Bushehr and Hormozgan (approximately at sea level) exhibit lower effective doses, at 0.36 mSv and 0.30 mSv, respectively (Mahmoud *et al.*, 2014).

A direct correlation between the background dose rate and a region's latitude has been established (UNSCEAR, 2000, Gholami *et al.*, 2011, Kam and Bozkurt, 2007). It can be observed that Buni Gari exhibits lower background gamma radiation levels when compared to regions at higher latitudes within Nigeria and globally (Ibianu, 1999, Bouzarjomehri and Ehrampoush, 2005). This phenomenon can be primarily attributed to the Earth's magnetic field, which intensifies as one moves towards the poles. The Earth's magnetic field exerts an influence on slow-moving charged particles, causing them to be redirected towards the polar regions. Comparing findings from various studies conducted in different regions reveals that the effective dose of background gamma radiation tends to increase with latitude, up to a latitude of 35 degrees north (Bahreyni *et al.,* 2009).

One significant discovery in our current study emerged when we compared our findings with that conducted in 2019, four years back, which aimed to assess the absorbed dose rate from natural gamma radiation in Buni Gari from soil samples (Abba and Yusuf, 2020). Our investigation revealed that, in the earlier study, the annual effective dose rates from natural gamma radiation ranged from 3×10^{-5} mSv to 4×10^{-4} mSv with an average value of 0.481 mSv. When we compared the results of these two similar studies conducted at different times, it became evident that the background gamma radiation levels in Buni Gari remained almost unchanged over the four years years. This finding is particularly noteworthy given the presence of operational quarry companies around the town. In light of this comparison, it can be concluded that quarrying activities within four years did not have a significant impact on the background gamma radiation levels in Buni Gari.

4.0 Conclusions

The annual effective dose from natural gamma radiation in Buni Gari, which stands at 0.372 mSv, is lower than the worldwide average. When we compare the findings of this current study to that of a previous similar study conducted in 2019, it becomes evident that the presence of quarrying activities did not have a substantial impact on the background gamma radiation levels in Buni Gari over four years.

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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

The authors declared no conflict of interest.

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Author's contribution

Dr. H.T. Abba and K.A. Busari went to the field for data collection. The manuscript was prepared by Dr. H. T. Abba, reviewed and edited by Dr. J. Waida