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Evaluation of Excessive Lifetime Cancer Risk Due to Gamma Radiation on Rocks in Shira Village, Bauchi State Nigeria

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Abstract: *This study evaluates the natural radioactivity levels and the associated excess lifetime cancer risk (ELCR) due to gamma radiation from rock samples in Shira Village, Bauchi State, Nigeria. Terrestrial radiation arises primarily from radionuclides such as ^{238}U, ^{232}Th, and ^{40}K present in geological formations. Understanding these radiation levels is essential for monitoring environmental safety and assessing public health risks. A total of 100 rock points were randomly sampled, and radiation readings were measured using a radiation survey meter. The absorbed dose rate in air was found to range from 70.0056 to 590.0472 nGy/h, with an average value of 228.9183 nGy/h, significantly exceeding the world average of 59.00 nGy/h. The excess lifetime cancer risk (ELCR) for indoor and outdoor exposure ranged from 1.201966 × 10^-3 to 10.13087 × 10^{-3} and 0.300492 × 10-3 to 2.532719 × 10^{-3}, respectively, with a total average of 4.913045 × 10^-3. These values are considerably higher than the global average of 0.29 × 10-3, indicating a potentially elevated health risk for residents in the study area. The results underscore the need for regular monitoring and the implementation of appropriate mitigation strategies to safeguard public health in Shira Village*

Keywords: *Radiation alert detector, excessive life cancer risks, gamma radiation and Shira hills, Bauchi State, Nigeria.*

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1.0 Introduction

The natural radioactivity in the environment arises due to the presence of natural radio nuclides mainly ^{238}U, ^{232}Th and ^{40}K in various geological formations. The terrestrial radiation comprises of radiation emitted from these radio nuclides and their progeny. ^{40}K is a singly occurring natural radionuclide, which also emits gamma radiation. Since, 98.5% of the gamma dose received from ^{238}U series, are emitted from ^{226}Ra and its daughter products, the contribution from ^{238}U and other precursors of ^{226}Ra are normally ignored. Radioactivity is common in the rocks, air, and soil every day, we ingest /inhale radio nuclide in the air we breathe, in the food we eat, the water we drink and in our building materials and homes. It is just everywhere. There is rare place on Earth that you can get away from Natural Radioactivity (Ahmed & Hussein 2011). The natural radiation levels of soil and rock depend upon their concentrations of radionuclides and the specific activity of the radio nuclides.. The emitted radiation is due to both the decay of the parent radio nuclides and their daughter radio nuclide (Shamsand *et al*, 2015). Measurements and studies of natural radioactivity in rocks are very important to determine the amount of change of the natural background activity with time as a result of any radioactive release, monitoring of any release of radioactivity to the environment is important for environmental protection (UNSCEAR, 2000). Despite the global interest in the measurement of natural background radiation and the extent of nuclear research and applications being carried out in Nigeria, the level of natural radioactivity for most of its environments has not been established, and effort has not been made to carry out an extensive measurement program to cover the entire country. Thus, data on the natural environment radioactivity are still sparse and limited. Radiation dose exposure presents hazardous health effects such as lung cancer from exposure to radon and its decay products (polonium 218 and polonium 214). Long-term exposure to elevated levels of radon gas and its daughters can lead to functional changes in respiratory organs and may cause lung cancer (khandaker, *et al* 2015). The main objective of the present work is the evaluation of excessive lifetime cancer risk due to gamma radiation on rocks in Shira Village, Bauchi State Nigeria.

1.1 Study Area

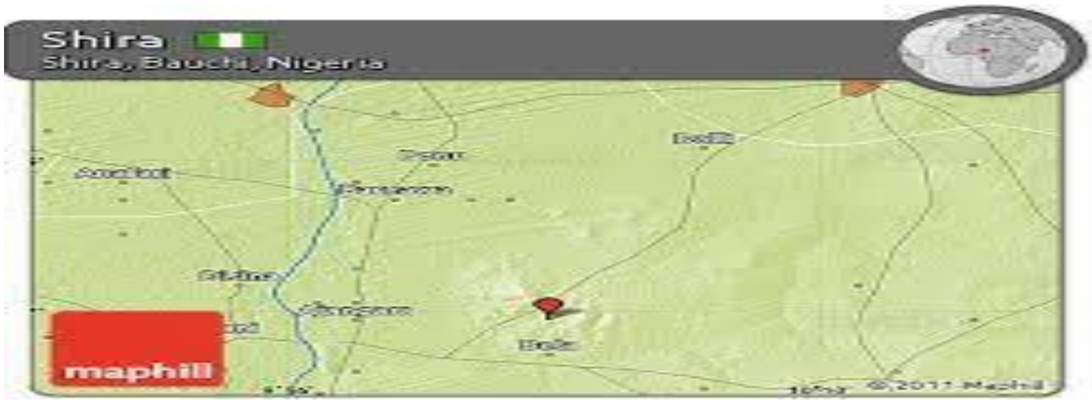
Shira local government area is one of the local government areas in Bauchi state Nigeria. Its administrative headquarters is located in Yana town, which area council contains districts of Shira, Beli, Audubun, Gagidoba, Bukul, Bangire, Disina, Faggo, Kilbori, Tsafi, Zubo and Tumfafi. It has an area of 1,321 km^2 and a population of 234,014 at the 2006 census. The postal code of the area is 750. It is located in the northern part of Bauchi state and shares boundaries with Katagum local government area in the north east, Giade local government area in the east and Jama'are local government area in the North West (Fig. 1).

1.2 Geology of the area

The most distinctive geologic features in the study area are the three exposed hill complexes, comprising one main ridge and two smaller secondary ridges covering an estimated 152 km^2. The main ridge, Sarkinna Dutse culminates at a height of 633.37m above sea level. The two smaller or secondary ridges are less exposed than the main ridge (Fig. 2). The composition of the rock ranges from quartz syenite to granite, with the central portion of the hill mostly composed of biotite granite (Bennett, 1981). The Shira Hill complex is an important part of the human geography and history of the area. The hills have not only served as a natural fortification for the past inhabitants but also as a refuge. It is on these hills, ridges and foothills that many of the early occupied sites are located, the hills and rocks constitute additional sources of revenue to the people through stone mining and quarrying. The rocks are mined using simple implements such as shovels and diggers, while the industrial companies stationed in Shira use heavy machinery for drilling and crushing the quartz/gravel into granite chips, sold as raw material for building and construction.

(redalyc.org)

Fig.: 1 Map of Bauchi state showing the study area



(maphill.com)

Fig. 2: Geological map showing the study area

2.0 Materials and Methods

2.1 Data collection

A total of hundred rock points were randomly selected within the study area. Background radiation readings were taken in the fields using a radiation survey meter. The meter was held at an elevation of 1 m above the ground level with its window facing the point under investigation. Readings were taken in mR/h directly from the display screen of the radiation meter and then converted into nGy/h. Global Positioning System was used to determine the coordinates of each location, at each survey point to reduce the error, and an average of the three readings were determined and recorded.

2.2 Data analysis

In order to evaluate the excess lifetime cancer risk associated with the rock samples from the study area, the following parameters were determined using established mathematical equations described below.

The absorbed dose is used to assess the potential for any biochemical changes in specific tissues. It quantifies the radiation energy that might be absorbed by a potentially exposed individual. The measured outdoor background exposure levels were converted to radiation absorbed dose rate in air using the equation below used by Idris *et al*. (2021)., Agbalagba *et al*. (2016) and Rafique *et al*. (2014).

The mean exposure rate in mR/hr for each location was converted to the absorbed dose rate in air in nGy/h, as shown below.

1milliRoentgen/hour = 2.7778 × 3600nGy/h

$$ADRAinnGy\frac{}{h} = ADRAin\frac{mR}{h} \times 2.778 \times 3600 \quad (1)$$

Where ADRA is the absorbed dose rate in nGyh-1. The annual effective dose equivalent was calculated using equations as shown below

$$AEDEindoormsv/y = \frac{\frac{ADRAnGy}{h} \times 0.7sv}{Gy} \times OF \times \frac{8760h}{y} \times 10 - 6 \quad (2)$$

$$AEDEoutdoormsv/y = \frac{\frac{ADRAnGy}{h}0.7sv}{Gy} \times OF \times \frac{8760h}{y} \times 10 - 6 \quad (3)$$

8760h is the total hours in a year, F is the dose conversion factor from the absorbed dose in air to the effective dose in Sv/Gy (F = 0.7 Sv/Gy), OF is the occupancy factor, the expected period the members of the population would spend within the study area. OF = 0.8 for indoor occupancy and 0.2 for outdoor occupancy as it is expected that human beings would spend 20 % of their time outdoors and 80% indoors as recommended by UNSCEAR (2008).

Excess lifetime cancer risk (ELCR) was evaluated using the AEDE values as used by Idris *et al*. (2021)., Agbalagba, *et al*., (2016) and Rafique *et al*. (2014).

$$ELCRindoor(\text{mSv}) = AEDE \times DL \times R \quad (4)$$

$$ELCRoutdoor(\text{mSv}) = AEDE \times DL \times RF \quad (5)$$

$$ELCR_{\text{Total}}\ (mSv) = AEDE\ (mSv)\ xDLxR\text{F}(3.4) \quad (6)$$

where DL is the average duration of life (70 years) and RF is the fatal cancer risk factor per sievert (Sv−1). For low-dose background radiation, which is considered to produce stochastic effects, ICRP 103 uses a fatal cancer risk factor value of 0.05 for public exposure (ICRP 1966) as used by (Lusimbo, 2019).

3.0 Results and Discussion

In this study absorbed dose rate in air, both indoor and outdoor excess lifelifetime cancer risks were taken into account for the calculation of total excess lifetime cancer risk (ELCR) . The measured absorbed dose rate in the study was found to range between 70.0056 nGy/h to 590.0472 nGy/h with an average value of 228.9183 nGy/h (Table 1). This is higher than the recorded world-weighted average of 59.00 nGyh-1 (Agbalagba *et al*., 2016) and the recommended safe limit of 84.0 $nGyh^{-1}$ (Ononugbo, 2016) for outdoor exposure. These dose rates results indicate contamination of the environment by radiation. which is higher than the world average of 55nGy/h given by UNSCEAR (2000). The level of absorbed dose rate was directly associated with the activity concentrations of radionuclides (^{238}U, ^{232}Th and ^{40}K) in the samples and cosmic rays, rocks always contain some natural radionuclides as uranium and thorium at different concentrations. These radionuclides are dispersed in the region only after long-lasting geological processes. Fig. 3 is a plot of the spatial variation of the absorbed dose rate.

The ing. above provides information about the dose rate of the measured points in the area, it was understood that the variation of the values of the measured point was according to the longitude and latitude. The excess lifetime cancer risk (ELCR) measured for indoor exposure ranged from 1.201966×10^{-3} to 10.13087×10^{-3} with an average value of 3.930436×10^{-3}. For outdoor exposure (ELCR) varies from 0.300492×10^{-3} to 2.532719×10^{-3} with a mean average of 0.982609×10^{-3}. The total excess lifetime cancer risk (ELCR) range from 1.50246×10^{-3} to 12.66359×10^{-3} with an average of 4.913045×10^{-3} which is higher than the world standard average of 0.29×10^{-3} see the Fig.4 below.

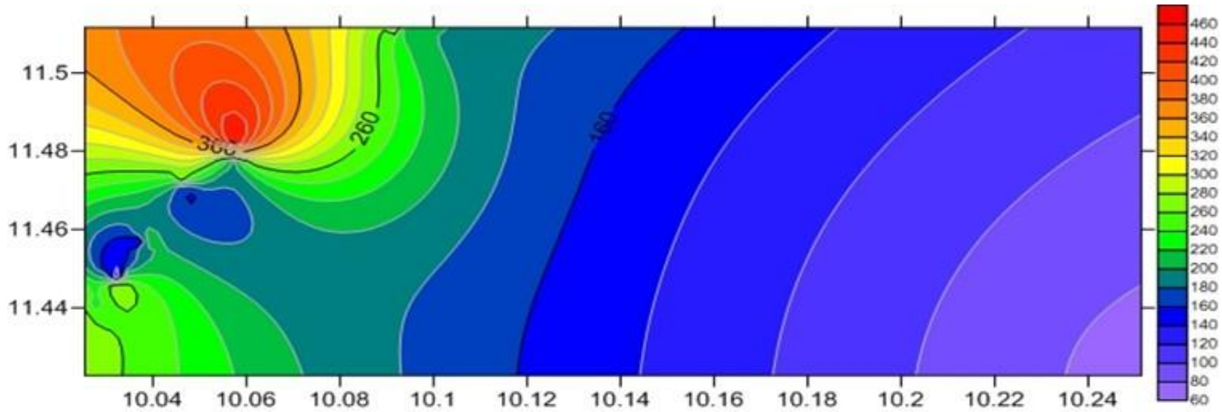


Fig. 3. Contour map showing average absorbed dose rate in air (nGy/h)

Fig. 4 provide radiation information on the probability of developing cancer over a lifetime at a given exposure level, the location at latitude 10.0576° and longitude 11.51152° has the highest excess lifetime cancer risk factor more than any other location within the area investigated. The mean value of excess lifetime cancer risk (ELCR) is 4.913045 x 10^{-3} which is in line with the value reported by Ononugbo *et al*. (2015) as 4.21x10-3 for Emologu village in River State, Nigeria. $3.21x10^{-3}$ reported by Qureshi *et al*. (2014) in the river's sediments of Northern Pakistan. $2.90x10^{-4}$ reported by Raymond (2016) in soils from Tudor Shaft mine environs, South Africa. $2.24x210^{-3}$ reported by Jafari *et al* (2017) in Gonabad, Iran, but higher than $0.449x10^{-3}$ reported by Sunday *et al*. (2017) and $0.794x10^{-3}$ reported by Idris *et al*. (2021) in Lafiya Metropolis, Nasarawa State, Nigeria. the mean value for excess lifetime cancer risk in this report is seen to be higher than the world's average of $0.29x10^{-3}$ recommended by (UNSCEAR 2000).

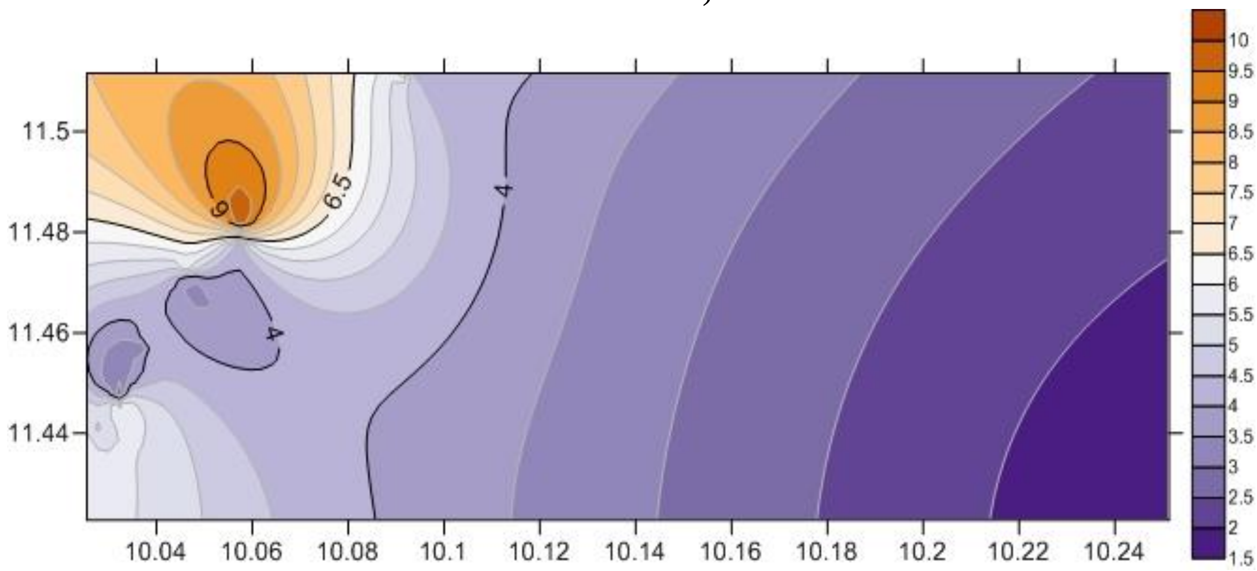


Fig. 4 contour map showing average excess lifetime cancer risk

It is also higher than the values recorded for most of the reported locations. Hence the area is at higher risk than those locations. It is, however, assumed that exposure to radiation for a long time has a risk of causing cancer. Men are by the report of Surveillance, Epidemiology, and End Results (SEER) cancer statistics, have a higher percentage lifetime cancer risk than women.

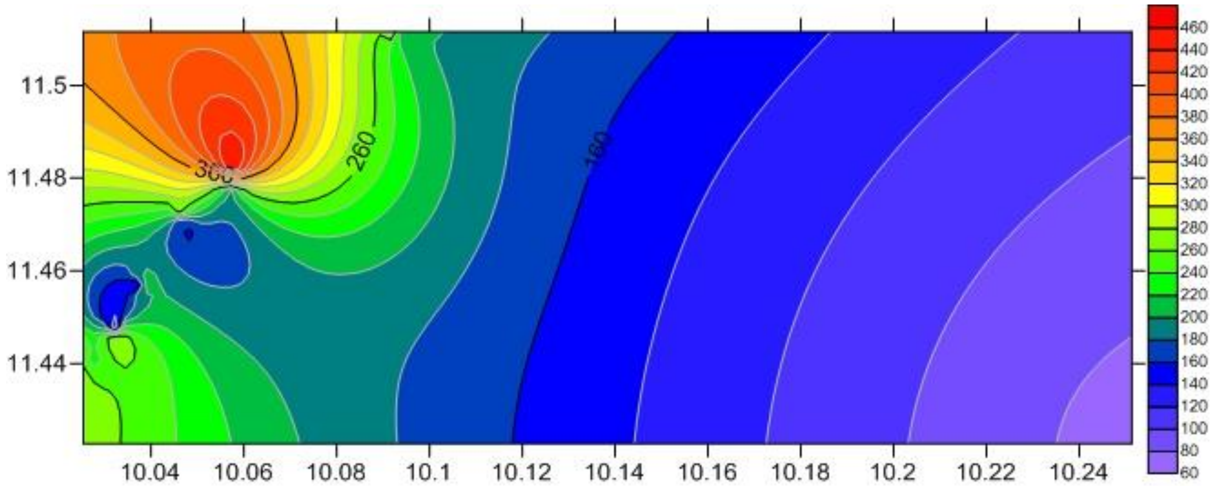


Fig. 3 Contour map showing average absorbed dose rate in air (nGy/hr)

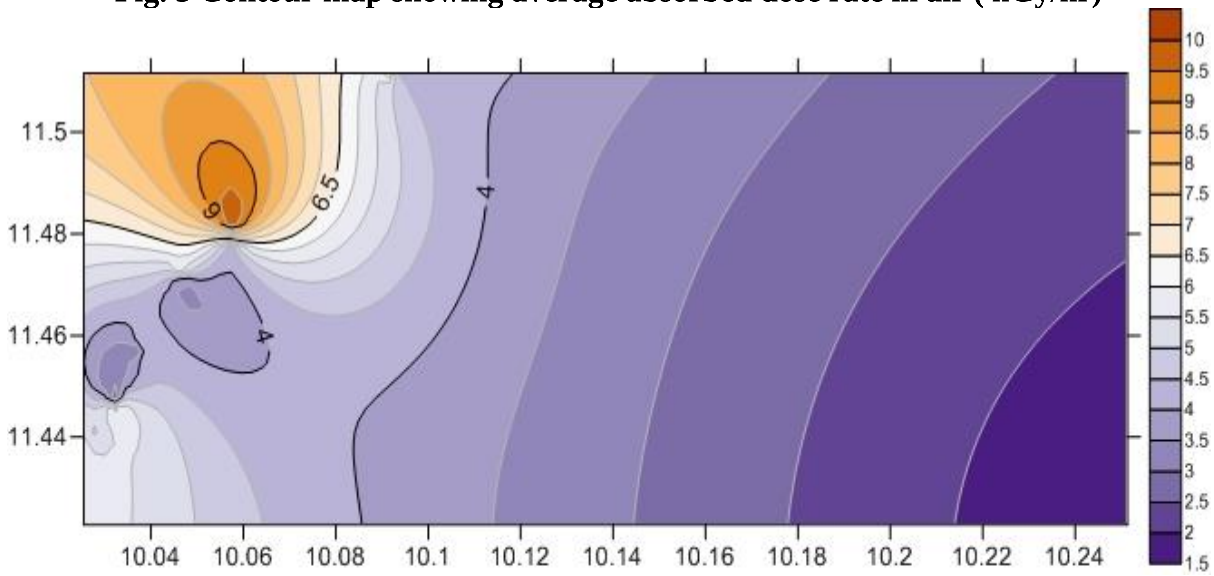


Fig. 4 contour map showing average excess lifetime cancer risk

4.0 Conclusion

This study assessed the natural radioactivity levels and associated excess lifetime cancer risk (ELCR) due to gamma radiation from rock samples in Shira Village, Bauchi State, Nigeria. Measurements showed that the absorbed dose rate in air ranged from 70.0056 to 590.0472 nGy/h, with an average of 228.9183 nGy/h, exceeding the global average of 59.00 nGy/h. The ELCR values for indoor and outdoor exposure were also higher than the global average, indicating increased cancer risk for residents. The findings highlight significant environmental contamination by natural radionuclides, which poses a potential health hazard. It is concluded that the elevated radiation levels could increase the risk of cancer among the local population. The study recommends regular monitoring of natural radioactivity, public awareness campaigns about the health risks, and implementing measures to minimize exposure to radiation in order to protect the health of the residents of Shira Village.

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Compliance with Ethical Standards Declaration

Ethical Approval

Not Applicable

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The authors declare that they have no known competing financial interests

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Availability of data and materials

Data would be made available on request.

Authors Contribution

This work was carried out in collaboration among all authors. Authors Bello Y. Idi, Rashida Adamu Bulkachuwa and Dauda Abubakar initiated the work. Authors Rashida Adamu Bulkachuwa, Bello Y. Idi, Dauda Abubakar, Abdullahi Lawal and Musa Muhammad Salihu managed the literature searches and guided the team. Authors S. A. Dalhatu, Dahiru Dahuwa and Salisu Tata performed Data analysis. All authors read and approved the final manuscript.