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Population Doses from Gamma Radiation Exposure around Damaturu Metropolis, Yobe State, Nigeria

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Abstract *Humans are exposed to radiation in their environment with or without their consent; and the exposure to natural background radiation is an unpreventable event on earth. Exposure to terrestrial background gamma radiation in Damaturu metropolis was measured in 65 locations using a hand held radiation survey meter (RDS-31). The gamma absorbed dose rate in air 1 m above ground surface ranged from 5 to 165 nGy h^{-1} with a mean value of 56±5 nGy h^{-1}. The study results revealed that, higher dose rates are located around the main roads within the city. The mean value was found to be within the set limit by UNSCEAR for normal background radiation. Thus, the dose rates are classified as low radiation level and are below the level to cause acute health effects in humans. The results obtained would serve as baseline data for further studies on background radiation in the study area.*

Key Words: *Gamma radiation dose rate, isodose map, kriging method*

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1.0 Introduction

The global population is continually exposed to background radiation from both natural and anthropogenic sources. The natural radiation comes from cosmic and terrestrial radionuclides within the earth's crust mainly due to primordial radionuclides ^{238}U, ^{232}Th and ^{40}K that were created during the earth's formation (Al-Jundi, 2002). According to UNSCEAR (2000), 86% of the total radiation exposed to the global population are consequences of natural radionuclides while 14% is from anthropogenic sources. The dosage of exposure to gamma radiation from natural sources is significantly determine by the amount of radionuclides in rocks and soil and vary from one location to another depending on the geology and geographical conditions of such locations (UNSCEAR, 2000). Therefore, exposure level to public varies from one geographical location to the other. Available literature revealed that people living in areas of granitic rock formation are more likely exposed to gamma radiation than those living in areas of sedimentary rocks indicating that different rock formation emits radiation at different rate (El-Arabi *et al.*, 2006). The worldwide annual effective dose received by the population from all natural and artificial sources is 2.8 mSv, out of which 85% of the dose (2.4 mSv) comes from only natural background radiations (Singh *et al.,* 2017).

Previous studies have shown that areas withhigh background radiation are found in Yangjiang, China; Kerele, India; and Ramsar, Iran (Ghiassi-Nejad *et al.*, 2002) and in Asia, maximum outdoor measurement was recorded in Malaysia and the maximum indoor measurement was recorded in Hong kong and Iran (Gholami *et al.*, 2011). A study by Karahan and Bayulken (2000) reported mean exposure of of 65 nGy^{-1} for Istanbul with equivalent annual effective dose of 80 μS. In a similar study, Leung *et al.* (1990) reported that before the Chernobyl accident, gamma dose rate for Hong Kong was 0.076 nGy y^{-1}. In a nationwide study, Furukawa and Shingaki (2012), found the average dose in Japan to be about 50 nGy y^{-1}. In Nigeria, several studies have been conducted to measure gamma radiation level in some areas. For instance, it is reported that the mean outdoor gamma radiation dose rate was 250 nGy y^{-1} in Jos, Plateau state (Abba *et al.*, 2017). Farai and Vincent (2006), reported that the equivalent dose due to outdoor exposure to radiation in Abeokuta, Nigeria ranged from 0.19 to 1.64 mSv/y with mean concentration of 0.45 $mSvy^{-1}$. A nationwide study of the terrestrial radiation in Nigeria (Farai and Jibiri, 2000) indicates that the mean annual effective dose equivalent is 0.27 mSv y^{-1}. Growth in population and technological advancement has led to the use and improper disposal of radioactive materials in

the environment. These activities will eventually enhance background concentrations of radiation and hence the amount and intensity that is emitted to the environment. Thus, studies of environmental natural gamma radiation level are significant in establishing baseline information on the geology and background level of radiation in such location .It helps in keeping data for normal background radiation before any eventualities in terms of radioactive contamination. Radiation data are useful tracers for atmospheric variational studies of environmental radioactivity and also furnish information that are relevant for evaluating national and international average values of radiometric and dosimetric quantities. It can also be used to check anthropogenic contamination of the environment (Ramli *et al.*, 2014).

Most of the studies conducted in the country are in the southern part of Nigeria with none or little in the northern region. Therefore, the present work aims at extending the survey to the towns in the northeastern region of Nigeria; it is also aimed at producing isodose map for the spatial distribution of background gamma radiation dose rates for the metropolis. The result of this survey would serve as baseline data for future references. The result is also required for producing radiological map for the region.

2.0 Material and methods

2.1 Study area

Damaturu is the state capital of Yobe state and is located between latitudes $11^0 39' 30'' - 11^0 47' 00''$ N and longitudes $11^0 34' 00'' - 12^0 02' 00''$ E (Fig.1). The town is on A3 highway and covers a land area of 2,366 km^2. According to 2006 census, the population of the area was ~~is~~ projected at 69,952 people for 2010 (NPC, 2006). Geologically, Damaturu is located within the fringe of Chad basin, The Chad basin constitute of sedimentary rocks such as clay, sands, sand stones, and shale intercalations (Agada et al,. 2020). The climate of Damaturu is characterised by short wet season (June – September) and long dry season (October – May), with high temperatures of about 39ºC to 49ºC. During the raining season, temperatures fall to about 25ºC with annual rainfall of about 500 to 1000 mm.

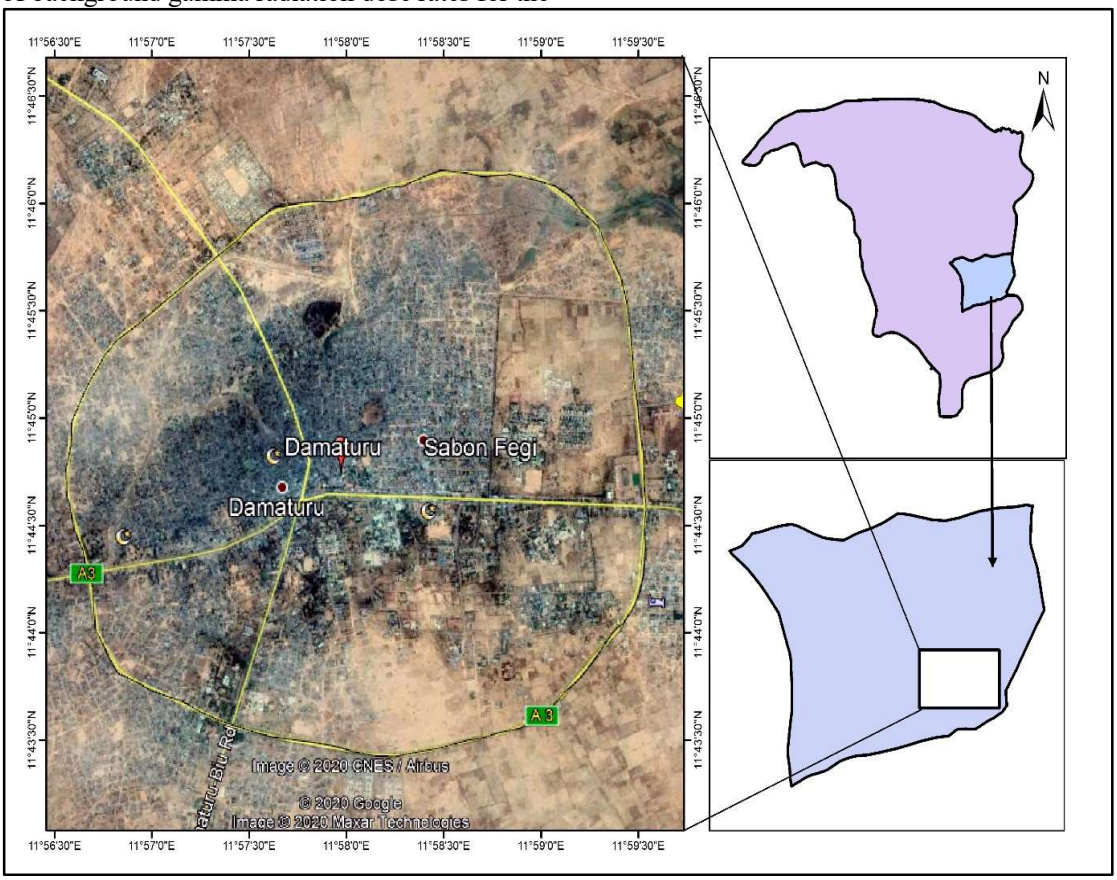

Fig. 1: Map of Yobe State showing study area where assessments were conducted.

2.2 Measurement of gamma radiation dose rate

A hand held modular radiation survey meter (RDS-31), was used to measure outdoor gamma radiation dose rates randomly at 65 different locations across the entire study area (Fig. 2). The instrument is versatile radiation detector and survey meter designed for a wide range of applications. Readings were displayed in μS h^{-1} which were subsequently converted to gamma absorbed dose per hour (1 nGy h^{-1} = 0.001 μS h^{-1}). Measurements were taking in open fields away from buildings and other structure to minimize interference from artificial sources. In order to minimize systematic error, the readings were taken in triplicate at each location and the average was recorded. Measurements were conducted at 1 m above the ground surface and the coordinates of the sampling locations were recorded using a Global Positioning System (GPS) device.

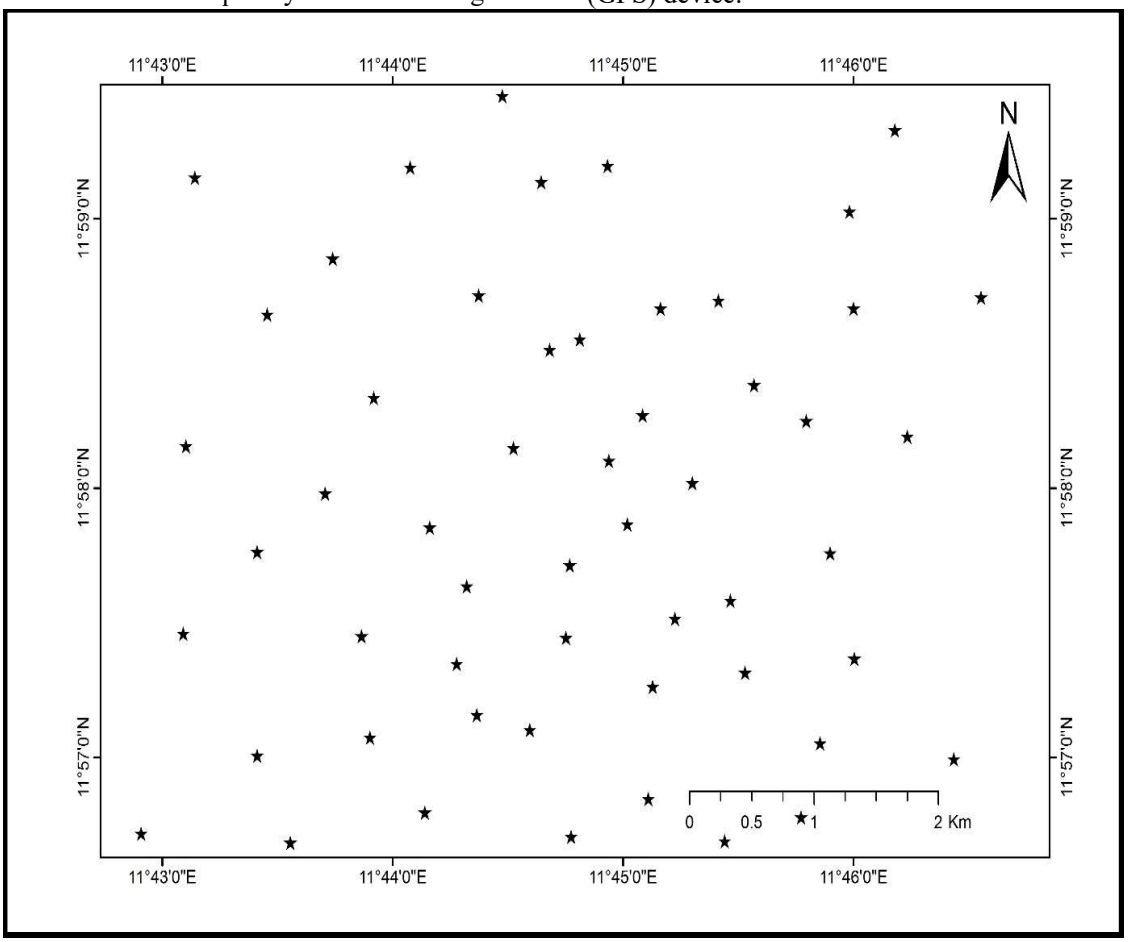

Fig. 2: Locations of gamma dose rates measurement

3.0 Results and Discussion

Table 1 shows the descriptive statistics of gamma radiation dose rates readings. The results indicate that dose rate in Damaturu metropolis ranged from 5 nGy h^{-1} to 165 nGy h^{-1} with a mean value of 56±5 nGy h^{-1}. The lowest dose rate was recorded in the northeastern part of the town, an area with low population density and less activities while the highest measured dose rate was measured in central part of the town, an area that is densely populated with significant human activities including heavy movement of automobiles. Enhanced gamma radiation levels were observed around the major roads within the metropolis. The results obtained indicate that background gamma radiation in Damaturu is below the UNSCEAR (2000) limit of 59 nGy h^{-1} for normal background gamma radiation. It also indicates that the natural background radiation level in the city does not pose ~~any~~ significant health risk to the inhabitants. Nevertheless, sources of higher radiation, especially around the major roads should be checked in order to minimize future induced risk

through additional emission. The results agreed with previous studies conducted in some cities in Nigeria (Agba *et al.*, 2006; Farai and Vincent, 2006; Obioha and Okonkwo, 2001; Ramli*, et al.*, 2014).

3.1 Isodose mapping of gamma radiation dose rates

Kriging method of interpolation using geographical information system (GIS) software was applied to plot the projection of dose rates for the entire study area. The Kriging provides the best unbiased linear estimation of dose-rate values (Sanusi *et al.*, 2014). Fig. 3 provides the spatial distribution of gamma radiation dose rates in air 1 m above the ground in Damaturu metropolis. It was observed that higher levels of dose rates are concentrated at the centre of the town and two locations in the northern part of the study area. This indicates the possibility of an anthropogenic sources in those areas with enhanced background radiation.

Table 1: Descriptive statistics of the measured gamma dose rates

Mean	56
Standard Error	5
Median	40
Mode	56
Standard Deviation	44
Kurtosis	0
Skewness	1
Range	160
Minimum	5
Maximum	165
Confidence Level (95%)	11

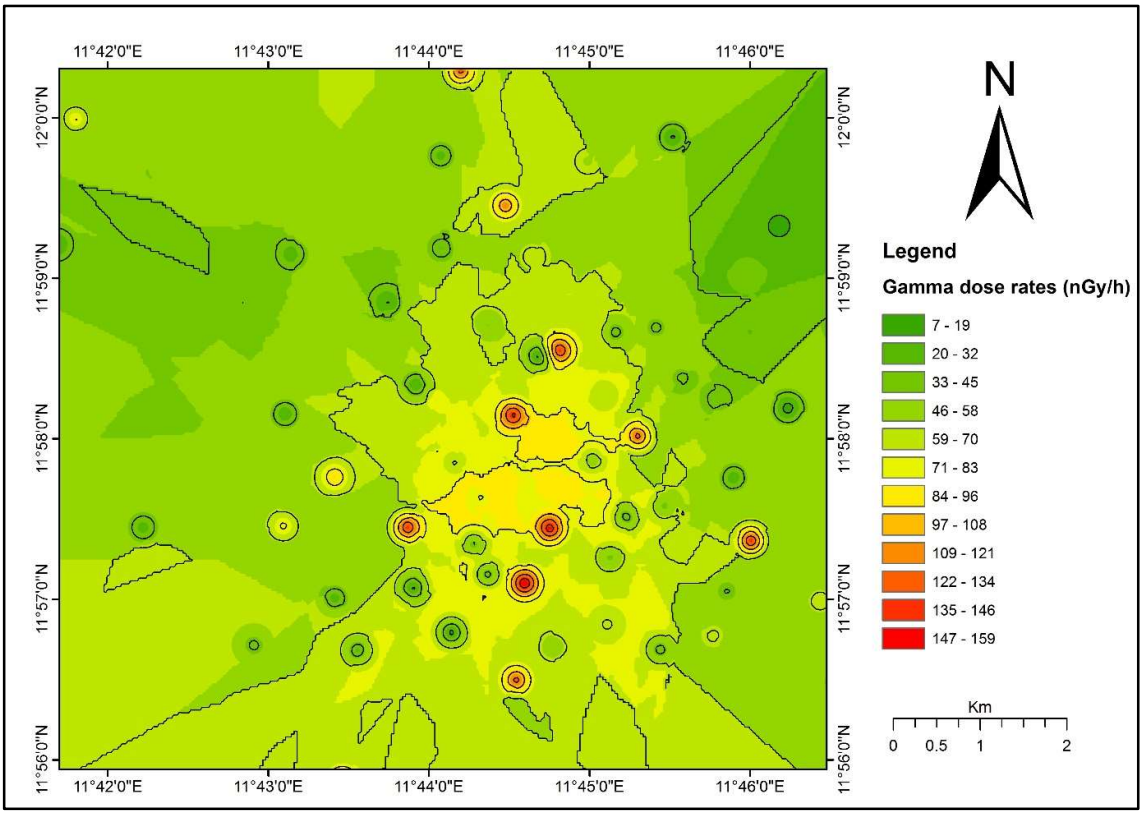

Fig. 3: Isodose Map of Damaturu Metropolis

4.0 Conclusion

This study present baseline information on the background gamma radiation dose rates in Damaturu and reveals that the lowest radiation level is in the northeastern zone of the city while the highest radiation value was observed in an area around the central market. Locations around the major roads were observed to exhibit higher dose rates. The results of this study are within the regulatory limits and are within the range of the average readings of radiation limits reported in literature. Results from the study area indicated that the natural background radiation level in the city does not pose any significant health risk to the

inhabitants. The results provide the essential baseline information for the assessment of any environmental radioactive contamination of the area in foreseeable future. It is therefore recommended that further studies should be carried out to identify the source of high dose rates within the city centre and around the major roads.

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