



ABSTRACT

Assessment of effective natural background radiation dose in Doma and Nasarawa Eggon Towns of Nasarawa State, Nigeria was calculated. The annual effective dose rate for both the indoor and outdoor data formed in each area were computed using an equation. 10 locations were selected in both towns. The survey meters used in this work was held at 1 m above the ground surface. It is observed that

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SSESSMENT OF EFFECTIVE NATURAL BACKGROUND RADIATION DOSE IN DOMA AND NASARAWA EGGON TOWNS, NASARAWA STATE, NIGERIA

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Introduction

We are exposed to natural radiation from the earth and outside the earth daily. We also receive exposure from man-made radiation, such as X-rays, radiation used for diagnosis diseases and therapeutic processes (Yusuf et al, 2022).

Natural occurring radioactive materials are present all around us; in the walls, stones, floors, schools, homes, offices and even in the food we eat and air we breathe. All our body organs, such as lung, skin, muscles, bones and tissues contain naturally occurring radioactive elements (Farai & Ademola, 2005). Industrial activities account for a significant percentage of contribution to total



the indoor annual effective dose rate for Doma town is from 0.9-1.1 mSv/yr and for Nasarawa Eggon town is from 0.90-1.17 mSv/yr. Data for the outdoor annual effective dose rate are within the recommended limits as it ranges from 0.23 to 0.28 mSv/yr for Doma town and 0.24-0.28 mSv/yr for Nasarawa Eggon town. It is found that the results are lower than the global recommended average of 2.4 mSv/yr. However, it is higher than the radiation dose limit of 1 mSv/yr for indoor individual members of the public in Nasarawa Eggon town. These results provide the essential baseline information for the assessment of any environmental radioactive contamination of the area in foreseeable future.

Keywords: Effective Dose, Environmental Radiation Monitoring, Public Exposure, Background Radiation.

environmental pollution and general degradation of the natural environment that we experience today (Hyacienth et al, 2022).

Furthermore, the advent of technology has further exposed us to radiation risk (Gholami et al, 2011). Some of the everyday sources of radiation emission are: Wi-Fi, power lines and other electrical products, 5G technology, cell phones cell phone towers and antennas, laser products smart metres microwave ovens etc (Sambo et al, 2024).

On average, Nigerians receive a radiation dose of about 0.62 rem (620 millirem) each year. Half of this dose comes from natural background radiation. Most of this background exposure come from radon in the air with smaller quantity from cosmic rays and the earth itself (Abdullahi et al, 2013).

It is no doubt that the quality of food, water and air we take is significant to our health. This is why Nigeria has made it a priority to monitor the environment through the ministry of environment by prioritizing environmental risk management (Caroline et al, 2013).

The government at all levels, have registered their intolerance towards the state of the environment and human health. This has prompted them to enact many decrees and promulgation of laws that compel citizens to respect the environment by keeping it clean (Agba et al, 2006). Sanitary and public health inspectors promote environmental health among Nigerians by ensuring that the monthly environmental



sanitation introduced in 1984 to ensure clean environment is obeyed and strictly adhere to. Through this routine program, which has become part and parcel of Nigerians, citizens are compelled to clean their surroundings at least once in a month (Olugbenga & Onesimus, 2009).

Generally, the biological effects of ionizing radiation vary with the type of energy (Mahmoud et al, 2020). A measure of the risk of biological harm is the dose of radiation that the tissue receives (Farai & Vicent, 2006). The unit of absorbed radiation dose is the Sievert (Sv). Since one Sievert is a large quantity, radiation doses normally encountered are expressed in milli-sievert (mSv) or micro-sievert (μ Sv) which are one-thousandth or one-millionth of a Sievert. For example, one chest X-ray will give about 0.2 mSv of radiation dose (UNSCEAR 1988).

Basic approaches to radiation protection are consistent all over the world (Ghiassi-nejad et al, 2002). The ICRP recommends that any exposure above the natural background radiation should be kept as low as reasonably achievable, but below the individual dose limits (Sadiq et al, 2010). The individual dose limit for radiation workers averaged over 5 years is 100 mSv, and for members of the general public, is 1 mSv per year (Farai et al, 2008).

In as much as strategies are put in place to monitor the intake of radiation, atomic radiation has no boundaries; and the injuries and clinical symptoms induced by exposure to ionizing radiation include; direct chromosomal transformation, indirect free-radical formation, radiation cataractogenesis, cancer induction, bone necrosis, etc (Termizi et al, 2014).

This research is therefore, intended to provide comprehensive Effective dose of natural background radiation in Doma and Nasarawa Eggon towns, Nasarawa State, Nigeria, bearing in mind the 2.4 mSv limit set by UNSCEAR and radiation dose limit of 1 mSv/yr for individual members of the public.

Review of Some Empirical Literature

Assessment and monitoring of the environment to curtail the excessive intake of radiation has been noted to be of importance, acting as insight to monitoring changes in environmental radioactivity related to anthropogenic activities or other events of release of radioactive elements.

Previous studies have shown that areas with high background radiation are found in Yangjiang, China; Kerele, India; and Ramsar, Iran; and in Asia, maximum outdoor



measurement was recorded in Malaysia and the maximum indoor measurement was recorded in Hong Kong and Iran (Sambo et al, 2021).

In Nigeria, studies have been conducted in different areas to measure the natural radiation level in the areas. For instance, Okeyode et al, 2019 reported that the equivalent dose due to outdoor exposure to radiation in Abeokuta, Nigeria ranged from 0.19 to 1.64 mSv /y with the mean of 0.45 mSv /y (9). A nationwide study of the terrestrial radiation in Nigeria according to Rasaki et al, 2019, indicates that the mean annual effective dose equivalent is 0.27mSv /y. Farai and Jibri in 2000 measured the background radiation in the mines of Nasarawa state; results indicated that Alizaga Quarry has the maximum reading of 2.60 mSv/y. While the effective dose equivalent at the Maloney Hill Quarry in Keffi is 1.75 mSv /y. A survey of gamma terrestrial radiation in Nigerian coal mine indicated mean outdoor readings of 10.4 mGy /h and 11.7 mGy/h for the Okaba and Okpara mines respectively (Mokobia and Balogun, 2004).

A study was conducted by Ajayi and Ibikunle in 2013, Oyo State, Nigeria, to investigate the radioactivity of surface soils in urban and rural areas. The result showed that the annual effective dose for urban areas was 0.1 mSv/yr, while that of rural areas was 0.3 mSv/yr, with a standard deviation of 0.02 mSv/yr and 0.3 mSv/yr for urban and rural areas, respectively. These are within the recommended standard set by UNSCEAR, 2000. Nwankwo et al, 2014 equally carried out a survey of ionizing radiation measurement and essay of corresponding dose rate around bottling and pharmaceutical facilities in Ilorin, Nigeria. The survey meters were held at 1 m above the ground surface while obtaining readings at 31 locations within the study area. Measured radiation levels range from 1.14 ± 0.09 to 2.48 ± 0.13 mSv/yr with a mean of 1.60 ± 0.26 mSv/ yr. The result shows that the exposure rates for all the stations are higher than the radiation dose limit of 1 mSv/yr for individual members of the public, while three stations are above the global average of 2.4 mSv/yr. It is recommended that areas with readings above global average be monitored closely to protect the public from adverse health effects.

Study Area

According to GPS coordinates, Doma lies on the geographical coordinates of $11^{\circ} 59' 0''$ N, $9^{\circ} 48' 0''$ E of Nasarawa State is a state in the North Central region of Nigeria and Nasarawa Eggon lies on the geographical coordinates of $8^{\circ} 43' 0''$ N, $8^{\circ} 32' 0''$ E of Nasarawa State is a state in the North Central region of Nigeria. Below is the map

of Nigeria capturing Nasarawa state, showing Doma and Nasarawa Eggon (Sadiq et al, 2010).

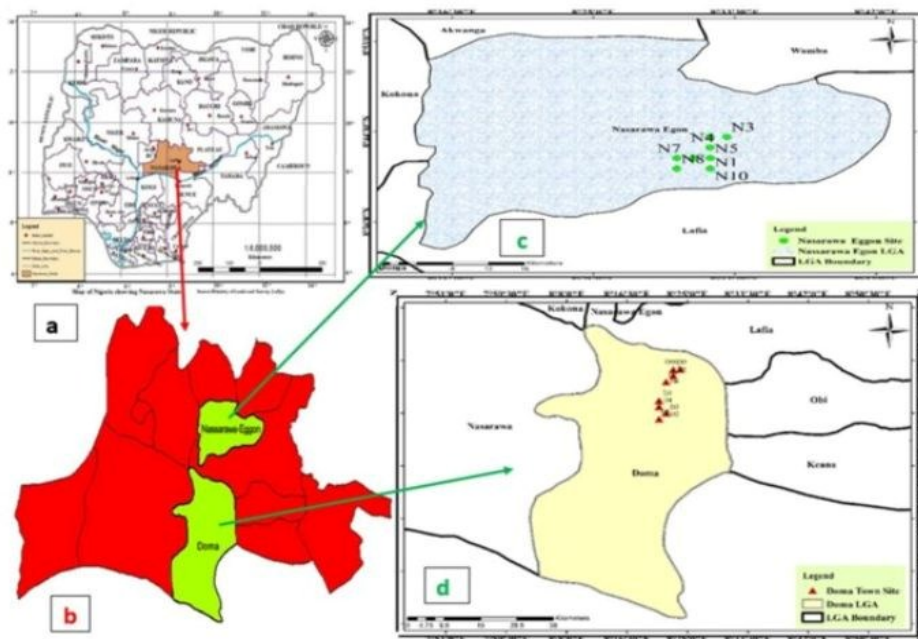


Figure 1: Map of Nigeria showing Nasarawa state (Anudu et al, 2011)

Material and Method

A calibrated Inspector Alert Nuclear radiation meter (SN:35440, by SE international, Inc. USA) was used for this study. The meter's sensitivity 3500 CPM/ (mR h-1) referenced to Cs-137 and its maximum alpha and beta efficiencies are 18% and 33% respectively. It has a halogen-quenched Geiger-Muller detector tube of effective diameter of 45 mm and a mica window density of 1.5-2.0 mg cm⁻² (Inspector alert operation manual).

Methodology

In this study, ten strategic locations were selected in Doma and Nasarawa Eggon respectively, due to some environmental factors. Some of these factors are: weather, soil moisture and other geological factors. Outdoor background radiation readings were taken in open fields that are away from buildings and Indoor measurements



were conducted in buildings and city halls. To account for errors in the data, ten (10) different readings were taken for both indoor and outdoor radiation in each sample area and the standard deviation of each data was obtained as the mean results. This is to minimize fluctuations and increase accuracy. The meter was held at 1 m above the ground level for both the indoor and outdoor radiation measurements.

Results and Discussion

In this section, results are presented in form of tables and graphs. Table 1 presents the equivalent dose rate (meter mean readings) and the annual effective dose equivalent for the areas in Doma. The table presents both the indoor and outdoor background radiation in the town. Table 3 presents the same parameters for the town of Nasarawa Eggon. Measurements were repeated ten times in order to obtain the average reading as well as the standard deviation (SD). The annual effective dose rate for both the indoor and outdoor data from each area were computed using equation (1) and (2)

$$E_i = X (\mu Sv/hr) \times 8760 \text{hrs/yr} \times 0.8$$

$$E_o = Y (\mu Sv/hr) \times 8760 \text{hrs/yr} \times 0.2$$

Where E_i and E_o are the indoor and outdoor effective dose equivalent (mSv/yr) respectively. X is the indoor meter reading (mSv/h) = Indoor absorbed dose rate and Y is the outdoor meter reading (mSv/h) = Outdoor absorbed dose rate. 0.8 and 0.2 are the indoor and outdoor occupancy factors respectively (Imeh et al, 2020). These occupancy factors are used to estimate the proportion of time that individuals spend in different environments, which can impact exposure to radiation. The ratios of indoor-to-outdoor background radiation were computed in order to compare with the UNSCEAR standard 1.5 for normal background.



Table 1: Indoor and outdoor background radiation in Doma town.

Area	Name of area	X ($\mu\text{Sv/hr}$)	Y ($\mu\text{Sv/hr}$)	$R = \frac{X}{Y}$	E _i (mSv/yr)	E _o (mSv/yr)
D ₁	Kasuwan Laraba	0.153	0.149	1.027	1.072	0.261
D ₂	St. Alusius Catholic Church	0.155	0.152	1.020	1.086	0.266
D ₃	Andoma's Palace	0.150	0.153	0.980	1.051	0.268
D ₄	Govt Sec Sch	0.128	0.134	0.955	0.897	0.235
D ₅	Govt College	0.148	0.136	1.088	1.037	0.238
D ₆	John Bosco	0.139	0.135	1.020	0.974	0.237
D ₇	Lafia Garrage	0.162	0.158	1.025	1.135	0.277
D ₈	RCM Primary Sch	0.146	0.142	1.028	1.023	0.249
D ₉	LG Secretariate	0.148	0.151	0.980	1.037	0.265
D ₁₀	Aliyu Ankwe's Wife Hospital	0.147	0.144	1.021	1.030	0.252

In the above table, the result shows that area D₇ (Lafia garage) has the highest indoor absorb dose rate, followed by area D₂ (St. Alusius Catholic Church). However, when it comes to outdoor absorbed dose rate, D₇ (Lafia garage) still maintain its leads while area D₃ (Andoma palace) is next. These could be traced to the fact that houses in these areas are built very closely without much spaces; this could result in high concentration of radon in the buildings. Also, mining activities are reported to be taking place not too far from the St. Alusius Catholic Church, Doma, which is in same axis with the area D₇.

It also indicates that the indoor and outdoor annual effective dose equivalent of the sample area D₇ (Lafia garage) is the highest (1.135 mSv/yr). Though, it is higher than the radiation dose limit of 1 mSv/yr for individual members of the public but below the



2.4 mSv limit set by international standard; and do not pose any significant health risk to the inhabitants, but should be checked.

Table 2: Indoor and outdoor background radiation in Nasarawa Eggon town.

Area	Name of area	X ($\mu\text{Sv/hr}$)	Y ($\mu\text{Sv/hr}$)	$R = \frac{X}{Y}$	E_i (mSv/yr)	E_o (mSv/yr)
N ₁	Govt Sci Sch	0.147	0.146	1.007	1.030	0.256
N ₂	Eggon Com Sec Sch	0.149	0.142	1.049	1.044	0.249
N ₃	Pilot Pri Sch	0.163	0.158	1.032	1.142	0.277
N ₄	Secretariate	0.169	0.157	1.076	1.114	0.275
N ₅	Mande Hall	0.143	0.140	1.021	1.002	0.245
N ₆	Kasuwa Doya	0.138	0.145	0.952	0.967	0.254
N ₇	New Market	0.142	0.139	1.022	0.995	0.244
N ₈	High Court	0.144	0.152	0.947	1.009	0.266
N ₉	Marafa Hall	0.142	0.139	1.022	0.995	0.244
N ₁₀	Police Station	0.167	0.154	1.084	1.170	0.270

Table 2 indicates that sample areas N₄ (Secretariate), N₁₀ (Police Station) and N₃ (Pilot Pri Sch) have the highest indoor and outdoor absorb dose rate in Nasarawa Eggon in those orders. This is traced to the fact that these locations are rocky and are on hill tops. In some of these locations, mining activities are taking place not too far from them.

Also, both the indoor and outdoor annual equivalent dose rate are higher in the sample areas listed above. Though, in comparison, the annual effective doses in these areas are below the 2.4 mSv limit set by UNSCEAR; and do not pose any much health risk to the occupants. However, the radon levels in these areas (N₄, N₁₀ and N₃) with a significantly higher radiation level should be checked in order to minimize the risk of any type of radiation-induced injuries in these areas. And taking into cognizance the individual member of the sampling areas, the radiation dose limit of 1 mSv/yr for individual members of the public is exceeded for the indoor annual effective dose rate of many of the locations.

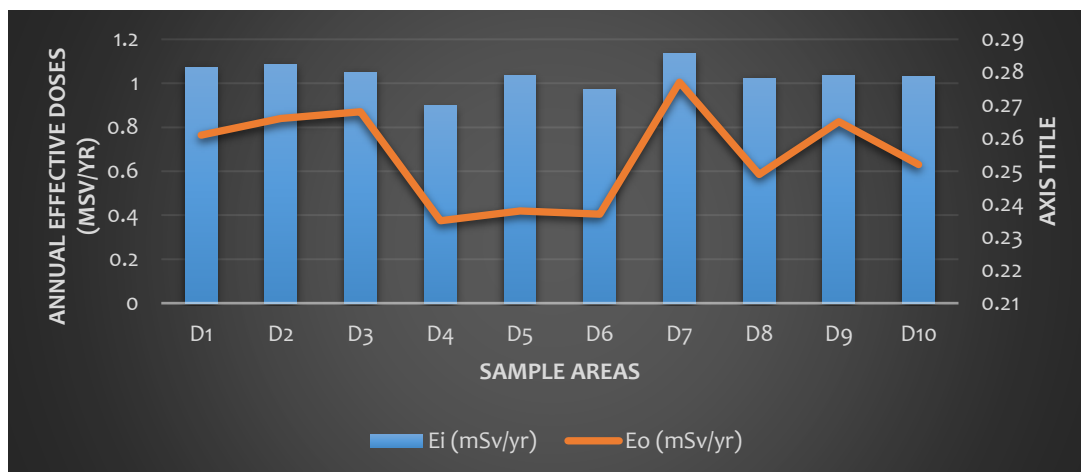


Figure 2: Indoor and outdoor Annual effective dose equivalent in Doma.

In this figure, it is now more obvious as the sample area D₇ has the highest indoor and outdoor annual effective dose rates. This location is rocky and near mining site.

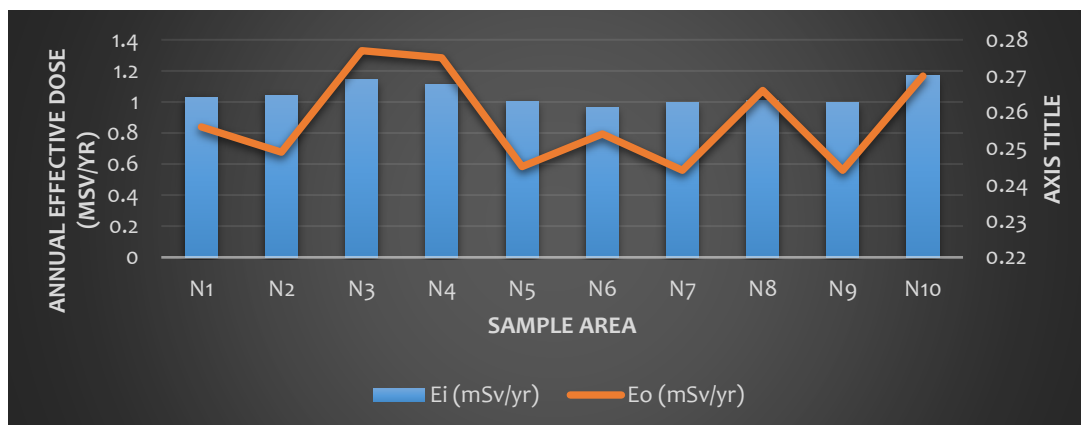


Figure 3: Indoor and outdoor Annual effective dose equivalent in Nasarawa Eggon

In this figure, sample areas N₃ N₁₀ and N₄ have the highest annual effective dose rate. However, they are below the 2.4 mSv limit set by UNSCEAR; and do not pose any significant health risk to the inhabitants.

The results are in agreement with previous works carried out in some Nigerian cities and were cited in the literature. Also, the result agreed with the standard results by UNSCEAR limit. As for the areas with higher indoor and outdoor radiation, it is recommended that the radon level in buildings around these areas be measured using the technique specified for radon gas measurement in buildings. It's hoped that the



result of this work would serve as a reference in the future; as well as serve as a benchmark for future works.

Conclusion

The average effective dose rates for both indoor and outdoor radiation exposure in Doma and Nasarawa Eggon towns have been measured using a halogen-quenched GM detector. These results provide the essential baseline information for the assessment of any environmental radioactive contamination of the area in foreseeable future. This study has therefore, shown that the radiation level in both Doma and Nasarawa Eggon are within the regulatory limits and are within the range of the average readings of radiation limits reported in the literatures. However, indoor radiation dose limit of 1 mSv/yr for individual members of the public is exceeded in many cases.

Recommendations

We therefore recommend that:

1. People should maintain a balanced diet, exercise regularly and avoid smoking.
2. People using town halls and other buildings for events should ensure proper ventilation and maintenance.
3. Government and individuals should provide means to monitor radiation levels in homes, workplaces and environments.
4. Radiation-emitting equipment should be regularly inspected and maintained.
5. People should limit time spent in areas with high radiation levels.
6. People should increase distance from radiation related sources.
7. Stakeholders should ensure medical image justification and optimization for medical applications of radiation

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