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Radiological Assessment of Exposure to Background Ionizing Radiation in Ogbomoso South Local Government, Oyo State, Nigeria

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ABSTRACT
The radiological evaluation of rural areas in developing countries is frequently overlooked due to the assumption of minimal radiation risk and low levels of industrialization. This research aims to fill this gap by assessing the background radiation level in Ogbomoso South Local Government, Oyo State, Nigeria, and estimating the radiological risks. One thousand sampling locations were randomly selected across the ten administrative wards of the study area, and the radiation level was examined using a dosimeter. The recorded dose rates varied between 0.09 and 0.17 μSvh^{-1}, with an overall mean of 0.13 μSvh^{-1}. This average is 48.2% lower than the global mean of 0.27 μSvh^{-1}. The estimated annual effective dose equivalent ranged from 0.15 to 0.30 mSvy^{-1}, with an average of 0.23 mSvy^{-1}, which is 23.1% below the acceptable limit of 1 mSvy^{-1}. The study shows that the current levels of radiation exposure do not present a significant radiological threat. It recommends establishing a regular monitoring program to observe changes over time, with this data serving as a baseline for Ogbomoso South Local Government.

Keywords:
Background ionizing radiation,
Ogbomoso South,
Oyo State,
Radiological Assessment.

INTRODUCTION

Gamma radiation, which arises from the natural decay of primordial radionuclides and cosmic rays, is the main type of ionizing radiation exposure for humans (UNSCEAR, 2000). This form of high-energy radiation is a major contributor to the overall background radiation that people encounter (UNSCEAR, 2000). Extended exposure to this radiation can damage cellular structures and lead to biological harm, thereby increasing the likelihood of developing cancer (IAEA, 2015). Exposures to radiation are mainly from non-serial ^{40}K, the decay series of ^{232}Th and ^{238}U found in different environmental matrices on the Earth's surface. The concentrations of these radionuclides vary with geological and geographical features of any region (UNSCEAR, 2000). Furthermore, human activities such as mining, medical procedures, and nuclear energy production enhance human exposure to ionizing radiation (Isola *et al.*, 2019; WHO, 2019). Consequently, background ionizing radiation (BIR) is an environmental element with significant health consequences (UNSCEAR, 2000).

Understanding the levels of background radiation in the environment is crucial for evaluating the impacts of radiation exposure on humans, estimating the natural radioactivity levels without needing laboratory tests (Al-Azmi, 2010), and serves as a foundational reference for evaluating potential radioactive contamination or pollution in the environment in the future (Olagbaju *et al.*, 2021). Unfortunately, the remote nature and varied characteristics of rural communities complicate the assessment and management of background radiation and radiological hazards (Nwankwo, 2014). Thus, the lack of data in rural settings restricts the understanding and recognition of the radiation hazards, highlighting the need for thorough radiological evaluations.

Despite numerous studies conducted in the developed area of Ogbomoso land, particularly in Ogbomoso North (Akinloye *et al.*, 2007; Akinloye, 2008; Oladapo and Oni, 2015; Isola *et al.*, 2018; Lawal *et al.*, 2023), there has been a lack of radiological research in the rural parts of the region. This study seeks to fill that gap by evaluating the background radiation levels in the administrative wards of Ogbomoso South Local Government, located in Oyo State, Nigeria, and by calculating the annual effective dose equivalent (AEDE). Furthermore, it establishes a baseline for eco-radiological data before any construction of infrastructural projects, including nuclear power plants, petrochemical facilities, industrial complexes, airports, and water supply systems.

MATERIALS AND METHODS

Study area

The study was carried out in 10 administrative wards within the Ogbomoso South Local Government, situated in southwestern Nigeria, specifically in Oyo State (Figure 1). It is the one of the Local Government created from the defunct Ogbomoso Local Government in 1991 by Military Administration. This area, located at approximately 8°13'0" N latitude and 4°15'0" E longitude, spans roughly 88 km². According to the National Population Commission (2006) the local government had a population of 100,379 persons. In its 2016 release, the population was projected to be 141,000 National Bureau of Statistics (2017). Ogbomoso South Local Government was selected for the study due to its distinct geological features and the variety of economic activities present, such as agriculture, artisanal textile manufacturing, and welding. Additionally, the region's ecological aspects, which include soil, water, and plant life, significantly influence the distribution and accumulation of naturally occurring radioactive materials.

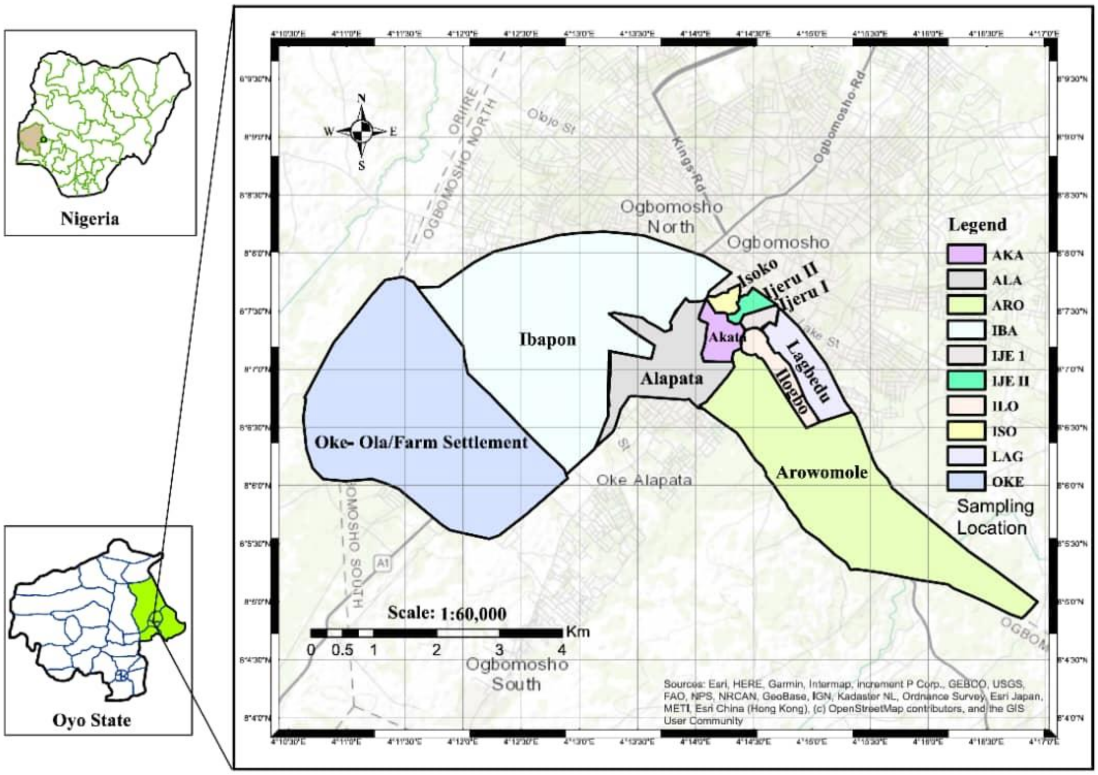

Figure 1: Map of the study area, indicating the sampling locations

Sampling Locations

One hundred sampling locations were chosen from each of the 10 rural administrative wards within the study region to assess background ionizing radiation (Figure 1). In total, 1000 measurements were conducted at intervals of 5 meters, with the average calculated after every pair of consecutive trial measurements.

Measurement of Background radiation

The background ionizing radiation was assessed using a Radex (RD 1503), a portable dosimeter that features a Geiger-Muller detector tube. This device can identify gamma and beta radiation. It functions effectively within a temperature range of -10°C to 50°C and can operate in relative humidity levels up to 80% at +25°C. At each sampling site, the detector was positioned at 1 m above the ground, which is a reasonable position of holding a dosimeter and the strategic location of radiosensitive organs, and a thorough scan was conducted to obtain a precise representation of the background radiation. This process was repeated at each location to ensure the consistency and reliability of the background ionizing radiation measurements across the administrative wards.

Estimation of Annual Effective Dose Equivalent

The annual effective dose equivalent (AEDE), which indicates the radiation dose absorbed by individuals residing in the study areas, was determined by Equation 1 (Fredrick, 2017).

$$AEDE\ (mSvy^{-1}) = ADR \times 8760\ (hy^{-1}) \times 0.2 \times 10^{-3} \quad (1)$$

where ADR is the average gamma dose rate in μSvh^{-1}, 0.2 is the outdoor occupancy factor, 8760 hy^{-1} is the conversion factor from hours to year, 10^{-3} is the conversion factor from $\mu Svhr^{-1}$ to $mSvhr^{-1}$.

RESULTS AND DISCUSSION

Table 1 provides a summary of the descriptive results obtained from the in-situ measurements of background ionizing radiation at various study locations. The findings indicated that the lowest levels of terrestrial gamma radiation were detected at three sites (ALA, ARO, and IJE II), while the highest levels were found at five locations (ISO, LAG, ARO, AKA, IJE II). The variations in dose rate values were noted across the ward and were quite similar to the average measurements. These differences in Average Dose Rate (ADR) values can be linked to the varying geological factors and soil properties across the wards, which affect the distribution and accumulation of naturally occurring radioactive materials (Beretka, 1985; UNSCEAR, 2000). The average gamma dose rates (ADR) in the area, as illustrated in Figure 2, ranged between 0.12 to 0.14 μSvh^{-1}, yielding an overall average of 0.13 μSvh^{-1}. The figure indicates that the results obtained from each location studied are consistent. The overall average for the study area is 48.2% lower than the global average of 0.27 μSvh^{-1} reported by UNSCEAR in 2000. This implies that the area is subject to minimal anthropogenic influence, with natural background radiation being the main source. The overall ADR value was also compared with findings from previous studies conducted in the urban region of Ogbomoso land and elsewhere, are as detailed in Table 2. The results of this study align with the range of background radiations documented in existing literature. The variations in the reported values may be due to the geological characteristics and human activities present at the locations of studies (UNSCEAR, 2000). In all, these investigations confirm that the levels of background ionizing radiation observed in the current study area are within safe parameters.

Table 1: Descriptive summary of the dose rate at each studied location

Locations	Min (μSvh^{-1})	Max (μSvh^{-1})	Mean (μSvh^{-1})
IJE I	0.10	0.15	0.12
IBA	0.10	0.16	0.13
ISO	0.11	0.17	0.13
ILO	0.11	0.16	0.13
LAG	0.11	0.17	0.13
ALA	0.09	0.16	0.13
ARO	0.09	0.17	0.14
AKA	0.11	0.17	0.14
IJE II	0.09	0.17	0.14
OKE	0.11	0.16	0.14

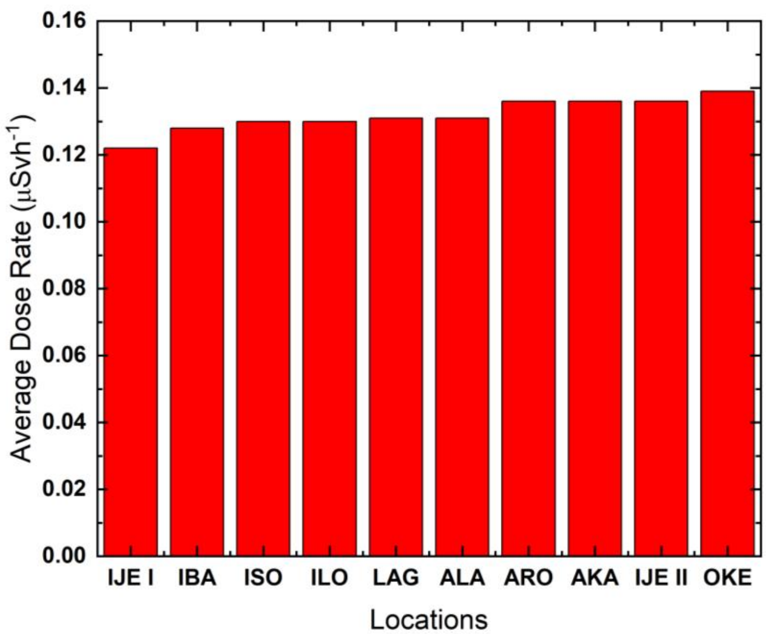

Figure 2: Distribution of the background radiation at each of the administrative wards

Table 2: Comparison of this results obtained for ADR with those from other studies

Author	**ADR Value** (μSvh^{-1})
Akinloye *et al*, 2007	0.04
Adewale *et al*., 2015	0.07
Ajayi and Ibikunle, 2015	0.13
Oladapo and Oni, 2015	0.04
Essiett *et al*., 2015	0.12
Osimobi *et al*., 2015	0.16
Alkasim *et al*., 2017	0.13
Isola *et al*., 2018	0.02
Olagbaju *et al*., 2021	0.05
Ajetunmobi *et al*., 2023	0.10
Present Study	0.13

The outcomes for background radiation were translated into the estimated annual effective dose equivalent (AEDE) results listed in Table 3. The findings indicated that IJE II recorded the lowest AEDE value, whereas the highest values were observed at ISO and LAG, respectively. The average calculated AEDE ranges between 0.21 and 0.24 mSvy^{-1}, with an overall mean of 0.23 mSvy^{-1}. This value is 23.1% lower than the recommended maximum limit of 1 mSvy^{-1} for the public, as stated by the ICRP (2007), demonstrating adherence to globally recognized radiation safety standards. The obtained values are consistent with AEDE figures from earlier studies. Although all estimated values fall within safe limits for public exposure, it is crucial to maintain ongoing monitoring, particularly in regions like OKE where higher values were noted. Areas with increased annual dose rates (ADR) and AEDE values might necessitate thorough environmental evaluations to pinpoint and address sources of elevated radiation levels.

Table 3: Descriptive summary of the annual effective dose equivalent at each studied location

Locations	**Min (mSvy^{-1})**	**Max (mSvy^{-1})**	**Mean (mSvy^{-1})**
IJE I	0.17	0.25	0.21
IBA	0.18	0.28	0.22
ISO	0.18	0.30	0.23
ILO	0.18	0.28	0.23
LAG	0.18	0.30	0.23
ALA	0.16	0.28	0.23
ARO	0.16	0.29	0.24
AKA	0.18	0.29	0.24
IJE II	0.15	0.29	0.24
OKE	0.18	0.27	0.24

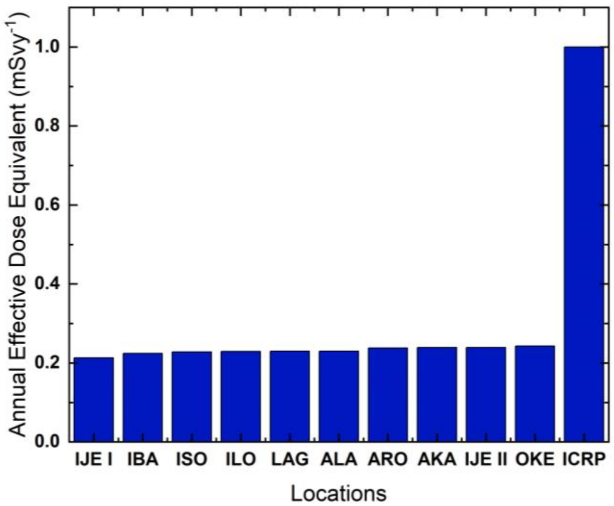

Figure 3: Comparison of the estimated AEDE with ICRP limit.

CONCLUSION

The current background ionizing radiation levels measured in Ogbomoso South Local Government are relatively low and remain within international thresholds, presenting no significant radiological threat. The findings showed that the background ionizing radiation and the estimated annual effective dose equivalent were 48.2% and 23.1% of the global average and the permissible limits, indicating a lower expected radiation exposure with no considerable health risk. It is hereby recommended than a routine radiological monitoring program be conducted to quickly detect any alterations or trends in environmental radiation levels, with this data serving as a baseline for the area under study.

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