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Spatial Distribution and Assessment of Background Ionizing Radiation in Gwagwalada, Abuja, Nigeria

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Abstract:** Background ionizing radiation (BIR) constitutes a major component of environmental radiation exposure and varies spatially due to geological, anthropogenic, and environmental factors. This study assessed the spatial distribution and levels of background ionizing radiation in Gwagwalada Area Council, Abuja, Nigeria. In situ radiation measurements were conducted across selected locations using a Geiger-Muller calibrated portable radiation dosimeter. The measured background ionizing radiation levels across Gwagwalada ranged from 0.11±0.02µSv/h to 0.42±0.05µSv/h, with a mean value of 0.17±0.09 µSv/h. The highest radiation level was observed at the University of Abuja Teaching Hospital (0.42 ± 0.58 µSv/h), followed by Phase II (0.21 ± 0.05 µSv/h) and Phase I (0.20 ± 0.04 µSv/h). Moderate levels were recorded at Angwadodo (0.15 ± 0.05 µSv/h), the University of Abuja Main Campus (0.15 ± 0.03 µSv/h), Phase III (0.13 ± 0.02 µSv/h), and Old Kutunku (0.12 ± 0.01 µSv/h), while the lowest values were observed at Paiko (0.11 ± 0.02 µSv/h) and the University of Abuja Mini Campus (0.11 ± 0.03 µSv/h). These results indicate a relatively moderate but variable distribution of background radiation across the study locations. Higher radiation levels were observed in areas with increased human activities. The findings indicate that background ionizing radiation levels in Gwagwalada are generally within safe limits; however, continuous monitoring is recommended to detect future changes due to urbanization and infrastructural development.

***Keywords:** Radiation, dose rate, Gwagwalada*

I. INTRODUCTION

Radiations are an essential part of our ecosystem. Ionizing radiation is widely utilized for beneficial purposes, including medical imaging, cancer therapy, sterilization of medical instruments, and various industrial processes [1, 2]. Yet, the environmental consequences of radiation leaks are severe and hazardous.

Background ionizing radiation originates from natural sources such as cosmic rays, terrestrial radionuclides, and internal radionuclides within the human body, as well as from anthropogenic activities, including medical procedures, industrial processes, and construction materials [3-5]. Natural background radiation contributes significantly to the total radiation dose received by the general population worldwide [6].

Variations in background radiation levels are strongly influenced by geological formations, soil composition, altitude, and human activities [7]. Urban expansion and increased infrastructural development may further modify environmental radiation levels through the use of naturally radioactive building materials and technological sources [6].

The study of the environmental consequences of radiation is essential for multiple reasons. It informs risk assessment, environmental management, and disaster preparedness strategies, while also guiding regulatory frameworks for nuclear safety and radiation protection. Insights gained from both historical accidents and ongoing environmental monitoring provide critical evidence for designing remediation measures, developing public health policies, and implementing sustainable land and water management practices.

Gwagwalada Area Council, located in the Federal Capital Territory (FCT) of Abuja, has experienced rapid population growth and infrastructural development in recent years. Despite this growth, limited data exist on the spatial distribution of background ionizing radiation in the area. Establishing baseline radiation levels is essential for environmental monitoring, public health protection, and radiological risk assessment.

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This study, therefore, aimed to assess the spatial distribution and magnitude of background ionizing radiation in Gwagwalada, Abuja, and to compare the measured values with internationally recommended safety limits.

The objectives are to:

i. Assess background radiation doses at different locations in Gwagwalada, Abuja
ii. Analyze the average and overall background radiation dose rate in Gwagwalada, Abuja

This review aims to synthesize global evidence on the environmental impacts of nuclear accidents and radiation leaks. By integrating findings from major historical events, naturally high-background radiation areas, and contemporary research on ecological and human exposure. Hence, this narrative synthesis seeks to provide a comprehensive understanding of radiation's consequences, highlights strategies for sustainable environmental protection, disaster preparedness, and effective regulatory oversight in the context of both natural and anthropogenic radiation hazards.

II. METHODS

Study Area

The location of the study was Abuja (9.0765°N, 7.3986°E), Federal Capital Territory, Nigeria. The field studies were carried out in the Gwagwalada area (8.9508°N, 7.0767°E), Abuja, Nigeria [3]. The area is characterized by a mix of residential, commercial, institutional, and agricultural land use, with underlying basement complex geology typical of north-central Nigeria.

Gwagwalada is a local government area and the main town in the Federal Capital Territory in Nigeria. Gwagwalada has an area of 1,043 km^2 and a population of 157,770 in 2006.[8] Although Gwagwalada's total population was more than a quarter of a million in 2023, it is bordered by other local governments, which are Abaji, Kuje, and Kwali.[9]

Instrumentation

Background ionizing radiation measurements were obtained using a portable calibrated radiation survey meter- RDS-31 Geiger-Müller counter, which ensures accuracy and reliability of measurements.

RDS-31 GEIGER MULLER COUNTER

Figure 1: RDS-31 Geiger Muller Counter

Measurement Procedure

In situ radiation measurements were carried out at selected sampling locations across Gwagwalada. Measurements were taken at approximately 50 centimeters above ground level. At each location, readings were recorded over a fixed time interval, and the average value was computed to minimize fluctuations.

Geographic coordinates of each sampling point were recorded using a handheld Global Positioning System (GPS) device to facilitate spatial analysis.

Spatial Analysis

Spatial distribution maps of background radiation were generated using Geographic Information System (GIS) software.

Data Analysis

Descriptive statistical analyses were performed to determine the mean, standard deviation, and overall mean of radiation dose rates using Jamovi software. Bar charts were plotted using Microsoft Excel 2021. Additionally, measured values were compared with international reference limits recommended by UNSCEAR and the International Atomic Energy Agency (IAEA) [10, 11].

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III. RESULTS

The measured background ionizing radiation levels across Gwagwalada ranged from 0.11±0.02μSv/h to 0.42±0.05μSv/h, with a mean value of 0.17±0.09 μSv/h. The highest radiation level was observed at the University of Abuja Teaching Hospital (0.42 ± 0.58 μSv/h), followed by Phase II (0.21 ± 0.05 μSv/h) and Phase I (0.20 ± 0.04 μSv/h). Moderate levels were recorded at Angwadodo (0.15 ± 0.05 μSv/h), the University of Abuja Main Campus (0.15 ± 0.03 μSv/h), Phase III (0.13 ± 0.02 μSv/h), and Old Kutunku (0.12 ± 0.01 μSv/h), while the lowest values were observed at Paiko (0.11 ± 0.02 μSv/h) and the University of Abuja Mini Campus (0.11 ± 0.03 μSv/h). These results indicate a relatively moderate but variable distribution of background radiation across the study locations.

Spatial distribution analysis (Figure 2) revealed noticeable variations in background radiation levels across different locations. Elevated radiation levels were observed in areas with dense human activities and road networks (Phase I and Phase II), while lower levels were recorded in less developed and vegetated areas (Paiko and Old Kutunku).

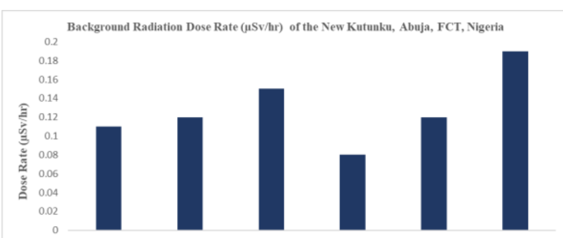

Figure 2: Background Radiation Dose Rate (μSv/hr) of the New Kutunku, Gwagwalada Area Council, Abuja, FCT, Nigeria

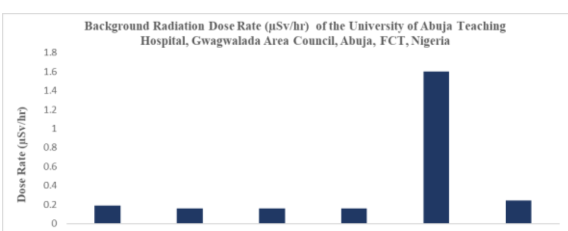

Figure 3: Background Radiation Dose Rate (µSv/hr) of the Gwagwalada Teaching Hospital, Gwagwalada Area Council, Abuja, FCT, Nigeria

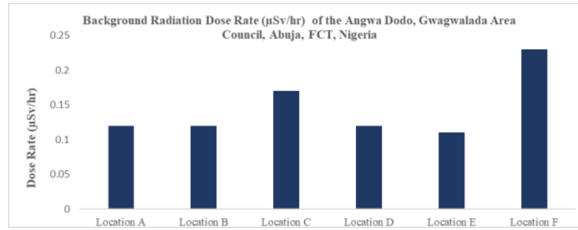

Figure 4: Background Radiation Dose Rate (µSv/hr) of the Angwadodo, Gwagwalada Area Council, Abuja, FCT, Nigeria

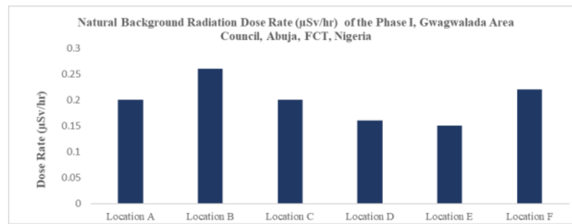

Figure 5: Background Radiation Dose Rate (µSv/hr) of the Phase I, Gwagwalada Area Council, Abuja, FCT, Nigeria

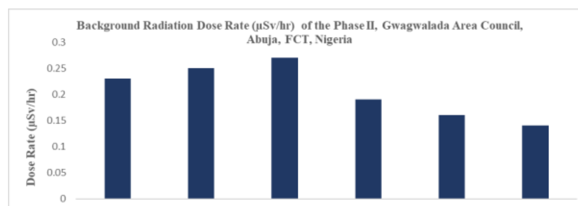

Figure 6: Background Radiation Dose Rate (µSv/hr) of the Phase II, Gwagwalada Area Council, Abuja, FCT, Nigeria

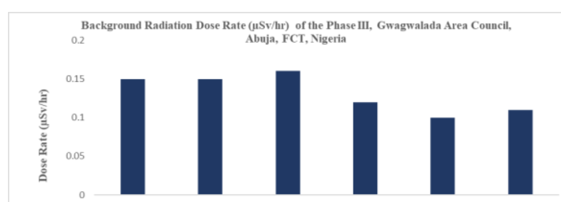

Figure 7: Background Radiation Dose Rate (µSv/hr) of the Phase III, Gwagwalada Area Council, Abuja, FCT, Nigeria

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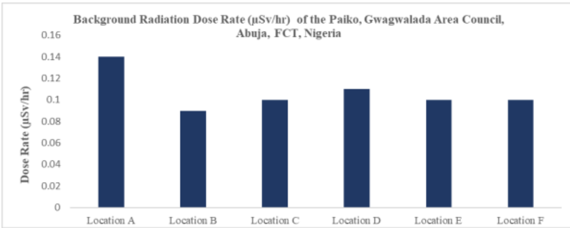

Figure 8: Background Radiation Dose Rate (µSv/hr) of the Paiko, Gwagwalada Area Council, Abuja, FCT, Nigeria

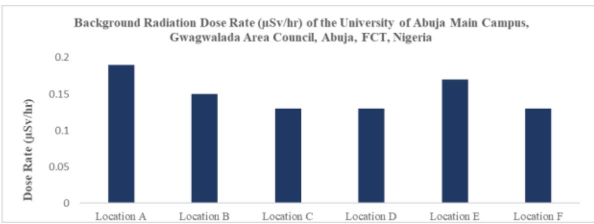

Figure 9: Background Radiation Dose Rate (µSv/hr) of the University of Abuja Main Campus, Gwagwalada Area Council, Abuja, FCT, Nigeria

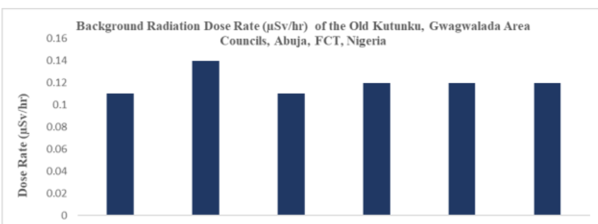

Figure 10: Background Radiation Dose Rate (µSv/hr) of the Old Kutunku, Gwagwalada Area Council, Abuja, FCT, Nigeria

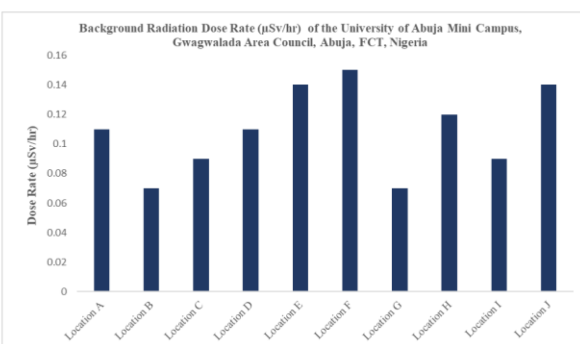

Figure 10: Background Radiation Dose Rate (µSv/hr) of the University of Abuja Mini Campus, Gwagwalada Area Council, Abuja, FCT, Nigeria

Table 1: Background Radiation Dose Rate (μSv/hr) in Gwagwalada Area Council, Abuja, FCT, Nigeria

	Mean ± SD
Overall mean	0.17±0.09
New Kutunku 8.930° N, 7.058° E	0.13±0.04
University Of Abuja Teaching Hospital (8.950° N, 7.060° E)	0.42±0.58
Angwadodo (8.948° N, 7.079° E)	0.15±0.05
Phase I (8.945° N, 7.085° E)	0.20±0.04
Phase II (8.945° N, 7.085° E)	0.21±0.05
Phase III (8.963° N, 7.064° E)	0.13±0.02
Paiko (9.020° N, 7.060° E)	0.11±0.02
Old Kutunku (8.930° N, 7.050° E)	0.12±0.01
University of Abuja Mini Campus (8.953° N, 7.073° E)	0.11±0.03
University of Abuja Main Campus (8.979° N, 7.179 °E)	0.15±0.03

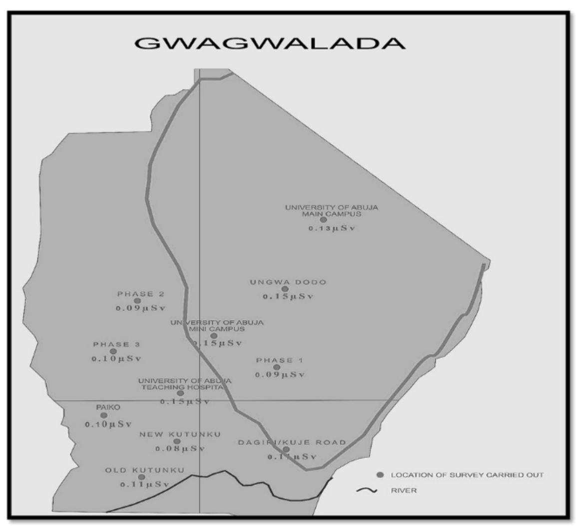

Figure 11: Spatial distribution of background radiation in Gwagwalada, Abuja, Nigeria

IV. DISCUSSION

The observed variations in background ionizing radiation levels across Gwagwalada can be attributed to differences in geological composition, land use patterns, and anthropogenic activities [7, 12]. Areas with relatively higher radiation levels are associated with granitic rocks, construction materials, and higher traffic density, all of which are known contributors to elevated environmental radiation.

The natural background ionizing radiation levels measured across Gwagwalada ranged from 0.11 to 0.42 μSv/h, with an overall mean dose rate of 0.17 ± 0.09 μSv/h. The overall mean dose rate of 0.17 ± 0.09 μSv/h indicates a low level of radiation exposure. This value falls within the typical global background radiation range of approximately 0.1–0.2 μSv/h and is considered safe [3, 10, 11]. However, it is slightly lower than the value reported by Adigun et al., who recorded a mean dose rate of 0.32 ± 0.09 μSv/h [3].

Based on the annual effective dose, the measured hourly dose rate corresponds to 1.49 ± 0.79 mSv/year. This value is lower than the 2.8 mSv/year reported by Adigun et al. and also below the global average annual background radiation level of 2.4 mSv/year reported by the IAEA [3, 10]. This falls within the general global range of 2-3 mSv/year, depending on the geographical location.

The established overall dose rate of background radiation in Gwagwalada Area Councils, Abuja, Nigeria, is not harmful and is essential for future environmental radiation assessments and for identifying potential radiological impacts arising from developmental activities.

V. CONCLUSION

This study assessed the spatial distribution and magnitude of background ionizing radiation in Gwagwalada, Abuja, Nigeria. The results indicate that background radiation levels in the area are generally within internationally accepted safety limits for public exposure.

VI. RECOMMENDATIONS

- Regular monitoring of background ionizing radiation in Gwagwalada
- Integration of radiation assessment into urban planning policies
- Public awareness on environmental radiation and health implications
- Further studies incorporating radionuclide-specific analysis

REFERENCES

[1] A. Aba, A. Ismaeel, A. Alboloushi, and O. Alboloushi, "Assessment of Radiation Exposure Hazards from Natural Sources in Kuwait," in *Environmental Hazards in the Arabian Gulf Region: Assessments and Solutions*, A. e.-a. K. Abd el-aal, A. Al-Enezi, and Q. E. Karam Eds. Cham: Springer Nature Switzerland, 2024, pp. 285–327.

[2] A. Asere and I. Ajayi, "Exposure to Ionizing Radiation and Radiological Implications: a review of ICRP, IAEA and UNSCEAR recommendations," *The International Journal Of Engineering And Science,* vol. 4, no. 6, pp. 29–33, 2015.

[3] P. O. Adigun, N. A. A. Azeez, and T. G. Akinwande, "Assessment of Background Radiations in Abuja, Federal Capital Territory, Nigeria," *ASRJETS,* Original vol. 101, no. 1, pp. 239–252, 2025. [Online]. Available: https://asrjetsjournal.org/American_Scientific_Journal/article/view/11450.

[4] J. Chavaudra, "Radioactivity," in *Handbook of Radiotherapy Physics*: CRC Press, 2021, pp. Vol1: 15–Vol1: 24.

[5] N. Van Dung, D. D. Thuan, D. D. Nhan, F. P. Carvalho, D. Van Thang, and N. H. Quang, "Radiation exposure in a region with natural high background radiation originated from rare earth element deposits at Bat Xat district, Vietnam," *Radiation and Environmental Biophysics,* vol. 61, no. 2, pp. 309–324, 2022/05/01 2022, doi: 10.1007/s00411-022-00971-9.

[6] B. Santhanabharathi *et al.*, "Source, fate and transfer of primordial radionuclides as potential contaminants in environmental matrices of high and low background radiation areas – a critical review," *International Journal of Environmental Analytical Chemistry,* vol. 105, no. 4, pp. 954–980, 2025/03/16 2025, doi: 10.1080/03067319.2023.2277891.

[7] B. Ojiego *et al.*, "Concentrations of heavy metals in soil samples from dumpsites located at Kuje and Kwali area councils, Abuja, Nigeria," *Journal of Materials and Environmental Sciences,* vol. 13, no. 9, pp. 1037–1046, 2022.

[8] Y. Simon and A. Samuel, "Analysis of Land-Use Conflict between Farmers and Pastoralists in Gwagwalada Area Council of Abuja, Nigeria," 07/29 2021.

[9] P. O. Adigun, "Simulation Prediction of Background Radiation Using Machine Learning," New Mexico Highlands University, 2023.

[10] IAEA, "Radiation in Everyday Life," ed, 2023.

[11] UNSCEAR, "The estimation of whole-body doses from the intake of radiocaesium following the accident at the Fukushima Daiichi nuclear power station," 2022. United Nations Scientific Committee on the Effects of Atomic Radiation.

[12] M. K. John, "Investigation of the effect of high concentration of radioactive elements on geothermal parameters within parts of Plateau State, Nigeria," Masters Dissertation, Physics, Federal University of Minna, FUTMinna Institutional Repository, 2023. [Online]. Available: http://repository.futminna.edu.ng:8080/jspui/handle/123456789/19846