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Assessment of Background Radiations in Abuja, Federal Capital Territory, Nigeria

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Abstract

Background radiation is everywhere and investigating the amount present in the background, surroundings and environment is essential to research and public health concerns. Humans experience it daily due to both natural and artificial incidents. These incidents include cosmic radiation, internal radiation, terrestrial radiation, nuclear events and medical operations. This research covered the investigation of two area councils, Gwagwalada and Kwali Area Councils in Abuja, Federal Capital Territory, Nigeria. Field exploration and data sampling dose rate were conducted at 11 locations which are the University of Abuja Mini Campus (8.9530N, 7.0730E), Gwagwalada Market (8.9417°N, 7.0775°E), Phase III Dumpsite (8.9637°N, 7.0646°E), Landfill @ Sharia Court (8.96175°N, 7.0816°E), University of Abuja Mini Campus- Boys Hostel (8.9453°N, 7.0703°E), Old Kutunku (8.9302°N, 7.0503°E), Kwali (8.8401°N, 7.0525°E), Yangoji (8.8208°N, 7.0341°E), Tunga Sarki (8.82079°N, 7.03408°E), Tongan Sanki Health Post (8.8249°N, 6.9484°E) and Tunga Galadima (8.8079°N, 6.9209°E). The average dose rate of the overall natural background radiations in Gwagwalada and Kwali Area Councils was 0.32±0.09µSv/hr, even though in places like Yangoji (0.42±0.11µSv/hr) and Tunga Sarki (0.45±0.13µSv/hr) which are in Kwali Area Council, have higher average dose rate than the average overall for the two area councils. This dose rate of 0.32±0.09 µSv/hr indicates a low level of radiation exposure. However, this level of radiation is slightly higher than typical background radiation, which is usually around 0.1 to 0.2µSv/hr, but it is still within a range considered safe for long-term exposure.

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1. Introduction

Background radiation is a prevalent event worldwide. Humans experience it daily due to both natural and artificial incidents [1]. These incidents include cosmic radiation, internal radiation, terrestrial radiation, nuclear events (power plants and fallout) and medical procedures [2]. The universe is naturally radioactive and approximately more than 80% of human-absorbed radiation doses [2]. Background radiation is an unavoidable part of our environment and is generally at low levels that are not harmful to human health. However, certain activities and locations can increase exposure, so monitoring and managing radiation levels in sensitive areas such as dumpsites, resident areas, poorly sanitized environments, healthcare and nuclear facilities are essential [3-5].

Background radiations are ionizing in nature and this ionizing effect is a type of energy released by atoms that have enough power to remove tightly bound electrons from atoms, creating ions.[6] This process is capable of causing significant damage to living tissues (radiation exposure) and is classified based on the source and form of radiation. Natural radiation contributes to ionizing radiation exposure from various sources: cosmic, terrestrial, and internal radiation. Specifically, this focuses on natural background radiation. Natural background radiation is the ionizing radiation from naturally occurring sources in the environment. These sources contribute to the overall radiation dose that we are exposed to daily. The standard dose rate for background radiation varies depending on location and factors like altitude. However, a typical average is around 2.4 millisieverts (mSv) per year [7]. This includes contributions from natural sources such as cosmic radiation, terrestrial radiation from the ground, and radon gas.

Cosmic radiation originates from outer space and consists of high-energy particles, such as protons and atomic nuclei, which bombard the Earth's atmosphere [2]. When these particles collide with atmospheric molecules, they produce secondary radiation, including gamma rays, neutrons, and other particles [8]. The initial energy of the photons constitutes a broad spectrum from a few electron volts (eV) to about 1,020 eV [2]. The intensity of cosmic radiation varies with altitude and latitude, being higher at greater altitudes and closer to the poles. Cosmic radiation de-energizes as it penetrates the atmosphere [2]. Astronauts and airline crew members and frequent flyers are exposed to higher levels of cosmic radiation due to their altitude during flights.

Terrestrial radiation comes from radioactive materials naturally found in the Earth's crust. Elements like uranium, thorium, and their decay products, including radon gas, contribute to this type of radiation [1, 2]. Radon, a colorless and odorless gas, is particularly significant as it mostly accumulates in buildings, especially in basements and poorly ventilated areas [3]. Prolonged exposure to high levels of radon may increase the risk of lung cancer [9]. Terrestrial radiation levels vary depending on the geological composition of the area, with some regions having higher natural radioactivity due to the presence of these elements.

Internal radiation refers to the radioactive isotopes naturally present in our bodies. These isotopes, such as potassium-40 and carbon-14, are incorporated into our tissues through the food we eat, the water we drink, and the air we breathe [3]. Although the levels of internal radiation are relatively low, they contribute to our overall radiation exposure. Potassium-40, for example, is a naturally occurring isotope of potassium that emits beta and gamma radiation and is found in small amounts in all living organisms [1, 10].

These radiations are based on ionizing radiation which are basically three namely alpha, beta and gamma radiation. Alpha particles are heavily charged particles consisting of two protons and two neutrons [6]. They have low penetration ability and can be stopped by a sheet of paper or the outer layer of skin. Alpha particles are primarily emitted by the decay of heavy elements like uranium and thorium [6]. Beta particles are high-energy, high-speed electrons or positrons with moderate penetration ability [6]. They can be stopped by a few millimeters of plastic or a sheet of aluminum. Beta particles are emitted by the decay of certain isotopes, such as potassium-40 and carbon-14 [6]. Gamma rays are high-energy electromagnetic radiation with high penetration ability [6]. They can penetrate several centimeters of lead or several meters of concrete. Gamma rays are emitted during the decay of radioactive elements like uranium, thorium, and radium [3]. Neutrons are uncharged particles with a mass similar to protons. They have very high penetration ability and can penetrate several meters of concrete or water. Neutrons are produced in nuclear reactions, cosmic radiation interactions, and some radioactive decay processes [6].

While natural background radiation contributes to our overall radiation dose, it is generally at levels that are not necessarily harmful to human health. However, knowledge of these sources helps in developing safety measures and guidelines to minimize exposure, especially in areas with elevated levels of terrestrial radiation or high radon concentrations. Eventually, natural background radiation is an unavoidable part of our environment, contributing to a low-level radiation dose that is generally not harmful to human health. This study evaluates and assesses the natural background radiation in multiple areas in Gwagwalada and Kwali Area Councils, Abuja, Nigeria. The objectives are:

- To survey multilocation in Gwagwalada and Kwali Area Councils, Abuja, Nigeria.
- To conduct field studies and data collection at multilocation in Gwagwalada and Kwali Area Councils, Abuja, Nigeria.
- To analyze and establish the average and overall dose rate of natural background radiation at multilocation in Gwagwalada and Kwali Area Councils, Abuja, Nigeria.

2. Methods

2.1 Description of the Study

The location of the study was Abuja (9.0765°N, 7.3986°E), Federal Capital Territory, Nigeria. The city is the capital and eighth most populous city of Nigeria.[11] [12]. The field studies were carried out in the Gwagwalada area (8.9508°N, 7.0767°E), and Kwali area (8.8403°N, 7.0539°E), Abuja, 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 [13]. 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 [12].

Kwali is one of the major settlements in the Federal Capital Territory [14]. It is located about 70km away from the Federal Capital City. The area covers a total of 1,700400 square kilometers or 8,895 hectares, located at the centre of a very fertile agricultural area with abundant clay deposits. It is located along the Kaduna-Lokoja Road.

The study investigated multilocations which residential areas, quarries, dumpsites, landfills, markets and warehouses. The locations were chosen because of the nature and activities carried out in the areas. The following were considered.

Table 2

Consumer items	Cigarettes, building materials, hydrocarbon products, food materials etc.
Areas	Factories, dumpsites, landfills, populated places.

2.2 Design and Technique of the Study

The study involved the measurement of the amount of radiation per unit of time from naturally occurring radioactive materials (NORM) which are present in the surroundings [12]. The radiation per unit of time is called a dose or dose rate which is based on radioactivity, a term used to describe the disintegration of atoms [6]. The technique used to record the amount of radiation exposure or natural background radiation in a place is to quantify these radiations and express them with time. The unit of absorbed radiation dose is the sievert (Sv). Since one sievert is large, radiation doses normally encountered are expressed in millisievert (mSv) or microsievert (μSv) [6]. The standard and average radiation exposure due to all-natural sources is 2.4 mSv (0.27μSv) per year as published by IAEA, reported by UNSCEAR and established by ICRP[15, 16]. The data captured were categorically the three radiations, namely alpha, beta, and gamma. The mean and overall dose rate of the natural background radiation were computed as well.

2.3 Instrumentation of the Study

1. Gamma Scout

Gamma Scout (model GS2 with serial number A20) was used as the field equipment to measure and obtain the dose rate of the background radiations. Gamma Scout is a part of the Gamma Scout series which is a radiation measuring device that measures alpha, beta, gamma radiation and also x-rays [17] The gamma senses ionizing radiation using a G-M (Geiger Muller) tube within a thin mica window. The device measures in mSv/hr or mRem/hr units, and wide range of temperatures (-40 -700C),

2. Timer and Stopwatch

A timer and stopwatch were used to record the time when the measurement and recording were done. It is necessary to maintain steady and regular timing for the measurement and fixation of the device (Gamma Scout) at the point of reading the background radiation.

3. Pegs

Pegs are used as point indicators, used to mark out where point where measurement and reading were taken

2.4 Software Toolkit of the Study

1. Microsoft Excel

Microsoft Excel 2016 is the spreadsheet application used for data entry, data sorting and data visualization.

2. Jamovi

Jamovi was used to perform the descriptive analysis of the collected data. Jamovi is a free and open-source statistical software designed to be user-friendly and accessible. It provides a suite of common statistical methods. Jamovi features an intuitive and straightforward interface, enabling users, including those with limited statistical knowledge, to perform analyses easily. The software offers a wide range of statistical procedures, such as t-tests, ANOVAs, regression, and more, allowing users to conduct both basic and advanced statistical analyses.[18] Built on the R statistical language, Jamovi allows users to write R code within the platform, providing access to the extensive range of R packages and functions [18].

2.4 Data Analysis.

The collected data on the dose rate of background radiation was presented using bar charts and tables. The data contained the dose rate of alpha, beta and gamma radiation as well as the average and overall dose rate.

efficacy.

3. Results

The field study covered many locations both Gwagwalada and Kwali Area Councils, in Abuja, Nigeria. The data collected included dose rates of alpha, beta, and gamma radiations. Samples were collected from more than 160 points and 11 locations. The various background radiations measured at various points in Abuja are illustrated in Figure 1-11.

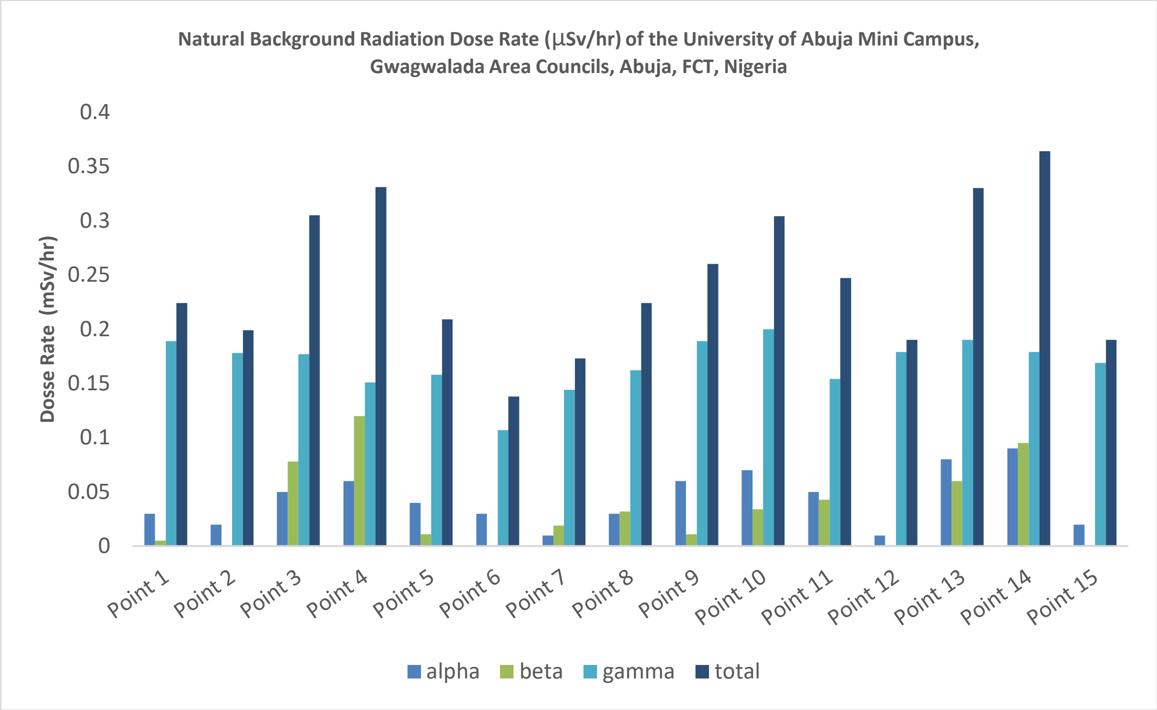

Figure 1: Natural Background Radiation Dose Rate (µSv/hr) of the University of Abuja Mini Campus, Gwagwalada Area Councils, Abuja, FCT, Nigeria

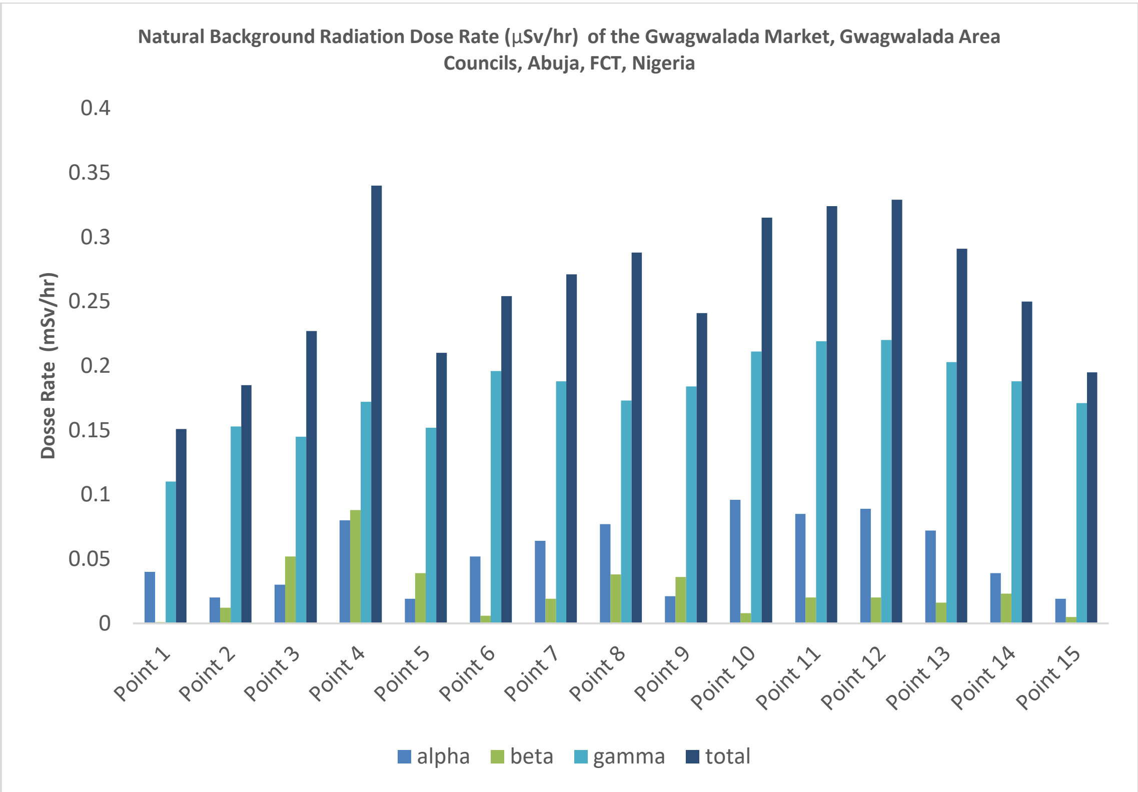

Figure 2: Natural Background Radiation Dose Rate (µSv/hr) of the Gwagwalada Market, Gwagwalada Area Councils, Abuja, FCT, Nigeria

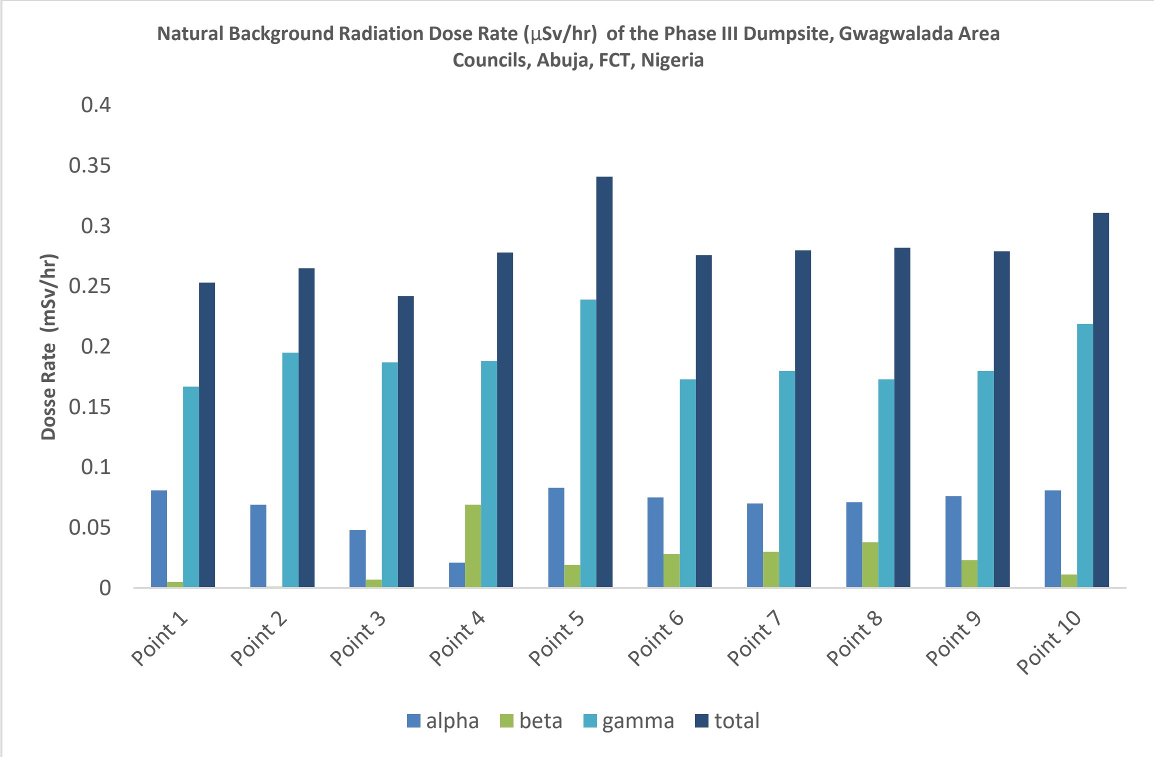

Figure 3: Natural Background Radiation Dose Rate (µSv/hr) of the Phase III Dumpsite, Gwagwalada Area Councils, Abuja, FCT, Nigeria

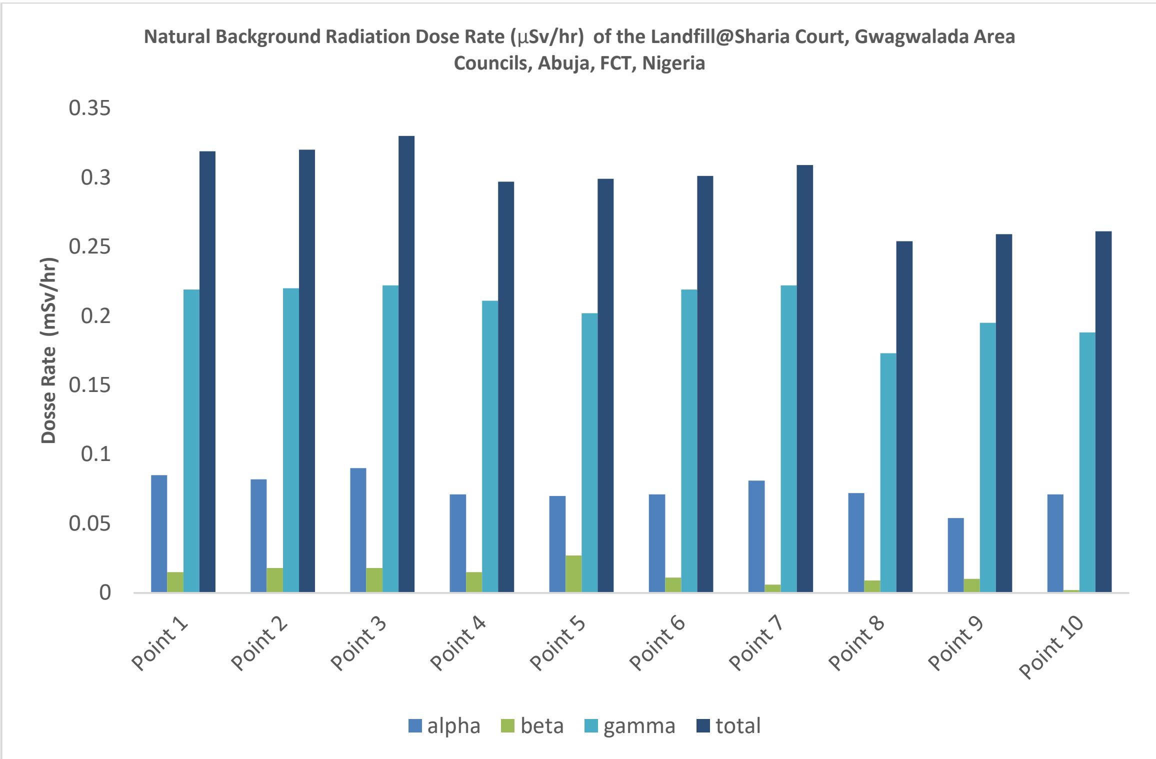

Figure 4: Natural Background Radiation Dose Rate (µSv/hr) of the Landfill@Sharia Court, Gwagwalada Area Councils, Abuja, FCT, Nigeria

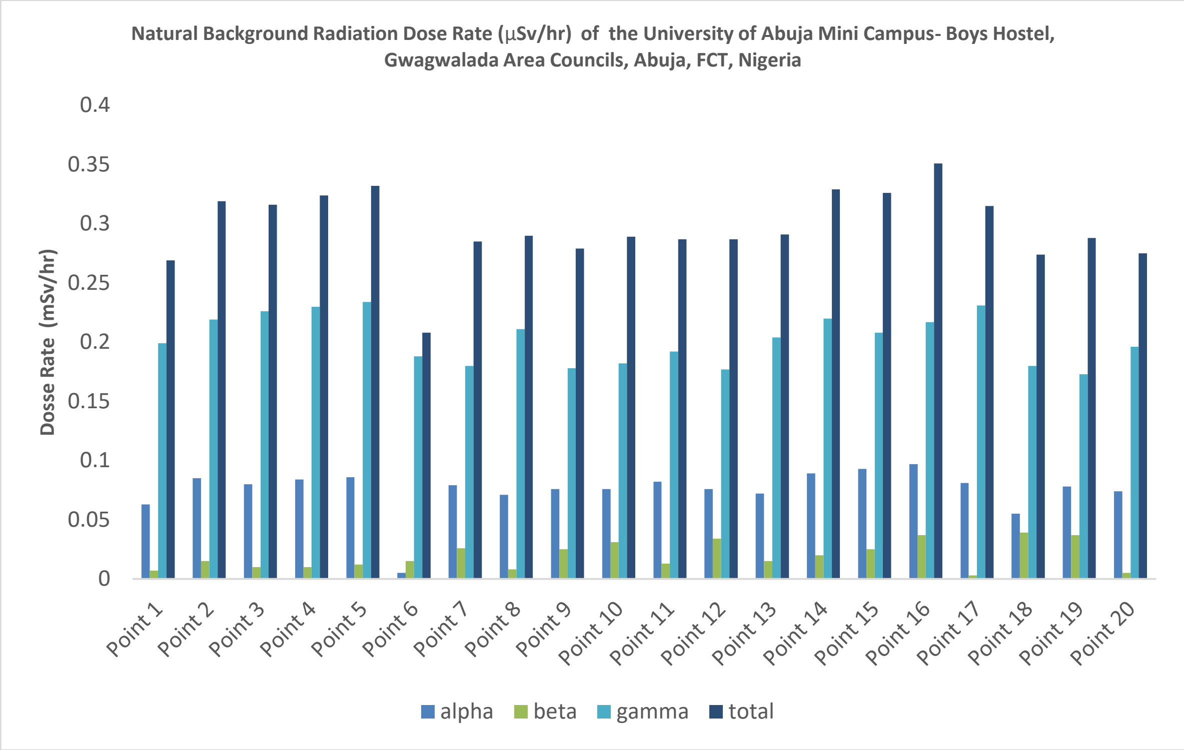

Figure 5: Natural Background Radiation Dose Rate (μSv/hr) of the University of Abuja Mini Campus- Boys Hostel, Gwagwalada Area Councils, Abuja, FCT, Nigeria

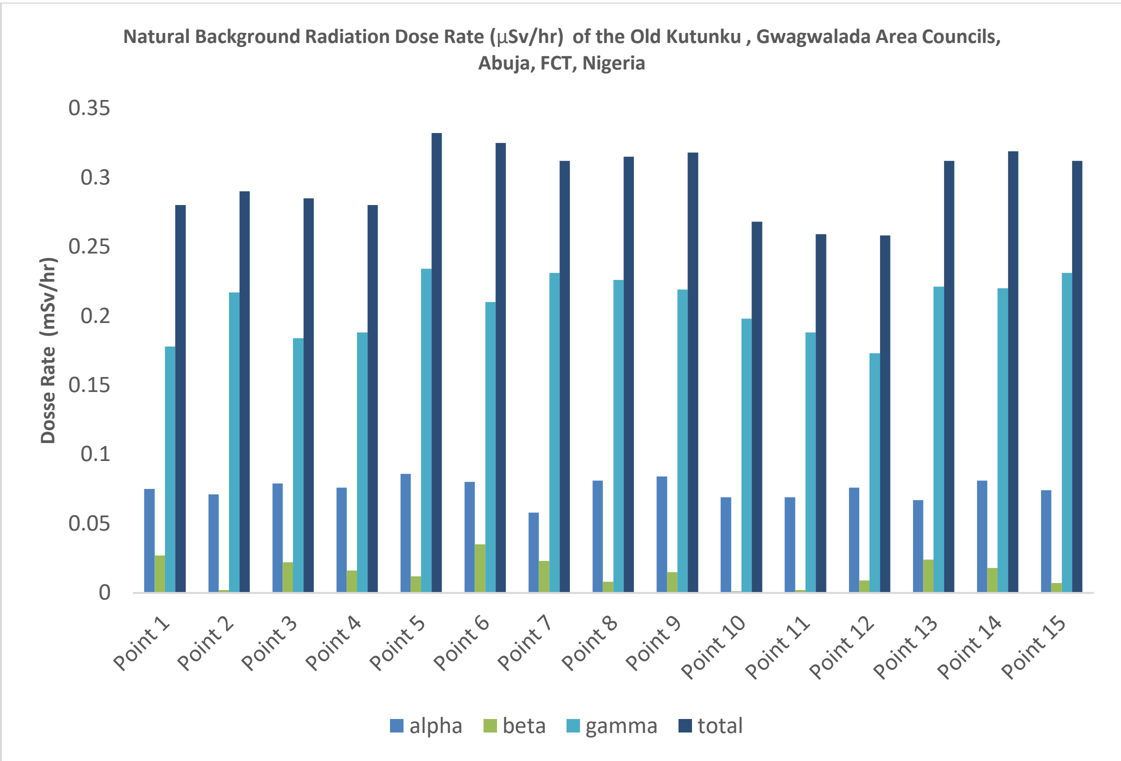

Figure 6: Natural Background Radiation Dose Rate (μSv/hr) of the Old Kutunku, Gwagwalada Area Councils, Abuja, FCT, Nigeria

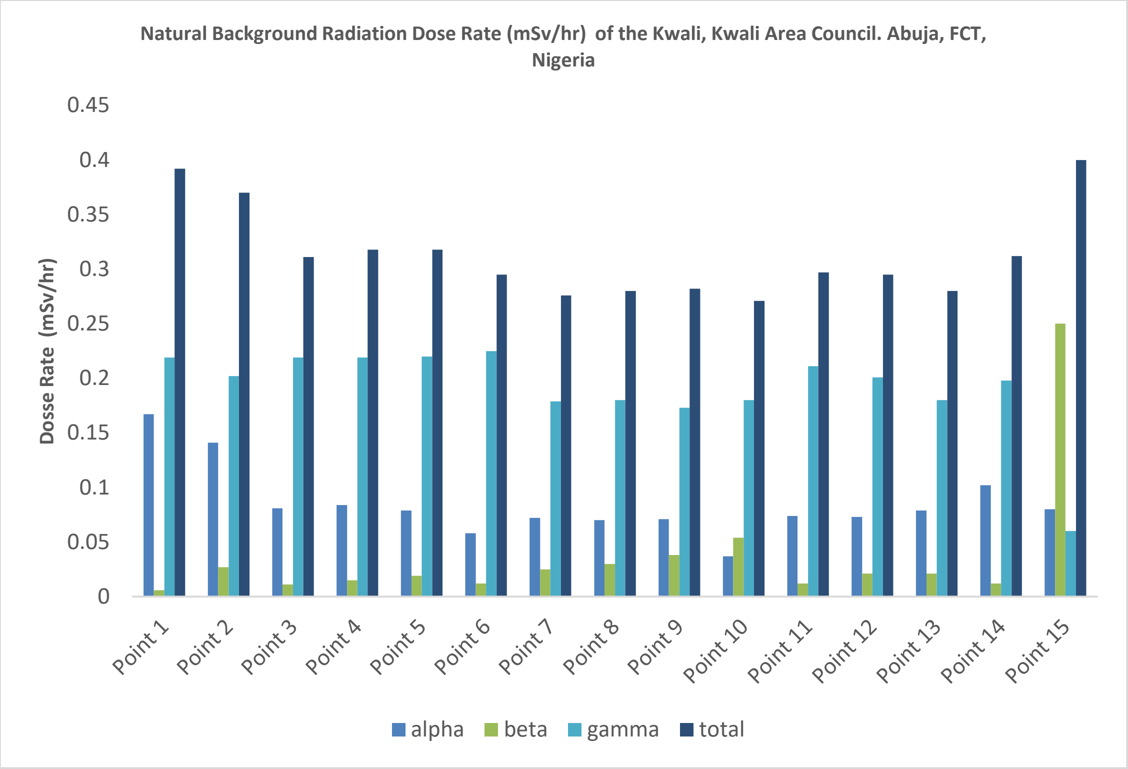

Figure 7: Natural Background Radiation Dose Rate (μSv/hr) of the Kwali, Kwali Area Council. Abuja, FCT, Nigeria

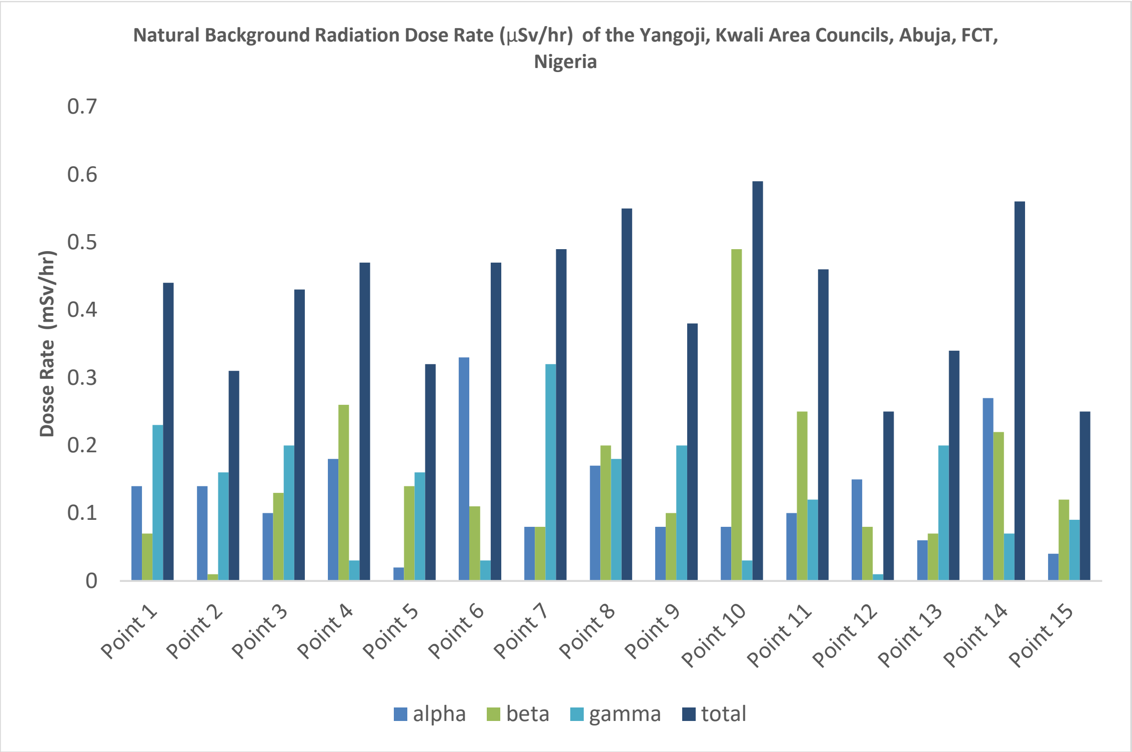

Figure 8: Natural Background Radiation Dose Rate (μSv/hr) of the Yangoji, Kwali Area Councils, Abuja, FCT, Nigeria

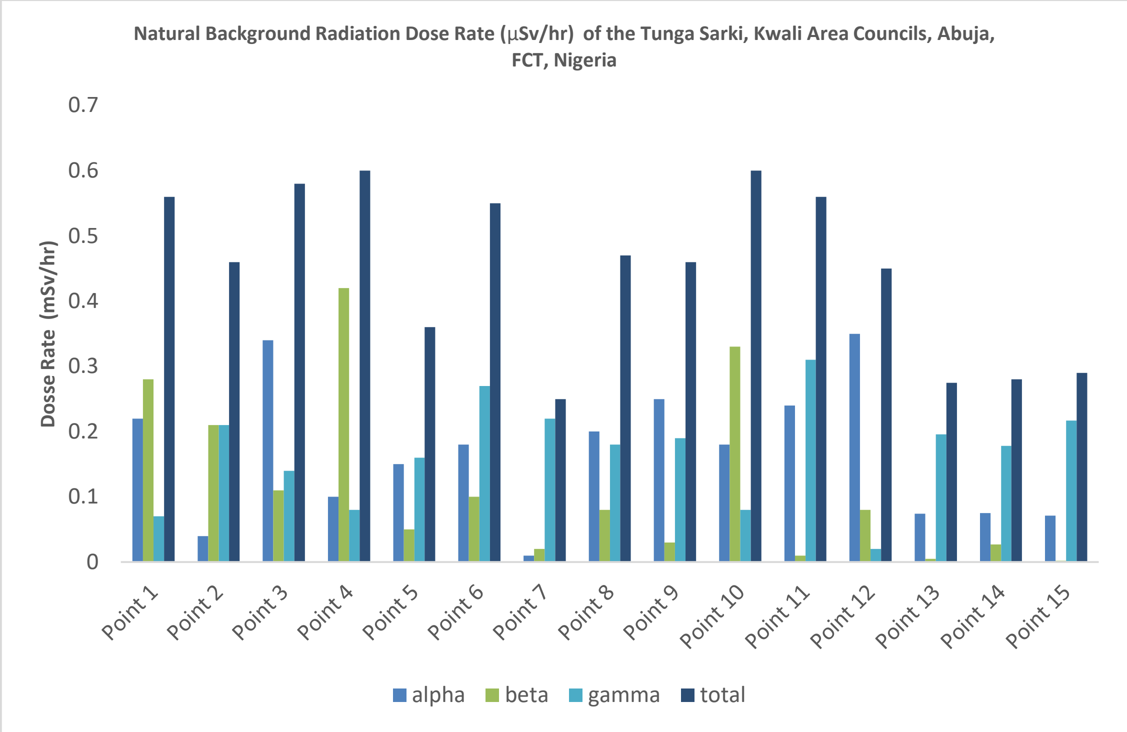

Figure 9: Natural Background Radiation Dose Rate (µSv/hr) of the Tunga Sarki, Kwali Area Councils, Abuja, FCT, Nigeria

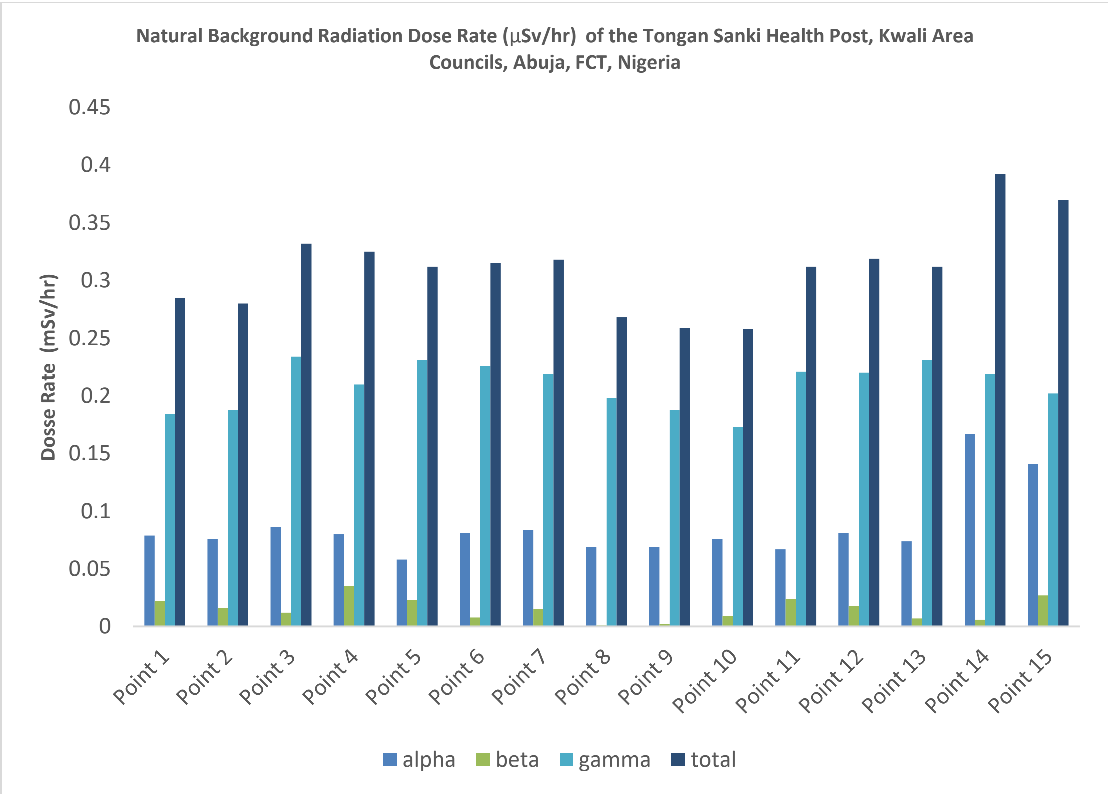

Figure 9: Natural Background Radiation Dose Rate (µSv/hr) of the Tongan Sanki Health Post, Kwali Area Councils, Abuja, FCT, Nigeria

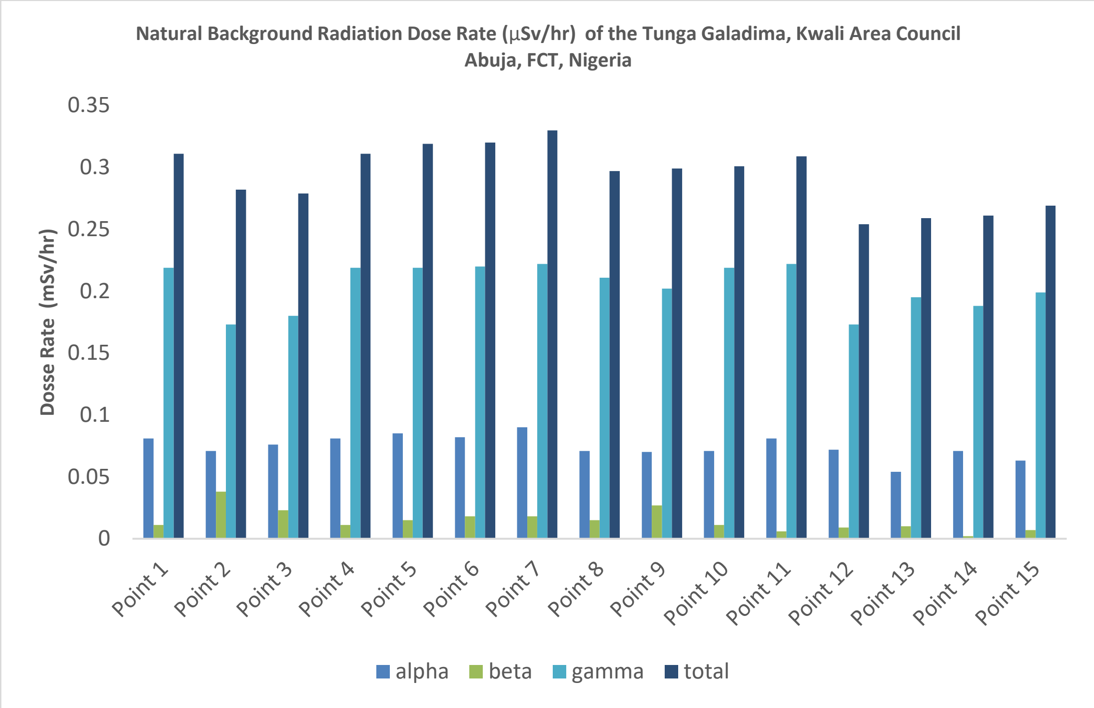

Figure 11: Natural Background Radiation Dose Rate (µSv/hr) of the Tunga Galadima, Kwali Area Council Abuja, FCT, Nigeria

Table 1: Natural Background Radiation Dose Rate (µSv/hr) in Gwagwalada and Kwali Area Councils, Abuja, FCT, Nigeria

	Alpha (Mean±SD)	**Beta (Mean±SD)**	**Gamma (Mean±SD)**	**Total (Mean±SD)**
Overall	0.085±0.06	0.043±0.07	0.19±0.05	0.32±0.09
University of Abuja Mini Campus (8.9530N, 7.0730E)	0.04±0.02	0.03±0.04	0.17±0.02	0.25±0.07
Gwagwalada Market (8.9417N, 7.0775E)	0.05±0.03	0.03±0.02	0.18±0.03	0.26±0.06
Phase III Dumpsite (8.9637N, 7.0646E)	0,07±0.02	0.02±0.02	0.19±0.02	0.28±0.03
Landfill @ Sharia Court (8.96175N, 7.0816E)	0.07±0.01	0.01±0.01	0.21±0.02	0.29±0.03
University of Abuja Mini Campus- Boys Hostel (8.9453N, 7.0703E)	0.08±0.02	0.02±0.01	0.20±0.02	0.30±0.03
Old Kutunku (8.9302N, 7.0503E)	0.08±0.01	0.01±0.01	0.21±0.02	0.30±0.02
Kwali (8.8401N, 7.0525E)	0.08±0.03	0.04±0.06	0.19±0.04	0.31±0.04
Yangoji (8.8208N, 7.0341E)	0.13±0.08	0.16±0.12	0.14±0.09	0.42±0.11
Tunga Sarki (8.82079N, 7.03408E)	0.17±0.10	0.12±0.13	0.17±0.08	0.45±0.13
Tongan Sanki Health Post (8.8249N, 6.9484E)	0.09±0.03	0.02±0.01	0.21±0.02	0.31±0.04
Tunga Galadima (8.8079N, 6.9209E)	0.07±0.01	0.01±0.01	0.20±0.02	0.29±0.02

4. Discussion

Background radiation is everywhere and investigating the amount present in the background, surroundings and environment is essential to study and monitor. This was one of the reasons that necessitated the assessment carried out in Abuja, Nigeria. The dose rate of the overall natural background radiations in Gwagwalada and Kwali Area Councils is 0.32±0.09µSv/hr. There are some places like Yangoji (0.42±0.11µSv/hr) and Tunga Sarki (0.45±0.13µSv/hr) which are in Kwali Area Council, have higher average dose rates than the average overall for the two area councils. The overall dose rate of 0.32±0.09 µSv/hr indicates a low level of radiation exposure. However, this level of radiation is slightly higher than typical background radiation, which is usually around 0.1 to 0.2 µSv/hr [14], but it is still within a range considered safe. Moreover, the overall dose rate in Gwagwalada and Kwali Area Councils is not harmful to human health. It is important to understand that background radiation at these levels is a natural part of our environment, and we are constantly exposed to it without adverse effects.

Comparably, the overall dose rate for Gwagwalada and Kwali Area Councils is higher than James and colleagues' findings carried out in Kwali Area Council in 2015, which was 0.108±0.003 µSv/h [14].

Additionally, if this hourly dose rate of 0.32 µSv/hr is converted to an annual dose that is; 2.8 mSv. This dose rate is higher than the standard average rate which is 2.4mSv per year [15]. but yet it is in the typical range of annual background radiation exposure (2 to 3 mSv per year), depending on the location [19]. Also, the average dose rate established in this study is higher compared to Aba and his colleagues findings which reported the average exposure rate, for adults and children in Kuwait being approximately 1.3 and 1.1 mSv, respectively [5]. The established overall dose rate of background radiation in Gwagwalada and Kwali Councils, Abuja, Nigeria is not harmful.

5. Conclusion

The average overall, dose rate of 0.32±0.09 µSv/hr indicates a level of radiation that poses no significant health risks and is well within the safety limits established by regulatory bodies. Hence, no additional safety measures are generally required for background radiation levels in Gwagwalada and Kwali Area Councils, Abuja, Nigeria, but future studies are highly recommended to validate and improve monitoring activities of background radiations in the mentioned areas.

6. Limitation of the Study

This study is limited based on sampling limitations, temporal variability and environmental factors. The sampling limitations arise from the number and distribution of sampling locations. Temporal variability is another challenge, as radiation levels fluctuate due to weather conditions, seasonal changes, and human activities. Environmental factors, such as soil composition, building materials, and geological formations, may influence radiation levels and vary across different locations, complicating the generalization of findings.

References

[1] T. Ramachandran, "Background radiation, people and the environment," Iranian Journal of Radiation Research, vol. 9, no. 2, pp. 63-76, 2011.

[2] D. Shahbazi-Gahrouei, M. Gholami, and S. Setayandeh, "A review on natural background radiation," Advanced Biomedical Research, vol. 2, no. 1, p. 65, 2013.

[3] 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.

[4] D. Patel, M. K. Jindal, P. S. Pamidimukkala, and D. Chakraborty, "Gamma radiation dose rate distribution in the Anand, Bharuch, Vadodara, and Narmada districts of Gujarat, India," Environmental Science and Pollution Research, vol. 30, no. 49, pp. 107104-107117, 2023/10/01 2023, doi: 10.1007/s11356-023-25711-4.

[5] A. Aba, A. Ismaeel, A. Albloushi, and O. Albloushi, "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.

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

[7] K. Eckerman, J. Harrison, H. Menzel, and C. Clement, "ICRP publication 119: compendium of dose coefficients based on ICRP publication 60," Annals of the ICRP, vol. 41, pp. 1-130, 2012.

[8] A. Kashlinsky, R. Arendt, F. Atrio-Barandela, N. Cappelluti, A. Ferrara, and G. Hasinger, "Looking at cosmic near-infrared background radiation anisotropies," Reviews of Modern Physics, vol. 90, no. 2, p. 025006, 2018.

[9] W. H. Organization, WHO handbook on indoor radon: a public health perspective. World Health Organization, 2009.

[10] T. Ishikawa, "Radiation Doses and Associated Risk From the Fukushima Nuclear Accident:A Review of Recent Publications," Asia Pacific Journal of Public Health, vol. 29, no. 2_suppl, pp. 18S-28S, 2017, doi: 10.1177/1010539516675703.

[11] O. Bashir, A. Reigns, O. Unimke, and S. Mshelia, "Population dynamics to urban spaces needs in one of africa’s largest cities: Abuja, the federal capital city of nigeria," I R E J, vol. 4, no. 10, pp. 124-130,

2021.

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

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

[14] I. James, I. Moses, J. Vandi, and U. Ikoh, "Measurement of indoor and outdoor background ionising radiation levels of Kwali General Hospital, Abuja," Journal of Applied Sciences and Environmental Management, vol. 19, no. 1, pp. 89-93, 2015.

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

[16] 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.

[17] N. Bassey, U. Kaigama, and A. Oluwasegun, "Radiometric Mapping of Song Area and Environs, Hawal Basement Complex, Northeast Nigeria," International Journal of Science and Technology, vol. 2, pp. 692-699, 10/01 2013.

[18] S. R. Khan, "Dataset and Codebook for Jamovi Tutorials," Journal of Interdisciplinary Perspectives and Scholarship, vol. 8, no. 1, p. 28, 2022.

[19] S. Nagataki and N. Takamura, "Radioactive Doses — Predicted and Actual — and Likely Health Effects," Clinical Oncology, vol. 28, no. 4, pp. 245-254, 2016/04/01/ 2016, doi: https://doi.org/10.1016/j.clon.2015.12.028.