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Assessment of Gamma Background Exposure Levels in some Selected Residential Houses in FCT Abuja, Nigeria

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Abstract: In this study, the assessement of Gamma Background Exposure Levels in some selected residential houses in FCT Abuja, Nigeria has been studied. The in-situ background gamma exposure rate level for ten houses and two separate measurement in the surroundings of at least 5m away from the houses werecarried out using a well calibrated portable Radex Nuclear Radiation Meter (model: RD 1212) at 1 m hieght above ground leveland a Global Positioning System (GPS) was used to record the geograaphical locations.The radiological hazards indices such as Absorbed Dose Rate, Annual Effective Dose Equivalent and Excess Life Cancer Risk were evaluated and compared with the recommended standard by International Commission on Radiological Protection. The exposure level obtained for the residential houses and its surroundings ranged from 0.05 to 0.09µSv/h. The calculated ADR, AEDE, and ELCR ranged from 0.088to 0.158mSv/yr, 6.13 x 10^{-5} to 1.10 x 10^{-4}mSv/yr, and 2.15 x 10^{-4} to 3.86 x 10^{-4} respectively. The mean values of the gamma background exposure levels (0.0713 mRh^{-1}), absorbed dose rates (3.02x10^{-4} nGyh^{-1}) and excess lifetime cancer risk (3.06×10^{-4}) are below the recommended safe limits of 0.013 mRh^{-1}, 84.0 nGyh^{-1}, 0.29×10^{-3} respectively as recommended by UNSCEAR and ICRP. The mean annual effective dose equivalent (8.623x10^{-5} mSvy^{-1}) is far below the recommended permissible limits of 1.00 mSvy^{-1} for general public exposure. The results showed that the houses and their surroundings within FCT Abuja investigated were radiologically safe and may not pose any risk to members of the public.

Keywords: Gamma Exposure Level, Residential Houses, Radex Nuclear Radiation Meter and Annual Effective Dose Equivalent..

1 Introduction

Background exposure from normal levels of the naturally occurring radioactive materials (NORMS) are present in all environmental materials and do not vary remarkably from place to place. Where human activities (Laboratory activities, pollution mining and others) have increase the relative concentration of the radionuclide, they are refer to as the technologically enhanced naturally occurring radioactive materials (TENORMS) [1]. The ambient radiation encompasses both the natural and artificial radioactivity in his environment [2]. Survey taken by the World Health Organization (WHO) and the international commission on radiological protection (ICRP) shows that residents of temperate climates spend only about 20% of their time outdoor and about 80% indoor(homes, schools offices or other buildings) [3].

Radiation dose depend on the intensity and energy of radiation, type of radiation, exposure time, the area exposed and the depth of energy deposition. Quantities, such as the absorbed dose, the effective dose and the equivalent dose have been introduced to specify the dose received and the biological effectiveness of that dose [4]. The absorbed dose (D); specifies the amount of radiation absorbed per unit mass of material, Its S.I unit is gray. (1Gy=1Jkg^{-1}). The absorbed dose rate (DR); is the rate at which an absorbed dose is received its units are (Gys^{-1} and mGyhr^{-1}). It is however important to mention that the biological effect depend not only on the total dose the tissue is exposed to, but also on the rate at which the dose was received. The equivalent dose rate (EDR); The absorbed dose do not give an accurate indication of the harm that radiation can do since equal absorbed doses do not necessarily have the same biological effects [5]. An absorbed dose of 0.1Gy of alpha radiation is more harmful than an absorbed dose of 0.1Gy of beta or gamma radiation. To reflect damage done

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in biological systems from different types of radiation, the equivalent dose is used. It is define in terms of the absorbed dose weighted by a factor which depends on the type of radiation. It unit is Sievert (Sv). Exposure to ionizing radiation poses a high risk and this risk may include cancer induction, radiation cataractogenesis, indirect chromosomal transformation. The practice being to keep one's exposure to ionizing radiation as low as reasonably possible is known as the ALARA principle [6]. However, Radon (^{222}Rn) finds its way indoor through building materials, diffusion, convection and through the soil under the building. Some of the materials used in the construction of buildings are known to be radioactive [7]. Considering these source of indoor background ionizing radiation, and the cold nature of the university, it is obvious that laboratory technologies, staff as well as students spend more time inside the laboratory either in search of warmness or carrying out research. Hence background ionizing radiation profile within and without those laboratories is crucial to assess the level of health risk of exposure to which the occupants and users of such laboratories are exposed when compare to the average effective dose of about 2.4mSv/yr reported by [8]. In this study, the Gamma Background Exposure Levels in some selected residential houses in FCT Abuja, Nigeria has been studied.

2 Materials and Method

2.1 Study Area

Abuja is the capital city of Nigeria, in the middle of the country. It covers an area of 1,769 km^2 and elevation of 360 m. The skyline of the city, which was built largely in the 1980s, is dominated by Aso Rock, an enormous monolith. It rises up behind the presidential Complex, which houses the residence and offices of the Nigerian president in the three Arms Zone on the eastern edge of the city. Nearby are the National Assembly and the Supreme Court of Nigeria.

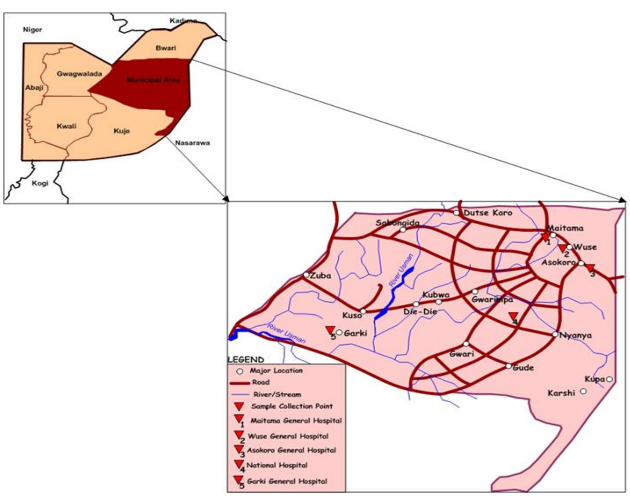

Fig.1: Map of Study Area.

2.2 Sampling and Measurement

Measurement of the exposure level was carried out using Radex (RD 1212) radiation survey meter which measured radiation absorbed dose rate in micro Sievert per hour (μSv/h).These radiation analysers are highly sophisticated, reliable and not expensive. The small and tight construction of the radiation analysis device ensures easy transportations with less expenses.

At each point of data collection, the meter was switched on and allowed to absorb radiation for a few seconds and the meter read at the highest stable point. For effective monitoring, the radiation meter was placed at 1m above ground level with the window of the meter directed towards the four different direction (North, South, East, and West), four readings were taken and the mean value was recorded. For each houses, readings were taken for both indoor and outdoor environment (two reading for outdoor and one reading for indoor). Measurements of exposure levels in this investigation were taken at 10m interval (for outdoor) in the afternoon between the hours of 1pm and 4pm for effective response of the meter to environmental radiation exposures according to the method of [9].

The precise locations of the sample point were determined using a geographical positioning system (GPS). The exposure rate obtained from the ancient houses around FCT Abuja, Nigeria were analyzed and compared with recommendedstandards. For effective computation of the experimental data from Exposure level (in μSv/hr) to other hazard parameters, a number of radiological health hazard indices calculations was performed using well established mathematical relations.

2.3 Radiological Hazards Indices

2.3.1 Absorbed Dose Rate (ADR)

The exposure (σ) measured in μSv/h is converted to annual absorbed dose rate ADR in mSv/yr according to equation 1.0 [5].

$$ADR\left(\frac{mSv}{yr}\right) = \sigma\left(\frac{\mu Sv}{h}\right) x\ OF\ x\ 24hrs\ x\ 365.25\ days\ x\ 10^{-3} \qquad 1$$

OF is the occupancy factor and absorbed dose is obtained in Gy/h from the measured exposure in μSv/h using the relationship

$$D(nGy/h) = \frac{\sigma(\mu Sv/h)}{Q}\ x\ 10^{-3} \qquad 2$$

Q is the quality factor=1.0 for gamma radiation

2.3.2 Annual Effective Dose Rate(AEDR)

The annual effective dose rate (AEDR) per year received by workers and the population is obtained from equation 2 [8].

$$AEDR\left(\frac{mSv}{yr}\right) = D\left(\frac{nGy}{h}\right) x\ 8760h\ x\ CF\ x\ OF \qquad 3$$

CF is the conversion factor of the absorbed dose in air to the effective dose.

$$CF = 0.7\frac{Sv}{Gy}, \quad 4$$

OF is the occupancy factor, the expected period the members of the population would spend within the study area. OF = 0.2 for outdoor as it is expected that human beings would spend 20 % of their time outdoors. Therefore AEDR for outdoor is obtained from equations 3 [6].

$$AEDR\left(\frac{mSv}{yr}\right) outdoor = D\left(\frac{nGy}{h}\right) x\ 8760h\ x\ \frac{0.7Sv}{Gy} x0.2x10^{-3} \quad 5$$

2.3.3 Excess Lifetime Cancer Risk (ELCR)

The excess lifetime cancer risk (ECLR) is calculated from equation 5 [10].

$$ECLR = AEDR\ x\ DL\ x\ RF \quad 6$$

Where DL is the duration of life (70 years) and RF is the risk factor, that is, the fatal cancer risk per Sievert. For stochastic effects ICRP 60 recommend RF = 0.05 for the public [10-14].

3 Results and Discursion

The background gamma exposure level was collected from residential houses around FCT, Abuja using a Redex (RD 1212) Radiation meter to measure the background radiation level in µSv/h. The background exposure level obtained for various houses and location in this study are presented in Table 1. The spotted points (houses) where these data were collected are coded from A to K and numbered (1 to 3) with house represented as H(the first latter). Points or houses with code 1 and 2 are data gotten from the measurement of background radiation level in the surroundings of the house, while those with code 3 are obtained from the interior of the house selected for this study. The highest value of exposure level was recorded in HA3, HC2, HE1, and HI2 with value of 0.09 µSv/h followed by Houses with code HA1, HC1, HJ2, HJ3 and HK3with value of 0.08 µSv/h. The lowest value of exposure level was recorded in House with code HB2 with value of 0.05 µSv/h.

Radiological parameters such as calculated annual absorbed dose rate(ADR), the annual effective dose rate (AEDR) and estimated excess cancer lifetime risk (ECLR) are the radialogical hazards indices used in accessing the health status of the study area and the calculated results are presented in Table 2.The radiological hazard indices obtained from the houses shows the mean exposure ranged between 0.05 to 0.09 µSv/h and the corresponding calculated Absorbed Dose Rate ranged between 0.88 to 0.16mSv/yr, while the calculated AEDE ranged between 6.13×10^{-5} to 1.10×10^{-4}mSv/yr. The corresponding estimated Excess Life Cancer Risk ranged between 2.1×10^{-4} to 3.86×10^{-4}. This shows that there is negligible amount residual radioactivity in the building materials which could be from the radionuclides of Radium(Ra), Thorium (Th), Uranium (U) and/or potassium (K) contain in the material that are far below level of concern [15-17].

4 Conclusions

The radiation exposure levels in the modern houses in some part of FCT Abuja, Nigeria have been carried out in order to assess the radiological implications to the people. The results show that all the AEDE evaluated were below the acceptable safe limits for the public and the ECLR was below the threshold level. This indicates that the building materials that were used may not pose any significant radiation hazard to the people.

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