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ASSESSMENT OF NATURAL IONIZING RADIATION IN TWO TERTIARY INSTITUTIONS OF NIGER STATE

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ABSTRACT
Background ionizing radiation attributed to natural sources has over the years been at increase due to increase in infrastructural facilities and population inducing more human activities within campuses. This called for very great concern because of it effects on the human at higher exposure doses. Consequently, the Assessment of the Natural Ionizing Radiation was carried out at Ibrahim Badamasi Babangida University, Lapai (IBBUL) and Niger State Polytechnic, Zungeru (NSPZ) with approximate populations of 7000 and 5200 students respectively. A portable Geiger-Mueller dosimeter was used at 19 different locations within the two tertiary institutions. The results revealed the Dose Rate variation from 0.14 to 0.186 µSv⁄hr, at IBBUL, while at NSPZ the variation was from 0.12 to 0.158 µSv⁄hr. For all the locations the mean Dose Rate was 0.154 µSv⁄hr with a standard deviation of 0.0195 µSv⁄hr. Generally, average Annual Effective Dose Rate obtained is 0.27 mSv/annum which fell within the recommended alarming limit of 1 mSv/annum given by the International Commission on Radiation Protection (ICRP) for non-occupational population exposure. This implied no adverse impact on the tenements within the two tertiary Institutions. However, part of the recommendations is that more work needs to be done on the soil to characterize the areas for possible radioactive source deposits which may be up to alarming magnitude in the near future.

Keywords: Background Gamma Radiation, Dose Rate, Annual Effective Dose, radioactive deposits, artesian miners

INTRODUCTION

Radiation threats can be divided into nuclear based threats (like nuclear weapons and nuclear power plant accidents), and radioactive material-based threats (like dirty bombs, or orphan (Eke & Emelue 2020). The presence of this kind of threats won’t be easily noted until trained experts with specialized equipment arrive to the scene. Therefore, environmental radiation monitoring which involves a systematic collection and analysis of certain environmental media, such as air, milk, and water, to determine the environmental radioactivity level is very vital to guaranteeing a sustainable healthy environment. In doing so, radioactivity levels of a targeted environment are measured and compared to the safety standards from the experts to determine the quality status of a target environment. The four types of radiations that are measured during such background radiation monitoring are; *Alpha particles* (α), which is not often considered as an external hazard because the dead layer of skin will absorb all alpha particles with no harmful effect. However, if inhaled or ingested, it can be an internal hazard (Ononugbo, et al., 2016). The second type is *Beta particles* (β), which is considered to be slightly external hazard and is mainly a skin and internal exposure hazard. The third radiation type is the *Gamma rays* (γ). These are external hazards, which can penetrate materials and travel much farther in matter than alpha and beta particles. All such forms of natural radiations from radionuclides found in rocks, building materials and soils in an environment constitutes terrestrial radiation. The recent increase in the institutional infrastructural facilities and unprecedented increase in campus population density calls for an undisputable concern by the experts (Onumejor, et al. 2019). Thus regular monitoring of such terrestrial radiation levels can be very instrumental to a guaranteed quality environment for healthy living. As it will detect any abnormal levels of radioactivity any given area as well as determining the long-term trends so that any changes in the radiological environment are promptly identified and mitigative actions are taken. It can also provide and be used to establish a knowledge base for proactive response to any possible nuclear materials accidents. All these are only achievable by sampling some environmental pathways for human exposure and directly measuring radiation levels at various target surroundings and compare the measurements with the global standards so as to ascertain its quality status.

Radiation has been described by Weisstein, (2014) as a type of energy emission or transmission in the form of a wave or particles via space or a material medium. The fact that Ionizing Radiation (IR) has enough energy to generate ionization distinguishes it from other types of radiation found in the environment, such as heat. Ionization has been said to be capable of causing molecular changes and the creation of chemical species that are harmful to chromosomal material in the water for which most of cells are made up of (Ononugbo, et al., 2016). IR energy, dose rate, exposure duration, Dose uniformity, and shielding, all influence the severity of IR injury (Ononugbo, et al., 2016). Despite that the consequences of low-level Radiation have not yet been fully studied, the effect of such radiation is modest at permitted Dose Rate limit, and in most occasions no significant adverse effect used to be detected (Ononugbo, et al., 2016).

Exposure to the IR which has the capability of knocking out electrons from the orbit around atoms, disrupting the electron/proton balance, thus potentially harming to cells, is an unavoidable part of life on Earth (Canadian Nuclear Safety Commission, 2012; Tsepav *et al*., 2018). The most common and freely exposed radiations to human and other living things are the IR present in the environment. As a result, in medical physics, determining the health risk of Background Radiation (BR) which is just a measure of IR existing in a given area that is not attributable to the deliberate introduction of Radiation sources (Tsepav *et al*., 2018). Cosmic and terrestrial Radiations are the major sources of BR. Cosmic Radiation is made up of energetic particles produced by spallation reactions in the outer space of the atmosphere, which enter the earth's atmosphere and contribute to BR. The interaction of these particles with molecules in the atmosphere could result in cosmogenic radionuclides. Long-lived cosmogenic radionuclides have decayed to generate terrestrial radionuclides that can be found in the air, soils, rocks, water, and construction materials (Pashazadeh *et al*., 2014; UNSCEAR, 2000). Natural environmental radiation is largely dependent on a region's geological and geographical factors, as well as the materials utilized in its buildings. As a result, BR levels may fluctuate depending on where you live.

This study was therefore conducted with the aim of measuring the BR at two campuses, compared it with the standard Gamma Absorbed Dose Rate (GADR) for students, staff, and members of the general public at two tertiary institutions in Niger State: Ibrahim Badamasi Babangida University, Lapai (IBBUL) and Niger State Polytechnic, Zungeru (NSPZ) to determine the environmental quality in relation to the BR. The values acquired as a result of this investigation will be included in the baseline data for environmental radiation in Niger State.

MATERIALS AND METHODS

Study locations: Lapai town is a Local Government area headquarters in Niger State, Nigeria, bordering the Federal Capital Territory at 9° 3' 0"N 6° 34' 0"E. It has a population of 110,127 and covers land area of 3,051 km² according to 1991 census figure. In the year 2005, this city became home to the IBB University. The population has continued to rise at a rapid pace since then. More than 7000 people live on the University campus, with the bulk of students living in campus hostels. Although there is no industry yet in the town that uses radioactive materials, the state's geology suggests that environmental radiation levels could be high (Oladipupo & Yabagi, 2015). The Niger State Polytechnic Zungeru is located between Zungeru and Wushishi (9° 48' 26"N 6° 9' 8"E) which are rural communities about 63 and 77 kilometers from Minna, Nigeria's capital. The residents of these two study locations have their main vocations as subsistence farming, fishing, and trading. Running water and exterior water are the types of water forms found in the area. The residents rely on this water source mostly for domestic consumption and activities (bathing, washing clothing, etc.) (Abdullahi and Saidu, 2011)

A portable Geiger-Mueller tube-based environmental radiation dosimeter (Digital alert Nuclear Radiation Monitor, S.E International, Inc. U.S.A) was used to assess the BR level at IBBUL and NSPZ. The dosimeter was created specifically to be used as a low-level survey meter. A Cesium-137 Gamma source was used to calibrate it.

The regions chosen for Background Radiation Assessment in the Institutions were picked at random, however they were evenly dispersed to cover each location. They include places where there are a lot of human interactions and presence throughout the academic season.

The following are the steps taken during field work:

i. At each location, the data was collected 6 feet which is approximately 2 meters away from the building entrance.

ii. The monitor was held in the air by a retort stand one meter above ground level at an open and uninterrupted level ground surface (Ononugbo, et al., 2016). At every point, the Total Count (TC) for 5 minutes was recorded.

iii. The average TC was then divided by 5 minutes to get count per minute (CPM). Using equation 1, each average CPM was converted to micro-Sievert per hour ($\mu Sv/hr$) (Eke & Emelue, 2020).

$$1CPM = 0.01\,\mu Sv/hr \quad (1)$$

iv. The Annual Effective Dosage (AED) was calculated using the BIR dose rates in Sv/hr, as shown in equation 2.

$$\text{AED } (mSv/yr) = DR \times T \times OF \times 10^{-3}\,\text{S} \quad (2)$$

v The mean equivalent Dose Rate per hour and the standard deviation were evaluated using (Equation 3 and 4 respectively).

$$\overline{X} = \frac{\sum X}{N} \quad (3)$$

Where $\overline{X} =$ mean, $\sum X =$ Sum of Dose Rate, and $N =$ Number of Dose Rate obtained.

$$\sigma = \sqrt{\frac{\sum\left(X-\overline{X}\right)^2}{N}} \quad (4)$$

Where $\sigma =$ Standard deviation, $N =$ Number of Dose Rate obtained, $X =$ Each Dose Rate obtained, and $\overline{X} =$ Mean Dose Rate.

Where DR is the measured absorbed radiation rate in micro-Sievert per Hour ($\mu Sv/hr$), T is the total number of hours in a year (8760), and OF is the outdoor occupancy factor (0.2).

Results and Discussions

The results are presented in the Tables and Figures. At IBBUL, the Dose Rate ranged from 0.14 $\mu Sv/hr$ to 0.186 $\mu Sv/hr$ as shown in Table 1. The lowest measured value of 0.14 $\mu Sv/hr$ was recorded from Hostel A, while the highest value of 0.186 $\mu Sv/hr$ was obtained from Faculty of Management and Social Science (FMSS). The result of BR at NSPZ are presented in Table 2, the minimum Dose Rate of 0.12 $\mu Sv/hr$ was obtained at Old School of Science (OSS) while the maximum Dose Rate of 0.158 $\mu Sv/hr$ was obtained at Female Hostel (FMH). Dose Rate obtained at IBBUL is higher than that of NSPZ, this disparity could be attributed to; the geology (concentration of rocks) as well as more infrastructural facilities at IBBUL (Echeweozo & Ugbede, 2020), the level of natural radioactivity of granite used as a building material within the Two Institutions (Haghparast *et al*., 2020), also, the population density could be additional influential factor. In all the 19 points assessed at two locations, the mean equivalent Dose Rate per hour was found to be 0.154 μSv/hr, with a standard deviation of 0.0195μSv/hr (Equation 3 and 4 respectively).

Table 1: Dose Rate at IBBUL

Location	Average Total Count	Count Per Minutes (CPM)	Dose Rate (μSv/hr)	Dose Rate (mSv/yr)
ADM	81	16.2	0.162	0.283824
FOA	87	17.4	0.174	0.304848
FOE	90	18.0	0.18	0.31536
FMSS	93	18.6	0.186	0.325872
FOS	89	17.8	0.178	0.311856
HOA	83	16.6	0.166	0.290832
HOB	70	14	0.14	0.24528
HOC	74	14.8	0.148	0.259296
NSDC	89	17.8	0.178	0.311856
Mean				0.294336
SD				0.027198

Table 2: Dose Rate at NSPZ

Location	Average Total Count	Count Per Minutes (CPM)	Dose Rate (μSv/hr)	Dose Rate (mSv/yr)
ADM	77	15.4	0.154	0.269808
FEH	79	15.8	0.158	0.276816
MHA	69	13.8	0.138	0.241776
MHB	70	14	0.14	0.24528
MHC	61	12.2	0.122	0.213744
MHD	77	15.4	0.154	0.269808
OSS	60	12	0.12	0.21024
SOE	78	15.6	0.156	0.273312
SEV	71	14.2	0.142	0.248784
SOS	68	13.6	0.136	0.238272
Mean				0.248784
SD				0.023937

The distribution of the Dose Rate values measured from the field compared to the world standard values are shown in Figures 1 and 2. The Dose Rates ranges respectively from 0.21 mSv/yr to 0.27 mSv/yr at the two tertiary institutions. The lowest value of 0.21 mSv/yr and the highest value of 0.27 mSv/yr were deduced from Niger State Polytechnic, Zungeru (NSPZ). The mean value of Dose Rate was 0.27 mSv/yr. The Average Annual Effective Dose obtained from this study is 0.27 $mSv/Annum$ which is still less than the recommended 1 $mSv/Annum$ limit set by International Commission on Radiation Protection (ICRP) for non-occupational population exposure.

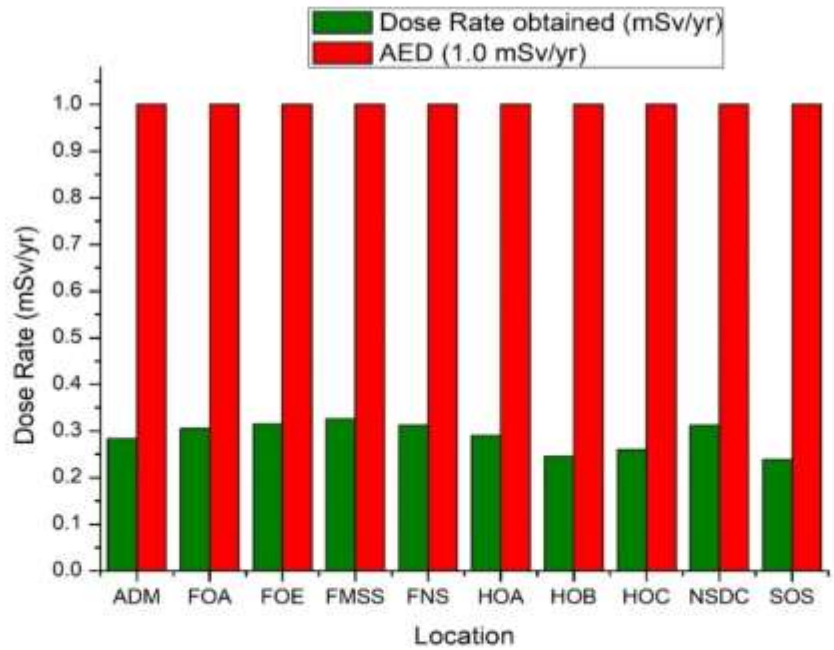

Figure 1: Dose Rate at IBBUL compared to standard Dose Rate

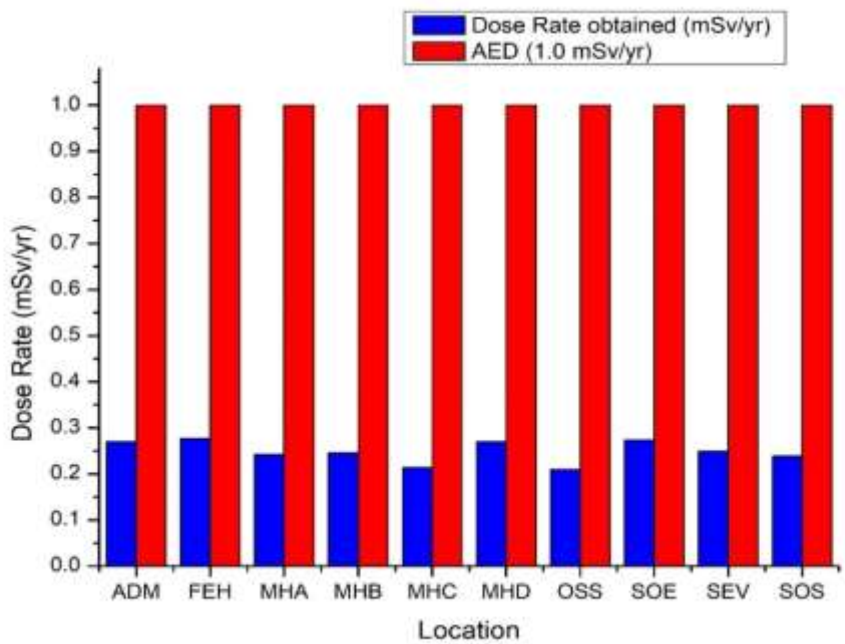

Figure 2: Dose Rate at NSPZ compared to standard Dose Rate

In general, as revealed in in (Table 3), Dose Rate values in each of the institutions studied are comparable to one another and can be attributed to natural sources because no other radiation generators are present. The Dose Rate of the probed areas were determined to be lower than the global average, and greater than studies undertaken by other researchers, although it is somehow closer to the study conducted by (Ononugbo, et al., 2016 & Ezekiel & Ezekiel, 2018)), possibly due to similar geology or human activities. It is lower than that of Luka mine, where the Dose levels are higher than world recommended limit. This could also be attributed to the geology or human activity variations (Haghparast *et al*., 2020).

Table 3: Comparison of Dose Rate from this work and other regions

Dose Rate (mSv/yr)	Region	Reference
1.000	World Standard	ICRP (2007)
0.189	Nigeria (Niger)	Ononugbo, et al., 2016
0.170	Nigeria (Delta)	Ezekiel & Ezekiel (2018)
1.700	Nigeria (Luka mine)	Sabo, *et al*. (2018)
0.070	Nigeria (Ebonyi)	Echeweozo & Ugbede (2020)
0.27	This work	Yahaya

CONCLUSION

The portable Geiger-Mueller tube-based Environmental Radiation dosimeter (Digital alert Nuclear Radiation Monitor, S.E International, Inc. U.S.A) used to assess BIR in the two populated Niger State Tertiary Institutions (Ibrahim Badamasi Babangida University, Lapai, and Niger State Polytechnic, Zungeru) successfully revealed the environmental quality status of the two areas in relation to the increasing students and infrastructural facilities. The observed elevated levels of BR at some investigated areas are attributable majorly to only natural sources (cosmic and terrestrial) since no any other artificial sources. The geology of the research regions having given an indication that the soil in both Lapai and Zungeru town may contains huge deposits of granite. Such granites have been widely recognized for their high quantities of Uranium, Thorium, and Potassium (Oladipupo & Yabagi, 2015). In order to determine the radionuclide responsible for the higher Gamma Dose Rates, a full radiological examination in the areas encompassed by this effort is required.

The elevated BIR observed in this survey confirms the possible presence of such natural radioactive mineral deposits in the survey regions. The survey hence revealed that the populace of Lapai and Zungeru has been exposed to such an external Gamma Dose rate. Despite that the dose rate levels obtained for this assessment are higher than those derived from other similar conducted assessment surveys elsewhere, with the exception of the Luka Mine assessment and the global average, yet, their Effective Annual Exposure is still lower than the ICRP's recommended dose limit.

On the over all, it is concluded that the concentration of the BR dose rate in the two investigated environments are still at safe level. However, considering the continued increase in population and other BR escalation influential factors, further environmental radiation assessment is recommended to ascertain the possible sources of background radiation dose rate and exposure, beside the terrestrial radiation sources. Also, regular monitoring and exploration for such NORM (naturally occurring radioactive materials) is hereby recommended as an environmental quality safety and sustainability measures as well as for economic purposes.

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