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 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 at 6 feet which is approximately 2 meters away from the building entrance.

Where DR is the measured absorbed radiation rate in micro-Sievert per hour (µSv/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 µSv/hr to 0.186 µSv/hr as shown in Table 1. The lowest measured value of 0.14 µSv/hr was recorded from Hostel A, while the highest value of 0.186 µSv/hr was obtained from Faculty of Management and Social Science (FMSS). The result of BR at NSPZ presented in Table 2, the minimum Dose Rate of 0.12 µSv/hr was obtained at Old School of Science (OSS) while the maximum Dose Rate of 0.158 µSv/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 (Echewoozo & 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 regions. The mean CPM was converted to micro-Sievert per hour (µSv/hr) (Eke & Emelue, 2020).

\[ I_{CPM} = 0.01 \mu S\text{Sv/hr} \]  

Where \( I_{CPM} \) is the mean CPM converted to micro-Sievert per hour. By dividing the CPM by 3600, the equivalent Dose Rate is then generated from the following equation:

\[ \mu S\text{Sv/hr} = \frac{CPM}{3600} \]  

Where CPM is the Count Per Minute.

For each measurement, the Average (AED) was then calculated using equation 1.

\[ AED = m\mu S\text{Sv/yr} = DR \times T \times OF \times 10^{-3} \text{ Sv} \]  

Where AED is the Annual Effective Dosage, m is the number of Dose Rate obtained, \( m = 1 \), DR is the measured Dose Rate in µSv/hr, T is the number of hours in a year, and OF is the outdoor occupancy factor (0.2). The results are presented in the Tables and Figures.
the 19 points assessed at two locations, the mean equivalent Dose Rate per hour was found to be 0.154 $\mu$Sv/hr, with a standard deviation of 0.0195$\mu$Sv/hr (Equation 3 and 4 respectively).

### Table 1: Dose Rate at IBBUL

| Location | Average Total Count | Count Per Minutes (CPM) | Dose Rate ($\mu$Sv/\(hr\)) | 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 ($\mu$Sv/\(hr\)) | 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/Annnum which is still less than the recommended 1 mSv/Annnum 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 (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).

| 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 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 & Yabadi, 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.

**REFERENCES**

Abdullahi and Saidu, T., (2011). Prevalence of Urinary Schistosomiasis Among School Aged Children in Wushishi Local Government Area of Niger State, NIGERIA. Journal of Pure and Applied Sciences, 4(2), 53–55. http://dx.doi.org/10.4314/bajopas.v4i2.10

Canadian Nuclear Safety Commission. (2012). Introduction to Radiation (Issue December).

Echeweozo, E. O., & Ugbede, F. O. (2020). Assessment of background ionizing radiation dose levels in quarry sites located in Ebonyi State, Nigeria. Journal of Applied Sciences and Environmental Management, 24(10), 1821–1826. https://doi.org/10.4314/jasem.v24i10.17

Eke, B., & Emelue, H. (2020). Measurement of background ionizing radiation in the federal university of technology owerri, Nigeria using calibrated digital geiger counter. International Journal of Physics Research and Applications, 3(1), 070–074. https://doi.org/10.29328/journal.ijpra.1001025

Ezekiel, A. O., & Ezekiel, A. O. (2018). Assessment of excess lifetime cancer risk from gamma radiation levels in Effurun and Warri city of Delta state, Nigeria Assessment of excess lifetime cancer risk from gamma radiation levels in Effurun and Warri city of Delta state, Nigeria. Integrative Medicine Research, 11(3), 367–380. https://doi.org/10.1016/j.jimrsc.2016.03.007

Haghparast, M., Ardekani, M. A., Navaser, M., Refahi, S., Najafzadeh, M., Ghaffari, H., & Masoumbeigi, M. (2020). Assessment of background radiation levels in the southeast of Iran, 2020, 1–4.

ICRP, (2007). ICRP Publication 103 The 2007 Recommendations of the International Commission on Radiological Protection.

ICRP. (2007b). The 2007 Recommendations of the International Commission on Radiological Protection. ICRP publication 103. Annals of the ICRP, 37(2–4), 1–332. https://doi.org/10.1016/j.icrp.2007.10.003
Mahmoud Pashazadeh, A., Aghajani, M., Nabipour, I., & Assadi, M. (2014). Annual effective dose from environmental gamma radiation in Bushehr city. *Journal of Environmental Health Science and Engineering, 12*(1), 4. https://doi.org/10.1186/2052-336X-12-4

Oladipupo, M. D., & Yabagi, J. A. (2015). Measurement of background gamma radiation levels at the main campus of Ibrahim Badamasi Babangida University Lapai , Niger State, Nigeria. 6(6), 95–98.

Ononugbo, C. P., Avwiri, G. O. and Tutumeni, G. (2016). Measurement of Natural Radioactivity And Evaluation of Radiation Hazards in Soil of Abua/Odual Districts Using Multivariable Statistical Approach. *Bri. J. Environ. Sci.* 4(1), pp. 35 – 48.

Onumejor, C. A. Akinpelu, A. Arijaje, T. E. Usikalu, M. R. Oladapo, O. F. Emetere, M. E.

Omeje, M and Achuka, J. A. (2019). Monitoring of Background Radiation in Selected Schools in Ota, Ogun State Nigeria by Direct Measurement of Terrestrial Radiation Dose Rate. *IOP Conf. Ser.:Earth Environ. Sci.* 331 012038

Pashazadeh, A. M., Aghajani, M., Nabipour, I., & Assadi, M. (2014). Annual effective dose from environmental gamma radiation in Bushehr city. *Journal Of Environmental Health Sciences & Engineering, 12*(4), 2–5.

Sabo, A., Sadiq, L. S., & Gamba, J. (2018). Radiological Assessment of Artisanal Gold Mining Sites in Luku, Niger State, Nigeria. *Journal of Environment Pollution and Human Health.* 6(2), 45–50.

Toossi, M. T. B., Yarahmadi, M., Aghamir, A., Jomehzadeh, A., Parast, M. H., & Tamjidi, A. (2009). *ch ive of ive.* 7(1), 41–47.

Tse pav, M. T., Yakubu, A., Gene, A. S., & Abbas, U. (2018). Assessment of Radiation Related Health Risks of Quarry Sites in the Vicinity of Lapai, North Central Nigeria. *Journal of Scientific & Engineering Research,* 9(4), 1414–1421.

UNSCEAR. (2000). Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes. In *UNSCEAR 2000 Report: Vol. I.*

UNSCEAR. (2010). *Sources and effects of ionizing radiation,* annex B: exposure of the public and workers from various sources of radiation. New York: United Nations Scientific Committee on the Effect of Atomic Radiations.

Weisstein, E. W. (2014). In *Eric Weisstein’s World of Physics.*