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IMPACT ASSESSMENT OF BACKGROUND RADIATION ON HABITANT AND THE MINING ENVIRONMENT AT LAPAI, AREA NIGER STATE, NIGERIA

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ABSTRACT

The anticipated implication of increase in background radiation levels at mineral exploitation sites and consequence on human and environment suggested investigating the Background Ionization Radiation (BIR) levels at a mining site located at closed to the communities of Lapai LGA of Niger State, Nigeria. An in-situ method of BIR measurement at thirty points within the study area was carried out using portable GQ GMC-320 Plus radiation meter at 1.0 m elevation above ground level with GPS for geographical location. The results indicated peak BIR levels of 0.22 mR/h at some points which is abnormal compared to recommendations by International Commission on Radiation Protection (ICRP) for normal environment, while BIR at some other points it was low-ranging, with lowest at 0.0010 mR/h which is in tandem with ICRP recommendation. The absorbed doses in all the points are far below the world average value. The values for the Annual Effective Dose for the entire site agreed with the permissible limits (1.00 mSv/yr) for the general public by the ICRP for non-occupational population exposure. The study therefore revealed that the BIR levels and the doses for the mineral exploitation site does not yet constitute any negative radiological health effect at this moment on the Artesian Miners and the environs. However, there is possibility of continued increase in the BIR level due to mining activities and so continued monitoring is recommended to avert possible health hazards.

Keywords: Absorbed Doses, Annual Effective Dose, Background Ionizing Radiation, Dose Rate, mineral exploitation

INTRODUCTION

Background radiation has been defined as dose or dose rate (or an observed measure related to the dose or dose rate) attributable to all sources other than the one(s) specified (by the International Atomic Energy Agency, 2007). So a distinction is made between dose which is already in a location, which is defined here as being "background", and the dose due to a deliberately introduced and specified source. This is important where radiation measurements are taken of a specified radiation source, where the existing background may affect this measurement. For instance, the measurement of radioactive contamination in a gamma radiation background could increase the total reading above that expected from the contamination alone. However, if no radiation source is specified as being of concern, then the total radiation dose measurement at a location is generally called the Background Radiation, and this is usually the case where an ambient dose rate is measured for environmental purposes as is the case in the present research.

The Tenements and other living organisms around the mining site are continuously exposed to such Background ionizing radiations which are naturally and freely occurring within the surrounding environment. This exposure as in other places has been in the increase over the years due to the increase human activities and thus, has attracted great concern because of the negative impact it has if it is at higher doses Ugbede (2018). Some of the common natural radiation sources includes; cosmic rays that enter the Earth from outer space and the naturally occurring radioactive minerals like uranium and thorium, potassium etc. (Ugbede, 2018). They are present everywhere in the environment; in rocks, soil, water, sediments, foods and including the human body itself (UNSCEAR, 2010). The concentration and gamma radiation from the radioactive nuclides vary significantly, depending on the geological and geographical features of a given region Ugbede (2018). The use of radiation sources in medical diagnosis and therapy, nuclear weapons, nuclear power plants, fertilizers production, research institutions as well as in consumers' products are other sources that have also contributed to increase in background radiation exposure and doses.

Owing to the mining activities within the area, subsurface topsoil tillage and digging activities have the capability of redistributing 0 - 40 m down layered subsurface to the top surface and radioactive elements initially associated with the subsurface also reach the top surface. The consequence of these activities is that the miners and the tenements in the immediate environments are exposed to such radiations and if at levels above the normal values will definitely have some negative consequences.

High radiation levels and doses in the environment are hazardous and can be a very serious challenge to both the environmental and Human Health quality. Ionizing radiations are highly energetic particles with characteristic high penetrating power. When such radiation passes through the biological cell, it causes both excitation and ionization which alters the cells structure (Emelue and Eke 2020). Exposure to high levels of gamma radiation causes a number of harmful effects in man such as mutation and cancer of various types and different kinds of diseases (Ugbede, 2018). The negative effects of this radiation dose is higher on children and adolescents (age range of those involved in the mining activities), as they are significantly more sensitive to radiation exposure than aged adults (Kamiya and Sasatani 2012). Epidemiological studies on some populations and childhood (Pediatric CT) exposed to radiations such as atomic bomb survivors or radiotherapy patients by Oxford Academic (2020) showed a significant increase of cancer risk at doses above 100 mSv which according to Kamiya and Sasatani (2012) may increase even at lower doses (between 50 - 100 mSv). It was identified that radiation damage to tissue and/or organs depends on the dose of radiation received, or the absorbed dose. The potential damage from an absorbed dose is also a function of the type of radiation and the sensitivity of the different tissues and organs of the body.

These radiation is type of energy emission or transmission which is in the form of a wave or particles via space or a material medium (Weisstein, 2014). Ionizing Radiation (IR) in this context is a type of energy released by atoms both from the surface and subsurface in the form of electromagnetic waves or particles. People get exposed to natural sources of such ir, such as from the subsurface mineral deposits, water, and vegetation, as well as from artificial sources like (human-made sources), such as χ-rays, Medical devices etc. It has many beneficial applications, including uses in medicine, industry, agriculture and research. However, as the use of IR increases, so does its potential for health hazards also increases, if not properly handled or contained. Acute health effects such as skin burns or acute radiation syndrome can occur when doses of radiation exceed certain levels and even its low doses can also increase the risk of longer term effects such as cancer.

As a result, in medical physics, determining the health risk of Background Radiation - a measurement of the amount of Ionizing Radiation existing in the Environment at a given area that is not attributable to the deliberate introduction of Radiation sources is critical (Tsepav *et al*., 2018).

Due to the radioactive contents of some of the exposed subsurface minerals, it is demanded that mining environments as well as Miners themselves are adequately protected against high radiation levels and doses. It is necessary that for any mining environment, Baseline Data about Background Radiation levels be provided. These will provide bases for assessing and monitoring any possible variations as a result of mining activities within the area. It will also serve as a guide in any epidemiological study of diseases traceable to Radiations. The perceived implication of increase background radiation levels of Mineral Exploitation areas due to exposures to the ground surface and other sources suggested the need to investigate the Background Ionization Radiation levels and doses in Mineral Exploitation site located in communities of Lapai LGA of Niger State. This study in the area is aimed at providing Baseline Data on background radiation in the mineral exploitation environments. The study will provide bases for assessing and monitoring any abnormal radiation variation Levels of the environment in further exploitation seasons. It will also determine the environmental quality of the targeted environment in relation to the background radiations from the minerals being exploited as well as from other terrestrial sources as it affect the tenement and other living organisms within the mining site.

METHODOLOGY

The Study Area

Study locations: Lapai town is the Local Government Area headquarters in Niger State, Nigeria, bordering the Federal Capital Territory at 9° 3' 0"N 6° 34' 0"E. The 2006 census data indicated that it has a population of 110,127 people and covers an area of 3,051 km². However from the year 2005, the population and economic activities has continued to rise at a rapid pace within Lapai town due to the establishment of Ibrahim Badamasi Babangida University. There is also mineral exploitation activity going on by some Artisan Miners, the Site of which is located at a very close proximity to the Lapai town within the tropical region of North-central Nigeria (Figure 1). The mineral exploitation Area is bounded by latitude 09^0 54' N to 09^0 52' N and longitude 06^0 59' E to 06^0 58' E. The major occupations of the people are Farming, Mining, fishing and trading. The mean Annual Rainfall of the area falls between 1600 mm and 1500 mm which usually lasted between 150 and 215 days. The geological information on the area indicated that it is part of the north central Nigerian Basement which is largely made up of metavolcanic and metasedimentary rocks. The area is underlain majorly by coarse to fine grained rock types as well as granite gneiss (Figure 2). The well-known joints and fractures are trending in the NNE – SSW (Figure). The joints have been filled with quartzofeldspatic veins, running for between 3 m and 6 m and displaying sharp contrast with their host rock and in some cases, show evidence of chilled margins (Aweda *et al.*, 2019). The mineral exploitation site was selected for Background Radiation Level Measurement.

Field Procedure and Deductions

Measurement of Background Ionizing Radiation (BIR) levels in the selected Mineral Exploitation Site was done using a portable GQ GMC-320 Plus nuclear radiation Monitor meter (manufactured by S.E International, Inc., USA). The detector contains a Geiger Muller tube capable of detecting α, β, γ and x-rays. When radiation passes through the Geiger tube, it triggers an electrical pulse which the CPU registers as a count and it is displayed on the screen in units of CPM, mR/h or μSv/h. Measurement were taken at 30 randomly selected points at intervals of 2 m which were evenly dispersed to cover the entire targeted area. The monitor was held in the air by a retort stand 1 m above ground level at an open and uninterrupted level ground surface (Olarinoye *et al*., 2010). The precise locations of each of the points within the study site were determined using a Geographical Positioning System (GPS). For each point, three BIR measurements were taken at an interval of ten minutes to account for any error due to fluctuation in the environmental parameters (Agbalagba, 2017). These were then averaged to a single BIR exposure reading for each point within the mineral exploitation site. Readings were taken between the hours of 1300 and 1600 because the radiation meter has a maximum response to radiation within these hours as recommended by the National Council on Radiation Protection and Measurements (NCRP, 1993). An in-situ approach of measurement with the standard practice of elevating the detector tube 1.0 m above ground level with its window facing the point under investigation was adopted to enable sample points maintain their original environmental characteristics (Agbalagba et al, 2016; Ugbede and Echeweozo, 2017). The mean BIR exposure rate obtained were quantitatively used to assess the environmental quality so as to determine its possible impact mineral exploiters as well as other tenements within the immediate environments by performing a number of Radiological Health Indices calculations such as Absorbed Dose Rate (ADR), Annual Effective Dose Equivalent (AEDE) and Excess Lifetime Cancer Risk (ELCR) using equations (1 – 3) (Rafique *et al*. (2014) and Agbalagba (2017). The ADR were evaluated using equation (1).

$$\mu Rh = 8.7GyhA = \eta Gh^{-1} = \frac{8.7\ x\ 10^{-3}}{\left(\frac{1}{8760y}\right)} \mu Gyy^{-1} \quad (1)$$

The computed absorbed dose rates were used to calculate the annual effective dose equivalent (AEDE) using equation (2).

$$AEDE = ADR\left(\frac{\eta Gy}{h}\right) x\ \frac{8760\text{h x } 0.7\text{ Sv}}{Gy\ x\ 0.2} \quad (2)$$

Where ADR is the absorbed dose rate in$\left(\frac{\eta Gy}{h}\right)$, 8760 is the total hours in a year, $\frac{0.7\text{ Sv}}{Gy}$ is the Dose Conversion Factor from absorbed dose in air to the effective dose with an occupancy factor of 0.2 for outdoor exposure as recommended by UNSCEAR (2008).

RESULTS AND DISCUSSION

The results for the BIR exposure level measurements parameters for the mineral exploitation area probed are given in Tables 1 and 2. The variation of the BIR levels of the surveyed Mining Site in comparison with some standard recommended values are depicted in Table 3 and Figure 1.

Table 1: Background Ionizing Radiation levels for the investigated points at the Mining Site location, Lapai, Niger State, Nigeria.

S/N	LOCATION	COUNT PER 10 MINUTES	DOSE RATE (μSv/h)	GEOGRAPHICAL LOCATION	
				LONGITUDES	LATITUDES
1	POINT 1	138.00	0.013	6.592853	9.522446
2	POINT 2	121.00	0.012	6.592854	9.515432
3	POINT 3	163.00	0.016	6.584178	9.527005
4	POINT4	121.00	0.012	6.584178	9.515432
5	POINT 5	121.00	0.012	6.592854	9.5374785
6	POINT 6	138.00	0.013	6.5807517	9.5264686
7	POINT 7	97.84	0.10	6.5875148	9.526492
8	POINT 8	163.07	0.016	6.57933	9.515432
9	POINT 9	179.39	0.018	6.579334	9.5264867
10	POINT 10	121.00	0.012	6.5928543	9.5265267
11	POINT 11	138.00	0.013	6.579384	9.5264867
12	POINT 12	179.39	0.018	6.5794079	9.5265267
13	POINT 13	138.00	0.013	6.5928543	9.515432
14	POINT 14	163.00	0.016	6.579383	9.5265311
15	POINT 15	121.00	0.012	6.5793	9.5266411
16	POINT 16	138.00	0.013	6.579196	9.526617
17	POINT 17	163.07	0.016	6.5779242	9.5263706
18	POINT 18	97.84	0.010	6.579263	9.5264075
19	POINT 19	97.84	0.010	6.5793417	9.5262652
20	POINT 20	121.00	0.012	6.579435	9.5263396
21	POINT 21	138.00	0.016	6.579511	9.526473
22	POINT 22	121.00	0.012	6.579517	9.526431
23	POINT 23	121.00	0.013	6.579575	9.526419
24	POINT 24	138.00	0.013	6.579574	9.526386
25	POINT 25	121.00	0.012	6.579501	9.526387
26	POINT 26	138.00	0.016	6.579419	9.526447
27	POINT 27	163.00	0.016	6.579387	9.526533
28	POINT 28	163.00	0.016	6.579353	9.526566
29	POINT 29	138.00	0.013	6.57934	9.526645
30	POINT 30	163.00	0.016	6.579346	9.526627

Table 2: Radiation Health guides associated with BIR at the Mining Site around Lapai Niger State.

S/No.	LOCATION	RADIATION HEALTH GUIDES	
		DOSE RATE (μSv/hr)	ANNUAL EFFECTIVE DOSE (mSv/yr)
1	POINT 1	0.013	0.17
2	POINT 2	0.012	0.15
3	POINT 3	0.016	0.20
4	POINT4	0.012	0.15
5	POINT 5	0.012	0.15
6	POINT 6	0.013	0.17
7	POINT 7	0.10	0.12
8	POINT 8	0.016	0.20
9	POINT 9	0.018	0.22
10	POINT 10	0.012	0.15
11	POINT 11	0.013	0.17
12	POINT 12	0.018	0.22
13	POINT 13	0.013	0.17
14	POINT 14	0.016	0.20
15	POINT 15	0.012	0.15
16	POINT 16	0.013	0.17
17	POINT 17	0.016	0.20
18	POINT 18	0.010	0.12
19	POINT 19	0.010	0.12
20	POINT 20	0.012	0.15
21	POINT 21	0.016	0.17
22	POINT 22	0.012	0.15
23	POINT 23	0.013	0.15
24	POINT 24	0.013	0.17
25	POINT 25	0.012	0.15
26	POINT 26	0.016	0.17
27	POINT 27	0.016	0.20
28	POINT 28	0.016	0.20
29	POINT 29	0.013	0.17
30	POINT 30	0.016	0.20

Table 3: Collation of Dose Rates from this work and some other regions

Dose Rate (μSv/yr)	Region	Reference
1.000	**World**	**ICRP (2008)**
0.189	Nigeria (Niger)	Olarinoye *et al*. (2010)
0.170	Nigeria (Delta)	Ezekiel & Ezekiel (2018)
1.700	Nigeria (Luka mine)	Sabo *et al*. (2018)
0.016	Nigeria (Ebonyi)	Ugbede, (2018)
0.070	Nigeria (Ebonyi)	Echeweozo & Ugbede (2020)
0.154	The present work	

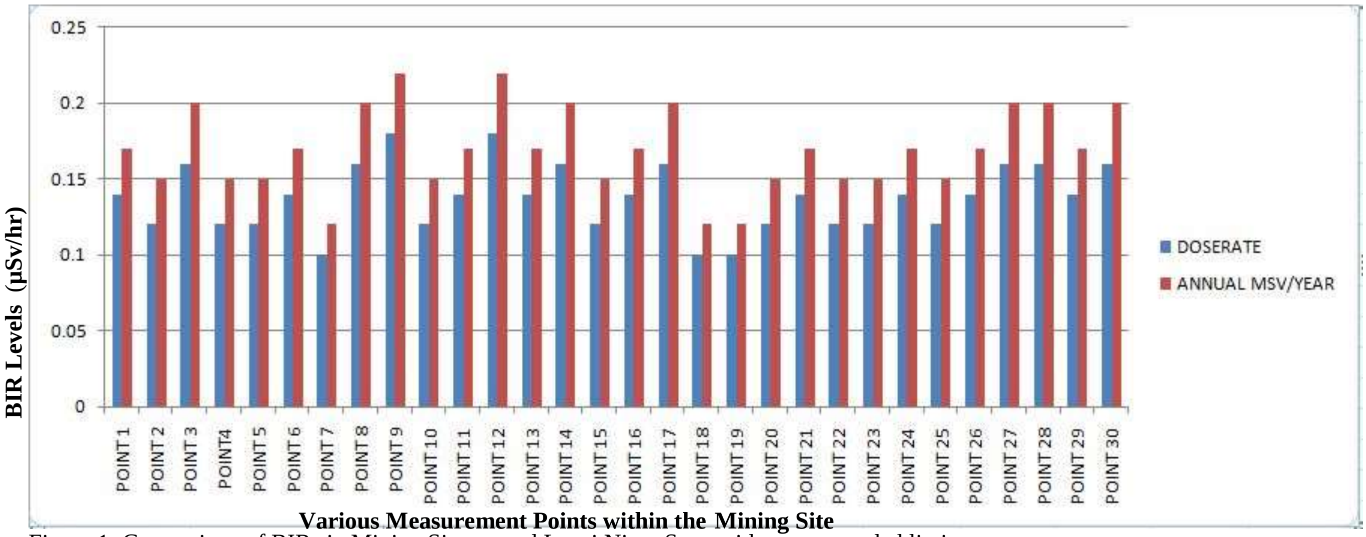

Figure 1: Comparison of BIRs in Mining Site around Lapai Niger State with recommended limit

In Table 1, the BIR levels indicated the range of dose rate from 0.010 to 0.018 µSv/h with mean value of 0.0006 ± 0.002 µSv/h. The annual effective dose for the area was observed to vary from 0.012 to 0.022 µSv/h, with same mean value of 0.169 ± 0.001 µSv/h. The corresponding mean absorbed doses and annual effective dose equivalent (Table 2) as a result of BIR exposure are respectively, 0.154 nGy/h and 0.170 µSv/y at the mineral exploitation site. Table 3 sampled the dose rate distributions in relation to world standard values. The values obtained at all the investigated 30 points were within the world standard recommended limiting value of 1.0 $\mu Sv/yr$ ((Echeweozo & Ugbede, 2020; ICRP, 2007).This variation in BIR values can be attributed to the mineral exposure due to the exploitation activity around the area which has the capability of raising the radioactivity content of the soil and consequently the radiation levels of the mineral exploitation environment. This therefore clearly reveals that the mean BIR level of the investigated Mining Site fell within the recommended ambient BIR exposure level (ICRP, 2007; Osimobi et al, 2015; Agbalagba et al 2016; Ugbede, 2018) even though some pockets of higher BIR were noticed at points 9 and 12 yet they are still within the ICRP threshold. The variation of the BIR levels of the surveyed area when compared with the standard recommended value and modeled across all the probed 30 points within the site (Figure 1) portrays clearer graphical representation of the BIR distributions within the Site. The absorbed doses in all the points are by far lower than the world average value of 59.00 nGy/h (Monica et al, 2016; Agbalagba, 2017) and recommended safe limit of 84.0 nGy/h (UNSCEAR, 2008). Monitoring annual effective dose which is a radiation protection guide that quantifies the whole body absorbed dose per year around such prone areas is very instrumental to a well secured and sustainable environmental quality. the present research findings (values for the annual effective dose) for all the points investigated are lower than the ICRP permissible limits of 1.00 µSv/yr for the general public and 20.00 µSv/yr for occupational workers within a year (ICRP, 2007). This interestingly implied that the studied areas are in good agreement with the permissible limit value based on the collation of the dose rate from other regions (Table 3). Inconsequently; the annual effective radiation doses at this level do not constitute any immediate radiological health effect on the artesian miners, the general Lapai communities and its environment.

CONCLUSION

The focus of this study was to determine the BIR levels at mineral exploitation site which is located at a proximity to the communities of Lapai LG Area of Niger State. The study has thus revealed a generally Low Radiation Levels in most points while few others experienced high ranging radiation levels which has been attributed to the geological and geographical settings of the areas as well as the on-going mineral exploitation activities taking place there. The observed higher related radiation doses above the normal background value could only be due to the natural sources (cosmic and terrestrial). According to the geology of the research regions, the soil in Lapai area may contains a huge deposit of granite. Granites are widely recognized for their high quantities of uranium, thorium, and potassium. This survey unveils the possible presence of radioactive mineral deposits in the survey region, as a result of which the Lapai community and its environs has been exposed to an external Radiation Dose Rate. Although the Dose Rate Levels obtained are generally still in agreement with those derived from other standard sources. This accordingly suggests the need for regulatory actions against any further possible BIR level increase at the mineral exploitation Site which by extension can affect the health quality of both the Lapai communities and their Environs.

REFERENCES

Agbalagba, E. O., Avwiri, G O. and Ononugbo, C. P. (2016). GIS mapping of impact of industrial activities on the terrestrial background ionizing radiation levels of Ughelli metropolis and its environs, Nigeria. *Environ. Earth Sci.* 75:1425 DOI 10.1007/s12665- 016-6216-y

Agbalagba, O. E. (2017). Assessment of excess lifetime cancer risk from gamma radiation levels in Effurun and Warri City of Delta State, Nigeria. J. Taibah Univ. Sci. 11(3):367–380.

Aweda A. K., Usman A, and Ige O. O., (2019). Geophysical Investigation of Groundwater at the Proposed Ibrahim Badamasi Babangida University Teaching Hospital Site, Lapai, Northcentral Nigeria. Lapai Journal of Applied and Natural Science. Volume 5(1), pp. 82 – 87.

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

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.jtusci.2016.03.007

Emelue, H. & Eke, B., (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

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.
International Atomic Energy Agency, (2007). IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection. ISBN 978901007070.

Kamiya K. and Sasatani M, (2012). Effectf of radiation exposure on human body. Nihon Rinsho, Japanese, PMID:22514910. Volume 70(3), pp.367 – 3674.

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.

Olarinoye, O., Ibrahim, S., Baba-kutigi, A. N., & Matthew, K. (2010). Measurement of Background Gamma Radiation Levels at Two Tertiary Institutions in Minna, Nigeria Measurement of Background Gamma Radiation Levels at Two Tertiary Institutions in. May 2015. https://doi.org/10.4314/jasem.v14i1.56491

Osimobi, JC; Agbalagba, EO; Avwiri, GO; Ononugbo, CP (2015). GIS mapping and background ionizing radiation (BIR) assessment of solid mineral mining sites in Enugu State, Nigeria. Open Acc. Lib. J. 2:1–9.

Oxford Academic, (2020). JNCI Monographs. Volume 2020, pp. 97 – 113.https://doi.org/10.1093/jncimonographs/igaa009

Rafique, M., Saeed, U. R., Muhammad, B., Wajid, A., Iftikhar, A., Khursheed, A. L., Khalil, A. M. (2014). Evaluation of excess life time cancer risk from gamma dose rates in Jhelum valley. J. Radiat. Res. Appl. Sci. 7:29–35.

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

Tsepav, 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.

Ugbede, F. O. (2018). Measurement of Background Ionizing Radiation Exposure Levels in Selected Farms in Communities of Ishielu LGA, Ebonyi State, Nigeria. J. Appl. Sci. Environ. Manage. Vol. 22(9), pp. 1427 - 1432

Ugbede, F. O. and Echeweozo, E. O. (2017). Estimation of annual effective dose and excess lifetime cancer risk from background ionizing radiation levels within and around quarry site in Okpoto-Ezillo, Ebonyi State, Nigeria. J. Environ. Earth Sci. 7(12):74–79.

UNSCEAR. (2008). 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 (2008). United Nations Scientific Committee on the effect of Atomic Radiation. 2008 report on the sources and effects of ionizing radiation. Report to the General Assembly with scientific annexes. United Nations, New York.

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.
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