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BACKGROUND RADIATION PROFILE OF NIGERIAN QUARRY SITES: A CASE STUDY OF AKAMKPA, CROSS RIVER STATE, CALABAR.

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Abstract

This research evaluates the profile of Background ionizing radiation (BIR) emanating from naturally occurring radionuclides from rock fragments at quarry sites in Akamkpa Local Government Area of Cross River State, Nigeria. An in-situ measurement approach using specialized Luckum Geiger Muller radiation (Gamma ray spectroscopy-NaT_1) detector optimized to record radiation at 762cm x 762cm micra window was carried out. A total of eight points each from two quarry sites; Cossel (CS) and Alabi Brothers (AB) at distances of 1cm and 1m above the ground and distances from 1m to 8m away from the source and from 7am to 5pm daily were covered for a period of sixteen days to determine the presence of background ionizing radiation level (BOL) from radionuclides in the sites. Measurements of outdoor dose equivalent (µSv/yr), annual effective dose equivalent (mSv/hr) and excess life-time cancer risk ($x10^{-3}$) found average values to be (0.191, 0.203), (0.322, 0.352), (0.912, 0.968) respectively for significant 1m above the ground. The values were within the permissible limit by ICRP of 1m above the ground and there is evidence of environmental radiation levels from rock fragments in the quarry sites.

Keyword: Background Radiation profile, Activities in Quarry sites, Gamma Ray Spectroscopy ($NAIT_1$) detector.

1. Introduction

Quarry sites produces wonderful natural materials for industrial uses specific ally for building and construction and purposes. These processes have created ways for another source of livelihood for youths in the area (Ode, 2017). Environmental effects of dust particles and naturally occurring radiation from radionuclides of rock fragments cannot be over emphasized (Ugbede and Echewuoze, (2020).

In Nigeria, several researches on mining activities like granite quarry sites have been carried out since the beginning of the last century; however, their radiological investigations date back to late 70s and 80s. Many of such researches have confirmed health risk associated with environmental radiation from quarry sites across Nigeria (Kerubo *et al*., 2020). It is however true that mineral content of quarry sites is not limited to granite rock only that contain radionuclides, other mineral like pressures stone may contribute some level of background radiation in the vicinity (Ofomola et al.,2023).

Studies by Nwankwo *et al.,* (2014), also shows that environmental survey of radiation associated with quarry exposes some level of radiation within the vicinities in quarry sites, but the level did not exceed the ICRP prescribed levels. Also Abai, *et al.,* 2021 surveyed radiological health implications of radionuclides from rock fragments in quarry sites, but did not establish baseline data of the background induced radiation in the area.

However, there is certainty of naturally occurring radioactive materials (Norm) in the vicinity of the surveyed sites which are potential risk to carcinogenesis. Such materials may include among others, all radioactive elements found in the environment. More so, anthropogenic activities like mining, rock blasting etc. have increased the percentage risk exposure of environment to radiation compared with the natural occurring situation (Mokobia et. al., 2006).

Exposure to naturally occurring radiation is responsible for the majority of an average person's yearly radiation dose but may not significantly be considered to have any special health impact. Though certain industries handle significant quantities of radioactive materials for industrial use, but there are flushed into their waste streams. When hazardous industrial materials are identified, such industries increasingly become subject to monitoring and regulation for excessive life-time risk (UNSEAR, 2000).

Basically speaking; Akamkpa quarries that play host to a lot of commercial activities arising from mining contains mixed geological formations ranging from igneous rock, sedimentary intrusions, granite, limestone, gipstone, tourmatine etc; provide for certain levels of radiation in the area (Abai, *et al.,* 2021). Percentage natural occurrence of this radiation may not be significance, but studies have shown that long term somatic or genetic effects may occur after a long interaction with ionizing radiation (Tsepave. *et al*., 2015). Therefore, it is pertinent to establish a baseline data on the background ionizing radiation profile within the area under study. This could inform government decision and occupants on the prevalence of radiation and possible mitigation against it.

2. 0 Material and methods

2.1 Description of study area.

Akamkpa is a local Government Area in Southern senatorial district of Cross River State, Nigeria. It experiences a climate of tropical monsoon which contains mangrove swamp and forest vegetation. It is located on latitudes $5^0 10^1$N, $5^0 42^1$N and longitude $8^0 2^1$E, $8^0 44^1$E as shown on Fig.1. (Abai *et al,* 2021). It has an area of 5,003 sqkm with more than 30 quarry sites predominantly. But specifically speaking, survey was carried in two most effective ones with high volume of industrial activities i.e A;abi Brothers(AB) and Crushrock Cossel (CS) Quarry sites.

2.2 Materials. The materials used for the survey include; metre rule, GPS, stop watch, Geiger Muller radiation (NaTI) detector, pen and a book.

Table 1: Location and Latitude of Survey Areas in Akamkpa LGA

Locations	latitude	longitude
Cosell Crush rock quarry industries LTD	5^0 12’ 5^0 32 N	8^0 21’ E 8^0 44’E
Alabi Brothers quarry New Netim	5^0 12’ 5^0 32N	8^0 20’ 8^0 34’E

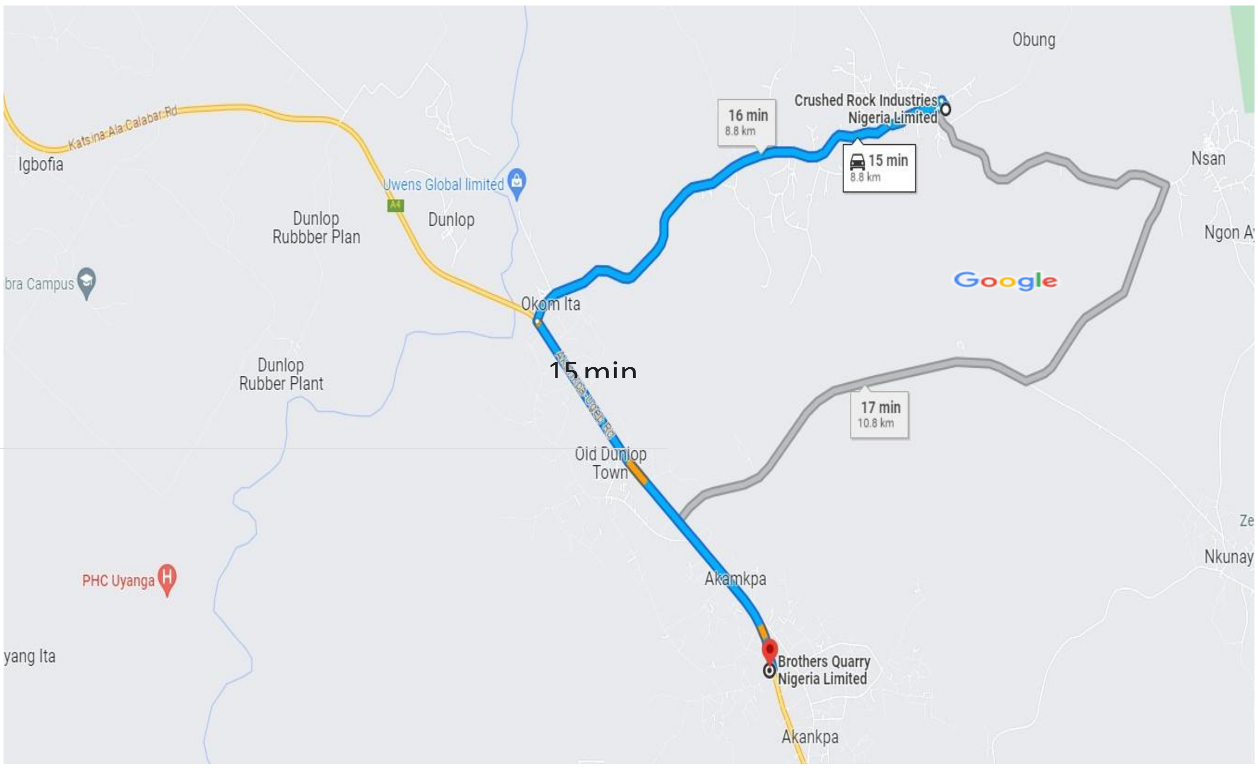

Fig 1: Cosel Crushed Rock Industries Nigeria Limited, Old Netim Village, Akamkpa And Alabi Brothers Quarry Nigeria Limited, Akamkpa LGA, Cross River State

2.3 Methods of Measuring Radiation

An in-situ measurement approach of background ionizing radiation (BIR) was adopted and preferred to obtain the profile radiation values. The outdoor radiation level was measured using specialized Luckum Geiger Muller radiation (NaTI) detector; optimized to record radiation at 762cm x 762cm micra window.

A total of sixteen (16) points which comprises eight (8) on each quarry sites were marked out. The points were chosen evenly to cover the area under study. Measurements were done at both 1.0cm and 1.0m above the ground level with detector window facing the point under investigations (Mokebia, 2016).

The locations marked as C_1 ---C_8 for Cossel sites and A_1 ----A_8 for Alabi Brothers sites have distances varying from 1m to 8m away from the sources. These sources were blast sites, dumpsites for crushed granites and other areas away from activity sites. Also, in each of the points of measurements, a GPS was used to determine the location points.

Measurements of outdoor dose equivalent (μSv/hr), calculations of annual effective dose equivalent (AEDE) (mSv/yr) value, and excess life-time cancer risk (ELCR) $x10^{-3}$, were determined at 3 minutes' intervals from 7 am to 6 pm. This process was repeated for a duration of eight (8) days in each site. Summary of average values of measurements in each distance was determined and the results tabulated as shown on tables 2 and 3. The determination of average value of measurement was necessary to cater for variations in temperature from morning to evening and from day one to day eight. Radiological assessment of Norms in samples is necessary to determine the effects of radiation exposure to the immediate environment and persons working in quarry sites.

The value of AEDE(mSv/yr) and ELCR($x10^{-3}$) were calculated using the formulae;

a) AEDE= Dose rate(μSv/hr) x8760 h x 0.2 x $0.7Sv.Gy^{-1}x10^{-6}$, (1)

where 0.2 is outdoor occupancy factor, $0.7Sv.Gy^{-1}$ is conversion factor.

b) Excess Life-time cancer risk (ECLR) = AEDE x ALD x CRF (2)

where ALD, CRF are average life duration of human (70yrs) and Cancer risk factor (0.05) for public (Mokobia and Oyibo, 2017).

c) External hazard index (Hex) $=A_{RA}/370 + A_{TH}/259 + A_K/4810$ (3)

where, A_{RA}, A_{TH}, A_k are activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Bq.kg-1

d) Internal hazard index (H_{int}) $= A_{RA}/370 + A_{TH}/259 + A_K/4810$ (4)

where ,A_{RA}, A_{TH}, A_k are activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Bq.kg-1

(Yang et al., 2005).

3.0 Results and discussion

The results of the research on tables 2 and 3 and figures 2 and 3 show some similarities in the distribution of dose equivalent (μSv/hr), calculated values of AEDE (mSv/yr) and ELCR ($x10^{-3}$) for both quarries at 1cm and 1m above the ground and 1m to 8m horizontal distances respectively. The observed data have values ranging between 0.123 to 0.255, for dose equivalent, 0.239 to 0.442 for AEDE and (0.586 to 1.39) $x10^{-3}$ for ELCR at a significant distance of 1m above the ground as recommended by ICRP on measurement of radiation above the ground.

Though the average values of dose equivalent (μSv/hr), AEDE (mSv /y r) and ELCR ($X10^{-3}$) were observed to be 0.197 μSv/ hr, 0.342 mSv/yr, (0.94 $x10^{-3}$) for both Cossel (CS) and ABol quarries respectively, which agree with Ofomola et al.,(2023) and Kerubo et al.,(2020) on the levels of ionizing radiation in the vicinities of quarry sites. The implication of the variations in the distribution in quarries measured and calculated radiation values do not suggest which of the quarries has higher values of EQ, AEDE and ECRL compared with another.

Table 2**:** Measured outdoor dose equivalent, AEDE and ELCR values for 1cm above the ground for Cossel (CSC) and Alabi(AB) quarry sites

Level	Dose Equivalent (μSv/yr)		AEDE **(**mSv/yr**)**		ELCR **(**$X10^{-3}$**)**	
L	CS	AB	CS	AB	CS	AB
C_1A_1	0.248	0.252	0.430	0.437	1.183	1.174
C_2A_2	0.306	0.353	0.531	0.612	1.460	1.683
C_3A_3	0.387	0.178	0.671	0.412	1.845	1.355
C_4A_4	0.348	0.222	0.602	0.543	1.658	1.493
C_5A_5	0.288	0.239	0.499	0.565	1.372	1.554

C_6A_6	0.193	0.173	0.335	0.447	0.921	1.230
C_7A_7	0.285	0.183	0.494	0.371	1.359	1.020
C_8A_8	0.256	0.149	0.444	0.416	1.221	1.144
Average	0.287	0.203	0.191	0.485	1.330	1.334

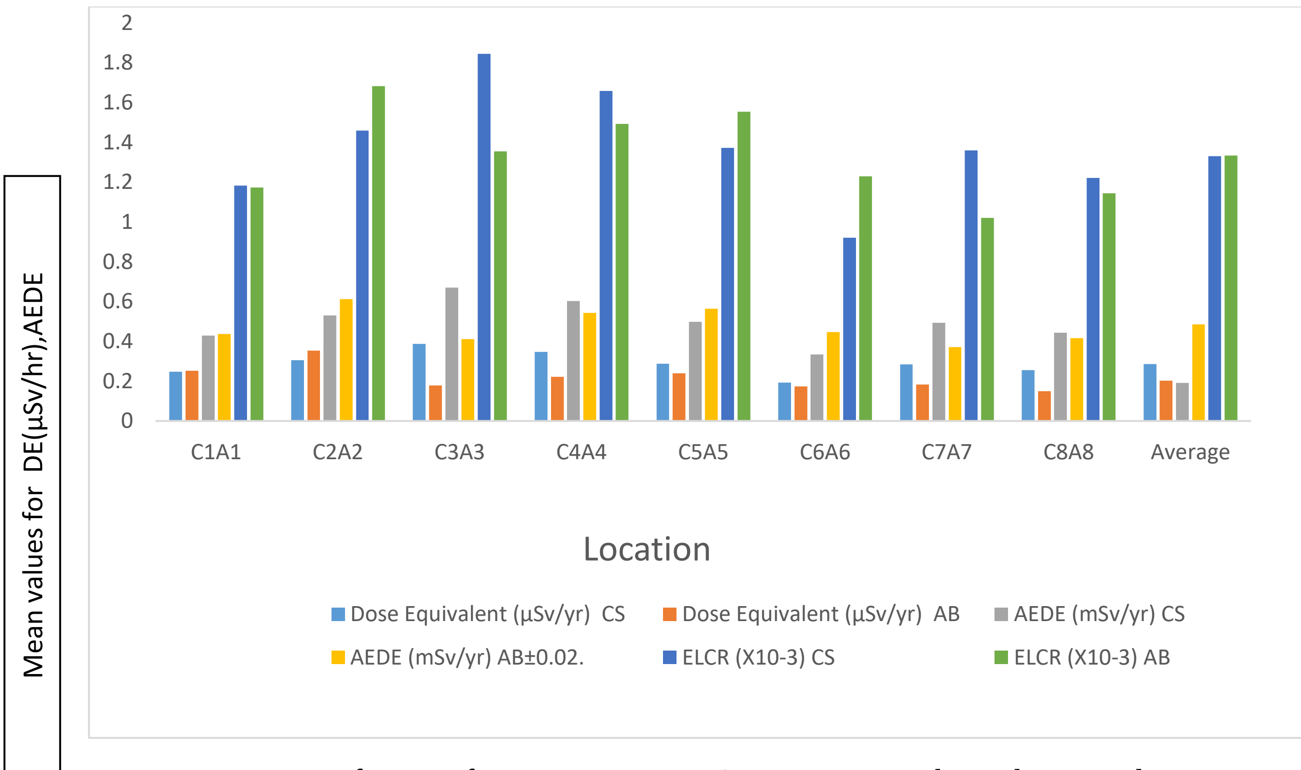

Fig. 2 Comparison of AEDE for CS, AB Quarry & ICRP at 1cm above the ground

Table 3**:** Calculated outdoor AEDE and ELCR values for 1m above the ground for Cossel (CS and Alabi(AB) sites Quarry

Level (m)	Dose Equivalent (µSv/hr)		AEDE (mSv/yr)		ELCR ($X10^{-3}$)	
L	CS	AB.	CS	AB	CS	AB
C_1A_1	0.167	0.233	0.290	0.404	0.798	1.111
C_2A_2	0.171	0.246	0.297	0.427	0.817	1.174
C_3A_3	0.233	0.178	0.404	0.309	1.111	0.850
C_4A_4	0.236	0.222	0.409	0.385	1.125	1.060
C_5A_5	0.255	0.239	0.442	0.414	1.216	1.139
C_6A_6	0.123	0.173	0.213	0.300	0.586	0.825
C_7A_7	0.207	0.183	0.359	0.317	0.987	0.872
C_8A_8	0.138	0.149	0.239	0.258	0.657	0.710
Average	0.191	0.203	0.332	0.352	0.912	0.968

Figures 2 and 3 give descriptive comparative representation of the occurrence of the AEDE(mSv/yr) and ELCR($X10^{-3}$) at both 1.0cm and 1.0m respectively in both quarries, using component bar charts, which show little variations in these values which are not significant.

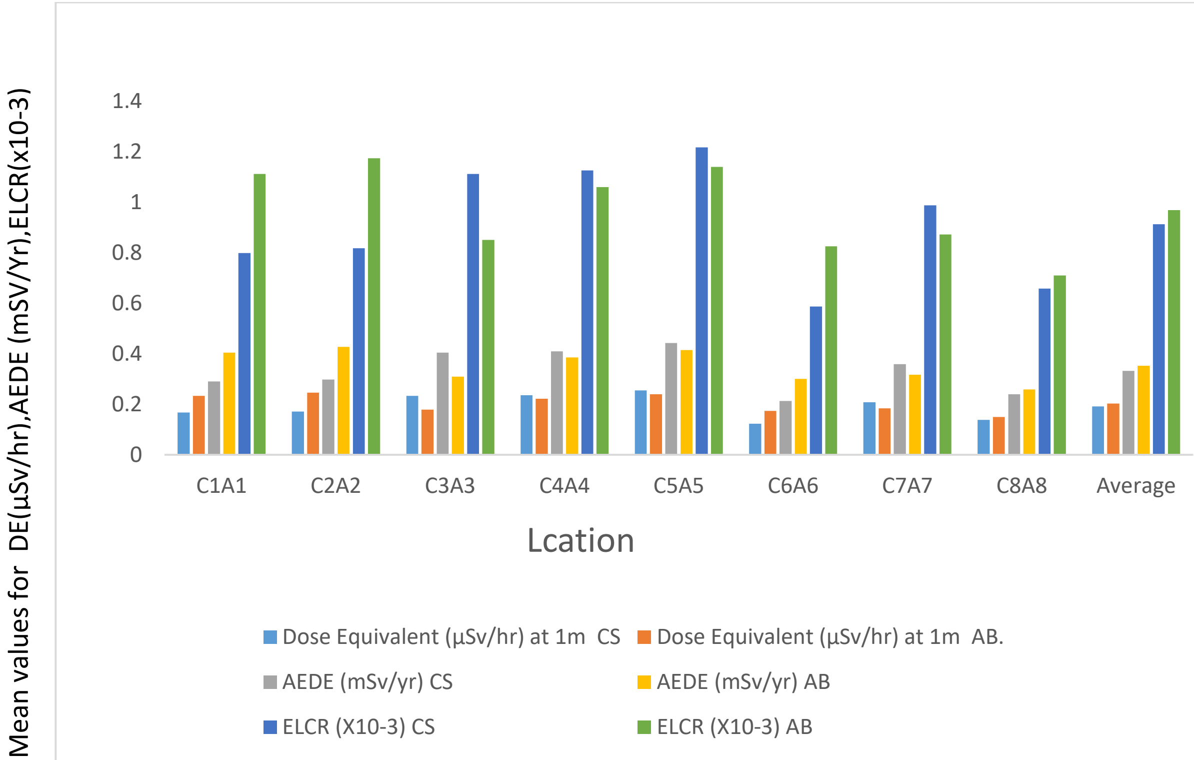

Fig. 2 Comparison of AEDE for CS, AB Quarry & ICRP at 1m

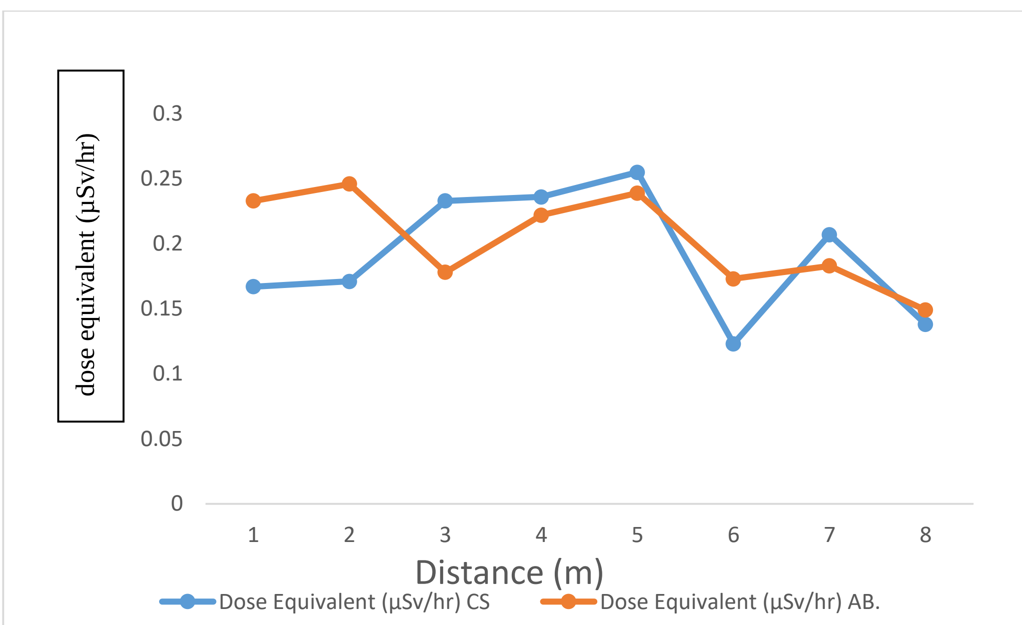

Fig. 4: Graph of dose equivalent (µSv/hr) for CS, AB Quarry sites & ICRP at distance (m) from the source.

In figure 4, the average dose equivalent (µSv/hr) for the two quarries shows an undulating profile of radiation distribution with no specific relation between distance away from the source and the amount of radiation equivalent dose received. This is because the values of dose equivalent (μSv/hr) rises at 2, 5 and 7m and drops at 3, 6 and 8m respectively from figure 4 which is not perfectly in agreement with Echelveozo and Ugbede, (2020), where radiation deceases with increased distance away from the source.

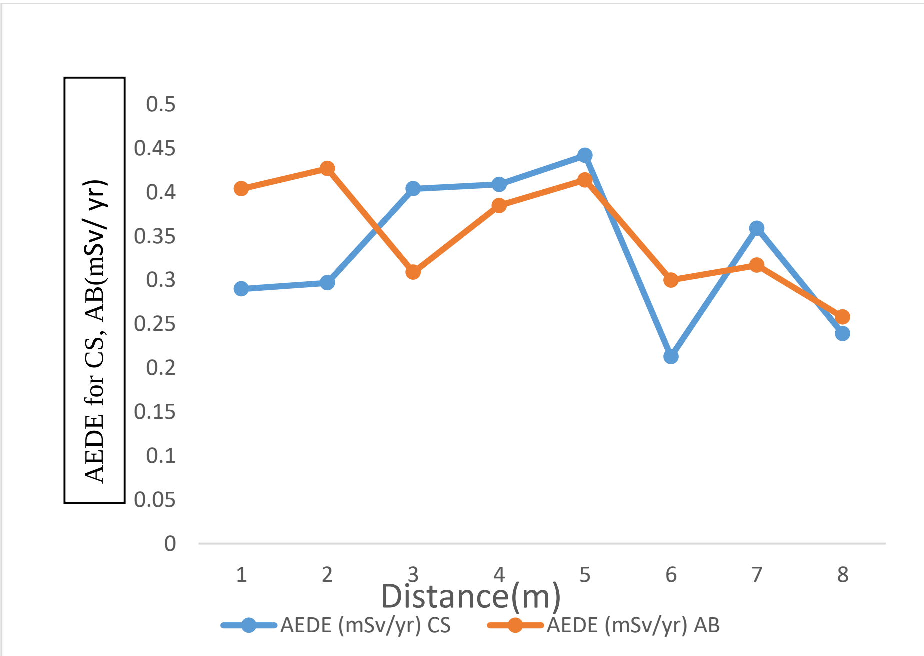

Fig. 5: Graph of AEDE for CS, AB sites against distance from the source

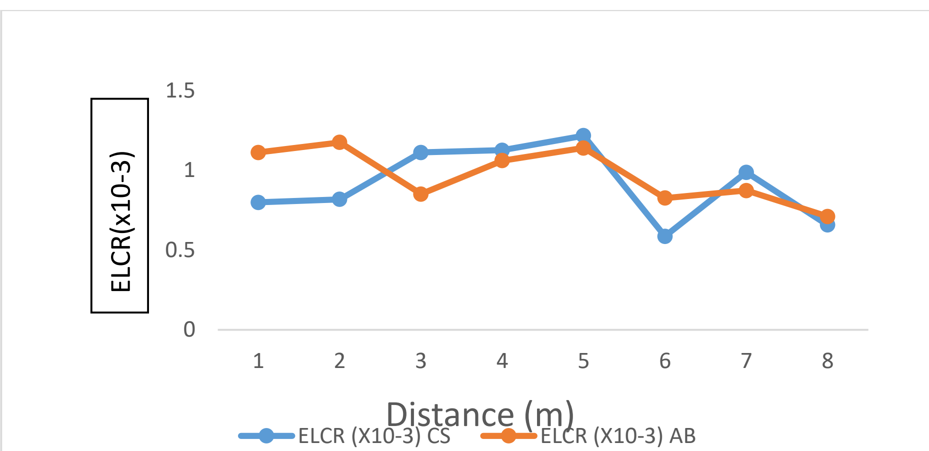

Fig. 6: Graph of ELCR(x10-1) for CS, AB Quarry sites against the distance (m) from the source

Interestingly too, figures 5, and 6 are illustrations of the relationships between the distance measured away from the source points and the level of background radiation associated with the area.. The same scenario shows that, AEDE (mSv/yr) and ELCR(x 10^{-3}) values increases and also decrease at distances away from the source. Though this suggest a close relationship between distances measured away from the source points and the amount of radiation received. The rise in values at certain distance away from source point may be accounted for by unnoticed presence of some radionuclide's activity.

However, the profile of radiation distribution levels on the two quarries under surveys compare with the 1CRP values at 1m distance above and away from the ground, is far lower. The distribution therefore shows that, as we migrate some metric distances above the ground from the radiation source, the values of radiation drop proportionally, but not the case with horizontal distances. Though the values are far below the recommended ICRP standard for 1m, but it does not underscore the fact that continuous interaction with low level ionizing radiation cannot have any longtime genetic effect or possible lethal dose. This may be brought about by exceeding the threshold and possibly braking the bond of the double Helix genetic structure

4. Conclusion

Ionizing Radiation profile of two quarry sites in Akamkpa Local Government Area of Cross River State was conducted using Gamma ray spectroscopy. The results show some levels of background radiation emanating from the quarry sites under surveys. Though, the values of radiation observed distance away from the sources have no specified relationship but, Cossel and Alabi Brothers quarry sites have average ionizing radiation profile values of dose equivalent of 0.197 μSv/hr; annual effective dose equivalent of 0.342 mSv/yr and excess life-time cancer risk of 0.94 $x10^{-3}$, which are below the recommended ICRP unit of 1 mSv/yr for 1m above the ground. The study presents baseline data of background radiation profile of the survey area. However, the background ionizing radiation value observed may not anyway pose any serious short-term radiological effects, but long-term interaction of the occupants and workers with radiation may result to genetic effect created by an overburdened threshold. It is, therefore, recommended that; the authority concern should encourage regular checks or routine monitory to suppress possibilities of the effects on employees and residents within the area to avoid harms from the activity.

References

Abai, I. J., Kamgba, F, A. and Ushie, P. O.(2021). Radiologgical Health Implications of Radiation Levels in Rock Fragment from Akamkpa Quarry Sites, South-South Nigeria. *Journal of Applied Phsics , 13(6): 04-09.*

Anemila, O. (2018). Radiometric Impact assessment around two Quarry sites, Benin-owo; expres way Southwestern Nigeria. *International Journal of Engineering & Geosciences 3 (1) .20-36*

Echelveozo, E. O and Ugbede, F. O. (2020). Assessment of background ionizing radiation dose level in Quarry sites located at Ebonyi state, Nigeria. *Journal of Applied Sciences and Environmental Management. .24(10).*

Kerubo, M. R., Peterson, N.W., Jackim. N. & Wychtte, A. (2020). Levels of ionizing radiation in selected Quarries in Nyamira. *Science Direct (Heliyon.) 6 (7). 404363. kenya.*

Mokobia, C. E. and Oyibo, B. (2017). Determination of Background Ionizing Radiation (BIR) Level in some selected farms in Delta State, *Nigeria. Journal of Science and Environment.115(1).* Facuity of Science and Agriculture, Abraka, Edo State.

Nwankwo, L. I., Akoshile, C. O., Alabi, A. B., Ojo, O.O. and Ayodele, T. A.(2014).Enviornmental Ionizing Radiation Survey of Quarry Sites in Ilorin Industrial Area, Nigeria. *Nigerian Journal of Basic and Applied Science.22(1&2):1-4.*

Ode, O. S. (2018)). Radiation Exposure Level in some Granite Quarry sites wihin Ohimini and Gwer-East Local Government Area of Benue State, Nigeria. Insights Medical Physics & Applied SCs .2 (2:9)

Ofomola, O. M., Ugbede, F. O & Anomohanram, O. (2023). Environmental Risk Assessment of Background Radiation; National Radioactivity and toxic elements in rocks and soils of Nkalegu, Quarry Southeastern Nigeria. *Journal of Hazard Materials Advances 10;* (100288).

Tsepav, M. T., Yakubu, A; Gene, A. S. and Usman, (2018). Assessment of Radiation Related Health Risk of Quarry Sites in the Vicinity of Lapai, North Central Nigeria. *International Journal of Scientific & Engineering Research 9(4). 1414-1421*.

United Nation Scientific committee on the effects of Atomic Radiation (UNSEAR, 2010). Sources and effects of ionizing radiation, Report to General Assembly with scientific annexes. 1. UN, New York.

Yang, Y; Wu, X; Wang,W; Lu, J; Wang, L. U; and Hsia, Y (2005). Radioactivity contents in soil of Xiazhuang granite area, china. *Appl Radiat Isot 63: 255-259*