https://dx.doi.org/10.4314/dujopas.v10i1c.2
ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 10 No. 1c March 2024*

Evaluation of Indoor and Outdoor Radiation Levels and its Health Hazard at Dennis Osadebay University, Asaba, Delta State, Nigeria

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Abstract

This research designed at evaluating the indoor and outdoor background ionizing radiation dose equivalent levels at Dennis Osadebay University, Asaba Delta state. The study was carried out at fifteen different locations around the university campus using a portable GQ GMC-320 detector to measure outdoor and indoor equivalent dose rate of the university campus. The mean values of outdoor and indoor equivalent dose rate obtained are 0.135 µSv/hr and 0.142 µSv/hr respectively. These mean values are vaguely lower compared to 0.274 µSv/hr world average limit. The mean values of annual effective radiation equivalent (AEDE) of outdoor and indoor are 0.788 mSv/y and 0.142 mSv/y respectively. Similarly, 2.153 and 0.716 are the obtained values for excess lifetime cancer risk (ELCR) outdoor and indoor around the university respectively. The calculated dose to organs showed that the testes have the highest organ dose of (0.533 and 0.039) mSv/y for indoor and outdoor respectively. The estimated AEDE around the university are below the permissible limit, while ELCR average values for both outdoor and indoor around the university exceeded the standard value. The implication of equivalent dose rate, AEDE and ELCR values is that the university environment appears to be safe from immediate radiation-related health effects due to BIR exposure. Nevertheless, the possibility that an individual may develop cancer over their lifetime within university environment.

Keywords: *Background, Geiger-Muller, Cancer, Osadebay*

INTRODUCTION

Ionizing radiation, arising from both natural and anthropogenic sources, is an omnipresent environmental factor that has long been a subject of scientific interest due to its potential impact on public health and the environment (UNSCEAR, 2008; Nte *et al.*, 2013). Already it is a known fact from scientific reports that radionuclides play significant role to human exposure to background ionizing radiation (Esi *et al.*, 2019; Ibrahim, *et al.*, 2014; Farai and Jibiri, 2003; Bamidele, 2013). The primary terrestrial source of ionizing radiation is naturally occurring radionuclides found in the Earth's crust, such as uranium, thorium, and potassium-40, which decay and release radiation (Ibrahim *et al.*, 2014). The presence and concentration of these radionuclides in the Earth's crust vary significantly according to local geological conditions. The level of background ionizing radiation is subject to significant variation in atmospheric and geological situation of the environment, which is known to be higher in granites rocks and lower in phosphate and shale rocks (Enyinna and Onwuka, 2014; Avwiri and Esi, 2015; Ohwoghere-Asuma and Esi, 2017). These rocks have relatively high radionuclide

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concentrations (Enyinna and Onwuka, 2014; Avwiri and Esi, 2015). Industry, research institute, medicine and domestic activities also add to radiation level of the environment. About 0.274μSv/hr has been estimated as the average background ionizing radiation dose received by humans globally, of which 80% comes from natural sources and 20% from anthropogenic sources. The global community has increasingly focused on evaluating radiation levels and their impact on the environment due to the harmful effects of ionizing radiation on living organisms. Ionizing radiation, with energy exceeding ten electronvolts (10 eV), possesses the capability to ionize atoms and molecules, as well as break chemical bonds, leading to significant chemical and biological alterations (Jwanbot *et al.,* 2013). The extent of radiation exposure can result in injuries and clinical symptoms, categorized as chronic or acute depending on the severity of the health effects. Excessive radiation exposure can lead to various biological health issues, including chromosomal changes, the initiation of cancer, the generation of free radicals, bone necrosis, and the development of radiation-induced cataracts (Avwiri, 2011).

The World Nuclear Association (2014) put forward a summary of the normal average public exposure to natural radiation, which is shown in Table 1.

Table 1: Typical Natural Radiation Exposure to People in Public (**Source**: World Nuclear Association, 2014).

Source of exposure Annual Effective Dose (mSv)	Annual Effective Dose (mSv)	Average	Typical Range
Cosmic radiation	Direct photon and ionization Component.	0.28	
	Nuclear element.	0.10	0.01-0.3
	Radionuclides from Cosmogenic.	0.01	
	Cosmogenic and the full spectrum.	0.39	
External terrestrial radiation	Outdoors.	0.07	
	Indoors.	0.41	0.05-0.4
	Total radiation emitted by land surfaces.	0.48	
Inhalation	Uranium and thorium series	0.006	
	Radon(Rn-222)	1.15	0.001-1.0
	Thoron(Rn-220)	0.10	
	Total exposure from inhalation	1.26	
Ingestion	K-40	0.17	
	Uranium and thorium series	0.12	0.1-0.2
	Total exposure from ingestion	0.29	
Total		2.42	1.2-1.9

The human body regularly adapts to the usual background radiation without causing harm to our health. Nonetheless, any exposure beyond this natural level may lead to specific health concerns. The ALARA principle, which is a radiation safety guideline, emphasizes the importance of keeping radiation exposure as low as reasonably achievable. To adhere to this principle and mitigate the potential harm of ionizing radiation, it is of utmost importance to carry out this study to ascertain the level of BIR exposure of workers within the university.

STUDY AREA

Dennis Osadebay University is a state owned university located in Asaba in Oshimili-South local government area, Delta State. It is situated nearby to the locality Iyiwundon. It is located between latitude 6.23535° or 6° 14' 7" north and longitude 6.7046° or 6° 42' 17" east with an elevation of about 34 metres (112 feet).

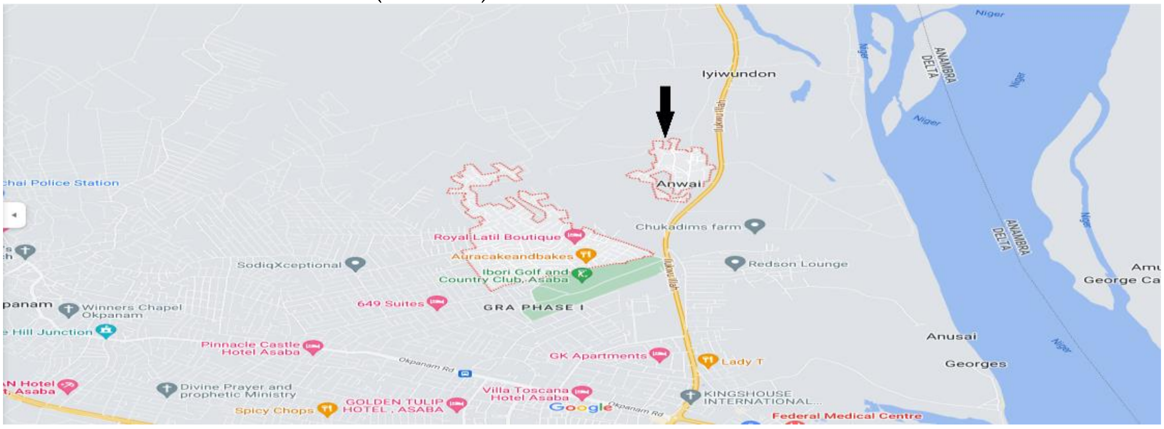

Fig 1: Map showing Anwai, Asaba Community (Google map)

MATERIALS AND METHODS

A portable radiation detector GQ GMC-320 was used to measure the equivalent dose levels of radiation absorbed in μSv/h within the Dennis Osadebay university campus. This detector is capable of detecting β-particles, γ-rays, and x-rays. It operates by generating an electrical pulse in the CPU whenever radiation passes through the Geiger tube, which is then recorded as a count. To conduct these measurements, a total of fifteen building were considered. Measurements were taken at a height of 1.0 meter above ground level, with the detector's window facing the specific point being investigated and a GPS was used to get the coordinates. At each point, three measurements of absorbed dose were taken, with a 3-minute interval between each measurement. These three readings were then averaged to determine the dose equivalent (DE) in air, measured in μSv/h. The average dose equivalent (DE) was then used to calculate the annual effective dose equivalent (AEDE) in mSv/yr for the workers and students within the university campus.

Annual Effective Dose Equivalent (AEDE)

The AEDE was calculated using the following formula (UNSCEAR, 2000;2008):

$$AEDEin\ (mSv/yr) = X(\mu Sv/yr) \times 8760 \times 0.8 \times 0.001 \quad (1)$$

$$AEDEout\ (mSv/yr) = X(\mu Sv/yr) \times 8760 \times 0.2 \times 0.001 \quad (2)$$

X= Absorbed Dose rate (ADR), 8760= the number of hours in one year, 0.8 = the indoor occupancy factor, 0.2 = the outdoor occupancy factor.

Excess Life Cancer Risk (ELCR)

The calculated AEDE values were used to determine the ELCR values in each of the locations using appropriate equations, as noted by Mokobia and Oyibo (2017)

$$ELCR = AEDE \times ALD \times CRF \quad (3)$$

Table 2: Values of constant parameters (ICRP, 2007).

S/No	Constant Parameters	Value
1	Average life duration	54.5 years
2	Cancer risk factor	0.05(Sv^{-1}),

Effective Dose Rate on Organs

The effective dose rate delivered to a particular organ was also calculated using the following relation

$$D_{organ} = OF \times AEDE \times F \quad (4)$$

Where OF (occupancy factor) = 0.8 for indoor and 0.2 for outdoor

F (conversion factor for organ dose from ingestion = 0.64 (lungs), 0.58 (ovaries), 0.69 (bone marrow), 0.82 (testes), 0.62 (kidneys), 0.46 (liver) and 0.68 (whole body).
The model of the annual effective dose to organs estimates the amount of radiation intake by a person (James *et al.,* 2020).

RESULTS AND DISCUSSION

Table 3: Calculated Indoor and Outdoor Mean Equivalent Dose Rates, Annual Effective Dose Equivalent (AEDE) and Excess Life-time Cancer Risk (ELCR)

Sampling Code	Locations	Indoor			Outdoor		
		Equivalent Dose Rate (μSv/hr)	AEDE (mSv/yr)	ELCR $\times 10^{-3}$	Equivalent Dose Rate (μSv/hr)	AEDE (mSv/yr)	ELCR $\times 10^{-3}$
DOU1	Environmental Science Complex	0.451	0.827	2.254	0.095	0.167	0.455
DOU2	Library	0.134	0.937	2.552	0.118	0.206	0.561
DOU3	Science Basement	0.156	1.093	2.978	0.129	0.226	0.616
DOU4	Admin Building	0.156	1.092	2.985	0.139	0.244	0.664
DOU5	Staff Club	0.084	0.591	1.611	0.087	0.153	0.416
DOU6	Works Department	0.126	0.885	2.412	0.124	0.218	0.593
DOU7	Physics Lab	0.097	0.680	1.852	0.103	0.180	0.491
DOU8	New Faculty of Agriculture Complex	0.156	1.033	2.980	0.106	0.186	0.507
DOU9	Faculty of Management and Social Science	0.090	0.629	1.705	0.134	0.235	0.641
DOU10	Faculty of Art	0.060	0.421	1.146	0.215	0.216	0.589
DOU11	1000 Capacity Lecture Theater	0.126	0.883	2.406	0.370	0.649	1.768
DOU12	Professor's Quarters	0.119	0.832	2.267	0.134	0.234	0.638
DOU13	NEEDS Assessment	0.097	0.678	1.847	0.139	0.241	0.663
DOU14	Faculty of Computing	0.081	0.566	1.542	0.137	0.241	0.657
DOU15	Anglican Hall	0.095	0.668	1.821	0.103	0.180	1.474
Average		**0.135**	**0.788**	**2.153**	**0.142**	**0.237**	**0.716**

Table 4. Dose to different organ of indoor of Dennis Osadebay University

Sampling Code	Lungs	Indoor		D_{organ} (mSv/yr)			
		Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole Body
DOU1	0.423	0.384	0.457	0.543	0.410	0.304	0.450
DOU2	0.496	0.450	0.535	0.635	0.480	0.356	0.527
DOU3	0.579	0.524	0.624	0.741	0.560	0.416	0.615
DOU4	0.578	0.523	0.623	0.741	0.560	0.415	0.614
DOU5	0.313	0.283	0.337	0.401	0.303	0.225	0.332
DOU6	0.468	0.424	0.505	0.600	0.454	0.337	0.498
DOU7	0.360	0.326	0.388	0.461	0.349	0.259	0.382
DOU8	0.547	0.495	0.589	0.701	0.530	0.393	0.581
DOU9	0.333	0.302	0.359	0.427	0.323	0.239	0.354
DOU10	0.223	0.202	0.240	0.285	0.216	0.160	0.237
DOU11	0.467	0.424	0.504	0.599	0.453	0.336	0.497
DOU12	0.440	0.399	0.475	0.564	0.427	0.317	0.468
DOU13	0.359	0.325	0.387	0.460	0.348	0.258	0.381
DOU14	0.300	0.271	0.323	0.384	0.290	0.215	0.318
DOU15	0.354	0.320	0.381	0.453	0.343	0.254	0.376
Average	**0.416**	**0.377**	**0.450**	**0.533**	**0.403**	**0.299**	**0.442**

Table 5. Dose to different organ of outdoor of Dennis Osadebay University

Sampling Code	Lungs	Outdoor		D_{organ} (mSv/yr)			
		Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole Body
DOU1	0.021	0.019	0.023	0.027	0.021	0.015	0.023
DOU2	0.0.26	0.024	0.028	0.034	0.026	0.019	0.028
DOU3	0.029	0.026	0.031	0.037	0.028	0.021	0.031
DOU4	0.031	0.028	0.034	0.040	0.030	0.022	0.033
DOU5	0.020	0.018	0.021	0.025	0.019	0.014	0.021
DOU6	0.028	0.025	0.030	0.036	0.027	0.020	0.030
DOU7	0.023	0.021	0.025	0.030	0.022	0.017	0.024
DOU8	0.024	0.022	0.026	0.031	0.023	0.017	0.025
DOU9	0.030	0.027	0.032	0.039	0.029	0.022	0.032
DOU10	0.028	0.025	0.030	0.035	0.027	0.020	0.030
DOU11	0.083	0.075	0.090	0.106	0.080	0.060	0.088
DOU12	0.030	0.027	0.032	0.038	0.030	0.022	0.032
DOU13	0.031	0.028	0.033	0.040	0.030	0.022	0.033
DOU14	0.031	0.028	0.033	0.040	0.030	0.022	0.033
DOU15	0.023	0.021	0.025	0.030	0.022	0.017	0.024
Average	**0.031**	**0.028**	**0.033**	**0.039**	**0.030**	**0.022**	**0.032**

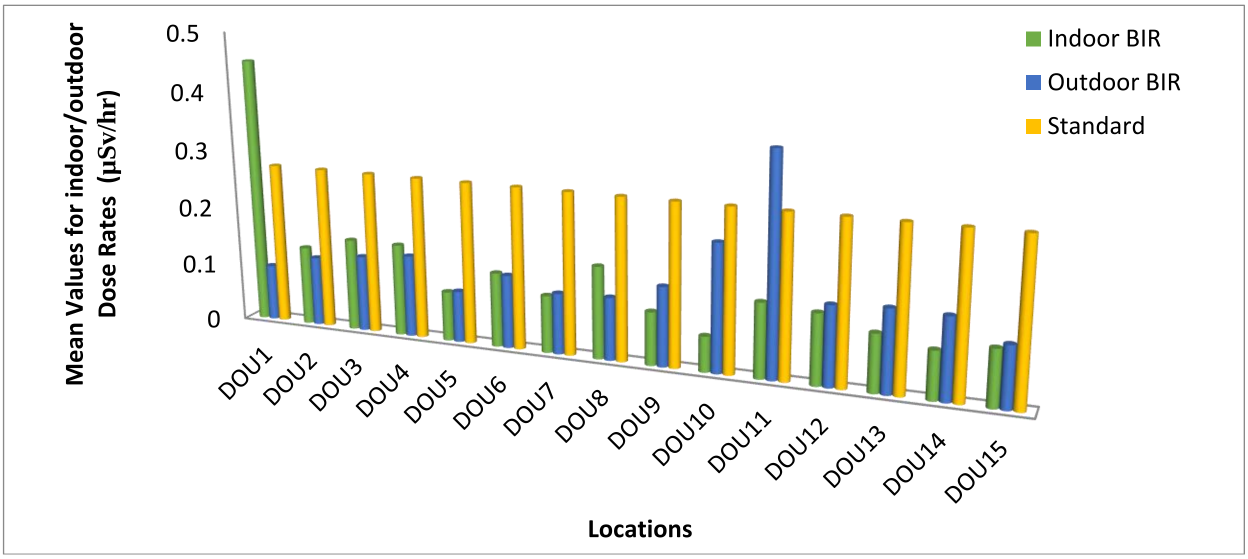

Fig 2: Comparison of the Mean values for Indoor and Outdoor BIR with Standard

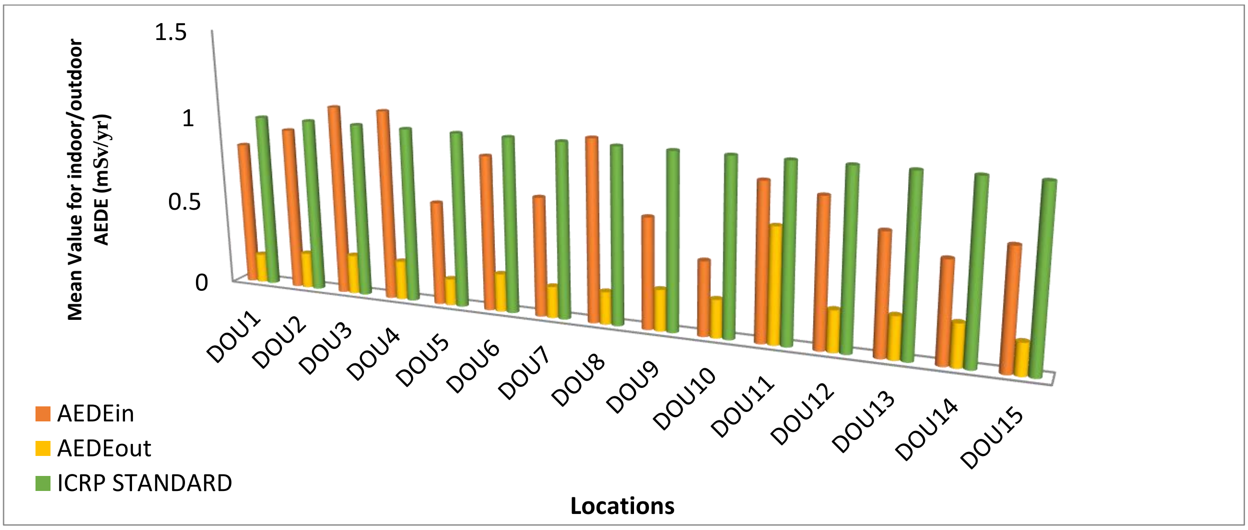

Fig. 3: Comparison of Indoor/Outdoor AEDE with ICRP Standard

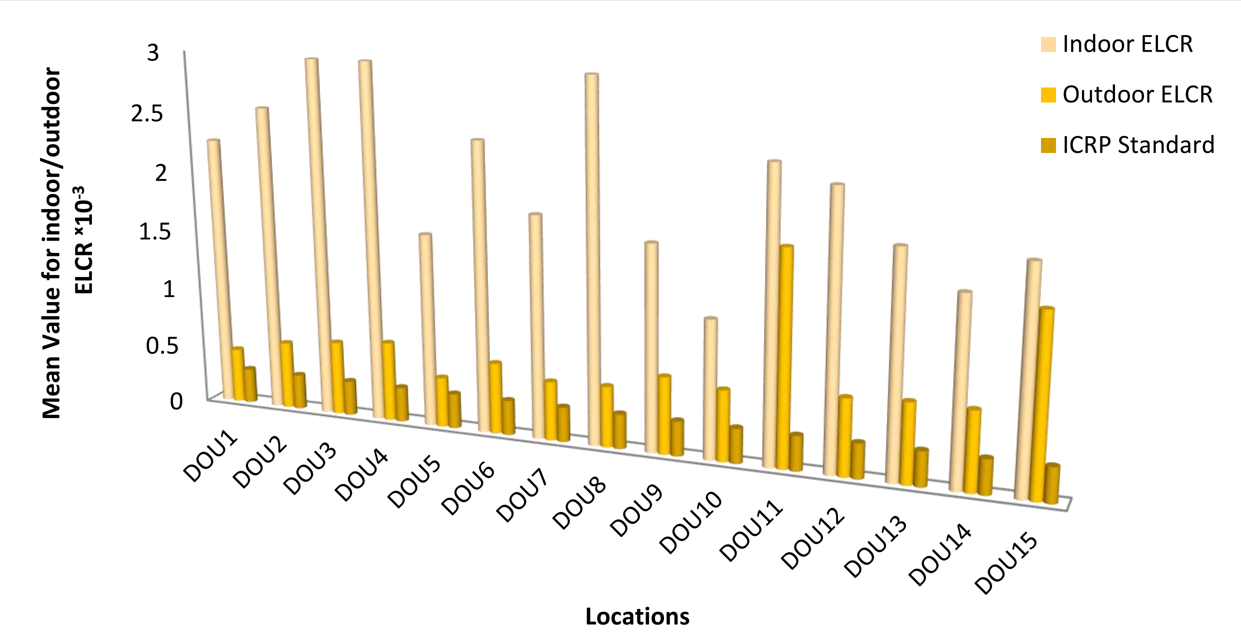

Fig. 4: Comparison of Indoor/Outdoor ELCR with ICRP Standard

The results (indoor and outdoor) of both measured and calculated results of mean BIR, AEDE, ELCR and D_{organ} are presented in Tables 3, 4 and 5 respectively. The mean values obtained, ranges from 0.060 µSv/hr to 0.451 µSv/hr with an average value of 0.135 µSv/hr. The maximum and minimum mean values are observed to be at theDOU1 and DOU10respectively. For the outdoor dose rate levels, itwas observed to vary from 0.087 µSv/hr to 0.370 µSv/hr with an average of 0.142 µSv/hr. The lowest equivalent dose rate mean value was recorded atDOU5 while the highest dose rate mean value was found to be at DOU11. In Figure 2, a comparison of the equivalent dose rate with standard dose limit was done. It can be observed that all building is within the permissible limit except for the indoor of DOU1 and the outdoor of DOU11 which are above the recommended dose limit, when compared to the 0.274 µSvhr^{-1} worldwide recommended average according to Okoye and Avwiri (2013), Avwiri and Esi (2014). Table 2 shows the mean results obtained for indoor AEDE, ranges from 0.421 µSv/hr to 1.093 µSv/hr with an average value of 0.788 µSv/hr. The maximum and minimum AEDE values are observed to be at the DOU3 and DOU10 respectively. The outdoor AEDE was observed to vary from 0.167 µSv/hr to 0.649 µSv/hr with an average of 0.142 µSv/hr. The lowest mean value is recorded atDOU1 while the highest mean value is found to be at DOU11 respectively. These are graphically shown in Figure 3 where values are compared. From the figure, it is evident that the obtained values forDOU3, DOU4 and DOU8 are each above the 1.0 mSv/yr recommended value (ICRP, 2007). This implies that the workers in these affected locations are radiologically unsafe. From the indoor ELCR results obtained the mean values range from 1.146 to 2.985 with an average of 2.153. The minimum and maximum equivalent dose rate is observed at DOU10and DOU4 respectively. The results obtained for the outdoor ELCR ranges from 0.416 to 1.768 with an average of 0.716. The minimum and maximum was seen at DOU5 and DOU11. From the graphical comparison shown in Figure 3, the obtained mean indoor and outdoor ELCR values for the various study locations when compared to the international standard of 0.29×10^{-3}, was found to be higher than the approved standard set by ICRP (2007). The implication is that the workers within this study location may likely be affected radiological within their life-time. It is therefore of importance that necessary agencies saddled with the responsibility of checkmating the overexposure to BIR in the environment at the detriment of the workers and the public, should monitor and regulate it. The calculated effective dose delivered to the adult body for Dennis Osadebay university are shown in Tables 3 and 4.The highest doses were observed in the testes, with 0.533 mSv/yr for indoor exposure and 0.039 mSv/yr for outdoor exposure. This is because the testes are particularly sensitive to radiation, as noted by Nwankwo et al. (2015). On the other hand, the liver showed the lowest values, with 0.299 mSv/yr for indoor exposure and 0.022 mSv/yr for outdoor exposure. The results indicate that the estimated radiation doses for various organs all fall below the internationally accepted limits of 1.0 mSv per year. The obtained results are in line with report of (Esi *et al.,* 2019; Benson and Ugbede, 2018; Nwankwo *et al.,* 2015; James *et al.,* 2020).

CONCLUSION

This research designed at evaluating the indoor and outdoor background ionizing radiation dose equivalent levels in Dennis Osadebay university Anwai, Asaba, Delta state. The findings revealed that the average indoor BIR equivalent dose levels was slightly lower than the outdoor BIR equivalent dose levels. The estimated average annual effective dose equivalent (AEDE) within and around the university buildings remained below the permissible limit of 1.00 mSv per year. However, the excess lifetime cancer risk (ELCR) values for both within and around the university environment exceeded the standard. This discrepancy can be attributed to the atmospheric, geological and geophysical conditions of the environment. The AEDE and ELCR values imply that the university environment, staffs and students are safe from immediate radiation-related health effects due to BIR exposure. Nevertheless, there is possibility that likelihood of individuals that may live within the university community over lifetime will been affected radiologically. Therefore, it is strongly suggested that local authorities, the university management and interested researchers should conduct regular monitoring and assessments of BIR levels and the radioactivity concentration of soil and water in the university community. This will help to evaluate the absorbed equivalent dose experienced by workers, students and residents on campus.

REFERENCES

Avwiri, G.O. (2011). Radiation – The Good, the Bad and the Ugly in our Environment. An Inaugural Lecture 79th Series University of Port Harcourt Press.

Avwiri G.O and Esi E.O (2014) Evaluation of background ionization radiation level in some selected dumpsites in Delta State, Nigeria. *Advances in Physics Theories and Applications* 35: 36-42

Avwiri G.O and Esi E.O (2015) Survey of background ionization radiation level in some selected automobile mechanic workshops in Uvwie LGA Delta State, *Nigeria. Journal of Environment and Earth Science*, 5: 8 - 17

Bamidele, L. (2013). Measurement of Ionizing Radiation Level in a High Altitude Town of Imesi-Ile, Osun State, Southwestern, *Nigeria. Environmental Research Journal* 7 (4-6): 79-82

Bension ID, Ugbede FO. Measurement of background ionizing radiation and evaluation of lifetime cancer risk in highly populated motor parks in Enugu City, Nigeria. *IOSR Journal of Applied Physics* (IOSR-JAR). 2018;10(3):77-82. Available:https://doi.org/10.9790/4861-1003017782.

De Felice F, Marchetti C, Marampon F, Cascialli G, Muzii L, Tombolini V. Radiation effects on male fertility. American Society of Andrology and European Academy of Andrology. 2018;2–7. Available:https://doi.org/10.1111/andr.12562. open_in_newISSN2047-2919eISSN2047-.

Enyinna, P. I. and Onwuka, M. (2014). Investigation of the Radiation exposure rate and Noise levels within crushrock quarry site in Ishiagu, Ebonyi State, *Nigeria. International Journal of Advanced Research in Physical Science (IJARPS)* Vol.1 (6); 56-62

Esi Oghenevovwero E., Ovie Edomi and Peter O. Odedede (2019) Assessment of Indoor and Outdoor Background Ionizing Radiation Level in School of Marine Technology, Burutu, Delta State, Nigeria. *Asian Journal of Research and Reviews in Physics* 2(3): 1-8

Farai, I. P. and Jibiri, N. N. (2003). Baseline Studies of terrestrial Gamma Radiation. Sources, Effects and Risk of Ionizing Radiation. Vol. 15. Oxford University Press, Oxford.

Ibrahim, M. S., Atta, E. R. and Zakaria, K. H. M. (2014). Assessment of Natural Radioactivity of some Quarries Raw Materials in El-Minya Governorate, Egypt. *Arab Journal of Nuclear Science and Applications* 47(1), (208-216)

ICRP. (International Commission on Radiological Protection). The 2007 recommendations of the international commission on radiological protection. Annals of the ICRP Publication 103. Elsevier. 2007; 2-4.

James IU, Moses IF, Akueche EC, Kuwen RD. (2020) Assessment of indoor and outdoor radiation levels and human health risk in Sheda Science and Technology Complex and its Environ, Abuja, *Nigeria. J. Appl. Sci. Environ. Manage.* 24(1):13–18.

Jwanbot, D.I., Izam, M.M and Gambo, M. (2013). Measuring of Indoor Background Ionizing Radiation in Some … *Science World Journal,* 7(2):5-8

Mokobia C.E. and Oyibo, B. (2017). Determination of Background Ionizing Radiation (BIR) Level in Some Selected Farms in Delta State, Nigeria. *Nigeria Journal of Science and Environment,* 15 (1).

Nte F, Chizurumoke M and Esi E.O (2013) Measurement of magnetic fields from liquid crystal display (LCD) computer monitors. *International Journal of Current Research* 5 (7), 1771-73

Nwankwo L, Adeoti D, Folarin A. (2015) Ionizing radiation measurements and assay of corresponding dose rate around bottling and pharmaceutical facilities in Ilorin, Nigeria. *Journal of Science and Technology (Ghana)* 34(2):84. Available:https://doi.org/10.4314/just.v34i2.10.

Ohwoghere-Asuma O and Esi E.O (2017) Investigation of Seawater Intrusion into Coastal Groundwater Aquifers of Escravos, Western Niger Delta, Nigeria. *J. Appl. Sci. Environ. Manage*. 21 (2), 362-369

Okoye P. and Avwiri, G.O. (2013). Evaluation of Background Ionizing Radiation Levels of Braithwaite Memorial Specialist Hospital Port Harcourt, Rivers State, Nigeria. *African Journal of Scientific and Industrial Research.* 2153-6

UNSCEAR, (2000). United Nations Scientific Committee on the Effects of Atomic Radiation. Source and Effects of Ionizing Radiation, United Nations. Scientific Committee on the Effects of Atomic Radiation, United Nations, New York.

UNSCEAR, (2008). United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation. Report to the General Assembly with Scientific Annexes. 1.