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ASSESSMENT OF EXCESS LIFE TIME CANCER RISK FROM GAMMA RADIATION EXPOSURE RATE IN TWO TERTIARY INSTITUTIONS IN BAYELSA STATE, NIGERIA

Anyalebechi Onyebuchi
Department of Physics, University of Port Harcourt, Rivers State, Nigeria

Godwin E. Ogobiri
Department of Physics, Niger Delta University, Bayelsa State

Woyengitonye Abadani Butler
Science Laboratory Technology Department, Federal Polytechnic Ekowe, Bayelsa State Nigeria

Ogan O. Favour
Science Laboratory Technology Department, Ken Saro-Wiwa Polytechnic Bori, Rivers state, Nigeria

ABSTRACT: *The present study assessed the excess lifetime cancer risk associated with gamma radiation exposure rate in two tertiary institutions in Bayelsa State, Nigeria using Radalert 100x^{TM}, nuclear radiation monitor which uses a Geiger Mueller tube to detect radiation emissions. The studied campuses of Niger Delta University (NDU) and Federal University of Otuoke (FUO) were delineated into eleven (11) and Ten (10) sections respectively. Results of the measurements showed that the highest exposure rate of 0.05mR/h (2.66msvy^{-1}) was recorded at NDUIP against 0.04mR/h (2.128msvy^{-}1) of FUOHL. Excess lifetime cancer risk analysis showed that at NDUIP, it was 1.866 x 10^{-3} and 1.500 x 10^{-3} at FUOHL. In calculated mean values for exposure rate (ER), Absorbed Dose Rate (ADR), Annual Effective Dose Equivalent (AEDE) and excess lifetime cancer rate (ELCR) it was; 0.030mR/h (1.596mSvy^{-1}), 238.06nGy/h, 0.290mSvly and 1.020 x 10^{-3} respectively for NDU and 0.02mR/h (1.064mSvy^{-1}), 204.45 nGy/h, 0.250mSvy^{-1} and 0.880 x 10^{-3} respectively in FUO. Compared with world average value (WAV) of 0.013mRlh (0.6916msvy^{-1}) for ER, 59.00nGy/h for ADR, 0.070mSvy^{-1} for AEDE and 0.290 x 10^{-3} for ELCR respectively. The calculated dose to organ showed that the testes have the highest organ dose of 0.087mSvy^{-1} in NDU and 0.070mSvy^{-1} in FUO respectively. The obtained mean values in both campuses exceed the WAV. However, the obtained results do not impose alarming danger, but effort should be made for control measures in compliance with ALARA Principle.*

KEYWORDS: lifetime, exposure, radiation, risk assessment

INTRODUCTION

Radiological hazard indices and their assessment are indispensable in radiation impact studies. The importance of this lies in the need to make a reasonable choice which would

lead to a valid analysis of hazards involved in radiation exposure. There are several sources of radiation exposure, galactic, cosmic rays, sporadic solar particles events from solar flares and neutrons cum gamma rays from interactions between space radiation and lunar soil in the moon. However, earth's atmosphere provides protection for humans on the surface. Though our activities are enhancing radiation level and invariable increase in exposure rate and other subsequent radiological indices. Other sources of radiation include primordial radionuclides; ^{40}K, ^{238}U and ^{232}Th that emanate from earth crust that are present everywhere in the environment like rocks, soil, water, sediments, foods including the human body itself (UNSCEHR 2008) the situation is stretched by the enormous use of electronic devices of all types and electric installations. This is why the issue of radiation and environmental protection is indispensable in universities which is a gathering of humans of all ages in large number, with all types of electronic devices. The practice of radiation protection emphasized that the exposure rate to radiation should be kept as how as reasonably achievable (The ALARA Principle). J.C. Osimobi, E.O. Agbalagba, G.O. Avwiri and C.P. Ononugbo, (2015) noted that, the estimation of exposure to ionizing radiation is therefore an important goal of regulatory authorities and radiation protection scientists. It is in line with this call that this present study was directed. Other literatures include; the work of (Ugbede & Benson 2018) which measured the BIR and Evaluated the life time cancer risk in highly populated motor parks in Enugu City Nigeria, the study revealed the BIR levels within the area are due to the presence of natural radionuclides which are enhanced by the various human activities. Agbalagba et al (2016) determined the excess lifetime cancer risk from measured BIR levels in active coal mine sites and environment. Agbalagba et al (2020) studied GIS mapping of BIR levels around fossil fuel and gas dispensing stations and assessment of their radiological risk implication. The mapping revealed that radiation levels in 38 of the 61-sampling locations (62.3%) exceeded the global ambient permissible level of 13.0μRh^{-1} (1.0 $mSvy^{-1}$) reported by UNSCEAR. There are other studies. The point of departure of the current study is that it emphasized the assessment of excess lifetime cancer risk from gamma radiation exposure rate in two tertiary institutions in Bayelsa State, Nigeria. The institutions are; Niger Delta University (NDU) and Federal University of Otuoke (FUO).

METHODOLOGY

This study was carried out in Bayelsa State at locations of 4° 59^{I} 245^{II}N, 6° $6^{I}$$255.5^{II}$E and 4° 47^{I} 36.4^{II}N, 6°$19^{I}12.$ 9^{II}E respectively. The measurement of radiation exposure rate in mR/h in the two tertiary institutions of Niger Delta University (NDU) and Federal University of Otuoke (FUO) was done using portable Radalert 100 X^{Tm}, a nuclear Radiation monitor, while the locations were determined and certified with a global positioning system (GPS) unit (Germin GPSMAP76CSx). A total of Eleven (11) and Ten (10) locations were marked out for measurement for NDU and FUO respectively. The locations were uniformly chosen to cover the studied area. An in-situ approach of measurement at 1.0m above the ground level, with the window of the detector facing the location under investigation was adopted to enable sampling locations maintain their original environmental behavior. Three exposure rate measurements in mR/h were taken

at each location at 3 minutes interval and averaged to a single value as average exposure rate. Radiological risks indices such as, the annual effective dose equivalent (AEDE), excess lifetime cancer risk (ELCR) and the amount of radiation intake by a person that enters and get accumulated in the different organs of the body (DO) were evaluated from the value of absorbed dose rate (ADR) determined from exposure rate (ER).

Measured values of exposure rate (ER) cum those of other determined variables were tabulated and their mean evaluated. The results were discussed and compared with those reported in similar studies and internationally recommended values.
The following equations were adopted in calculation:

$$AEDE\ (mSvy^{-1}) = ADR\ (nGy) \times 8760 \times 0.7\ Sv/Gy \times 0.2 \quad [1]$$

$$ELCR = AEDE\ (mSvy^{-1})\ XDLXRF \quad [2]$$

Where 8760 is the number of hours in a year, 0.7 Sv/Gy is the dose conversion factor and 0.2 is the occupancy factor. DL is the average duration of life or live expectancy, taken as (70yrs) and RF is the fatal cancer risk factor value of 0.05 per publish exposure (i.e. 5% per sievert when discussing the risk of cancer from radiation exposure).

$$DO\ (mSvy^{-1}) = of \times AEDE\ (mSvy^{-1})\ X\ F \quad [3]$$

Where OF is the occupancy factor (0.2) and F is the organ of interest conversion factor.

RESULTS AND DISCUSSION

Table 1: measured exposure rate and the evaluated radiological indices in the Eleven (ii) Locations in NDU, located at; 4º59'24.5" N, 6º06'25.8" E

Location code	Exposure dose rate (mR/h)	Absorbed dose rate (nGy/h)	AEDE (mSv/y)	ELCR x 10^{-3}	DO (mS/y) ovaries	DO (mSv/y) Testes	DO (mSv/y) Lungs
NDUAA	0.020±0.00	174.00	0.213	0.746	0.023	0.035	0.027
NDUFA	0.024±0.00	208.80	0.256	0.896	0.028	0.042	0.033
NDUFS	0.030±0.01	261.00	0.320	1.120	0.035	0.053	0.041
NDUFSS	0.028±0.00	243.60	0.299	1.047	0.033	0.049	0.038
NDUPS	0.045±0.00	391.50	0.480	1.680	0.053	0.079	0.061
NDUIP	0.05±0.01	435.00	0.533	1.866	0.059	0.87	0.068
NDUGT	0.011±0.00	95.70	0.117	0.410	0.013	0.019	0.015
NDUVC	0.035±0.01	304.50	0.373	1.306	0.041	0.061	0.048
NDUAB	0.025±0.00	217.50	0.267	0.935	0.029	0.044	0.034
NDUPharm	0.015±0.00	130.50	0.160	0.560	0.018	0.026	0.021
NDUENG	0.018±0.00	156.6	0.192	0.672	0.021	0.032	0.025
MEAN±SEM	0.03±0.01	238.06±100.52	0.290±0.12	1.020±0.43	0.03±0.01	0.05±0.02	0.04±0.02

The codes are: NDU – Niger Delta University
NDUAA – Agric/Auditorium
NDUFA – Faculty and Arts
NDUFS – Faculty of Science
NDUFSS – Faculty of Social Science

NDUPS – Post Graduate School
NDUGT – Gate
NDUVC – Vice Chancellor Office
NDU Pharm – Pharmacy Building
NDU ENG – Engineering Building

Table 2: showing radiation exposure rate and determined radiological indices in the selected ten (10) locations in FUO located at $4^{o}47^{I}36.4^{''}$ N, $6^{o}19^{I}12.9^{''}$ E

Location code	Exposure dose rare (mR/h)	Absorbed dose rate (nGy/h)	AEDE (mSv/y)	ELCR x 10^{-3}	DO (mS/y) ovaries	DO (mSv/y) Testes	DO (mSv/y) Lungs
FUOCL	0.03±0.01	261.00	0.320	1.120	0.035	0.053	0.041
FUOBA	0.01±0.00	87.00	0.107	0.375	0.012	0.018	0.014
FUOES	0.010±0.01	87.00	0.107	0.375	0.012	0.018	0.014
FUOFS	0.02±0.00	174.00	0.213	0.746	0.023	0.035	0.027
FUOTF	0.020±0.00	174.00	0.213	0.746	0.023	0.035	0.027
FUOHL	0.040±0.01	348.00	0.427	1.500	0.047	0.070	0.055
FUOENI	0.028±0.01	243.00	0.299	1.049	0.033	0.049	0.038
FUOEN2	0.035±0.01	304.50	0.373	1.306	0.041	0.061	0.048
FUOEF	0.017±0.01	147.90	0.181	0.634	0.020	0.030	0.023
FUOSA	0.025±0.01	217.50	0.267	0.935	0.029	0.044	0.034
Mean ± SEM	0.02±0.01	204.45±82.56	0.25.01	0.88±0.36	0.03±0.01	0.04±0.02	0.03±0.01

The codes are: FUO – Federal University Otuoke
FUOCL – Central Library
FUOGA – United Bank of Africa
FUOES – Faculty of Education/Social Science
FUOFS – Faculty of Science
FUOTF – TetFund Building
FUOHL – Hostel
$FUOEN_1$ – Outside Environment 1
$FUOEN_2$ – Outside Environment 2
FUOEF – Engineering Faculty
FUOSA –

Table 3.Showing mean values and world average values (WAV)

	Mean Exposure dose rate (EDR) (mR/h)	Mean absorbed dose rate ADR (nGy/h)	Mean AEDE (mSv/y)	Mean ELCR X 10^{-3}
Niger Delta University (NDU)	0.030	238	0.290	1.020
Federal University Otuoke (FUO)	0.020	204	0.250	0.880
World Average Value (WAV)	0.013	59.000	0.070	0.290

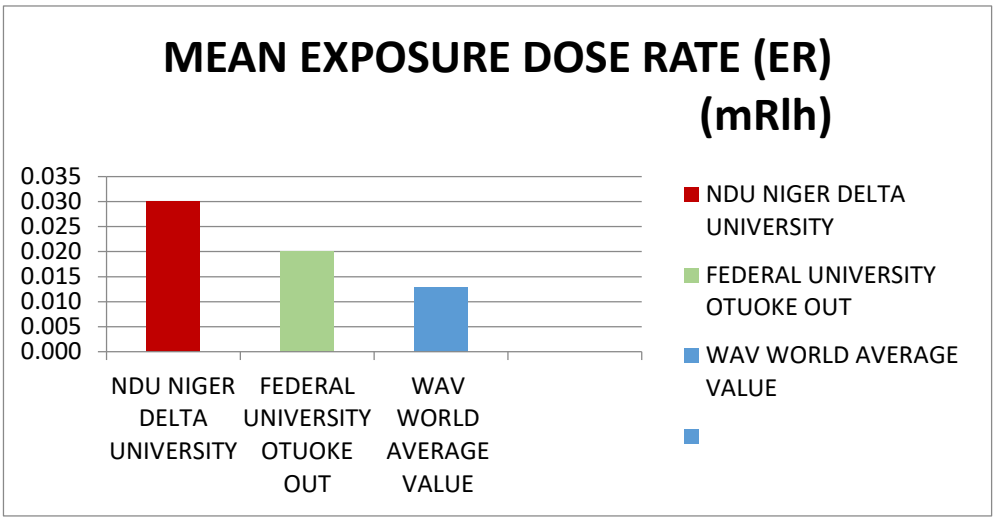

Fig. 1 Mean ER vs Location code

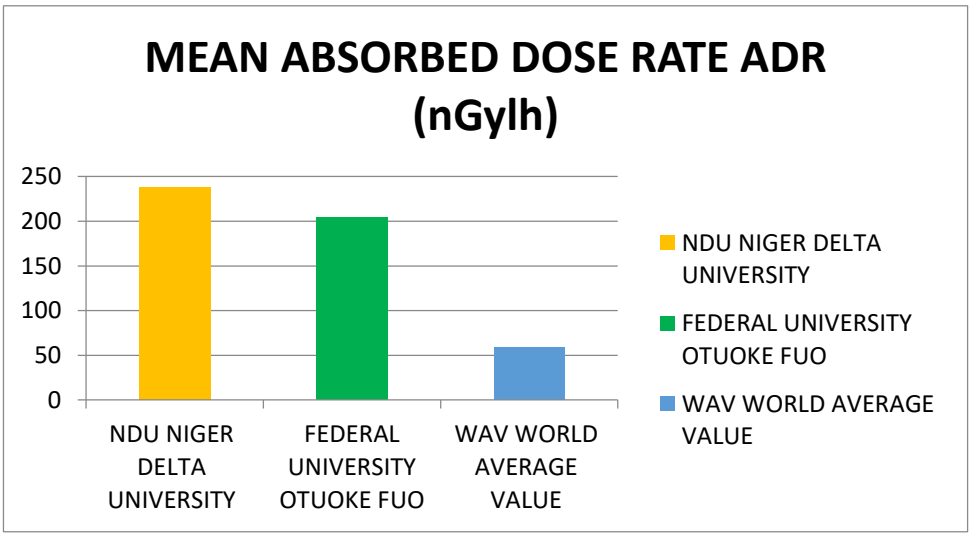

Fig. 2 Mean ADR vs Location code

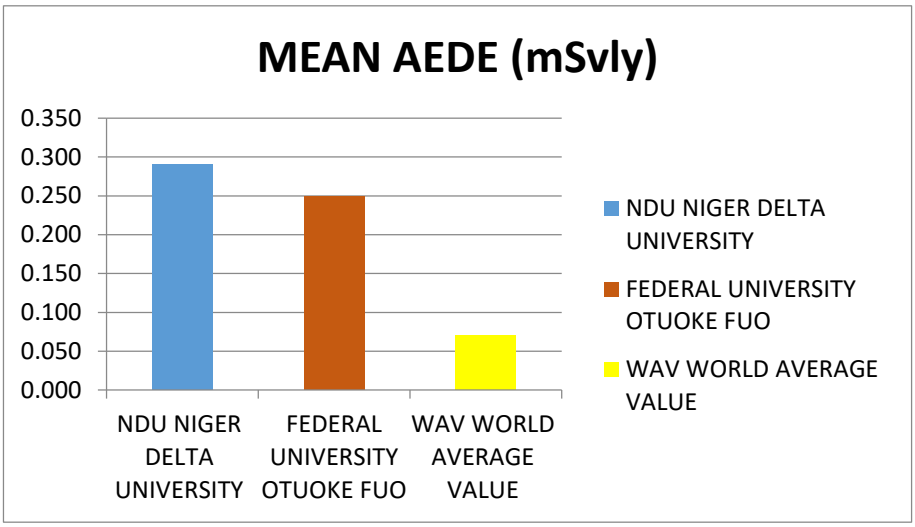

Fig. 3 Mean AEDE vs Location code

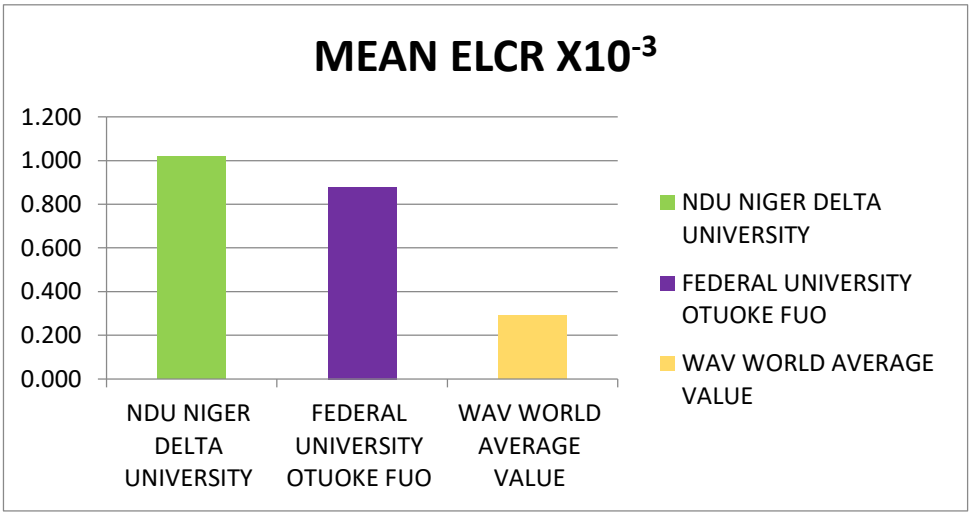

Fig. 4 Mean ELCR X 10 $^{-3}$ vs Location code

DISCUSSION

From the records presented in tables 1 and 2 NDU radiation exposure rate from the sampled locations ranged from 0.015mR/h – 0.050mR/h (0.798mSv/y – 2.66 mSv/y) with the peak of 0.05mR/h (2.66mSvy^{-1}) at the NDUIP. At FUO, the exposure rate range was 0.010mR/h - 0.040mR/h (0.532mSvly – 2.13mSvly) with peak of 0.040mR/h (2.13mSvy^{-1}) at FUOHL. Calculated mean values of 0.030mR/h (1.596mSvy-1) for exposure rate in NDU and 0.020mR/h (1.064mSy-1) for FUO as tabulated in Table 3 are way higher than the WAV value of 0.013mR/h (0.692Svy^{-1}). The exposure rate is the amount of ionizing radiation per hour in a given environment, measured in milliroentgen per hour mR/h. subsequently, the absorbed dose rate recorded were 238nGy/h and 204nGy/h for NDU and FUO respectively. Compared with world average value (WAV) of 59.00nGy/h and recommended safe limit of 84.00nGy/h. the reported figures for both

NDU and FUO were; 75.21%, and 64.71%, 71.1% and 58.8% greater than the WAV and the recommended safe limit respectively. (UNSCEAR 2008, Monica et al 2016, Agbalagba 2017). Monica et al 2016, opined that the difference noted in gamma dose rare might be attributed to variations in soil composition. Structures and devices might equally be aiding the observed variations.

Similarly the annual effective dose equivalent (AEDE) of 0.290Sv/y and 0.250mSv/y calculated as mean value in NDU and FUO as shown in Table 3 and Fig. 1 are equally higher than the WAV of 0.07mSv/y but lower than the International Commission on Radiological Protection (ICPR 103,2007) recommended permissible limit of 1.00mSv/y for general public. Consequently, the same trend was observed in the determined mean value for Excess Lifetime Cancer Risk (ELCR), with NDU reported mean value of $1.020x10^{-3}$ and $0.88x10^{-3}$ for FUO, against $0.290x10^{-3}$ WAV.

Analysis of the amount of radiation intake that enters and get accumulated in the different organs of the body (DO) in the case of this study, considering Tables 1 and 2 –Testes, Ovaries and Lungs, showed that the testes in both institutions was more prone with results of 0.087mSv/y and $0.070mSvy^{-1}$ for NDU and FUO each – the lung had 0.068msvly for NDU and 0.055mSvly in FUO with ovaries of 0.059mSvly in NDU and 0.047 $mSvly^{-1}$ FUO. All reported figures are the highest of their respective locations.

CONCLUSION

Part of the emphasis of this study was to conduct a radiological risk assessment to estimate the probability of a fetal cancer development in persons within the vicinity of the gamma radiation exposure over a lifetime in the two tertiary institutions. Indications from the reported results are not suggesting any emergency of hazardous state but it will be noted that low dose radiation exposure may still induce cancer formation on an exposed person in a time (T). T could be at advanced age of the person, given that all other variable is constant. It is on this ground, that this study is highly recommending strict adherence to ALARA principle-keeping radiation exposure "as low as reasonably achievable". Therefore, the institutions under review are advice to constitute radiation monitoring team that will regularly monitor the university environment and make recommendations for protection. Regular studies are also encouraged by radiation protection scientist.

REFERENCE

ICRP-recommendations of the international commission on radiological protection: Annals of the ICRP publication 103, 2007 (PP. 2-4) Elsevier.

Osimobi, J.C., Agbalagba, E.O., Avwiri, G. O., and Ononugbo, C.P (2015) GIS mapping and background ionizing radiation (BIR) Assessment of solid mineral mining sites in Enugu state, Nigeria. Open access library journal 2;2015 e1979 http://:dxdoi.org/10.4236/09Lib 110/979.

Agbalagba, O.E (2017) Assessment of Excess Lifetime Cancer Risk from Gamma Radiation Levels in Effurun and Warri City of Delta State, Nigeria. Journal of Taibah University for Science 11, 2017, 367-380.

Monica, S., Visnu-Prasad, A.K., Soniya, S.R and Jojo, P.J (2016) estimation of indoor and outdoor effective doses and lifetime cancer risk from gamma dose rates. Along the coastal region of Kollam district Kerala. Radiation protection and environment: 39, 2016, 38-43.

Spycher, B.D., Lupatsch J.E., Zwahlen, M., Rooslin, M., Niggli, F., Grotzer M.A., Rischewski J., Egger M., and Kuehni C.E (2015) background ionizing radiation and the risk of childhood cancer, a census-based nationwide colour study Environ Health perspect 123:622-628, http://:doc.dviorg/10.1289/ehp.1408548.

Ugbede, F.O., Benson I.D (2018) measurement of background ionizing radiation and evaluation of lifetime cancer risk in highly populated motor parks in Enugu city, Nigeria. 10SR journal of applied physics (10SR-JAP) e-ISSN: 2278-4801. Vol 10, issue 3 ver. PP77-82

UNSCEAR, united nations scientific committee on the effect of atomic radiation report on the sources and effects of ionizing radiation. Report to the general assembly with scientific ANNEXES. United nations 2008, New York