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Evaluation of Radiation Exposure Rate and Determination of Excess Life Time Cancer Risk in Lecture Halls in Niger Delta University, Bayelsa State Nigeria

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Abstract: - The radiation exposure rate (ER) in lecture halls in Niger Delta University (NDU) Bayelsa State Nigeria has been evaluated and the excess lifetime cancer risk (ELCR) determined, including the corresponding annual effective dose equivalent (AEDE). The exposure rate was measured using Radalert 100X™ Device which uses a Geiger muller tube to detect radiation in the Four (4) Lecture Halls in the university. The highest average indoor ADR, AEDE and ELCR of: 463.280nGy/h, 2.270msv/y and $7.900x10^{-3}$ respectively were reported in Hall 1 code named LH_1. Comparatively Hall 4 (LH_4) had the lowest values of ADR 226.20nGy/h, AEDE 1.110msv/y and ELCR 3.880×10^{-3}. The organ evaluation shows the teste with reported value of 1.490msv/y and the ovaries 0.570msv/y. These values are higher than the world average as submitted.

Keywords: Indoor Radiation exposure, Lifetime Cancer risk, Lecture Halls

I. Introduction

There is no known value at which continued exposure rate to a radiation dose does not pose a risk. The evaluation of radiation hazard indices is very indispensable given its usefulness in appraising the radiological effects. The need to make a reliable choice that will lead to a good analysis of hazards involved in radiation exposure entails that radiological hazard indices assessments are properly carried out Radiation call for the transmission of energy either as a wave or particle in a given medium. International Atomic Energy Agency (IAEA, 1989) categories radiation as: electromagnetic (visible light, x-ray), acoustic radiation (sound, ultrasound) and particle radiation (Neutron). Fount of radiation exposure encompass; cosmic ray galactic Neutron and gamma ray from interaction between space radiation and lunar soil in the moon, sporadic solar particles upshot from solar flares and primordial radionuclide, K^{40}, U^{238} and Th^{232} coming from earth crust such as rock, soil, water, sediments and foods plus human body (manickavasagan and Jayasuriya, 2016). These sources are reinforced by our extensive use of electronic devices in communication, application of radio therapy in medicine and other electric installations.

Well known impact of radiation is visible in the area of human and animal health in form of cancer. At high doses and perhaps low doses too, radiation might increase the risk of cardiovascular disease and some other non-cancer disease (Kamiya etal 2015). The dose response relation for cancer at low doses are assumed for behoof of radiological protection to be linear without a threshold. It is in response to these outlined observations that the practice of radiation protection emphasized that the exposure rate to radiation should be kept as low as reasonably achievable (ALARA Principle).

Several works have been done in the area of radiation generally. Ogbobiri etal (2022) carried out an estimation of radiation exposure rate and evaluation of life-time cancer risk in two waste dump sites in Yenagoa Metropolis in Bayelsa State, Nigeria. Anyalebechi etal (2021) studied the assessment of Excess Life-time risk from gamma radiation exposure rate in two tertiary institutions in Bayelsa State, Nigeria. Ugbede etal (2018) worked on the measurement of background ionizing radiation (BIR) and evaluation of life-time cancer risk in highly populated motor parks in Enugu City Nigeria. Others include; Okeyode etal (2019); Kamiya etal (2015), Manickavasagan etal (2016) et cetera. We justify this particular work from the rise in cancer and related health issues in recent times is Bayelsa. these calls for concern and concerted efforts in sourcing it possible roots no matter how little it may be contributing. This is why we are shifting attention to indoor radiation exposure rate in halls of Learning in Niger Delta University. It has been shown that building materials may add to indoor Radon level in addition to Radon that get into halls and homes through cracks, foundations and waters. Those building materials such as concrete bricks, gypsum, granites and chemicals in paints can emit beta and gamma radiation and the halls may not be well and regularly ventilated. The current work evaluates radiation exposure rate and excess life time cancer rate in Four (4) Lecture halls in Niger Delta University (NDU) Amassoma Bayelsa State, Nigeria.

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II. Materials and Methods

Materials used are Garmin (GPS 72 made in USA) and Radalert 100X™, hand held nuclear radiation monitor and general-purpose Geiger counter that measures alpha, beta, gamma and x-radiation, including radioactive minerals in the earth.

The study was conducted in four (4) lecture halls in Niger Delta University (NDU) Amassoma Bayelsa State, Nigeria located within $4^{0}5^{1}9124.45^{11}$N and $6^{0}6^{1}230,96^{11}$E. The halls were code named; LH_1, LH_2, LH_3, and LH_4 respectively. Each hall was further divided into four (4) points for radiation exposure capturing and measurement. The radiation exposure in mR/h was monitored with the Radalert 100X™ device positioned at 1m above the ground level with the Alpha window of the monitor facing the area under study enabling the area to maintain its original environmental quality. The Radalert 100X™ uses a Geiger-Muller tube to detect radiation. The Geiger tube generate a pulse of electrical current each time radiation passes through the tube and causes ionization. Each pulse is electronically detected and registers as a count. This count in the current work was displayed in mR/h according to the chosen mode and conversions carried out to required units. The measurements of the exposure rate in mR/h were taken at each point within intervals of three (3) minutes and the value averaged to a single value as average exposure rate. Results were tabulated and radiological indices determined and discussed.

The following equations were applied in the determination of radiological indices;

AEDE (msvy^{-1}) = ADR (nGy/h) x 8760 x 0.7Sv/Gy x OF…………………….(1)

ELCR = AEDE (msvy^{-1}) x DL x RF…………………………………..……(2)

DO (msv/y) OF x AEDE (msv/y) x F………………………………..…….….(3)

Where 8760 is the number of hours in one 365 days (1 year), 0.7Sv/Gy is the dose conversion factor and OF is the occupancy factor, in this case indoor, DL is the average duration of life, taken as 70yrs. RF is fatal cancer risk factor, taken as 0.05 and F is the organ of interest conversion factor.

III. Result

Table 1: Measured exposure rate and determined radiological indices in Hall LH_1.

Location Hall Code	**Exposure does rate (mR/h)**	**Absorbed close rate (nGy/h)**	**AEDE (mSvy^{-1})**	**ELCR x 10^{-3}**	**DO (mSv/y) Ovaries**	**DO (mSv/y) Testes**
LH_1.1	0.052±0.00	452.40	2.219	7.767	1.030	1.456
LH_1.2	0.052±0.00	452.40	2.219	7.767	1.030	1.456
LH_1.3	0.048±0.00	417.60	2.050	7.175	0.951	1.345
LH_1.4	0.061±0.00	530.70	2.603	9.111	1.207	1.708
Mean	0.05±0.00	463.28±41.44	2.27±0.2	7.96±0.71	1.05±0.09	1.49±0.13

Table 2: Showing radiation exposure rate in Hall LH_2 and its radiological indices.

Location Hall Code	**Exposure does rate (mR/h)**	**Absorbed close rate (nGy/h)**	**AEDE (mSvy^{-1})**	**ELCR x 10^{-3}**	**DO (mSv/y) Ovaries**	**DO (mSv/y) Testes**
LH_2.1	0.033±0.00	287.10	1.408	4.928	0.653	0.924
LH_2.2	0.040±0.01	348.00	1.707	5.975	0.792	1.120
LH_2.3	0.055±0.01	478.50	2.347	8.215	1.089	1.540
LH_2.4	0.078±0.02	678.60	3.330	11.655	1.545	2.184
Mean	0.05±0.02	4488.05±49.99	2.2±0.74	7.69±2.58	1.02±0.34	1.44±0.48

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS | Volume VIII Issue III March 2023

Table 3: Determined exposure rate and evaluated radiological indices in LH_3.

Location Hall Code	Exposure does rate (mR/h)	Absorbed close rate (nGy/h)	AEDE ($mSvy^{-1}$)	ELCR x 10^{-3}	DO (mSv/y) Ovaries	DO (mSv/y) Testes
LH_3.1	0.057±0.00	469.80	2.305	8.068	1.069	1.512
LH_3.2	0.049±0.00	426.30	2.091	7.319	0.970	1.372
LH_3.3	0.047±0.00	408.90	2.006	7.021	0.931	1.316
LH_3.4	0.045±0.01	391.50	1.921	6.724	0.891	1.262
Mean	0.05±0.00	424.13±29.1	2.08±0.14	7.28±0.5	0.97±0.07	1.37±0.09

Table 4: Showing result of the measured exposure rate in Hall LH_4.

Location Hall Code	Exposure does rate (mR/h)	Absorbed close rate (nGy/h)	AEDE ($mSvy^{-1}$)	ELCR x 10^{-3}	DO (mSv/y) Ovaries	DO (mSv/y) Testes
LH_4.1	0.052±0.00	452.40	2.219	7.767	1.030	1.456
LH_4.2	0.013±0.01	113.10	0.555	1.943	0.258	0.364
LH_4.3	0.012±0.00	104.40	0.512	1.792	0.238	0.336
LH_4.4	0.027±0.00	234.90	1.152	4.032	0.534	0.756
Mean	0.03±0.02	226.2±40.42	1.11±0.69	3.88±2.41	0.51±0.32	0.73±0.45

Table 5: The mean values of the halls

Hall Code	ER (mR/h)	ADR (nGy/h)	AEDE ($mSvy^{-1}$)	ELCR x 10^{-3}	DO (mSv/y) Ovaries	DO (mSv/y) Testes
LH_1	0.050	463.280	2.270	7.960	1.050	1.490
LH_2	0.050	448.050	2.200	7.690	1.020	1.440
LH_3	0.050	424.130	2.080	7.280	0.970	1.370
LH_4	0.030	226.200	1.110	3.880	0.510	0.730

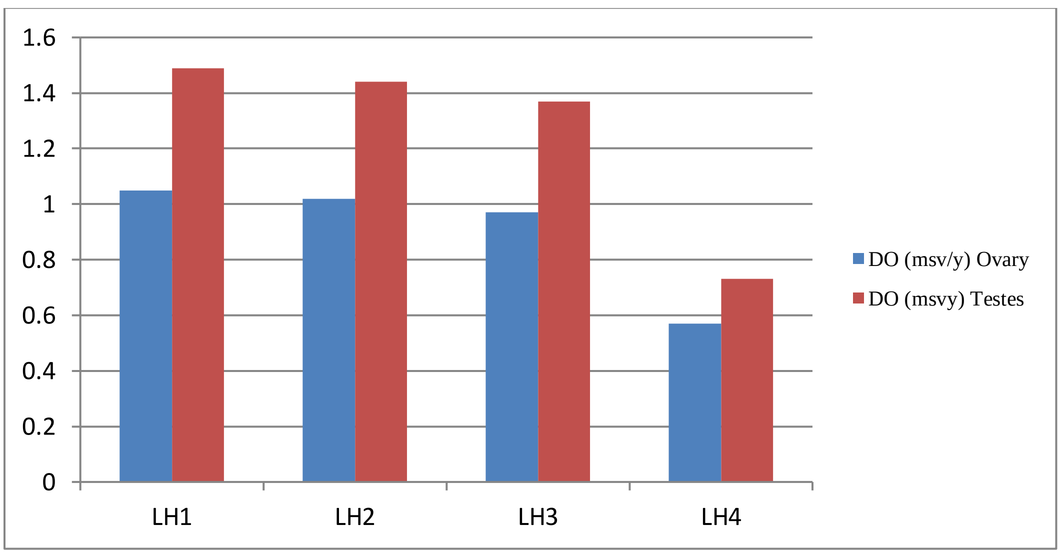

Fig 1: Bar Chart of DO(mSvy-1) ovaries, testes against LH_{1-4}

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS | Volume VIII Issue III March 2023

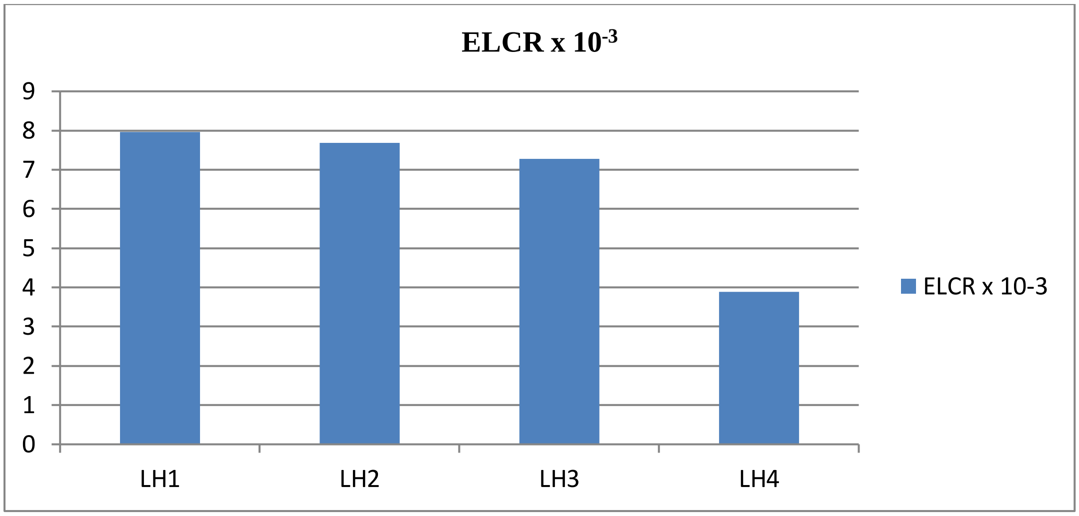

Fig 2: Showing ELCR x 10^{-3} distribution across the four studied halls

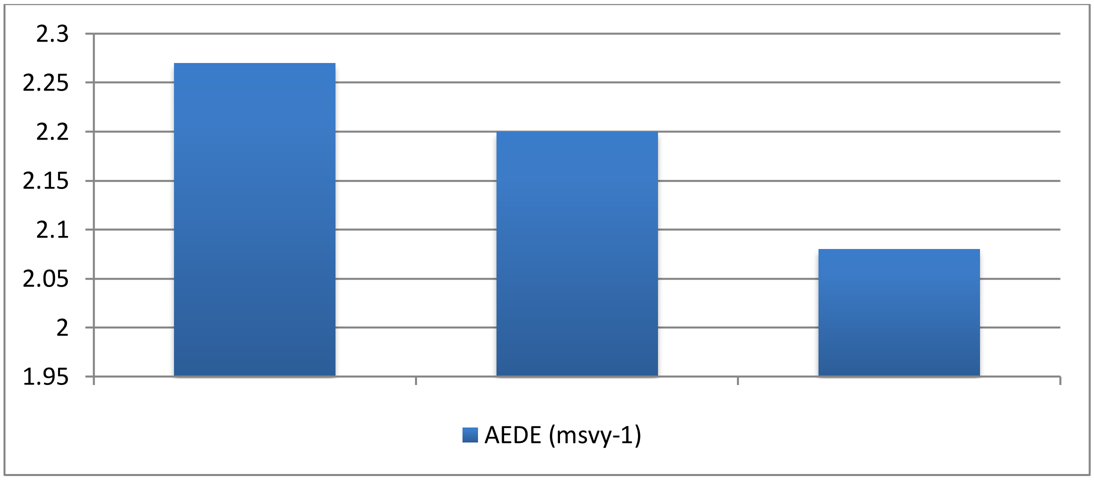

Fig 3: Result of the Annual Effect dose equivalent across the halls

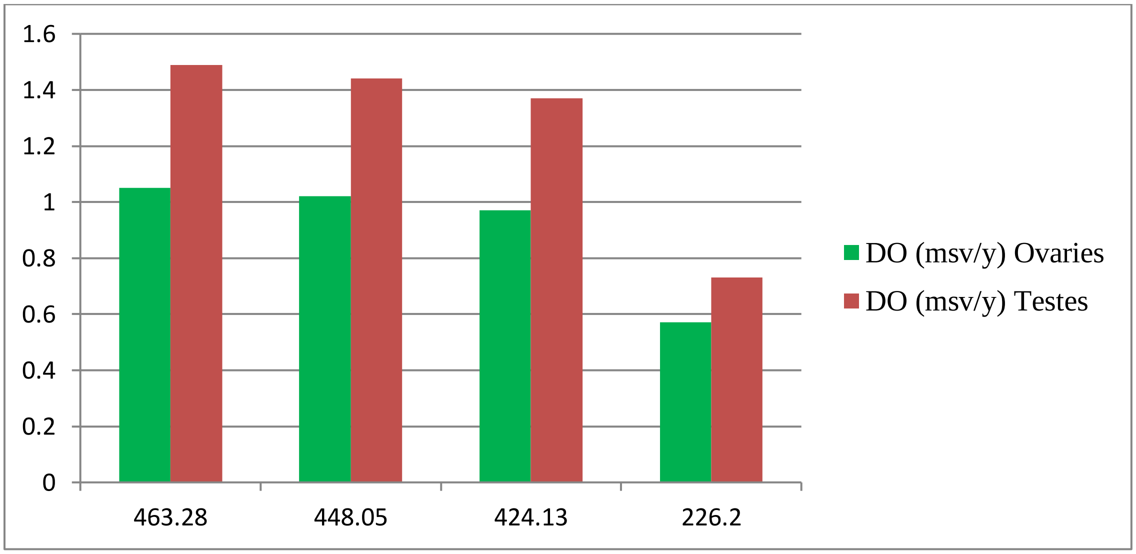

Fig. 4: Pattern of ovaries and testes response to Absorbed Dose rate (ADR nGy/h) in each of the Halls reported

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS | Volume VIII Issue III March 2023

IV. Discussion

In this current effort, the results from tables 1-4 and figs 1-4 as presented shows absorbed dose rate (ADR) was highest in LH_4 with a value of 463.280nGy/h. Also highest in annual effective dose equivalent (AEDE) and excess lifetime cancer risk (ELCR) with pointed mean values of 2.270mSvy^{-1} and 7.900 x 10^{-3} respectively. Close value was reported in halls; LH_2 and LH_3. However, there was marked reduction in Hall LH_4 where exposure rate (ER) was 0.030mR/h (1.596mSv/y), ADR 226.20nGy/h, AEDE 1.110msv/y and ELCR 3.880 X 10^{-3} respectively. All as mean values. The same distribution pattern was noted in the estimated possible organ impact analysis, where testes had the highest in Hall LH_1 with recorded value of 1.490mSvy^{-1} and ovaries came lowest with 0.570 mSv/y in Hall LH_4.

Similar figures have been reported in other indoor radiation analysis. Esiami et al (2018) reported a value of 2.4mSv for AED and ELCR of 10.3 x 10^{-3}. The result pattern is also supported by the submission of the work of Okeyode et al (2019) that showed a result of 2.782mSv for AED. These values are higher than that of the average worldwide indoor gamma radiation effective dose of 0.41mSv/y which is comparable with mean annual effective dose of cosmic radiation, estimated to be 0.32 mSv/y but lower than that of national council on radiation protection and measurement (NCRP) which place the average annual radiation dose per person in the U.S. at 6.2mSv (620millirem) and CT single procedure impart on chest (8.0mSv) or the pelvis (10mSv).

V. Conclusion

This current work has highlighted the need for the management of the institution to review the university Curriculum to include electives on radiation for awareness, Lecture time and timetable, so as to address the obvious threat pose by the escalated values of ADR, AEDE and ELCR as reported and interpreted. The study will further help in future structural design and material selection given that some of the material emits radiation. The existing halls studied should be well ventilated during lecture period or human occupation and the time of occupation reduced.

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