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Assessment of Indoor and Outdoor Background Ionizing Radiation Level in School of Marine Technology, Burutu, Delta State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author OEE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OEE and OE managed the analyses of the study. Author OEE, OV and POO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The ionizing radiation has the tendency of causing damage to man and its environments, hence the assessment of indoor and outdoor background ionizing radiation level in Delta State School of Marine Technology, Burutu, Delta State, Nigeria, was carried out using well calibrated and tested radiation meter (Digilert 100). The study was done in a period of ten calendar months. The purpose of this study is to obtain baseline data for indoor and outdoor Background Ionizing Radiation **(**BIR) level and health effect on man and the environment. For the indoor and outdoor measurement, readings were taken in three consecutive times in one location at a height of 1 meter above the ground for each point. The geographical positioning system (GPS) was equally employed in determining the coordinates of the area. The results from BIR measurement revealed that indoor

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readings range from 0,009 $mRhr^{-1}$ to 0,019 $mRhr^{-1}$ with a mean value of 0,015 $mRhr^{-1}$ and for the outdoor ranges 0,010 $mRhr^{-1}$ to 0,020 $mRhr^{-1}$ with a mean value of 0,014 $mRhr^{-1}$. The radiation health parameters calculated, for dose rate and Annual Effective Dose Equivalent (AEDE) have their mean values to be 1,135 $mGyr^{-1}$ and 1,035 $mGyr^{-1}$ for indoor and 0,635 $mSvyr^{-1}$ and 0,145 $mSvyr^{-1}$ for outdoor respectively. But the mean values of Excess Lifetime Cancer Risks (ELCR) for indoor and outdoor are 1,729 and 0,394 respectively. The deviation in BIR level and its radiological parameters are attributed to oil and gas activities in the study areas. The implication is that the area is radiologically unhealthy, the effect may not be significant but long term exposure may be dangerous. Therefore, it is imperative for radiation protection agencies to swing into regulatory action and there should be monitoring of the environment in order to reduce pollution.

Keywords: Indoor; exposure; dose; cancer.

1. INTRODUCTION

Radiation is the transfer of energy from the outer space to the earth and can also emerge within the earth. It is broadly grouped into natural (cosmic) and anthropogenic (man-made). These are further categorized into ionizing and non-ionizing. The ionizing radiation has the tendency of knocking out electrons out of the orbit around the atom and can potentially damaging cells. In fact, it is dangerous to man and its environments. Radiation can cause damage to living tissues, cancer and skin burns when exposed to it, hence we should apply the principle of as low as reasonably achievable (ALARA) at all level [1, 2,3]. The non-ionizing radiation does not carry enough energy to ionize atom or molecules hence are less effective but only have enough energy for excitation, the movement of an electron to a higher energy state.

The depletion of the ozone layer has automatically increased the level of the cosmic rays reaching the earth surface and it is being increased by human activities [4,5]. Research as showed that cosmic radiation (photon) and terrestrial radionuclides (^{40}K, ^{232}Th, and ^{238}U) produces background radiation [6,1]. It was noted that the level of background radiation is fairly constant over the world, being 0,008 $mRhr^{-1}$ to 0,015 $mRhr^{-1}$ [5]. But other countries like India, China and Brazil have higher background ionizing radiation (BIR) and this is attributed to the high concentration of radioactive minerals (Monozite) in the soil [1].

Adejugbagbe [3] carried a radiometric mapping of federal university Oye Ekiti main campus. The results revealed that the global average of radiation level measured in the study area was 0,55 μSv/hr which translate to 0,482 mSv/yr for annual dose rate and it is below the worldwide average of 2,4 $mSvyr^{-1}$ [7] and the dose limit of 1,0 mSv/yr [8]. Nyango, [9] carried out a measurement on background radiation in University of Jos environment and reported a mean equivalent does of 2,059 mSv/yr. This value is within the limits level of background radiation. Akpolile and Akpolile, [10] carried out a study on the assessment of background gamma radiation in different farmland in Ethiope East Local Government Area (L.G.A) of Delta State, Nigeria. The average background radiation for the farmland in the study areas ranges from 0,07 μSv/yr to 0,11 μSv/yr. The outdoor/indoor effective doses obtained were 177,66 μSv/yr and 710,63 μSv/yr respectively. When compared with standards the values obtained were lower than standard.

The study areas constitute one of the major oil producing community in the Niger Delta region of Nigeria. And as such, oil and gas activities are been carried out on daily basis in the study areas. Several kinds of literature has affirmed the effect of oil and gas activities as a major contributing factor of the increasing background ionizing radiation levels in our environment [11], [5,12]. Therefore, it is of great importance, in carrying out an assessment of indoor and outdoor background ionizing radiation in the study area with the view of determining BIR level and to provide reference data for future studies. The results obtained will equally be used in determining the health implication of the public.

2. MATERIALS AND METHODS

The background ionization radiation (BIR) of both indoor and outdoor of Delta State School of Marine Technology (Desomatec) Burutu, Delta State, Nigeria has been measured. The study area lies between longitude 5°4 and 6°45 east of the Greenwich meridian and latitude 5°21' and 6°32' north of the equator. The temperature ranges between 21° and 28° with high humidity.

The measurement was done using the Digilert 100 radiation survey instrument and Global Positioning System (GPS). The Digilert 100 radiation survey instrument was well calibrated and tested by the National Institute of Radiation Protection and Research, University Of Ibadan. The study was done within ten months. The radiation alert meter was suspended 1 meter above the ground level on a retort stand, for the measurement, reading was taken in three consecutive times in each point maximum response of the meter used for the measurement was ensure by taking the reading between the hours of 1300 and 1600 hours [13,12]. The measurements were made in each location at least three transverses in each location. The mean and dose equivalent for indoor and outdoor for each location was then computed from the measured BIR values using the expression below in equation 1 [12].

$$1mRh^{-1} = \frac{0.96\ x\ 24\ x\ 365}{100} = mSvyr^{-1} \quad (1)$$

0,96 is the conversion factor, 24 is the number of hours in a day, and 365 is the number of days in a year. The calculation of radiation health parameter of the study area was computed in Table 3 using the usual appropriate equation for the Gamma Dose Rate (DR), Annual Dose Equivalent (ADE) and Excess Lifetime Cancer Risk (ELCR).

The gamma dose rate is expressed by [14] as:

$$DR(mRh^{-1}) = 76.212mGy^{-1} \quad (2)$$

Annual Dose Equivalent is

$$AEDE\ (mSvy^{-1}) = \frac{DR\ (8760hr\ x\ 0.7\ x\ 0.80}{365\ x\ 24hr} \quad (3)$$

Where DR is the dose rate obtained from the calculated mean value of BIR levels. For indoor (0.8) and outdoor (0.2).

Excess Lifetime Cancer Risks (ELCR) was expressed by [12] as:

$$ELCR = ADE\ X\ ADL\ X\ CRF \quad (4)$$

Where the AEDE is Annual Effective Dose Equivalent "ADL" average age duration of life expectancy estimated to be 70 years [14], [15] to be (54,5 years) for Nigerian Lifetime expectancy. And CRF is the risk factor (Sv) i.e Fatal cancer per Sievert for stochastic effects, uses RF as 0,05 for the public.

3. RESULTS

The results of the background ionizing radiation (BIR) level and its computed radiological parameters of School of Marine Technology, Burutu, Delta State, Nigeria are as presented in Tables 1 to 3. And the figures are presented in Figs. 1 to 4.

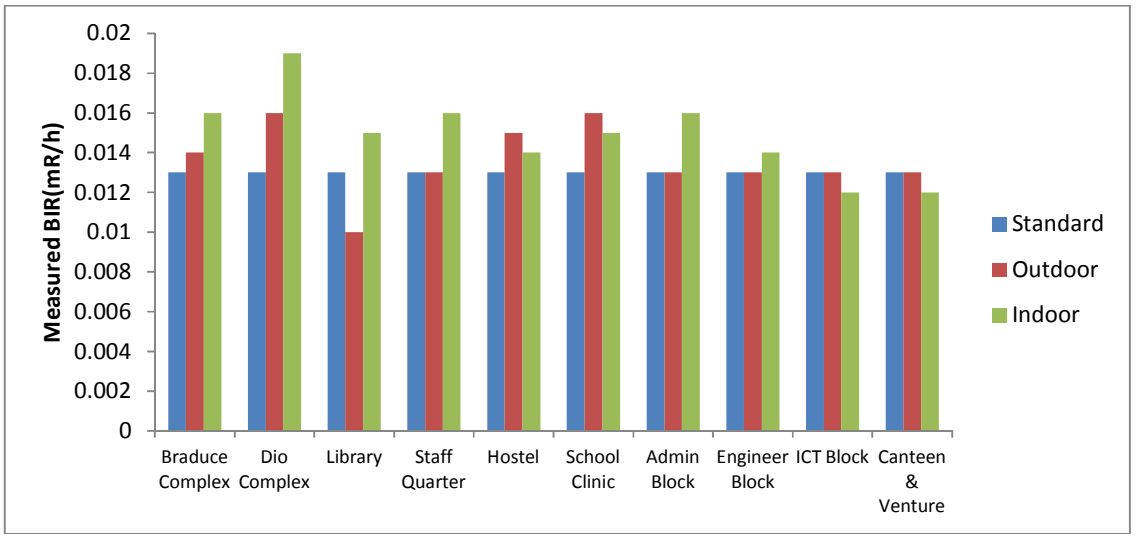

Fig. 1. Inter-comparison of indoor/outdoor BIR with standard

Table 1. Measured background ionizing radiation (mRh^{-1})

Location		Code	Coordinates	Indoor		Outdoor	
				Measured values (mRh^{-1})	Annual dose equivalent ($mSvy^{-1}$)	Measured values (mRh^{-1})	Annual dose equivalent ($mSvy^{-1}$)
X_1				0.016	1.372	0.013	1.093
BRADUCE COMPLEX	X_2	BC	E5°5, 6°45’	0.016	1.318	0.013	1.149
X_3			N5°21’,6°31’	0.017	1.460	0.017	1.480
X_4				0.019	1.592	0.013	1.093
DIO’S COMPLEX	X_5	DC	E5°6, 6°43’	0.017	1.429	0.011	0.925
X_6			N5°21’, 6°34’	0.019	1.598	0.017	1.429
	X_7			0.019	1.598	0.010	0.869
LIBRARY	X_8	LB	E5°6, 6°48’	0.012	0.037	0.011	0.925
X_9			N5°22, 6°33’	0.013	1.065	0.010	0.869
X_{10}				0.016	1.374	0.013	1.121
STAFF QUARTERS	X_{11}	SQ	E5°6, 6°42’	0.016	1.318	0.012	1.009
X_{12}			N5°23, 6°22’	0.017	1.402	0.014	1.177
X_{13}				0.012	1.037	0.015	1.289
HOSTELS	X_{14}	HT	E5°6, 6°23’	0.016	1.374	0.014	1.205
X_{15}			N5°34, 6°18’	0.013	1.065	0.017	1.402
X_{16}				0.016	1.318	0.018	1.486
SCHOOL CLINIC	X_{17}	SC	E5°6, 6°23’	0.016	1.318	0.015	1.289
X_{18}			N5°36’, 60°30’	0.014	1.177	0.016	1.318
X_{19}				0.016	1.318	0.013	1.121
ADMIN BLOCK	X_{20}	AB	E5°6, 6°28’	0.015	1.233	0.014	1.177
X_{21}			N5°31’, 6°32’	0.016	1.318	0.013	1.121
X_{22}				0.013	1.065	0.013	1.121
ENGINEER BLOCK	X_{23}	EB	$E5^06$, 6^028’	0.013	1.065	0.013	1.121
X_{24}			$N5^033$’, 6^033’	0.017	1.402	0.013	1.121
X_{25}				0.015	1.233	0.011	0.925
ICT BLOCK	X_{26}	IB	E5°6, 6°21’	0.017	1.402	0.020	1.682
X_{27}			N5°23, 6°24’	0.016	1.318	0.017	1.402
X_{28}				0.009	0.070	0.011	0.925
CANTEEN & VENTURE	X_{29}	CV	E5°6, 6°27’	0.013	1.065	0.016	1.318
X_{30}			N5°28, 6°30’	0.015	1.233	0.011	0.925

Table 2. Mean values for measurement BIR (mRh^{-1}) and dose equivalent ($mSvyr^{-1}$) for indoor/outdoor

Location	Code	Indoor		Outdoor	
		Mean values (mRh^{-1})	Annual dose equivalent ($mSvy^{-1}$)	Mean Value (mRh^{-1})	Annual dose equivalent ($mSvy^{-1}$)
BRADUCE COMPLEX	BC	0.016	1.384	0.014	1.243
DIO COMPLEX	DC	0.019	1.005	0.016	1.373
LIBRARY	LB	0.015	1.215	0.010	0.888
STAFF QUARTER	SQ	0.016	1.031	0.013	1.102
HOSTEL	HT	0.014	1.159	0.015	1.299
SCHOOL CLINIC	SC	0.015	1.271	0.016	1.346
ADMIN BLOCK	AB	0.016	0.894	0.013	1.193
ENGINEER BLOCK	EB	0.014	1.177	0.013	1.345
ICT BLOCK	IB	0.012	0.789	0.013	1.075
CANTEEN & VENTURE	CV	0.012	0.789	0.013	1.075
Mean		0.015	1.069	0.014	1.472

Table 3. Calculated radiation health parameter associated with BIR levels for indoor/outdoor in Desomatec

Indoor			Outdoor		
Dose Rate ($mGyr^{-1}$)	AEDE ($mSvyr^{-1}$)	ELCR ($x10^{-3}$)	Dose Rate ($mGyr^{-1}$)	AEDE ($mSvyr^{-1}$)	ELCR ($x10^{-3}$)
1.219	0.682	1.848	1.066	0.149	0.406
1.448	0.810	2.207	1.219	0.170	0.463
1.143	0.640	1.744	0.762	0.106	0.289
1.219	0.682	1.858	0.990	0.138	0.376
1.066	0.596	1.624	1.143	0.160	0.436
1.143	0.640	1.744	1.219	0.170	0.463
1.219	0.682	1.858	0.990	0.138	0.376
1.066	0.596	1.624	0.990	0.138	0.376
0.914	0.511	1.392	0.990	0.138	0.376
0.914	0.511	1.392	0.990	0.138	0.376
1.135	**0.635**	**1.729**	**1.035**	**0.145**	**0.394**

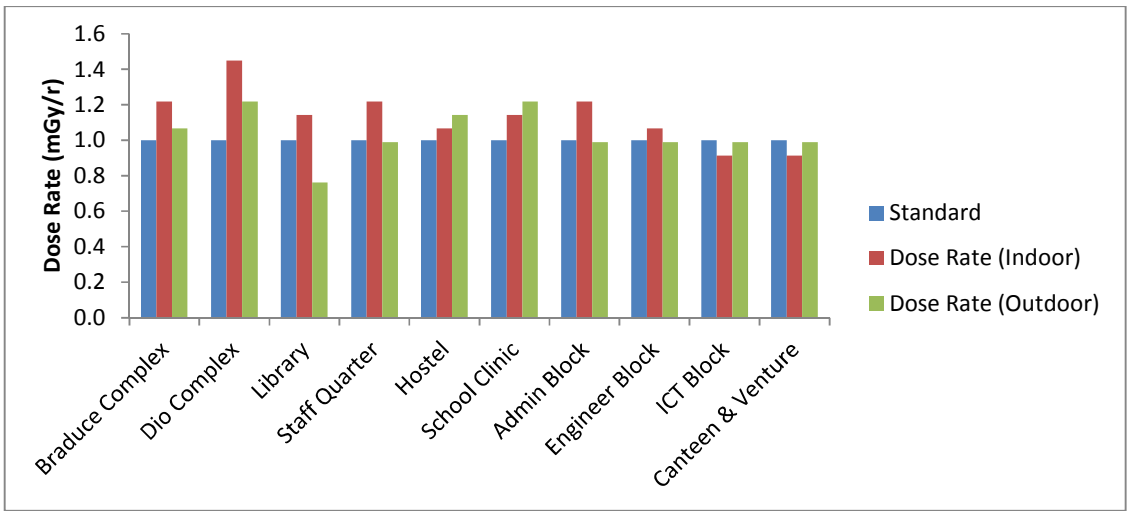

Fig. 2. Inter-comparison of indoor/outdoor dose rate with standard

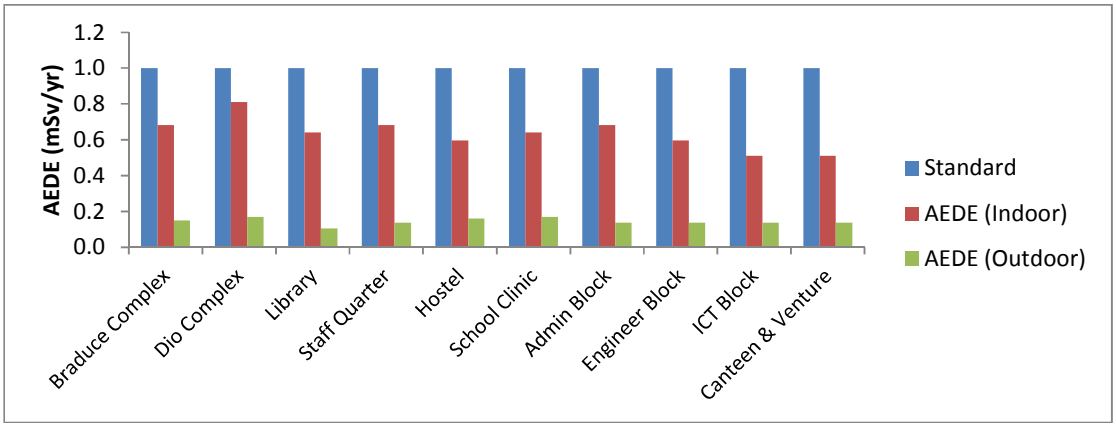

Fig. 3. Inter-comparison of indoor/outdoor AEDE with standard

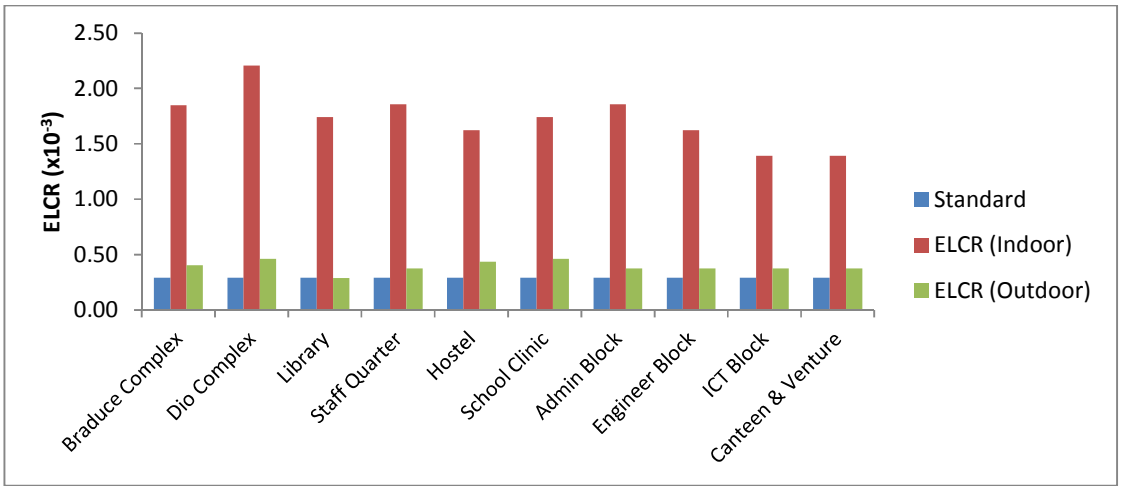

Fig. 4. Inter-comparison of indoor/outdoor ELCR with standard

4. DISCUSSION

Assessment of indoor and outdoor background ionizing radiation (BIR) level in School of Marine Technology, Burutu, Delta State, Nigeria has been carried out as shown in Tables 1 and 2. The results for indoor BIR ranged from 0.009 to 0.019 $mRhr^{-1}$ with a mean value of 0.015$mRhr^{-1}$, the minimum and maximum values been observed at Canteen/Venture, Dio Complex and Library as the highest values. And the dose equivalent for the indoor reading ranges from 0,037 $mSvy^{-1}$ to 1,598 $mSvy^{-1}$ with a mean value of 1,069 $mSvyr^{-1}$. The maximum and minimum been recorded for Dio Complex, Library and Canteen/Venture respectively.

The results for outdoor BIR range from 0,010 $mRhr^{-1}$ to 0,020 $mRhr^{-1}$ with a mean value of 0,014 $mRhr^{-1}$; the minimum and maximum values are observed at Library and Admin Block respectively. The Annual Dose Equivalent (ADE) for outdoor ranged from 0,869 $mSvyr^{-1}$ to 1,682 $mSvyr^{-1}$ with a mean value of 1,472 $mSvyr^{-1}$, the minimum and maximum are equally recorded for Library, and ICT Block respectively.

Comparing the obtained mean results for both indoor and outdoor, the indoor values is higher than the outdoor and may be attributed to the kind of constriction materials like soil and brick used for the buildings. Also comparing with other studies carried out in Nigeria they are in tandem and well compared. The obtained mean values for indoor and outdoor BIR are above worldwide stipulation value of 0,013 $mRhr^{-1}$ [8]. This is graphically displayed in Fig. 1, in an undulating pattern of distribution of these measured BIR values and with standard [16,17,12], has presented this radiation distribution pattern in

different literature. However, some areas observed low BIR such as Library, Hostel, and Canteen/Venture respectively.

The mean values for radiation health parameter of the population are computed for indoor and outdoor BIR. The mean values for the dose rate and Excess Lifetime cancer risk for indoor and outdoor are higher than their respective global stipulation of 1,0 mGy^{-1} and 0,29 x 10^{-3} respectively. And for Annual Effective Dose Equivalent (AEDE) for both indoor and outdoor are lower than the world average of 1,0 $mSvy^{-1}$ [18,19]. This is depicted in Table 3 and Fig. 2 to 4 respectively. Comparing the indoor and outdoor results obtained with previous works in [3,9], it was observed that the obtained results and its computed radiological parameter values are slightly higher than previous research works done in a different location in Nigeria. This can be attributed the oil and gas activities that are going on in the study area. The implication of these results obtained simply means that the study area is radiologically unhealthy for the public. Although effects may not be significant now, long term exposure may be hazardous to the populace.

5. CONCLUSION

Conclusively, the obtained mean indoor and outdoor BIR and some radiological parameters values such as dose rate and excess Lifetime Cancer risk are higher than world average limits. But AEDE for both indoor and outdoor are lower than the world average of 1,0 $mSvyr^{-1}$. The implication is that the environment under study have been polluted with oil and gas activities and the resultant effects are the increase of the BIR level in the areas, which have aftermath effects on the public. The effects may not be immediate but long term exposure may be harmful. Therefore, it is important for radiation protection agencies to swing into regulatory action and promptly monitored the environment to avoid pollution.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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