



Evaluation of Background Ionizing Radiation (BIR) Due to Oil Spills Activities in Some Select Communities in Bayelsa State, Southern Nigeria

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Abstract

Measurements of background ionizing radiation (BIR) in six select communities and one oil spill site in Bayelsa State, Southern Nigeria were carried out to assess the BIR status of these communities in order to quantify the radiological health risk posed to residents. Direct measurements of radiation were employed using a well-calibrated Geodetic Positioning System (etrex 10 Garmin) and a Digilert Nuclear Radiation Monitor. Results obtained from averaging the exposure rates across the six communities and one oil spill site (1 - 7) in this order Elebele (1), Emeyal 1 (2), Emeyal 2 (3), Imiringi (4), Otuasega (5), Oruma (6) and the oil spill site (Tie-Inn manifold at Kolo-Creek) (7) revealed 0.008 mRh^{-1} , 0.009 mRh^{-1} , 0.009 mRh^{-1} , 0.008 mRh^{-1} , 0.008 mRh^{-1} , 0.007 mRh^{-1} and 0.10 mRh^{-1} correspondingly.

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These results, when juxtaposed with the International Commission on Radiological Protection (ICRP) value, were lower compared with the accepted magnitude of 0.013 mRh^{-1} . Also, the mean absorbed dose rates from the study areas (Communities and oil spill site 1 - 7) as estimated were 70.47 nGyh^{-1} , 76.56 nGyh^{-1} , 74.82 nGyh^{-1} , 68.7 nGyh^{-1} , 68.73 nGyh^{-1} , 63.51 nGyh^{-1} and 90.48 nGyh^{-1} , correspondingly where 90.48 nGyh^{-1} was a bit above the ICRP limit with 1.16 nGyh^{-1} . Computed values of Annual Effective Dose Equivalence (AEDE) for outdoor exposure at areas 1 -7 were 0.11 mSvy^{-1} , 0.12 mSvy^{-1} , 0.11 mSvy^{-1} , 0.10 mSvy^{-1} , 0.11 mSvy^{-1} , 0.10 mSvy^{-1} and 0.14 mSvy^{-1} in that order. The mean excess lifetime cancer risk (ELCR) calculated and obtained from the following areas Elebele, Emeyal 1, Emeyal 2, Imiringi, Otuasega, Oruma and oil spill site gave $0.27 \times 10^{-3} \text{ mSvy}^{-1}$, $0.29 \times 10^{-3} \text{ mSvy}^{-1}$, $0.29 \times 10^{-3} \text{ mSvy}^{-1}$, $0.26 \times 10^{-3} \text{ mSvy}^{-1}$, 0.26 mSvy^{-1} , $0.24 \times 10^{-3} \text{ mSvy}^{-1}$ and $0.35 \times 10^{-3} \text{ mSvy}^{-1}$ respectively. However, ELCR

measured at Emeyal 1 and 2 were exactly the same as the ICRP value, unlike the oil spill site, which value exceeded the recommended value of $0.29 \times 10^{-3} \text{ mSv}^{-1}$. The obtained values for BIR in all the study areas were lower than acceptable limit given by ICRP whereas the absorbed dose computed were below the recommended rate except at the Tie-Inn manifold, which was higher. The average AEDE calculated in the entire area were within the safe limit. However, the ELCR as estimated were below ICRP benchmark of $0.29 \times 10^{-3} \text{ mSv}^{-1}$ in 4 areas and exactly the same value at 2 locations, while the limit was exceeded at the Tie-Inn manifold near Kolo-Creek. The ELCR result showed that BIR in the three locations was capable of causing radiological health risks to the residents in the near future owing to petroleum activities in the areas.

Keywords: BIR, AEDE, ELCR, ICRP, Communities.

1.0 Introduction

Nigeria is one of the countries in Africa that is blessed with numerous natural resources, especially fossil fuel deposits in the Niger Delta countryside. The existence of the petroleum deposits has led to numerous explorations and exploitations activities in the region, resulting at times in oil spillage, gas flaring etc., thus contaminating and posing serious threats to both terrestrial and aquatic lives in the Niger Delta. Approximately 2.52 million barrels of crude oil are produced in the region per day, contributing significantly to the Gross Domestic Product of the nation (Kola-Olusanya and Mekuleyi, 2018). The global economy is almost solely reliant on petroleum as its major source of energy and the high demand for energy production has caused a significant flow of crude oil and its components or compositions into the surroundings. The

ecosystem of the Niger Delta is among the highest levels of bio-diversity on the global scene. Factors such as advanced industrialization and human standards of living have triggered high energy demands globally (Liu *et al.*, 2012).

The exploration and exploitation of crude oil activities may have ushered in fortunes for the country, but their activities have equally led to the destruction of the environment, especially when proper safety procedures are not followed accordingly. Such unsafe activities may lead to the transfer of naturally occurring radioactive materials (NORM), which are present in the earth's crust, to the surface of the planet (Babatunde *et al.*, 2019). Various environmental problems have occurred due to these explorations and exploitations activities in Niger the Delta areas which have negatively impacted on its ecosystem due to oil spills into the oil producing areas. Human exposure to this natural radioactivity, which spreads upon the earth's surface through different geological formations like rock, earth crust, soil, water and air, etc., and terrestrial sources of naturally occurring radioactivity level change due to the geological makeup of the particular environment, radiochemical condition, geographic location, and the circulation of radionuclides on the ground (UNSCEAR, 2000; Kayakoku and Dogru, 2017; Kola-Olusanya and Mekuleyi 2018).

Radioactivity is always naturally occurring in the environment from the foundation of the earth. However, the input of artificial sources became heightened through activities such as oil spillage, discharge of toxic chemicals, discharge of water into the land and water bodies, sewage disposal etc (Ademola and Ehiedu, 2010). BIR occurs in three main ways viz telluric radiation, man-made and cosmic rays. Background ionizing radiation can equally contaminate the environment when it

exceeds an acceptable limit or levels (professional and community limits), (Agbalagba *et al.*, 2016). Once radionuclides are found in the environment, plants, animals and fishes are ready to take up these radionuclides and introduce them into the food chain. Also, animals, fish and plants within the marine setting usually amass radionuclides to a certain level that is above those of the surroundings (Babatunde *et al.*, 2019). Ionizing radiation sources are commonly used all over the world, particularly in areas of agriculture, the petroleum industry, medicine, and research institutions. Amongst these, the petroleum sector is the most widely used in Nigeria due to its importance to the economy. The use of modern technologies has triggered an increase in the rate and level of oil and gas operations and thus creating serious concerns that, require urgent attention. The petroleum industry is the major importer and consumer of radioactive materials, which are used within upstream and downstream sectors, besides medical exposures, (Kola-Olusanya and Mekuleyi 2018). Instruments such as nuclear level density gauges, nuclear well logging, the application of radiotracers in oil well management and industrial radiography are excellent sources of ionizing radiation. Nevertheless, numerous protective measures have been enacted to ensure the safety of lives and the environment against accidents, equipment failures, human error, improper discharge, mishandling of equipment, etc.

Natural and artificial radioactive sources likely pollute the quality of the air, aquatic and soil environments, through different pathways like rivers, creeks, and dispersion. The radiological pollution of the environment as a result of radioactive materials is capable of causing both external and internal exposure to radiation. The ability of radioactivity to be present in aquatic environments is enhanced primarily as a result of

its solubility in water. Equally, traces of radioactive elements such as Uranium, Potassium, and Thorium are found in almost every type of rock, water and sand. NORM is available everywhere in our surrounding; within, on, below the earth and the atmosphere (Taskin *et al.*, 2009).

Every livelihood is susceptible to external as well as naturally occurring radionuclides in their local environment and also to internal radiation from water, air and food that they consume (Rajesh, 2006). Distribution of naturally occurring radionuclide like Potassium 40 (^{40}K), Uranium 238 (^{238}U), and Thorium 232 (^{232}Th) with other radioactive elements in solid/water directly depends on the nature of the material through which they are concentrated. Therefore, excessive exposure of the public or occupational worker to ionizing radiation could lead to serious health challenges, like eye cataracts, lung cancer and mental imbalances. Background ionizing radiation levels in the select areas are not yet established based on the aforementioned risk due to exposure to radiation. Hence, there is need to carry out background ionizing radiation studies in these select areas and their environment since industrial activities are on the increase, enhancing the occurrence of naturally occurring radionuclide.

2.0 Materials and Methods

The materials used in the background ionizing radiation investigation were a survey meter, (Digilert, Nuclear Radiation Monitor with serial number-60555) and a Global Positioning System (GPS), used for determination of coordinates at each measuring location.

Digilert (digital exposure rate meters using Caesium -137) detectors count ionizing events and display the reading on the liquid crystal display (LCD). The measurement's unit is

controlled using mode switch and shows readings in the choice of counts per minute (cpm), milliRoentgen per hour (mRh^{-1}) or accumulated counts. The numeric display gives current radiation readings in counts per minute from 0 to 50,000, if it is set in cpm mode. When X 1000 is displayed, the numeric value is multiplied by 1000 to obtain the overall reading. The display indicates the total number of counts that have been accrued from 0 to 60,000 since the switch

was turned to this position. Whenever the monitor is operating, the red count light glows if a count is perceived. Information regarding the mode setting, the current function, and the battery level is displayed on the LCD through a number of indicators. The survey meter used was standardized at the National Institute of Radiation Protection and Research Centre (NIRPR), University of Ibadan and is still valid. A flow diagram of the survey meter is shown in Figure 1.

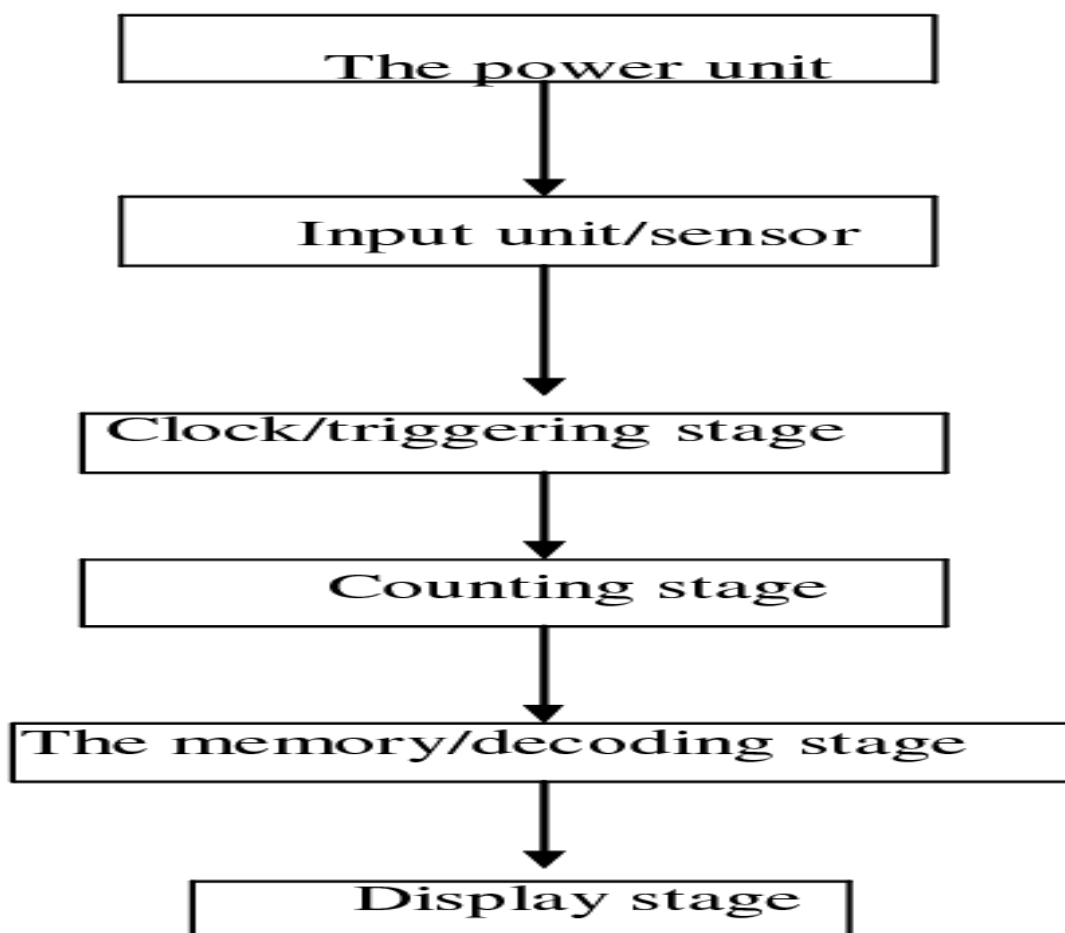


Figure 1: Flow diagram of processing stages in survey meter

2.1 Method

The research was purely experimental. In-situ measurements of radiation exposure rate were done to determine background ionizing radiation due to oil spilled/bunkering activities in the select communities in Bayelsa State which was

randomly measured. The exposure level in the field was measured using a moveable survey meter at select communities in Ogbia Local Government Area in Bayelsa State as shown in Figure 2 and their coordinates were taken with the GPS.

3.2 Annual Effective Dose Equivalent (AEDE)

A radiation protection indicator called the annual effective dose assesses the annual dose taken by the entire body. For outdoor computation of AEDE, a dosage conversion term of 0.7 Sv per Gy was used as suggested by UNSCEAR, (1993). The conversion coefficient from annual effective dosage equivalent and absorbed dosage in air to effective dosage received by an adult has an occupancy number of 0.25 for open-air exposure and an indoor occupancy number of 0.8. The AEDE was obtained from equations 2 and 3 for outdoor and indoor respectively.

$$AEDE_{(outdoor)} (mSvy^{-1}) = D_{(air)} (nGyh^{-1}) \times 8760 \text{ h} \times 0.7 \text{ Sv/Gy} \times 0.25 \times 10^{-6} \quad (2)$$

$$AEDE_{(indoor)} (mSvy^{-1}) = D_{(air)} (nGyh^{-1}) \times 8760 \text{ h} \times 0.7 \text{ Sv/Gy} \times 0.8 \times 10^{-6} \quad (3)$$

where 8760h is the total hours per year.

3.3 The Excess Lifetime Cancer Risk (ELCR)

The term "ELCR" refers to the elevated lifelong cancer risk that results from a person's radiation exposure. Therefore, there is need to determine the excess cancer risk over a lifetime (Taskin et al., 2009). Thus, ELCR can be calculated from Equation 4:

$$ELCR (mSv/y) = AEDE \times \text{Mean duration of life (DL)} \times \text{Risk factor (RF)} \quad (4)$$

where AEDE = annual effective dose equivalent, DL= duration of average lifetime (taken to be 50 years in the study area) and RF = fatal cancer risk factor ($0.05Svy^{-1}$). For low-dosage background radiation which is viewed to be responsible for stochastic effects, ICRP 60 uses a fatal cancer risk quantity of 0.05 for communal exposure (Rafique et al., 2014; Taskin et al, 2009).

4.0 Results

4.1 Background Ionizing Radiation Levels

The select samples of results for measured BIR exposure rates and calculated radiological risk variables are shown in Tables 1 - 4. Figure 3 shows a comparison of the estimated mean measured radiation exposure rate with ICRP standard values, while Figure 4 displays a comparison of the estimated average absorbed dose rate with the world standard. Figure 5 gives the comparison of the estimated average (ELCR) with the accepted safe limit and Figure 6 compares the estimated average of annual effective dose equivalent with the accepted average limit. The following are the results of radiation exposure rates obtained at different locations. Emeyal 1 and 2 communities, Oruma community and Tie Inn manifold as presented in Tables 1 to 4, show exposure rate values ranging from 0.006 - 0.01 mRhr⁻¹, 0.005 to 0.01 mRhr⁻¹., 0.005 - 0.008 mRhr⁻¹., and 0.006 - 0.013 mRhr⁻¹ with a mean value of 0.009 mRhr⁻¹, 0.009 mRhr⁻¹, 0.007 mRhr⁻¹ and 0.010 mRhr⁻¹ correspondingly.

5.0 Discussion

From the results obtained in the study as displayed in Tables 1 through 4; the mean values of exposure rate in these six communities and the oil spilled site are all below the ICRP limit (0.013 mRh⁻¹) (ICRP, 2003) shown also in Fig. 3. However, the radiation exposure rate recorded at oil spilled site extended from 0.007-0.013 mRh⁻¹ with a mean value of 0.010 mRh⁻¹. This value, when compared with the ICRP standard, had a difference of only 0.003 mRh⁻¹, implying that the exposure rate of that environment can be enhanced with little more radiation activity. Although the average exposure rate in these six communities was lower than the ICRP standard, further hydrocarbon explorations by oil companies operating in the area may trigger a surge in the level of ionizing radiation. The BIR mean values from this study ranged from 0.007 - 0.010 mRh⁻¹.

Table 1: Average BIR Exposure rate and the estimated Risk Parameters of Emeyal 1 Community in Ogbia LGA

S/n	Location	Geographical coordinates	Average Exposure Rate (mRh ⁻¹)	Absorbed dose (nGy/h)	AEDE (mSv/y)	ELCR (x 10 ⁻³ mSvy ⁻¹)
1	Town Hall	N4°49.8846 E6°21.11712	0.009	78.3	0.12	0.3
2	primary School	N4°49.89402 E6°21.0276	0.006	52.2	0.08	0.2
3	Tonymo filling station	N4°49.79112 E6°21.00738	0.01	87	0.13	0.33
4	Otuoke Junction	N4°49.71078 E6°21.09582	0.01	87	0.13	0.33
5	Living Faith Church	N4°49.64022 E6°21.1305	0.01	87	0.13	0.33
6	Corpers Lodge	N4°49.64058 E6°21.22812	0.01	87	0.13	0.33
7	Anglican Church Emeyal 1	N4°49.72368 E6°21.1902	0.01	87	0.13	0.33
8	Apostolic church Maritime Assembly Nig.	N4°49.93842 E6°21.10152	0.007	60.9	0.09	0.23
9	Community Secondary School	N4°49.96782 E6°21.09042	0.009	78.3	0.12	0.3
10	Deeper Life Camp Ground	N4°49.9623 E6°21.98602	0.007	60.9	0.09	0.23
Mean			0.009	76.56	0.12	0.29

Table 2: Average BIR radiation exposure rate and the estimated risk parameters of Emeyal 2 community in Ogbia LGA

S/n	Location	Geographical coordinates	Average. Exposure Rate (mR/h)	Absorbed dose (nGy/h)	AEDE (mSv/y)	ELCR (x 10 ⁻³ mSv/y)
1	No 1 HRH Isaac Odoko Road Emeyal 2	N4°50.4366 E6°21.03852	0.008	69.6	0.11	0.27
2	No 2 King Odogu Charles Road Emeyal 2	N4°50.26758 E6°20.9619	0.009	78.3	0.12	0.3
3	St. Luke's Church Emeyal 2	N4°50.1612 E6°20.98098	0.005	43.5	0.07	0.17
4	Community girls Secondary School	N4°50.1444 E6°21.04632	0.007	60.9	0.09	0.23
5	GODs Guiding Church emeyal 2	N4°50.2458 E6°21.042	0.008	69.6	0.11	0.27
6	No 10 Chief EnoniSingaIgrubia road Emeyal 2	N4°50.415 E6°21.08412	0.01	87	0.13	0.33
7	Town Hall Emeyal 2	N4°50.3025 E6°21.08772	0.01	87	0.13	0.33
8	St. Luke's Nursery and Primary school Emeyal 2	N4°50.23188 E6°21.0717	0.009	78.3	0.12	0.3
9	ObhanEmeyal Youth council Secretariat	N4°50.45502 E6°21.1425	0.01	87	0.13	0.33
10	Judiciary customary court Emeyal 2	N4°50.51442 E6°21.19848	0.01	87	0.13	0.33
	Mean		0.009	74.82	0.11	0.29

Table 3: Average BIR Exposure rate and Estimated Risk parameters in Oruma Community in Ogbia LGA

S/n	Location	Geographical coordinates	Average. Exposure Rate (mRh ⁻¹)	Absorbed dose (nGyh ⁻¹)	AEDE (mSvy ⁻¹)	ELCR (x 10 ⁻³ mSvy ⁻¹)
1	Community Secondary School Oruma	N4°55.31568 E6°25.08786	0.007	60.9	0.09	0.23
2	Holy Ghost Catholic Parish Oruma	N4°55.10082 E6°25.06212	0.007	60.9	0.09	0.23
3	Oruma Civic Centre	N4°55.01052 E6°25.1427	0.009	78.3	0.12	0.3
4	Oruma Community Corper Lodge	N4°55.10472 E6°25.17648	0.008	69.6	0.11	0.27
5	Oruma Community Town Hall	N4°55.05054 E6°24.11336	0.005	43.5	0.07	0.17
6	Oruma Health centre	N4°55.23474 E6°25.05054	0.006	52.2	0.08	0.2
7	Oruma Bridge	N4°55.05252 E6°24.98652	0.008	69.6	0.11	0.27
8	Ebifuro Compound Oruma	N4°55.96072 E6°25.11612	0.007	60.9	0.09	0.23
9	Success Cool room Oruma	N4°55.1025 E6°24.91338	0.008	69.6	0.11	0.27
10	Dogas Hospital Yibama (Oruma)	N4°55.93162 E6°25.24962	0.008	69.6	0.11	0.27
	Mean		0.007	63.51	0.10	0.24

Table 4: Average BIR Exposure rate and Estimated Risk parameters in Tie-Inn Manifold Kolo Creek in Ogbia LGA

S/n	Location	Geographical coordinates	Average. Exposure Rate (mRh ⁻¹)	Absorbed dose (nGyh ⁻¹)	AEDE (mSvy ⁻¹)	ELCR (x 10 ⁻³ mSvy ⁻¹)
1	TIE-INN OSSP 1	N4°54.20082 E6°21.4698	0.007	60.9	0.09	0.23
2	TIE-INN OSSP 2	N4°54.19062 E6°21.45528	0.01	87	0.13	0.33
3	TIE-INN OSSP 3	N4°54.1863 E6°21.44502	0.011	95.7	0.15	0.37
4	TIE-INN OSSP 4	N4°54.17232 E6°21.44472	0.012	104.4	0.16	0.4
5	TIE-INN OSSP 5	N4°54.17502 E6°21.43992	0.011	95.7	0.15	0.37
6	TIE-INN OSSP 6	N4°54.18252 E6°21.4296	0.011	95.7	0.15	0.37
7	TIE-INN OSSP 7	N4°54.16218 E6°21.45648	0.013	113.1	0.17	0.43
8	TIE-INN OSSP 8	N4°54.16728 E6°21.46008	0.007	60.9	0.09	0.23
9	TIE-INN OSSP 9	N4°54.13158 E6°21.4743	0.011	95.7	0.15	0.37
10	TIE-INN OSSP10	N4°54.12888 E6°21.46992	0.011	95.7	0.15	0.37
	Mean		0.01	90.48	0.14	0.35

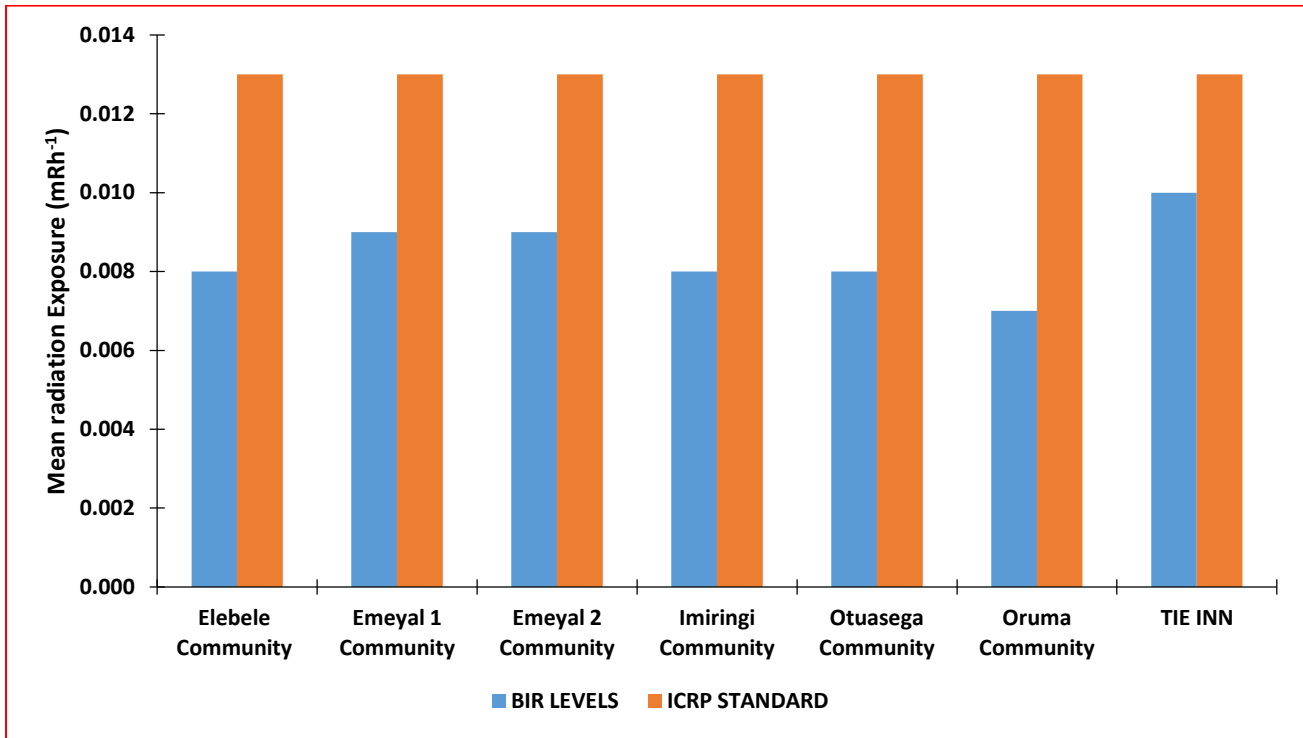


Figure 3: Comparison of the Average Exposure rate with the ICRP Standard

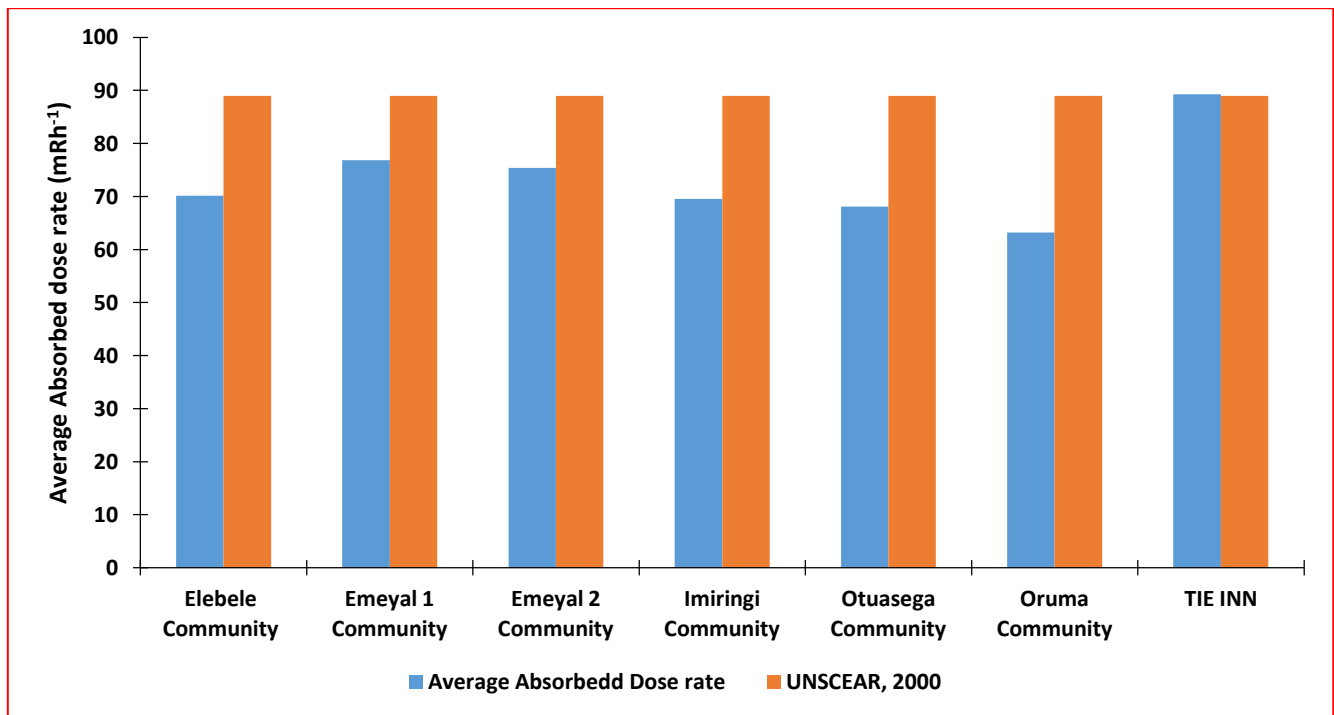


Figure 4: Comparison of Average Absorbed Dose rate with accepted UNSCEAR value

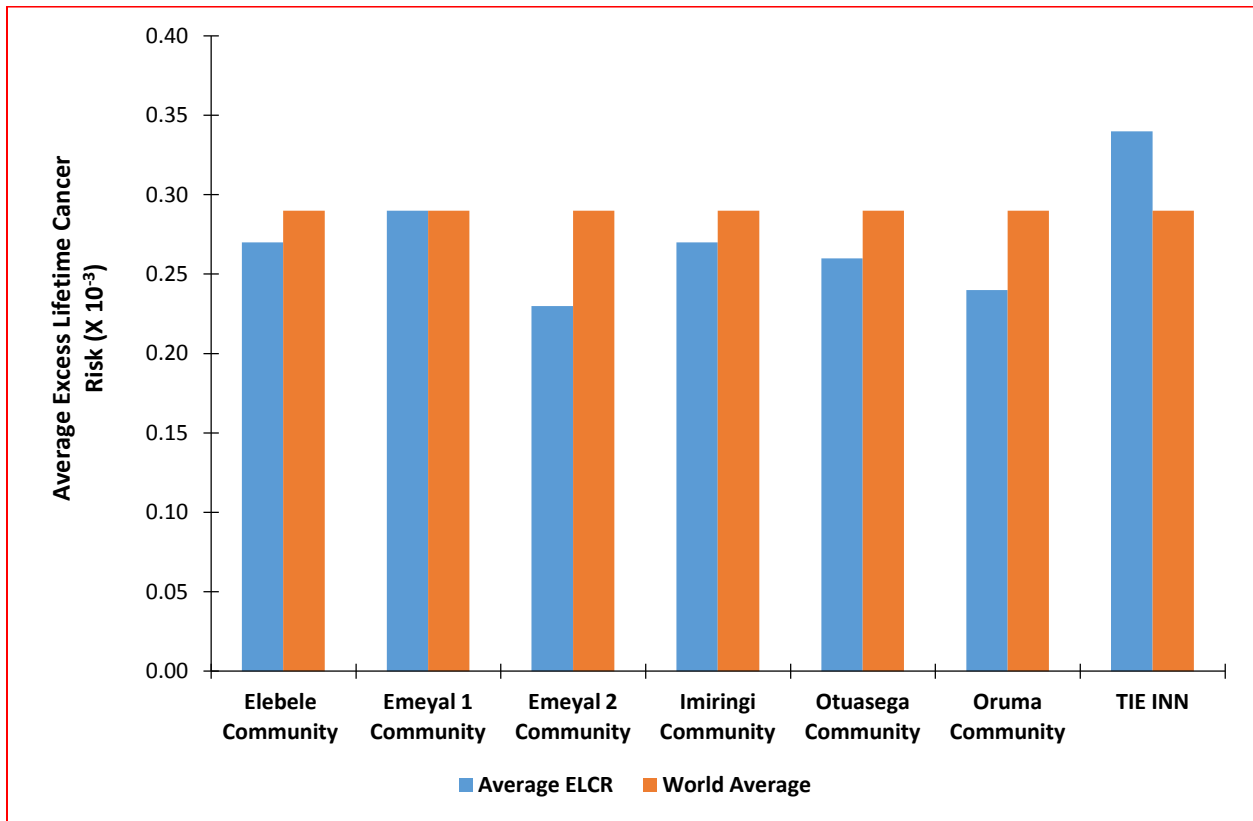


Figure 5 Comparison of Average ELCR with accepted safe limit

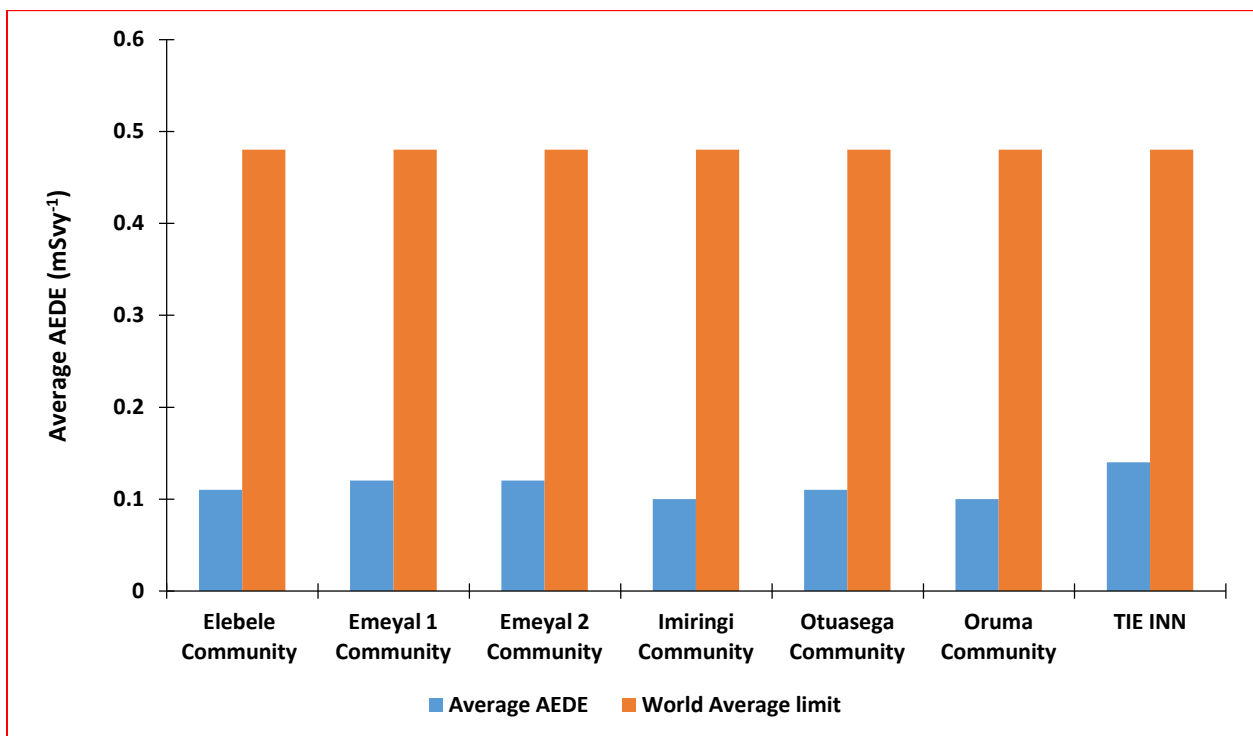


Figure 6: Comparison of Average AEDE with accepted World Average limit

A value of 0.013mRh^{-1} was obtained at Tie Inn OSSP 7 which was exactly the ICRP limit. Oruma community had the least exposure rate as seen in Table 3 and Figure 3. Emeyal 1 and 2 communities recorded 0.09 mRh^{-1} while Imiringi, Otusega, and Elebele villages gave 0.08 mRh^{-1} . This range of values is slightly lower than that reported by Avwiri and Esi (2014) and Chukwuocha and Enyinna (2010). Avwiri and Esi (2014), investigated BIR levels from oil spill location at Obodo Creek, Gokana Local Government Area, Rivers State, Nigeria and recorded mean values of $0.0155 - 0.0171\text{ mRh}^{-1}$. Also, Chukwuocha and Enyinna, (2010) monitored radiation levels from facilities in select oil wells in Bayelsa and Rivers State and obtained average values ranging from $0.013\text{ mRh}^{-1} - 0.014\text{ mRh}^{-1}$. The variance in observed measurements may be either from the fact that the exploration activities in our study areas are not as high as theirs or the Bayelsa State flood of 2022 had reduced the BIR. The average value of the absorbed dose rate (Fig. 4) assessed from exposure rate of six villages and one oil spilled site, such as Elebele community, Emeyal 1 community, Emeyal 2 community, Imiringi community, Otuasega community, Oruma community and oil spilled site was 70.47 nGyh^{-1} , 76.56 nGyh^{-1} , 74.82 nGyh^{-1} , 68.7 nGyh^{-1} , 68.73 nGyh^{-1} , 63.51 nGyh^{-1} and 90.48 nGyh^{-1} accordingly. All the magnitudes obtained from the six communities were below permissible value of 89 nGyh^{-1} , except that at the oil spilled site at Tie- Inn manifold Kolo Creek which was a bit above the recommended standard with differences of 1.16 nGyh^{-1} , while Oruma community (Table 3) had the lowest value among the communities. The average absorbed dose rate of the study locations which ranged from $63.51 - 90.48\text{ nGyh}^{-1}$ was less than that stated by Agbalagba (2017). He studied the outdoor absorbed dose rate at Effurun and Warri L.G.A.

in Delta State, Nigeria for each zone and obtained values that ranged from $121.90 - 190.16\text{ nGyh}^{-1}$ with a mean record of 141.30 nGyh^{-1} . The obtained average readings for the annual effective dose equivalent (Fig. 6) of Elebele community, Emeyal 1 community, Emeyal 2 community, Imiringi community, Otuasega community, Oruma community and one Oil spilled site are 0.11 mSvy^{-1} , 0.12 mSvy^{-1} , 0.11 mSvy^{-1} , 0.10 mSvy^{-1} , 0.11 mSvy^{-1} , 0.10 mSvy^{-1} , and 0.14 mSvy^{-1} correspondingly. The values showed that the AEDE for these communities, including the site of oil spillage were much smaller than the accepted limit of 0.48 mSvy^{-1} . Although the value at oil spill site (Table 4) was a bit higher than the selected communities, Oruma and Imiringi communities (Figure 6) were the lowest amongst them. The AEDE of this work ranged from $0.010 - 0.14\text{ mSvy}^{-1}$ and is lower than that reported by Agbalagba (2017), whose value was peaked at 0.17 mSvy^{-1} when compared.

The estimated mean ELCR for the study communities (Figure 5), including the oil spill site, was: Elebele community had 0.27×10^{-3} , Emeyal 1 community had 0.29×10^{-3} , Emeyal 2 community had 0.29×10^{-3} , Imiringi community had 0.26×10^{-3} , Otuasega community had 0.26×10^{-3} , Oruma community had 0.24×10^{-3} and oil spill site had 0.35×10^{-3} . The presented values of this study showed that oil spill site exceeded the recommended limit of 0.29×10^{-3} , while Emeyal 1 and 2 communities had exact values within the recommended limit. However, the Imiringi and Elebele communities' values were close to the accepted limit, while the Oruma community had the lowest value.

The presented values of this study showed that oil spill site exceeded the recommended limit of $0.29 \times 10^{-3}\text{ mSvy}^{-1}$, while Emeyal 1 and 2 communities had exact values with the

recommended limit. However, the Imiringi and Elebele communities' values were close to the accepted limit, while the Oruma community had the lowest value. Therefore, the chance of contacting cancer over time by people residing within or close to the oil spill area is possible, the same applies to the residents of Emeyal 1 and 2 communities, especially when oil exploration activities that are capable of triggering up BIR in the environment are out. The result clearly revealed that residents in Tie Inn are at the risk of cancer presently as the ELCR limit had been exceeded there.

The ELCR average of this work ranged from $0.24 \times 10^{-3} \text{ mSvy}^{-1}$ – $0.35 \times 10^{-3} \text{ mSvy}^{-1}$ and is smaller than the ELCR mean value of $0.61 \times 10^{-3} \text{ mSvy}^{-1}$ as reported by Agbalagba (2017). The high excess lifetime cancer risk value obtained at Tie-inn manifold in Kolo Creek indicates that there is a possibility the residents who spend more than 50 years there, will contact cancer due to background ionizing exposure.

Oruma community has the lowest values among the study areas because of its distance from the oil operations area while the control site Tie Inn most in all studied parameters. Hence, we opined that the farer the distance from the point of oil exploration, the safer the area and vice versa. Also, all the results from this study were lower than the results from Awwiri and Esi, (2014), Chukwuocha and Enyinna, (2010) and Agbalagba, (2017). The differences could be a result of low oil and gas activities or could be as a result of year 2022 flood in Bayelsa State.

6.0 Conclusion

The background ionizing radiation average values obtained for all the select communities including oil spill sites, were below the world average value of 0.013 mRhr^{-1} . The highest mean

values measured in the study were at the oil spillage site with a mean value of 0.010 mRhr^{-1} . This value, when compared with the ICRP standard, had a difference of only 0.003 mRhr^{-1} implying that the exposure rate of that environment can be enhanced with little more radiation activity.. The oil spill site mean values are the highest amongst the select locations and such values are credited to the spillage from oil and gas activities within the facility. The obtained average readings for the annual effective dose equivalent in the six communities and one Oil spilled site showed that the AEDE for these communities, including the site of oil spillage were much smaller than the accepted limit of 0.48 mSvy^{-1} . The average value of the absorbed dose rate assessed from exposure rate of six villages and the oil spilled site, all had magnitudes below permissible value of 89 nGyh^{-1} , except that at the oil spilled site at Tie- Inn manifold Kolo Creek which was a bit above the recommended standard with differences of 1.16 nGyh^{-1} , while Oruma community had the lowest value among the communities. Also, the mean background ionizing radiation levels recorded in this research are lower than the values reported in most areas of the Niger Delta, Nigeria, probably due to the 2022 flood. The mean absorbed dose rate (D) value obtained in all six select villages was less than the world average value, although the Tie-inn manifold in Kolo Creek was slightly higher than the ICRP standard. The excess lifetime cancer risk results recorded from this research for five communities were lower than the ICRP value. However, Emeyal 1 and 2 had exact values with the ICRP value and the Tie-inn manifold in Kolo Creek magnitude exceeded the limit. The high excess lifetime cancer risk value obtained at the oil spill site indicated a possibility for its residents who spend above 50 years in the area, to contact cancer as a result of background ionizing exposure. Finally, this investigation has

exposed that most background ionizing radiation parameters measured were still within acceptable limits except few health risks or threats that may likely occur in the future but not immediate.

Conflict of interest: The authors declare that they are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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