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Determination of Terrestrial Radiation Level of Obite, Rivers State

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Abstract

Purpose: The perceived implication of increase in background radiation level of Obite Community due to inputs of hydrocarbon leakages and its emissions, lead to this research work, which investigated the background ionizing radiation levels of the area.

Methodology: An in-situ background ionizing radiation measurement was carried out using radiation meter (Digilert 200) at an elevation of 1.0m above ground level with a Global Positioning System (G.P.S) for geographical location.

Results: The background ionizing radiation (BIR) results obtained, varies from 0.007 to 0.024 (mR/hr) with a mean value of 0.013 (mR/hr). The values of Absorbed Dose Rate ranges from 60.9 to 208.0 nGy/hr with a mean value of 115.10±0.003 nGy/hr, which is higher than the recommended safe limit of 84.0 nGy/hr (UNCEAR, 2018). The Annual Effective Dose Equivalent (AEDE) varies from 0.009 to 0.38 mSv/yr with mean of 0.198 mSv/yr, is lower than the safe limit of 1.0 mSv/yr stipulated by ICRP (2003) and WHO (2008). The Excess Lifetime Cancer Risk (ELCR) values ranges from 0.32 to 0.09 x 10^{1} with a mean of 0.062 x 10^{-1}, is higher than the ICRP standard of 0.29 x 10^{-3} (ICRP, 2003).

Conclusions: These results indicate an increase in cancer risk for individuals within the study area. The results were also summarized using the contour map to show various areas of high radiation distributions with interpretation of variability in concentration, in relation to geographical locations within the study area.

Keywords: *Ranuclides, Background radiation level, Absorbed dose, Effective dose, Obite Community*

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INTRODUCTION

Background radiation is part of the natural environment as such, humans and other living organisms are continuously exposed to it. This has increased on daily bases due to anthropogenic activities with great concerns putting into considerations its effects when exposed to high doses. The human exposure to background ionizing radiation of a particular environment is affected by various factors such as altitude and latitude (Chad-Umoren and Briggs-Kamara, 2010). Most exposures to radiation sources are modified by anthropogenic activities like the radio nuclides released to the environment during mineral processing (UNSCEAR, 2010). The exposure to high level of gamma radiation has a number of harmful effects, such as mutation and cancer of various types (Aziz et al., 2014).

According to Jibiri et al. (1993), radionuclides are unstable elements, which in the process of attaining stability, spontaneously disintegrates, giving out dangerous ionizing radiation to the environment. However, the background radiation level of a particular place, is linearly propotional to the ecological formation of such area (Jibiri et al; 1993). The inheritance of radiological consequences posed by oil and gas exploration, exploitation, mining and processing of petroleum activities across the Niger Delta, has been heavy for the past forty (40) years (Ononugbo et al, 2011). These activities have altered the natural ionizing radiation exposure level to both workers and the members of the general public. ICRP report, (1990) states, that radiation dose of about 80% to man emanates from natural sources of which radon contributes about 55%. Radiation doses received by individuals at higher level, puts those individuals at a greater risk of developing cancer, considering their exposure time. The impact of low radiation dose may not manifest immediately, until many years after exposure and no level of radiation exposure despite how low, for which it does not pose a risk to life (Avwiri et al, 2010). The external radiations mainly emanate from radionuclides in soil and are emitted within 15-30cm of the top soil in the earth surface (Farai and Vincent, 2006).

Sigalo and Briggs-Kamara (2004) carried out a study on the background radiation levels within twelve riverine communities of the Niger Delta. This was to investigate whether or not the onshore oil activities, has increased the level of background radiation of the environment. The study showed a result range of 0.57±0.16 to 0.85±0.19 mSv/yr, which are below the set limit in a normal

environment of 1mSv/yr by the European Council for Nuclear Research (CERN, 1995). Also, Osimobi *et al* (2005) investigated the background ionizing radiation level in few solid mining sites in Enugu State, and reported a result of 38.5% elevation above the normal radiation level. Ovuomarie-Kelvine *et al* (2018), reported an average value range of 12.00±0.10 to 22.00±2.10 μRh^{-1} in the oilfield, while in the communities, the results ranges from 9.00±1.00 to 11.00±0.30 NRh^{-1}, as it studied the terrestrial radiation levels around oil spill sites in Rivers and Bayelsa, which was concluded that the background radiation levels in the area, exceeded normal background levels compared to the world standard.

Ionizing radiations are highly energetic with characteristic high penetrating power. When such radiation penetrates into the biological cell, it causes both excitation and ionization which alters the cells formation (Emelue et al., 2014). Quantities, such as the absorbed dose, effective dose and the equivalent dose, have been introduced to measure the amount of dose received and the level of biological effectiveness of that dose (Akpa, 2010).

Study Area

The study area is Obite Community of Egi Clan in Ogba/Egbema/Ndoni Local Government Area of Rivers State. It lies between the latitude of $5^{o}15'3.06'N$ and longitude of $6^{o}39'27.81'E$, with a fast-growing population of over 5,400 persons (Umunakwe and Aharanwa, 2015). Obite community shares boundary with other communities such as Ogbagi, Ogbogu, Ede, Akabuka, Obuobu and Omoku as their neighbouring town. Obite community hosts Total Exploration and Production Nigeria Limited, the operators of OML 58, as well as different pipelines from Shell Petroleum Development Company of Nigeria (SPDC).

MATERIALS AND METHODS

Data Collection

A Global Positioning System (G.P.S) was used to measure the geographical co-ordiantes of the sampling points. Nuclear Radiation Monitor (Digilert 200) was used to measure the background radiation level, which identifies Alpha, Beta, Gamma and X-radiations. The meter was caliberated in terms of its functional quantities. The meter recorded dose rate in milli-roentgen per hour ($mR\ hr^{-1}$), which was converted to absorbed dose rate in Nano gray per hour ($nGhr^{-1}$). The meter was placed about one meter above the ground level for maximum detection, as most stable point was

recorded. The measurement was repeated at each measuring point, recording three readings for every point, with an aggregate of thirty (30) readings taken altogether from the research area.

Figure 1.1: Global Positioning System and Nuclear Radiation Monitor (Digilert 200)

Radiological Health Risk Parameters

Absorbed Dose Rate (ADR)

Data obtained for the external exposure rate in mR/hr was converted into absorbed dose rate in nGy/hr using the conversion factor. Absorbed dose is a physical quantity D representing the mean energy conveyed to matter per unit mass by ionizing radiation.

Absorbed Dose = exposure dose rate x 8.7 (nGy/hr)

1μR/hr =8.7 nGy/hr

$$= \frac{8.7\ X\ 10^{-3}\mu gY}{1/_{8}760} = 76.212\mu Gyh^{-1} \qquad 1.5$$

Equivalent Dose

Equivalent Dose is the product of the average absorbed dose (DTR) of radiation (R) in a tissue and radiation weighting factor(WR). The equivalent dose is use to assess how much biological damage is expected from the absorbed dose of certain type of radiation

$$\text{Equivalent Dose} = 1\text{mR/hr} = \frac{0.96x24x365}{100} \quad (\text{mSv/yr}) \qquad 1.6$$

Annual Effective Dose Equivalent

Measured absorbed gamma dose rates were used to calculate the annual effective dose equivalent received by the people of the surveyed area. Dose conversion factors of 0.7 Sv/Gy, occupying factor for indoor and outdoor of 0.70 (18/24) and 0.2(6/24) was used to calculate for the annual effective dose equivalent (AEDE).

The annual effective dose (AEDE) is determined using the equation by (Mhuhammad *et al.* 2014), in line with ICRP (2007) guideline.

AEDE (outdoor) (mSv/yr)

= Absorbed dose rate (nGy/h)×8760h × 0.7 Sv/Gy × 0.25 1.7

Excess Lifetime Cancer Risk (ELCR)

Excess lifetime cancer risk deals with the possibility of developing cancer over a lifetime at a given exposure level. The average duration of life is 70 years while the risk factor for public exposure is 0.05 (ICRP 60).

Excess Lifetime Cancer Risk (ELCR) is calculated using the expression;

ELCR = AEDE × Average Duration of Life (DL) × Risk Factor (RF) 1.8

Contour mapping

Contour maps were created by the view of locating area of high radiation distribution of the measured background ionizing radiation, outdoor radiation level. The locations coordinates measured with geographical positioning system (GPS) and the result obtained were used to plot the contour map with the aid of software (Surfer8 software). In this study, the map represents the sampling locations and it summarizes the radiation level of the study area. The maps are helpful in interpretation of the variability in concentration in relation of the geographical location within the study location.

RESULTS AND DISCUSSION

In-situ Measurement Results

The results of the *in-situ* measurement of the background ionizing radiation (BIR) levels outdoor of the study area and their respective geographical coordinate are presented in Tables 4.1 and Table 4.2 below, Figure 4.1 show the Comparison of Exposure Dose Rate (mR/hr) with Standard, Figure 4.2 Show the comparison of Absorbed Dose Rate **(nGy/hr)** with Standard, Figure 4.3 shows Comparison of Annual Effective Dose Equivalent (AEDE), Figure 4.4 show the Comparison of

Excess Life Cancer Risk with ICRP Standard (2007) and Figure 4.5 show the contour map of the study area.

Table: 4.1: Background Ionizing Radiation measurement of the study Area

Sampling Points	Code	GPS READING	Exposure Dose Rate ($mRhr^{-1}$)			Exposure Dose Rate Mean ($mRhr^{-1}$)
			1st Reading	2nd Reading	3rd Reading	
Civic Centre	$OBRM_1$	$NO5^0$15.274' $E006^0$ 39.383'	0.007	0.019	0.006	0.011±0.003
Church of God	$OBRM_2$	$N05^0$ 15.284' $E006^{03}$9.435'	0.013	0.009	0.009	0.010±0.001
Best Man Layout Point 1	$OBRM_3$	$N05^0$15.237' $E006^0$ 39.472'	0.007	0.013	0.007	0.009±0.001
Best Man Layout Point 2	$OBRM_4$	$N05^0$15.227' $E006^0$ 39.497'	0.013	0.006	0.015	0.011±0.000
Best Man Layout Junction	$OBRM_5$	$N05^0$15.176' $E006^0$39.500'	0.009	0.006	0.015	0.010±0.002

Faith Maternity	$OBRM_6$	$N05^0$15.134’ $E006^0$39.573’	0.007	0.017	0.017	0.014±0.002
Farmland By Best man	$OBRM_7$	$N05^0$15.067’ $E006^0$39.581’	0.009	0.007	0.015	0.010±0.001
Oil Location Junction	$OBRM_8$	$N05^0$15.046’ $E006^0$39.584’	0.009	0.013	0.019	0.014±0.002
Oil Location Road	$OBRM_9$	$N05^0$15’036’ $E006^0$39.569’	0.011	0.007	0.011	0.010±0.002
Titi-Ikpe Resort	$OBRM_{10}$	$N05^0$15.049’ $E006^0$39.597’	0.011	0.007	0.009	0.009±0.002
Titi Ikpe Transformer	$OBRM_{11}$	$NO5^0$15.038’ $E006^0$39.609’	0.013	0.007	0.011	0.010±0.002
Water Project Point	$OBRM_{12}$	$N05^0$15.010’ $E006^0$39.665’	0.026	0.020	0.017	0.021±0.001
Egita Road Obite	$OBRM_{13}$	$NO5^0$14.992’ $E006^0$39.690’	0.015	0.015	0.011	0.014±0.002

Greater Evangelism Church	$OBRM_{14}$	$N05^{0}14.998'$ $E006^{0}39.697'$	0.015	0.022	0.022	0.020±0.002
Living Faith Church	$OBRM_{15}$	$N05^{0}14.990'$ $E006^{0}39.719$	0.021	0.017	0.013	0.017±0.002
Total Guest House Obite	$OBRM_{16}$	$N05^{0}14.981'$ $E006^{0}39.806'$	0.024	0.019	0.017	0.020±0.003
Assembly Of God Church	$OBRM_{17}$	$N05^{0}15.986'$ $E006^{0}39.467'$	0.020	0.021	0.022	0.021±0.001
Church of God Jerusalem	$OBRM_{18}$	$NO5^{0}15.015'$ $E006^{0}39.516'$	0.011	0.036	0.026	0.024±0.002
Egita Road By Market Obite	$OBRM_{19}$	$NO5^{0}15.003'$ $E006^{0}39.487'$	0.007	0.013	0.013	0.011±0.002
Obite First Market Junction	$OBRM_{20}$	$N05^{0}15.015'$ $E006^{0}39.437'$	0.019	0.022	0.019	0.020±0.003
Obite Second Market Junction	$OBRM_{21}$	$NO5^{0}15.018'$ $E006^{0}39.418'$	0.009	0.011	0.015	0.012±0.002
Market Point	$OBRM_{22}$	$N05^{0}15.018'$	0.010	0.009	0.013	0.010±0.000

		E006^{0}39.389’				
Obite Market Roundabout	$OBRM_{23}$	N05^{0}15.017’ E006^{0}39.362’	0.011	0.009	0.011	0.010±0.001
Obite Playground Road	$OBRM_{24}$	N05^{0}15.019’ E006^{0}39.338’	0.007	0.013	0.009	0.010±0.002
Obite Town Hall	$OBRM_{25}$	N05^{0}15.033’ E006^{0}39.331’	0.007	0.008	0.006	0.007±0.001
Obite Play Ground	$OBRM_{26}$	N05^{0}15.032’ E006^{0}39.326’	0.009	0.010	0.011	0.010±0.002
Govt.Comp.Sec. Sch. Obite	$OBRM_{27}$	N05^{0}15.059’ E006^{0}39.276’	0.022	0.021	0.013	0.019±0.001
Gov. Comp. Sec. Sch. Class block	$OBRM_{28}$	N05^{0}15.035’ E006^{0}39.272’	0.013	0.015	0.007	0.012±0.002
Administrative block	$OBRM_{29}$	N05^{0}15.058’ E006^{0}39.232’	0.011	0.015	0.011	0.012±0.003
Corpers Lodge.	$OBRM_{30}$	N05^{0}15.022’ E006^{0}39.235’	0.006	0.009	0.011	0.009±0.001

Table: 4.2: Radiological Parameters

Sampling Points	**Code**	**Exposure dose rate ($mRhr^{-1}$)**	**EQUIVALENT DOSE (mSv/yr)**	**ABSORBED DOSE (nGy/hr)**	**AEDE OUTDOOR (mSv/yr)**	**ELCR $\times 10^{-3}$**
Civic Centre	OBR M_1	0.011±0.003	0.925	95.7	0.15	0.51
Church of God	OBR M_2	0.010±0.001	0.841	87.0	0.14	0.49
Best Man Layout Point 1	OBR M_3	0.009±0.001	0.757	78.3	0.12	0.42
Best Man Layout Point 2	OBR M_4	0.011±0.000	0.925	95.7	0.15	0.51
Best Man Layout Junction	OBR M_5	0.010±0.002	0.841	87.0	0.14	0.49
Faith Maternity	OBR M_6	0.014±0.002	1.177	121.8	0.20	0.70
Farmland By Best man	OBR M_7	0.010±0.001	0.841	87.0	0.14	0.49
Oil Location Junction	OBR M_8	0.014±0.002	1.177	121.8	0.20	0.70

Oil Location Road	OBR M_9	0.010±0.002	0.841	87.0	0.14	0.49
Titi-Ikpe Resort	OBR M_{10}	0.009±0.002	0.757	78.3	0.12	0.42
Titi Ikpe Transformer	OBR M_{11}	0.010±0.002	0.841	87.0	0.14	0.49
Water Project Point	OBR M_{12}	0.021±0.001	1.766	182.7	0.35	0.94
Egita Road Obite	OBR M_{13}	0.014±0.002	1.177	121.8	0.20	0.70
Greater Evangelism Church	OBR M_{14}	0.020±0.002	1.682	174.0	0.33	0.89
Living Faith Church	OBR M_{15}	0.017±0.002	1.429	147.9	0.23	0.81
Total Guest House Obite	OBR M_{16}	0.020±0.003	1.682	174.0	0.33	0.89
Assembly Of God Church	OBR M_{17}	0.021±0.001	1.766	182.7	0.35	0.94
Church of God Jerusalem	OBR M_{18}	0.024±0.002	2.018	208.0	0.39	1.09
Egita Road By Market Obite	OBR M_{19}	0.011±0.002	0.925	95.7	0.15	0.51

Obite First Market Junction	OBR M_{20}	0.020±0.003	1.682	174.0	0.33	0.89
Obite Second Market Junction	OBR M_{21}	0.012±0.002	1.009	104.4	0.17	0.60
Market Point	OBR M_{22}	0.010±0.000	0.841	87.0	0.14	0.49
Obite Market Roundabout	OBR M_{23}	0.010±0.001	0.841	87.0	0.14	0.49
ObitePlayground Road	OBR M_{24}	0.010±0.002	0.841	87.0	0.14	0.49
Obite Town Hall	OBR M_{25}	0.007±0.001	0.588	60.9	0.09	0.32
Obite Play Ground	OBR M_{26}	0.010±0.002	0.841	87.0	0.14	0.49
Govt.Comp.Sec. Sch. Obite	OBR M_{27}	0.019±0.001	1.598	165.3	0.27	0.85
Gov. Comp. Sec. Sch. Class block	OBR M_{28}	0.012±0.002	1.009	104.4	0.17	0.60
Administrative block	OBR M_{29}	0.012±0.003	1.009	104.4	0.17	0.60

Corpers Lodge.	OBR M_{30}	0.009±0.001	0.757	78.3	0.12	0.42
Mean		**0.013±0.002**	**1.113±0.001**	**115.10±0.003**	**0.195±0.001**	**0.624±0.002**

Figure 4.1 Show the comparison of Exposure Dose Rate (BIR) mR/hr with Standard

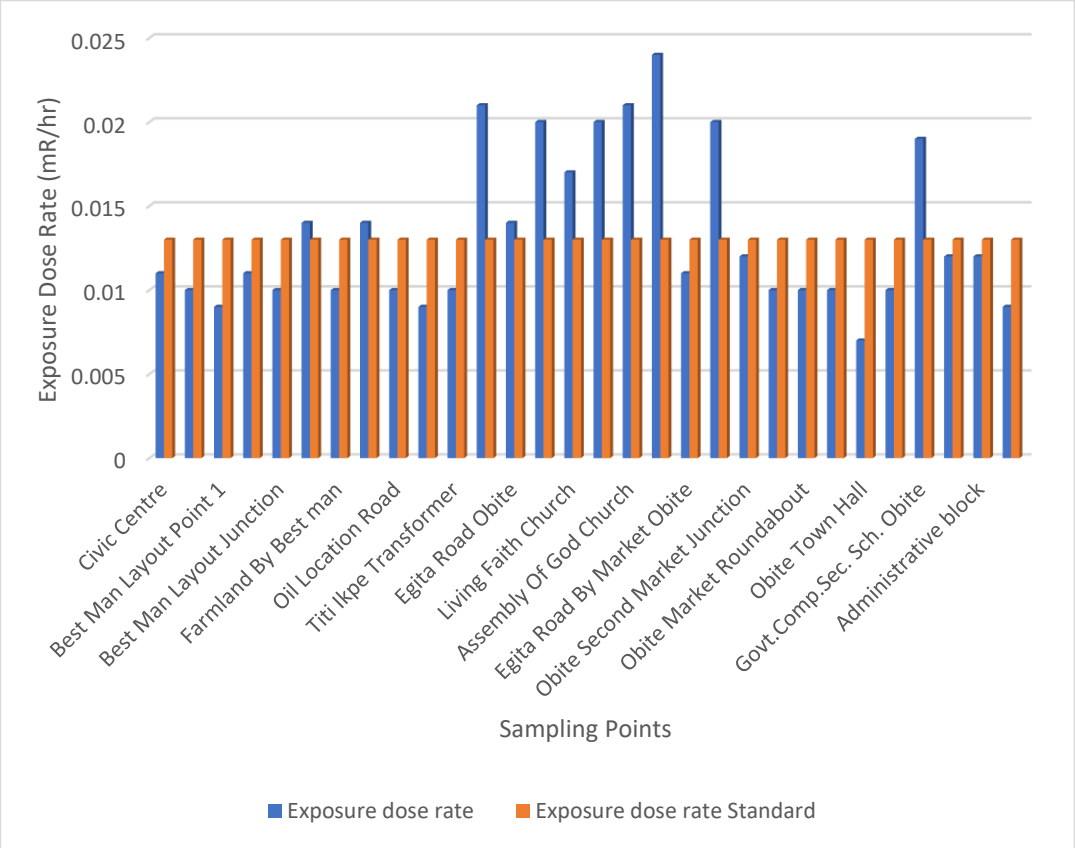

Figure 4.2: Show the comparison of Absorbed Dose Rate(nGy/hr) with Standard

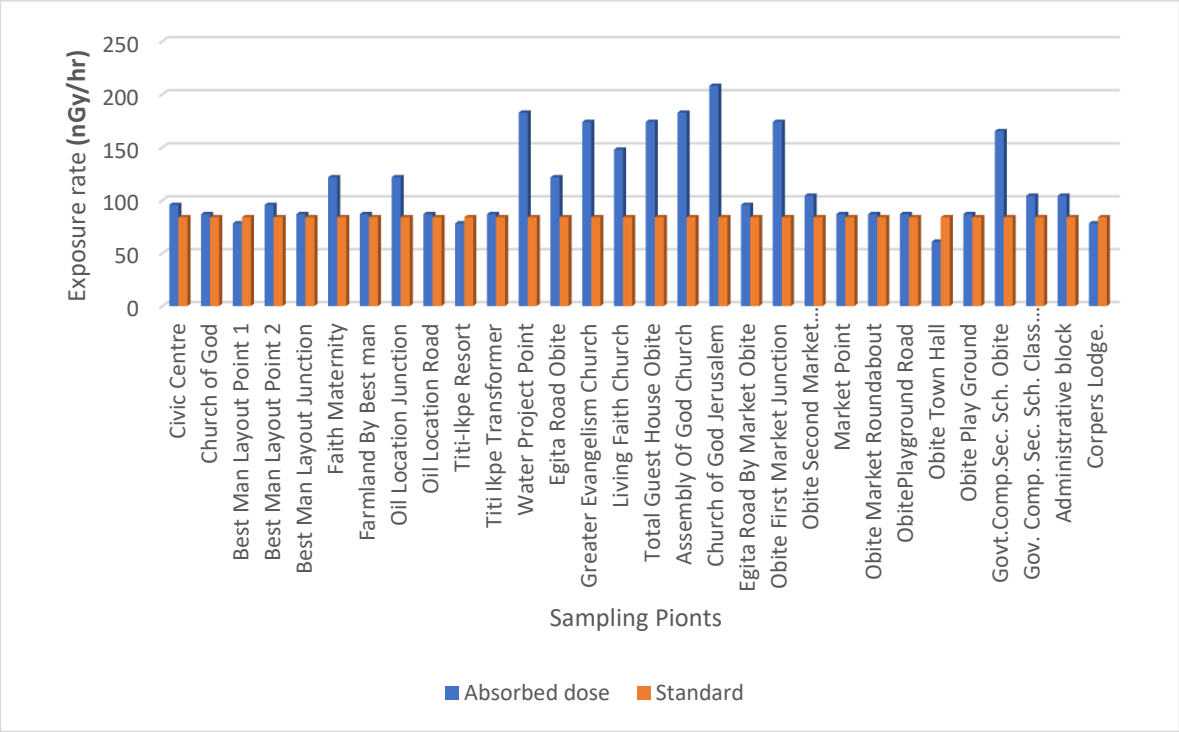

Figure 4.3: Show the comparison of AEDE with Standard

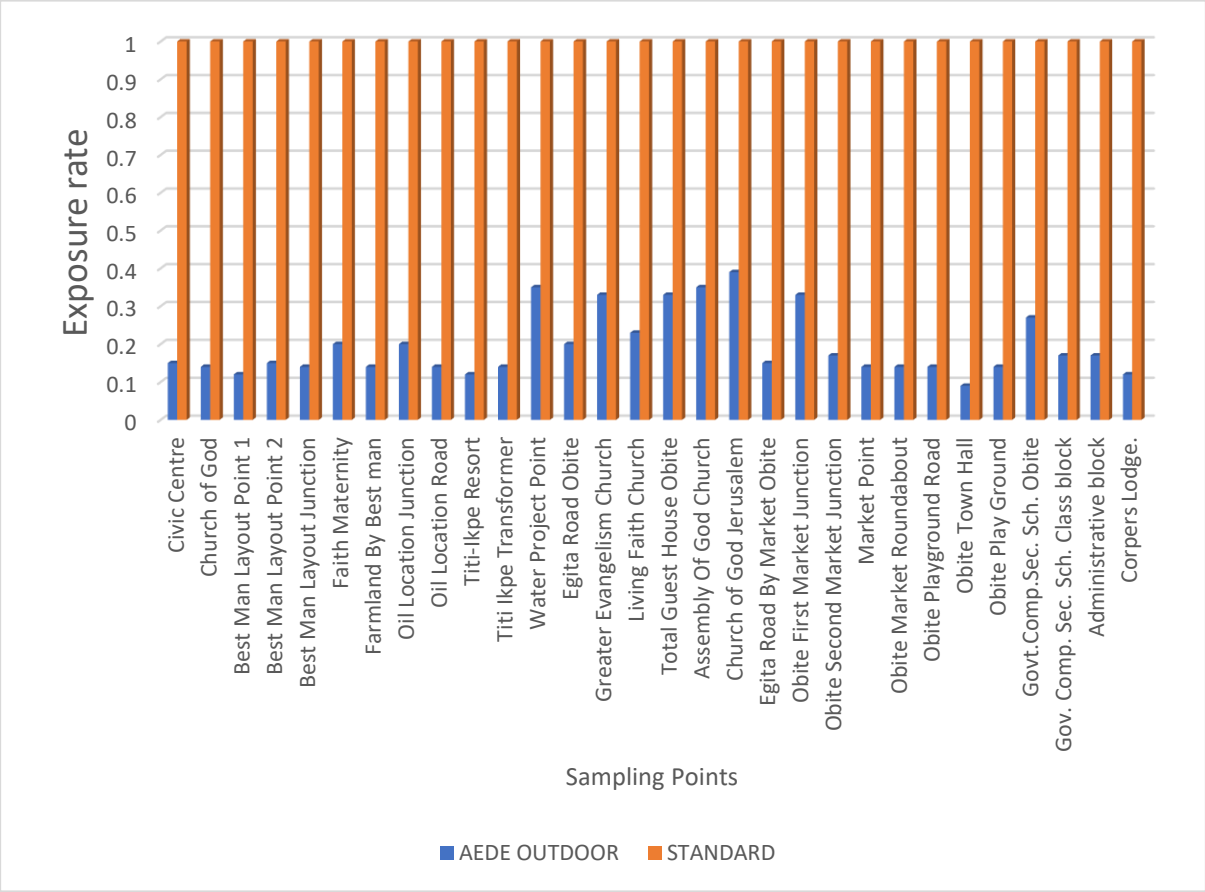

Figure 4.4: Show the comparison of Excess Life Cancer Risk with Standard

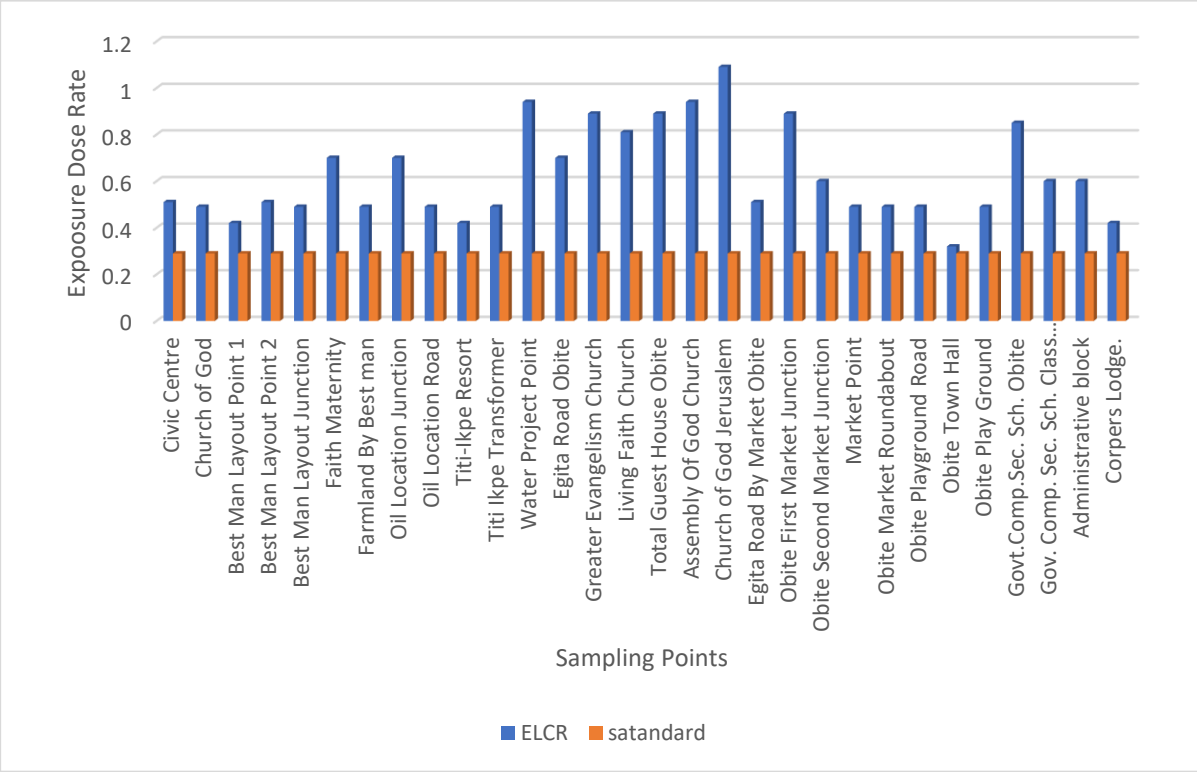

Figure 4.5: Show the Contour Map of the Study Area

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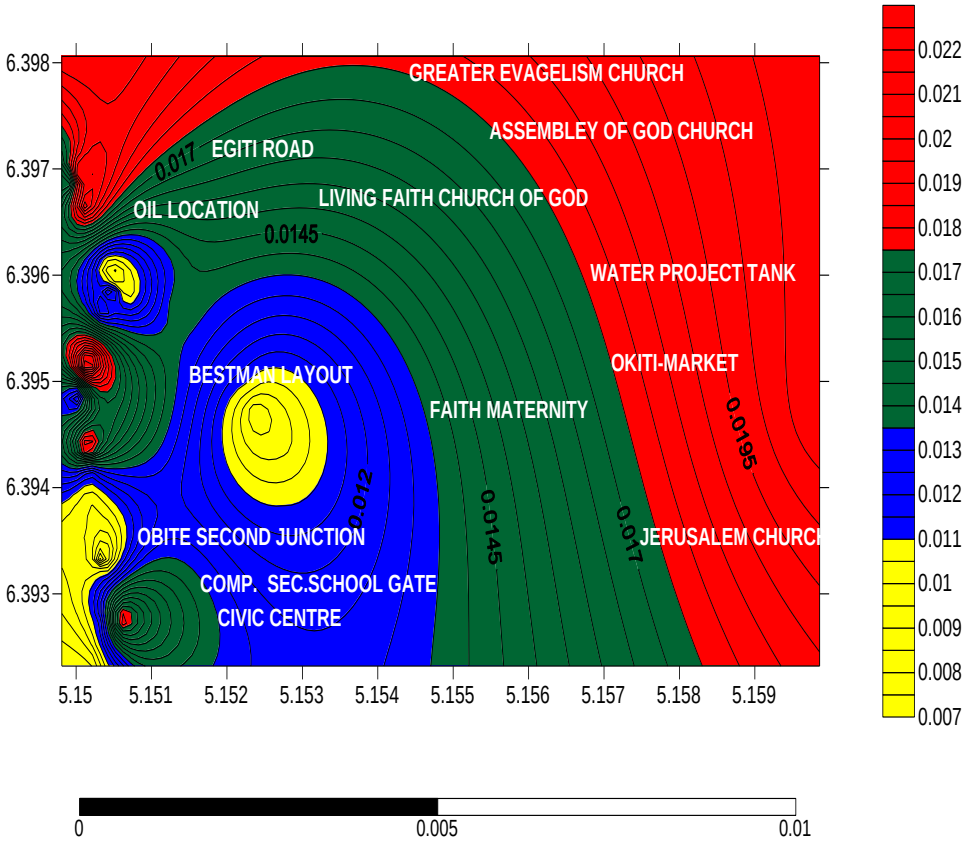

DISCUSSION

The result of the In-situ measurement of the background ionizing radiation exposure are presented in table 4.1 and 4.2, with their respective coordinate. Figure 4.1 show the comparison of the exposure dose rate (BIR) of the study area as figure 4.2 shows the comparison of Absorbed Dose rate in $nGhr^{-1}$, with standard. Figure 4.2 shows the comparison of Annual Effective Dose Equivalent (AEDE) with ICRP standards while figure 4.4 shows the comparison of Excess Lifetime Cancer Risk (ELCR) with ICRP standard. Figure 4.5 shows the contour map of the study area. From table 4.1, the results showed high values within the areas were industrial activities are carried out on daily bases. The high mean values of 0.024, 0.021, 0.021, 0.020, 0.020, 0.020 and

0.017, obtained in these areas, indicates that the activities of the companies within the areas may have raised the background radiation level in the environment. The concentration variations was also analysed using a contour map to give a clearer understanding. The red colour areas in the contour map; represents areas of high cocnentrations with high values that are higher than the ICRP recommended value. These areas are also the major operational regions of the companies with activities that may have raised the background radiation level. The green colour areas in the map, are regions that have slightly higher values than the ICRP recommended values. The purple colour areas, are the regions within the recommended values of the ICRP 2003 while the regions with the yellow colours, have values lower than the ICRP recommended standards.

The background ionizing radiation (BIR) result varies from 0.007 to 0.24 (mR/hr) with a mean value of 0.013(mR/hr). The highest mean of 0.24 (mR/hr) was obtained at church of Jerusalem and the lowest value of 0.007(mR/hr) was obtained at Obite Town Hall. Figure 4.1 shows the comparison of the exposure dose rate with the standard value of 0.013(mR/hr). The BIR results were slightly higher than the ICRP standard value but slightly lower compared with the work carried out by Avwiri G.O *et al* (2017) on radiological health risk due to gamma dose rates around Okposi Okwu and uburu salt lakes, Ebonyi State. The values when compared with results obtained by Sigalo and Briggs-Kamara (2004), were higher but are still within the global standards. The high values recorded within the study area are in locations close to the oil producing company within the study area which shows that the community members that are living or doing business transaction within these locations are likely exposed to high radiation due to the activities of the company.

The value of Absorbed Dose Rate varies from 60.9 to 208.0 nGy/hr with mean value of 115.10$\pm$0.003 nGy/hr, the obtained mean is lower than the value reported by Ugbede and Benson *(*2018) but higher than the recommended safe limit of 84.0 nGy/hr (UNCEAR 2008). The high value obtained may be due to the presence of radionuclide within the environment or due to the leakage of oil company facility within the study area. The Annual Effective Dose Equivalent (AEDE) varies from 0.009 to 0.35mSv/yr with mean of 0.195 mSv/yr which is lower than the safe limit of 1.0 mSv/yr stipulated by ICRP (2003) and WHO (2008) for the general public. The results of the Annual Effective Dose Equivalent (AEDE) is lower than the work carried out by Oladele.,

et al (2018) on Indoor and outdoor gamma radiation exposure levels showing average annual effective dose of 1.56 ± 0.33 mSv, which is higher than the world average value (1.0 mSv).

The Excess Lifetime Cancer Risk (ELCR) varies from 0.32 to $1.09x10^{-1}$ showing lower value at Obite Town Hall and a higher value at Egita road by Obite market with mean of $0.62x10^{-1}$ which is higher than the ICRP standard of $0.29x10^{-3}$ and the work of Taskin *et al.,* (2009). The variation of ELCR may be due to pipe leakage of the oil company present in the community or due to the concentration of radionuclide in building materials. The ELCR values of the study area exceeded the worldwide average value of 0.29×10^{-3} which imply that the dwellers within the selected study area may develop cancer over a lifetime considering seventy (70) years as the average lifespan of humans within the environment.

CONCLUSION

This study assessed the background ionizing radiation level of Obite Community, using a nuclear radiation monitor (Digilert 200) and a Global Positioning System (G.P.S). Radiological health risk such as Exposure Dose Rate, Absorbed Dose Rate, Annual Effective Dose Equivalent and the Excess Lifetime Cancer Risk were assessed from the measured background ionizing radiation. The study revealed that the results when compared with the recommended background ionizing radiation standard, exceeded the safe limits stipulated by UNCEAR (2008) and ICRP (2003). The high values of background ionizing radiation recorded, implies that the dwellers within the selected study area may develop cancer over a lifetime, considering seventy (70) years as the average lifespan of humans within the environment. It is therefore important that an urgent enlightenment and strict monitoring by both government and private agencies be carried out to avert an outbreak of disease in the near future.

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