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Measurement of Ionizing Radiation Exposure Rate and Determination of Radiological Risk in Ogu Community, Bayelsa State, Nigeria

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Abstract

The presence of radiation in the environment could lead to health risks. Radiation exposure to humans could be through inhalation, ingestion, irradiation from external sources and more. Hence the need for reliable and unceasing measurement of background ionizing radiation. The background ionizing radiation in Ogu community has been measured and radiation hazards calculated. The Radalert-100X was used for the measurement at thirty randomly selected sampling points across. Results show that background ionizing radiation, absorbed dose rate, annual effective dose equivalent as well as excess life cancer risk ranges from (0.006 – 0.026) mRh^{-1} with average of 0.012 mRh^{-1}, (52.20 – 226.20) $nGyh^{-1}$ with average of 104.40 $nGyh^{-1}$, (0.50 – 2.19) $mSvy^{-1}$ with average of 1.01 $mSvy^{-1}$, (0.080 – 0.347) $mSvy^{-1}$ with average of 0.160 $mSvy^{-1}$ and (0.280 – 1.215)$\times 10^{-3}$with average of 0.560 $\times 10^{-3}$ respectively. Plots from the results show that nearly all measured points have values above world averages except for equivalent dose. This is an indication of probability of developing radiological consequences by residents of Ogu after exposure for a long time.

Key words: Radiation exposure, environment, absorbed dose rate.

1. Introduction

Proper, correct and reliable measurement of background ionizing radiation (BIR) within an environment should be a continuous process because of its health implication. Sources of radiation in the environment could be manmade or natural. Man-made radiation is produced by commercial, industrial, military and health related processes. Natural source can be cosmic or terrestrial. Natural radiation is certainly present in our environment but its quantity varies depending on the location (Akortia *et al.,* 2021; Hunt, 1987). Reports have it that natural radiation sources contribute about 87 % of radiation doses humans receive. Natural radiation sources are present in all the elements that made up the earth including natural radioactivity in the human body, (Olagbaju *et al.,* 2021; Osiga, 2014). Radiation exposure to humans could be through inhalation, ingestion, irradiation from external sources and more. The concern is that exposure could cause changes in human cells including genetic mutilation which could eventually lead to cancer. Therefore, the World Health Organization (WHO) recommends that yearly exposure to the general public should not exceed 1 mSv (Ogola *et al.,* 2016). It is hence necessary to preserve human and the environment from radiation and its effects. One way of doing that is to continuously monitor the environmental radiation level, especially in a community like Ogu, because of increase in both human and industrial activities in the community. This work is aimed at measuring ionizing radiation exposure in Ogu community to determine radiological hazards.

Study area

Ogu is in Yenagoa local government area in Bayelsa State, it is part of Nigeria's Niger Delta Region. The area is underlain by sedimentary rock. The Benin, Agbada and Akata formations are the geological formation that occur in the area (Nwankwoala and Oborie, 2014). Bayelsa state is known for hydrocarbon exploration and exploitation due to the abundance of crude and natural gas in the area (Okumagba, 2011). Ogu's vegetation is made up of mangrove forests, freshwater swamps, and tidal flats which is characteristic of Nigeria's Niger Delta. The area is known for its rich biodiversity, with various species of flora and fauna adapted to the unique wetland environment. Figure 1 below shows Ogu community.

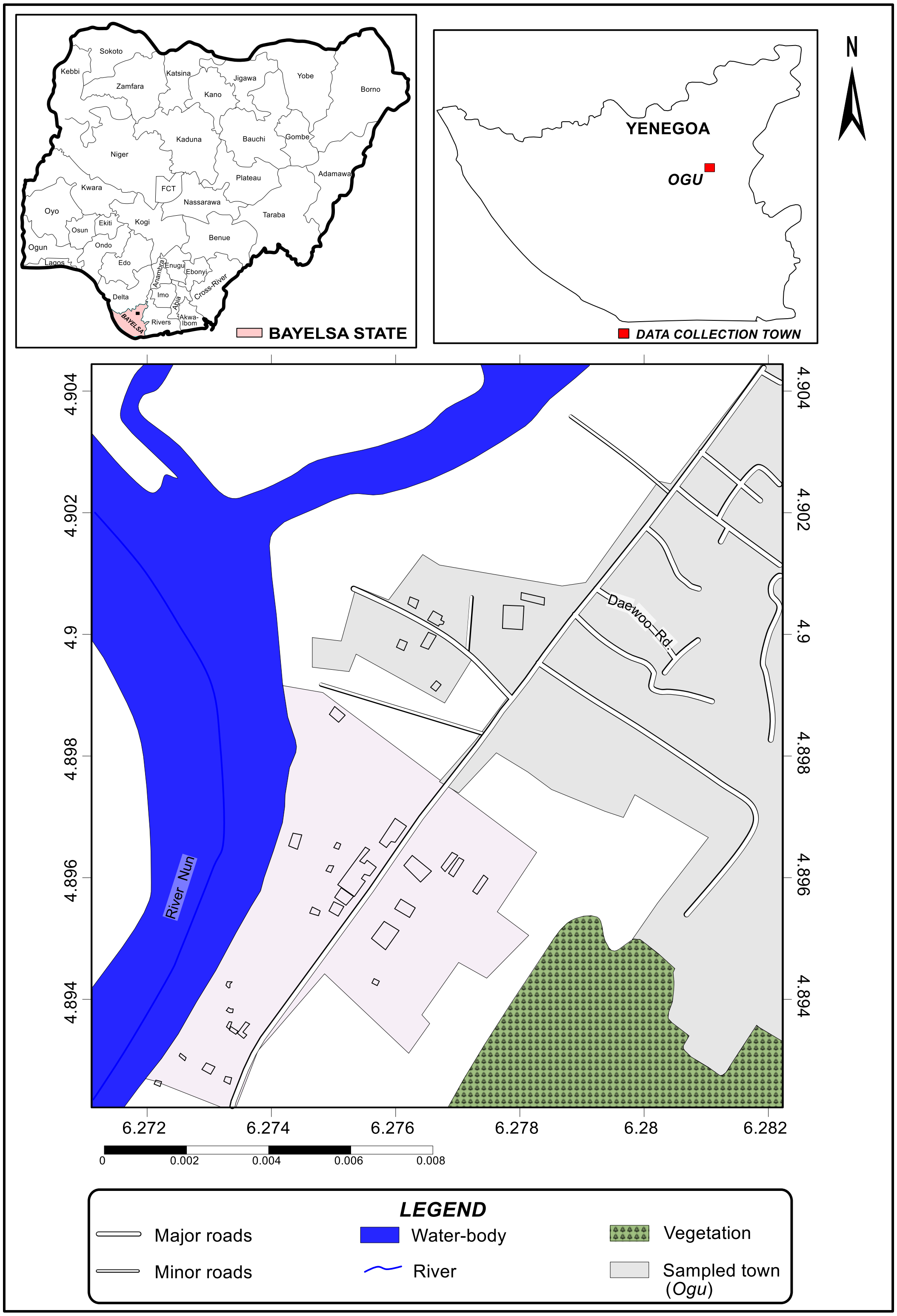

Figure 1: Map of Ogu community

2. Materials and method

A digital radiation meter, Radalert-100X, was utilized in the assessment of background radiation around Ogu community. The digital meter uses a Geiger-Muller (G-M) counter that is in it to detect background radiation. The Geiger-Muller tube contained in the radiation alert inspector creates pulse current as soon as radiation goes into the tube which results in ionization (Ovuomarie-Kelvin *et al.,* 2018). The signal generated is electronically identified and recorded as count. This Radiation meter was calibrated using ^{137}Cs source of known energy. It is programmed to monitor exposure in milli-Roentgen per hour with accuracy of ± 15 % (Biere *et al.*, 2023). At each measurement location, the radiation meter was positioned one meter from the ground for approximately 120 seconds with its window facing the location from where the exposure will be measured. This in-situ method in measurement is a standard practice which allows sample to maintain their original environmental properties during measurement (Yusuf *et al.*, 2022). The exposure rates recorded were used to quantify other radiological risks.

Absorbed dose rate

Absorbed dose D ($nGyh^{-1}$), is quantity of energy deposited per unit mass of material, like living tissue (NCRP, 1993). The background ionizing radiation values obtained in mRh^{-1} were changed to absorbed dose rate applying equation 1, (Rafique *et al.,* 2014).

$$1\, mRh^{-1} = 8.7\, \mathrm{n}Gyh^{-1} \times 10^3 = 8700\, nGyh^{-1} \qquad (1)$$

Equivalent dose rate

To evaluate whole-body exposure rate for one year, we use equation 2 (Mgbeokwere *et al.,* 2021).

$$1\mathrm{mRh}^{-1} = \frac{0.96 \times 24 \times 365}{100}\, mSvy^{-1} \qquad (2)$$

Annual effective dose equivalent (AEDE)

Annual effective dose equivalent AEDE. This parameter is utilized in calculating the likelihood of long-term effect which could happen in the future. AEDE was calculated by the use of equation 2 (UNSCEAR, 2008).

$$AEDE\ (mSvy^{-1}) = D(nGyh^{-1}) \times 8760\,h \times CF \times OF \times 10^{-3} \qquad (3)$$

Where D is absorbed dose rate in $nGyh^{-1}$, 8760 h is the number of in one year, CF is dose conversion factor from absorbed dose in air to effective dose in Sv/Gy. CF = 0.7 Sv/Gy. OF is occupancy factor, the probable time that people would spend outdoor in the study area, OF = 0.2 as suggested by UNSCEAR, 2008

Excess lifetime cancer risk (ELCR)

The ELCR is a quantity that is used to determine the likelihood of development of cancer owing to contact with ionizing radiation. ECLR is given by equation 4 (Agbalabga, 2016).

$$ECLR = AEDE\ (mSvy^{-1}) \times DL \times RF \qquad (4)$$

Where DL = 70 years (average life duration) and RF is the fatal cancer risk factor expressed in per sievert (Sv^{-1}). In the case of low background radiation, which is anticipated to result to stochastic effects, ICRP 103 recommends a threshold of 0.05 Sv^{-1} for the public (ICRP, 2007).

3. Results and Discussion

Results of exposure rate measured at the twenty-five locations were converted to absorbed dose, Equivalent dose rate, Annual effective dose equivalent and Excess life cancer risk are shown in table 1. Background ionizing radiation measured at the community ranged from (0.006 to 0.026) $mRh^{-1}$with average of 0.012 mRh^{-1}. This shows that the average exposed rate value is lower than the safe limit of 0.013 mRh^{-1}given by the International Committee of Radiological Protection (Taskin *et al.*, 2009). Absorbed dose which was calculated from the exposure rate varies from minimum value of (52.20 to 226.20) $nGyh^{-1}$ with an average value of 104.40 $nGyh^{-1}$. The average absorbed dose rate is significantly greater compared to the global average of 59.0 $nGyh^{-1}$ (UNSCEAR, 2008; Agbalagba, 2016). Equivalent dose rate ranged from (0.50 to 2.19) $mSvy^{-1}$ with average of 1.01 $mSvy^{-1}$. The average equivalent dose obtained in the study is just about the safe limit of 1.0 $mSvy^{-1}$, (ICRP, 2007). Annual effective dose equivalent ranges from (0.080 to 0.347) $mSvy^{-1}$ with average of 0.160 $mSvy^{-1}$. The mean values here is above the global average of 0.07 $mSvy^{-1}$ for outdoor (Ononugbo and Nte, 2017). Excess life cancer risk calculated in the study area varies from (0.280 to 1.215) $\times 10^{-3}$ with an average sum of 0.560 $\times 10^{-3}$. The average of this study is slightly higher than the world average 0.29 x 10^{-3} by UNSCEAR.

Table 1: Exposure rates and other radiological parameters obtained

S/N	Exposure rate (mR/h)	Absorbed dose (nGy/h)	Equivalent dose (µSv/y)	AEDE (mSv/y)	ELCR x 10^{-3}
1	0.014	121.80	1.18	0.187	0.654
2	0.011	95.70	0.93	0.147	0.513
3	0.015	130.50	1.26	0.200	0.700
4	0.026	226.20	2.19	0.347	1.215
5	0.009	78.30	0.74	0.120	0.420
6	0.011	95.70	0.93	0.147	0.513
7	0.013	113.10	1.09	0.173	0.606
8	0.012	104.40	1.01	0.160	0.560
9	0.012	104.40	1.01	0.160	0.560
10	0.010	87.00	0.84	0.133	0.467
11	0.010	87.00	0.84	0.133	0.467
12	0.012	104.40	1.01	0.160	0.560
13	0.006	52.20	0.50	0.080	0.280
14	0.013	113.10	1.09	0.173	0.606
15	0.013	113.10	1.09	0.173	0.606
16	0.014	121.80	1.18	0.187	0.654
17	0.014	121.80	1.18	0.187	0.654
18	0.011	95.70	0.93	0.147	0.513
19	0.011	95.70	0.93	0.147	0.513
20	0.011	95.70	0.93	0.147	0.513
21	0.014	121.80	1.18	0.187	0.654
22	0.011	95.70	0.93	0.147	0.513
23	0.014	121.80	1.18	0.187	0.654
24	0.012	104.40	1.01	0.160	0.560
25	0.010	87.00	0.84	0.133	0.467
AVE	**0.012**	**104.40**	**1.01**	**0.160**	**0.560**

Plots of calculated parameters against world standards are shown in figures 2 to 5 below. The reading in sampling point 4 shows a spike that is significantly above the study average. It is revealing that a foreign body is detected. Figures shows that nearly all measured points have values above world averages except for equivalent dose. Nevertheless, compared to some other Nigerian coastal cities, the averages of the radiation measures in Ogu are lower (Ononugbo and Nte 2017; Nwanne et al 2021).

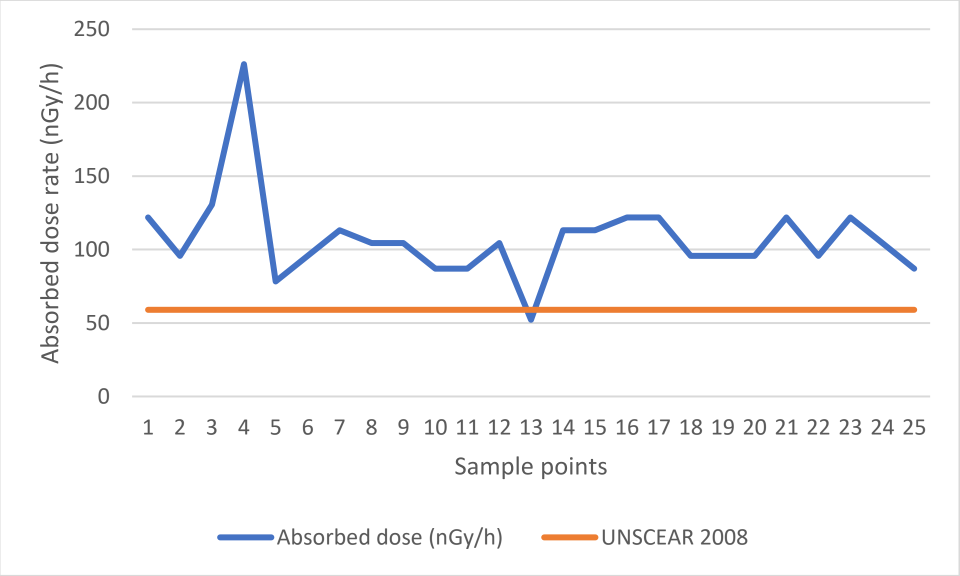

Figure 2: Plot of absorbed dose rate obtained in Ogu against UNSCEAR 2008 average

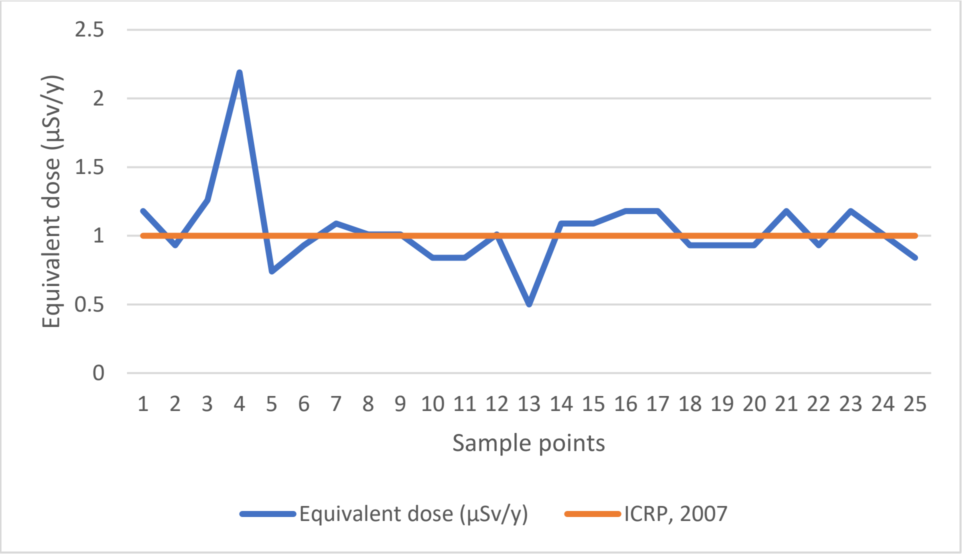

Figure 3: Plot of Equivalent dose rate in Ogu against ICRP average

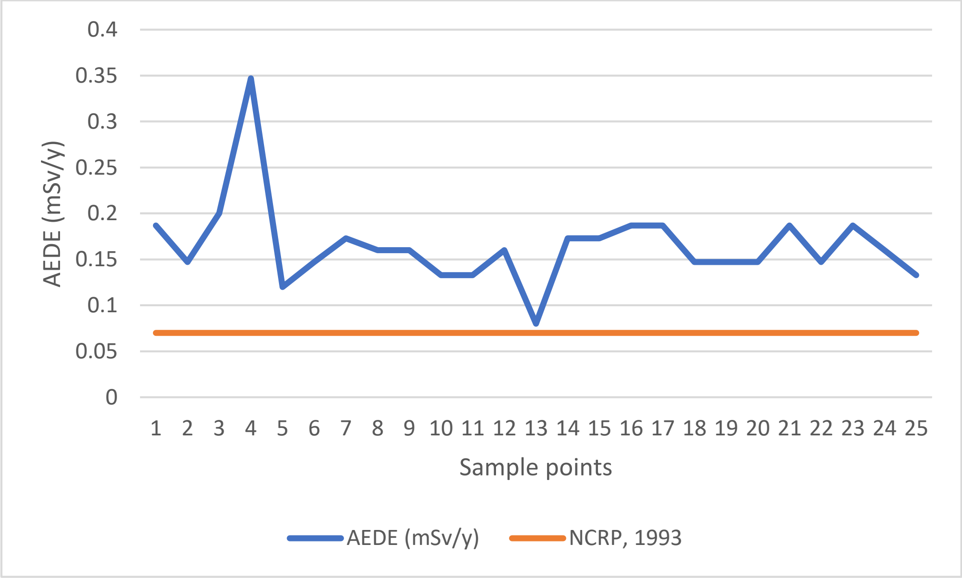

Figure 4: Plot of AEDE in Ogu against NCRP average

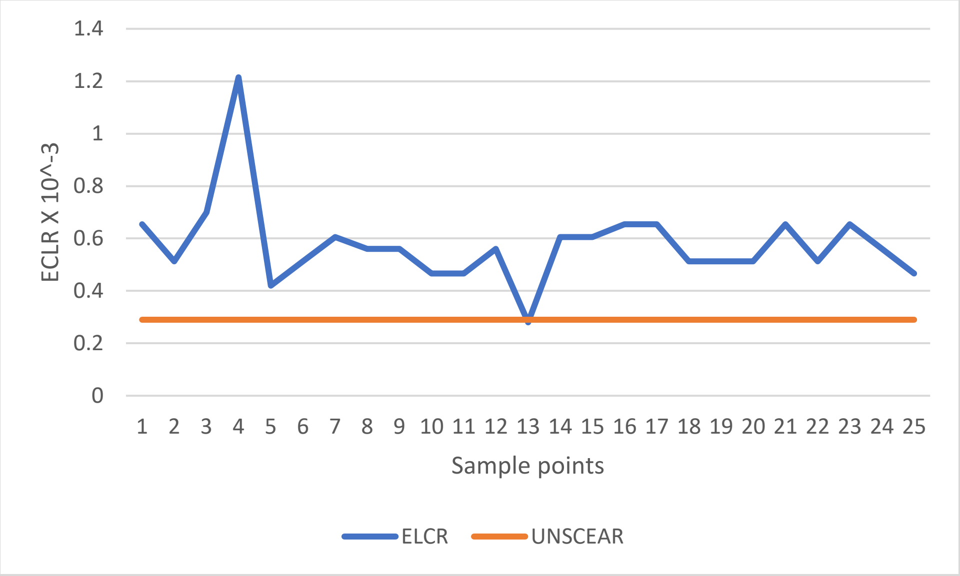

Figure 5: Plot of ELCR in Ogu against UNSCEAR 2008 average

Conclusion

Ambient exposure rate in Ogu community has been measured. The value of absorbed dose rate at point 4 is over three times the average of the study area. It is an indication of the existence of foreign body. Results have also shown that the averages of all parameters calculated are above the corresponding global average values. This is an indication of the probability of developing radiological consequences, ranging from changes in human cells to death of residents of Ogu after exposure for a long time. It becomes necessary to recommend regular monitoring of radiation level in Ogu and to also investigate levels of radionuclides present in Ogu community.

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