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Assessment of Radiological Parameters in Selected Communities Close to A Major Oil and Gas Facility in Bayelsa State, South-South, Nigeria

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ABSTRACT
Background radiation in an environment differs in different places and are functions of the amount of naturally occurring radioactive materials presents in soils, air, and water. The possibility of the radiation level in communities sited so close and not too close to oil processing companies cannot be overruled. This is simply because there are possible links such as erosion, wind speed, work activities around the oil processing companies and oil spillage that may possibly link these communities to the activities in the oil processing companies. The background ionizing radiation levels of two adjacent communities near a major oil and gas facility in Bayelsa has been investigated. Ambient dose rates were measured in forty- four sampling points at using Radiation alert inspector survey meter. The measured ambient dose rates, the calculated absorbed dose rates, annual effective dose equivalent and excess lifetime cancer risks for Obunagha and Okolobiri ranged from {(0.010 – 0.028) mRh^{-1} with the mean 0.015 mRh^{-1} , (78−174) $nGyh^{-1}$ with the mean 135.5 $nGyh^{-1}$,(0.120 −0.373) $mSvh^{-1}$ with the mean of 0.208 $mSvh^{-1}$, $(0.331-0.373)\times10^{-3}$ } with a mean of 0.573 10^{-3} } and (0.007 – 0.034) mRh^{-1} with mean 0.018 mRh^{-1} , (60.9−295.8) $nGyh^{-1}$ with the mean 155.1) $nGyh^{-1}$,(0.093−0.453) $mSvh^{-1}$ with the mean of 0.238 $mSvh^{-1}$and $(0.258-1.104)\times10^{-3}$ } with mean 0.656×10^{-3} respectively. Measured and calculated radiological parameters are all greater than the world average. Conclusively, dwellers in these communities are exposed to ionizing radiation greater than the recommended safe limits which at long run may put them at health risks. Furthermore, a more extensive radiological studies is recommended for the two communities.

Keywords:
Assessment,
Radiological parameters,
Oil and gas facility,
Communities

INTRODUCTION

Humans are continuously engrossed in ionizing radiations occurring naturally in the environment (Hunt,1987) and the exposure if above the safe limit have negative health effect on man. The exposure of humans to ionizing radiation might be owing to cosmic rays and natural radionuclides sources in food, drinking water and air (NCRP, 1976). Effect of interactions with radiation on people have been studied on a large measure in recent years (Jibiri and Biere, 2011). The consequence begins with preliminary variations at molecular, cellular, tissue as well as whole-body level which could grow to widespread variation of health concerns varying from irritation, radiation-induced cancer, genetic disorders to instant loss of life (Ononugbo and Nte, 2017). The selected communities for the study are known to harbor lower scale workers of the oil and gas facility. Secondly, large numbers of pipelines are known to run through these communities and the possibilities of oil spillage through oil thefts may not be completely ruled out. Reports have shown that, with the institution of nuclear regulatory body in Nigeria, public attention on effects of ionizing radiation on human populace has increased greatly in the country. However, not much of such reports are from the Nigeria's Niger Delta region. The essence of this research is to measure dose rates in selected communities to estimate radiological parameters associated with the exposure of the dwellers in the communities to background ionizing radiation. This study seeks to fill the information gap concerning radiological hazards if any for the selected areas for the study. To the best of the knowledge of the researcher, there has been such study carried out in the area, hence it the study will serve as reference point for further studies.

Description of study area

Bayelsa is a state in Southern Nigeria. It has one of the largest oil and gas deposit in Nigeria. The population of Bayelsa State according to 2022 census is two million, five hundred and thirty seen thousand, four hundred (2,537, 400) and Obunagha and Okolobiri is a subset population of the population of Bayelsa. The latitude and longitude of the study locations is 5^0 1' 56'' N and 6° 18' 37" E. The climate of Bayelsa is Bayelsa tropical monsoon with yearly temperature of 28.64 °C and the precipitation is about 241.52 millimeters. It rains for over 260 days and 47 days of dry season annually. The mean humidity is about 82% and UV index of 6. The yearly problem of flood in Bayelsa is due to its location in the coast of Atlantic Ocean. The setting of Bayelsa. like other numerous communities in the Niger Delta region, are entangled with exploration and exploitation of oil resources. Obunagha is host community to a major oil and gas plant, a planned private refinery as well as a power plant. The oil and gas plant has a high-rise construction from where gas is flared regularly. Obunagha and Okolobiri, where measurement took place, are located about 1 km and 2 km respectively from the oil and gas plant. The flora in the area of study is categorized by combination of mangrove jungles, freshwater swamps, and tidal flats. Major occupations of the study areas include fishing, farming. Civil servants and trading. Figure 1 shows the location map of the study area.

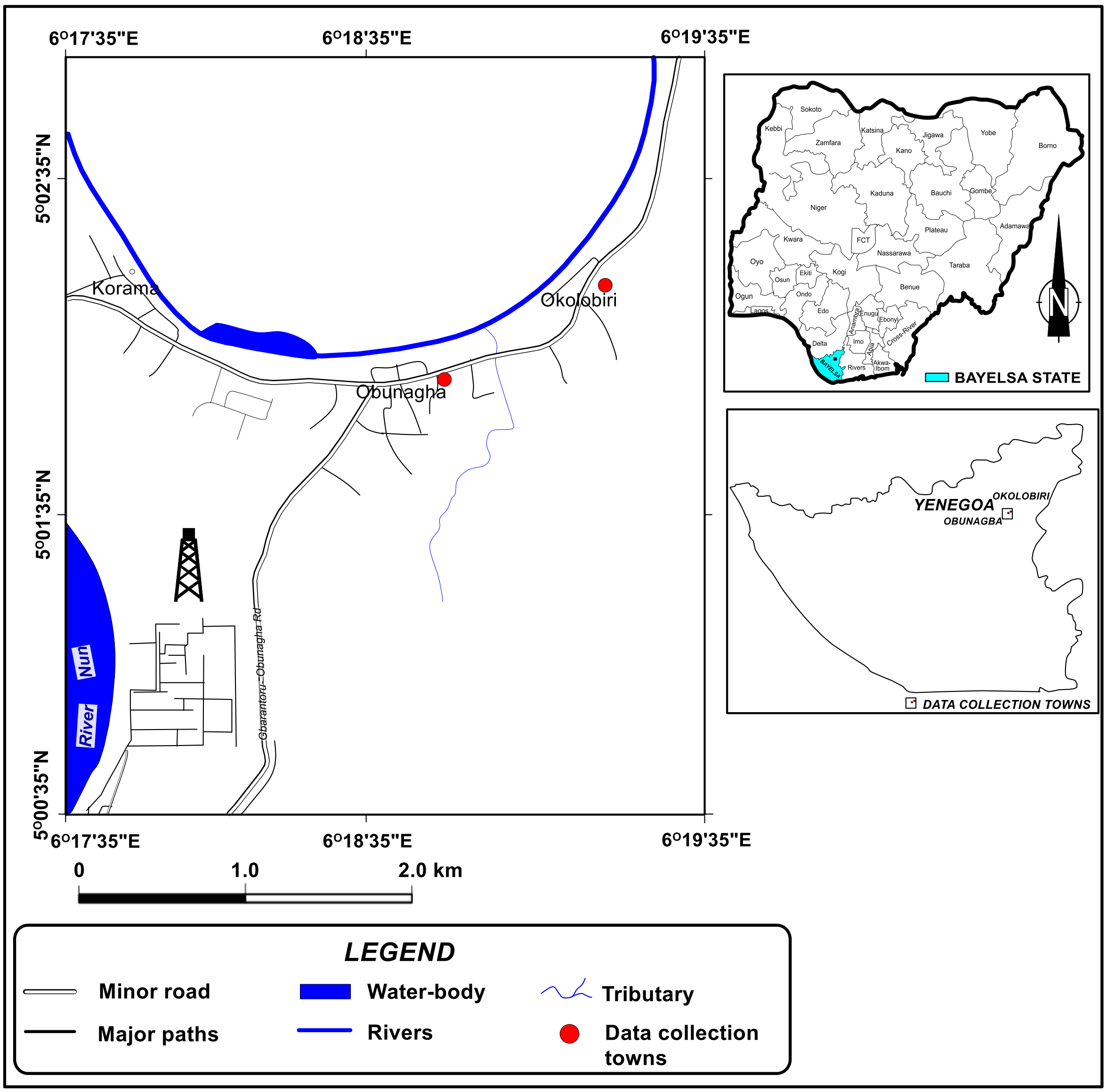

Figure 1: map showing Obunagha and Okolobiri

MATERIALS AND METHODS

Radiation alert inspector (RADALERT), which is a moveable digital radiation detection monitoring device was used to quantify the background ionizing radiation (BIR) across both communities. The digital radiation meter measures background radiation by means of an inbuilt Geiger-Muller (G-M) counter. The Geiger-Muller tube in the RADALERT produces a signal every moment radiation goes in to the tube then makes ionization to occur (Ovuomarie-Kelvin e*t al.*, 2018). Every pulse produced is automatically picked then recorded as a count. The radiation alert inspector was standardized by the use of ^{137}Cs source of specific energy and made to quantify the exposure in milli Roentgen per hour (mRhr^{-1}) and with accuracy ±15%. Measurement was done in a total of twenty-two points per community. The spread of the points was such that each community was adequately covered. At each point where measurements were taken, the RADALERT was positioned 1 m from the ground level while its window faced the supposed source. The detector was then switched on to absorb radiation, until the readings became steady. This process was repeated at each measurement point and the average of two readings of background ionizing radiation gotten at each point was recorded in mRhr^{-1}.

Radiological Hazards Indices

The background ionizing radiation (BIR) values gotten were used in estimating the following parameters which are related with exposure of dwellers of these two communities to background ionizing radiation.

Absorbed dose rate in air (ADR)

Absorbed dose rate which is used to evaluate probable biological variations in specific tissues was estimated by means of equation 1 as given by Rafique *et al* (2014)

$$1\,\mu Rh^{-1} = 8.7\ \text{n}Gyh^{-1} = \frac{8.7 \times 10^{-3}}{(1/8760y)}\,nGyy^{-1} \quad (1)$$

This can be written as

$$1\,mRh^{-1} = 8.7\ \text{n}Gyh^{-1} \times 10^{3} = 8700\,nGyh^{-1} \quad (2)$$

Annual effective dose equivalent (AEDE)

Annual effective dose equivalent AEDE. This parameter is used to calculate the potential for long-term health effect which may happen in the future. AEDE was calculated by the use of equation 3 (UNSCEAR, 2008).

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

Where D is absorbed dose rate in $nGyy^{-1}$, 8760 h is total hours 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, time anticipated that people would spend outdoor in the study area, OF = 0.2 as suggested by UNSCEAR, 2008

Excess lifetime cancer risk (ELCR)

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

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

Where DL = 70 years (average life duration) and RF is fatal cancer risk factor expressed in per sievert (Sv^{-1}). For low dose background radiation that are expected to yield stochastic effects, ICRP 103 uses a value of 0.05 Sv^{-1} for public (ICRP, 2007).

RESULTS AND DISCUSSION

This aspect presents the findings of the study. Tables 1 and 2 below presents results of measured background radiation as well as calculated radiological indices associated with exposure of the dwellers of Obunagha and Okolobiri communities to background radiation measured these areas of study. Figures 1, 2 and 3 presents the pictorial representation of the outcomes of the study

Table 1: Measured and estimated radiological parameters at Obunagha community

SPOTS OF DATA COLLECTION	BIR (mRh^{-1})	ADR (nGyh^{-1})	AEDE (mSvy^{-1})	ELCR (x 10^{-3})
1	0.010	87.0	0.133	0.368
2	0.019	165.3	0.253	0.699
3	0.014	121.8	0.187	0.515
4	0.013	113.1	0.173	0.479
5	0.015	130.5	0.200	0.552
6	0.016	139.2	0.213	0.589
7	0.013	113.1	0.173	0.479
8	0.014	121.8	0.187	0.515
9	0.014	121.8	0.187	0.515
10	0.012	104.4	0.160	0.442
11	0.014	121.8	0.187	0.515
12	0.014	121.8	0.187	0.515
13	0.016	139.2	0.213	0.589

14	0.018	156.6	0.240	0.663
15	0.018	156.6	0.240	0.663
16	0.021	182.7	0.280	0.773
17	0.028	243.6	0.373	1.031
18	0.020	174.0	0.267	0.736
19	0.014	121.8	0.187	0.515
20	0.014	121.8	0.187	0.515
21	0.009	78.3	0.120	0.331
22	0.019	165.3	0.253	0.699
23	0.013	113.1	0.173	0.479
Average	**0.015**	**135.5**	**0.208**	**0.573**

As seen in the Table 1, the measured background radiation falls between (0.008 – 0.030) mR^{-1} with mean 0.015 mR^{-1}. The calculated absorbed dose rates in air falls between from (77.0 – 242.0) $nGyh^{-1}$ with mean 135.5 $nGyh^{-1}$. Annual effective dose equivalent and the excess lifetime cancer risk falls between (0.10 – 0.250) $mSvh^{-1}$ with a mean of 0.208 $mSvh^{-1}$ and (0.350 – 1.010) $\times\ 10^{-3}$with the mean 0.573 $\times\ 10^{-3}$**.**

In Table 2, the measured background radiation falls between (0.010 – 0.023) mR^{-1} with mean 0.018 mR^{-1}. Again, the calculated absorbed dose rates in air falls between from (60.0 – 296.0) $nGyh^{-1}$ with mean 155.1 $nGyh^{-1}$. The annual effective dose equivalent and excess lifetime cancer risk falls between (0.14 – 0.450) $mSvh^{-1}$ with a mean of 0.238 $mSvh^{-1}$ and (0.390 – 1.290) x 10^{-3} with mean of 0.656 x 10^{-3}**.** Results of the values of the measured and estimated parameters for Okolobiri community are greater than that of Obunagba community. This may be due to the fact that the Okolobiri is a bigger community with expected higher number of people, and probably higher number of buried pipe lines, possibly oil spillage, the type of materials used for building and the numbers of building used in Okolobiri. ((Nowak and Solecki, 2015). Also, the work activities at the Okolobiri are also expected to be greater. All the values of the parameters for the present study were above world average as recommended by UNSCEAR 2000. However, the mean values of the parameters in the study were lower than the means values presented by Idris *et al.*, 2021 and Ilugo *et al.*, 2021. They are however above the values presented by Popoola *et al.*, 2019, Ugbede 2018, Ramli *et al.*, 2014, Benson and Ugbede 2018, Ononugbo and Anekwe 2020, Onumejor *et al.*, 2019 and Furo *et al* 2023.

Table 2: Measured and estimated radiological parameters at Okolobiri community

SPOTS OF DATA COLLECTION	BIR (mRh^{-1})	ADR ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR (x 10^{-3})
1	0.015	130.5	0.200	0.552
2	0.019	165.3	0.253	0.699
3	0.012	104.4	0.160	0.442
4	0.012	104.4	0.160	0.442
5	0.019	165.3	0.253	0.699
6	0.022	191.4	0.293	0.810
7	0.014	121.8	0.187	0.515
8	0.015	130.5	0.200	0.552
9	0.020	174.0	0.267	0.736
10	0.024	208.8	0.320	0.883
11	0.030	261.0	0.400	1.104
12	0.011	95.7	0.147	0.405
13	0.016	139.2	0.213	0.589
14	0.034	295.8	0.453	1.252
15	0.020	174.0	0.267	0.736
16	0.030	261.0	0.400	1.104
17	0.018	156.6	0.240	0.663
18	0.021	182.7	0.280	0.773
19	0.011	95.7	0.147	0.405
20	0.013	113.1	0.173	0.479
21	0.007	60.9	0.093	0.258
22	0.011	95.7	0.147	0.405

23	0.016	139.2	0.213	0.589
Average	**0.018**	**155.1**	**0.238**	**0.656**

Figures 1 and 2 are bar charts of comparison for the measured higher values of background radiation and estimated absorbed dose rates for the study and the values recommended by UNSCEAR, 2000. Figure 3 presents a line graph of comparison between calculated values of the excess lifetime cancer risk from this study and values recommended by UNSCEAR, 2000.

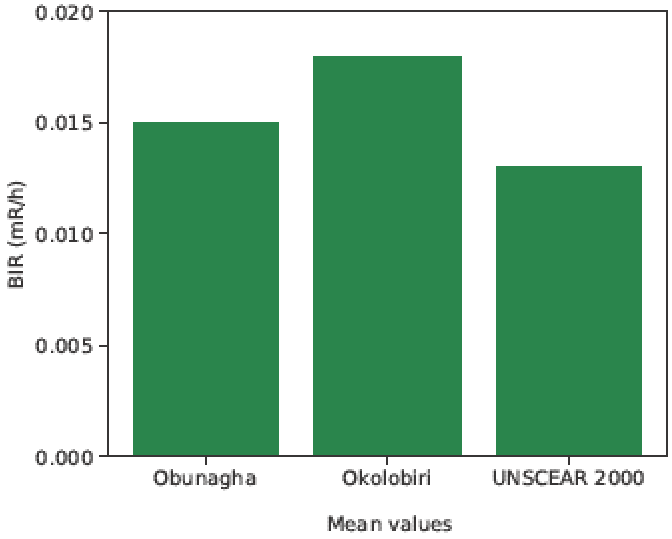

Figure 1: Bar chart of comparing of the mean values of background radiation with values recommended by UNSCEAR (2000)

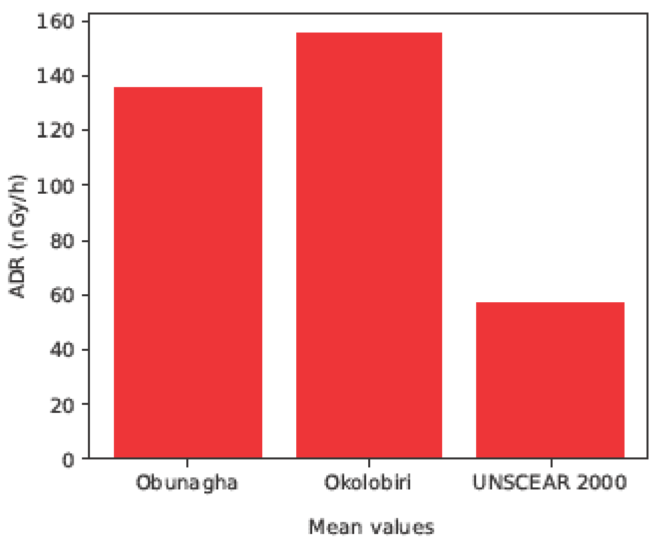

Figure 2: Bar chart of comparison of mean values of estimated absorbed dose rates with values recommended by UNSCEAR (2000)

The mean values of ECLR in Obunagha is about two times the world average while the mean value 0f estimated excess lifetime cancer in Okolobiri is a little above twice the world average.

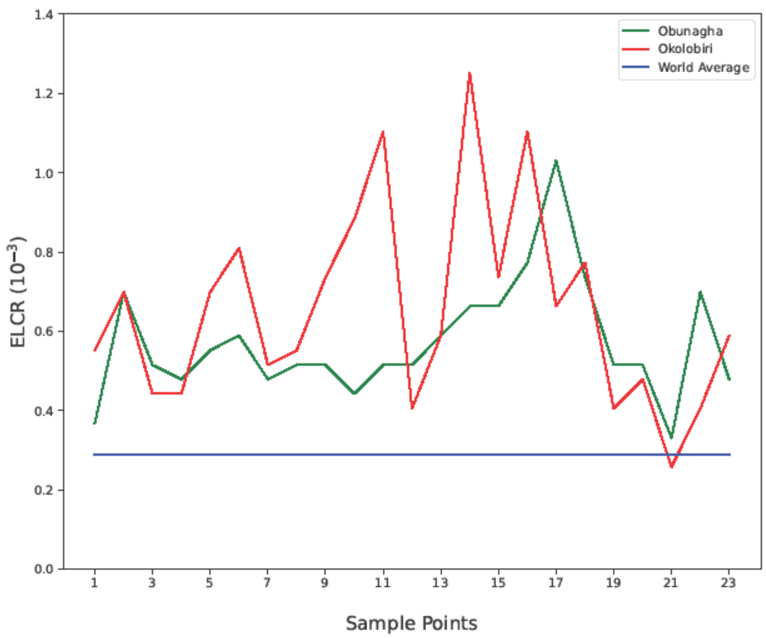

Figure 3: Line graph of comparison between estimated values of excess lifetime cancer risk and values recommended by UNSCEAR, 2000.

CONCLUSION

In this present study, background ionizing radiation measurements have been carried out in two oil and gas concealing communities. In terms of locations of sample collection (which some places are points of dense population) 86.95% of the background radiation measurements values were noted to above the world average of 0.013 mRhr^{-1} in Obunagha while 73.91% of the background radiation measurements in Okolobiri were above the world average of 0.013 mRhr^{-1}. Mean absorbed dose rates in air for Obunagha and Okololobiri are 135.5 nGyh^{-1} and 155.1 nGyh^{-1} respectively. Both values were more than twice higher than world average of 57 nGyh^{-1}. The estimated annual effective doses equivalent for this study are within the safe limits of 1.0 mSv. However, estimated values of excess lifetime cancer risks for this study are well above the world average of 0.29 x 10^{-3}. This study suggests possible health challenges of people living in the areas of study. The exposure level of dwellers in the selected communities for the present study necessitates further radiological studies in the areas. This will ensure deeper understanding of exposure level to background radiation in Obunagha and Okolobiri.

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