



MEASUREMENT OF BACKGROUND IONIZING RADIATION LEVEL AND DOSE RISK AROUND NIGERIA'S FIRST OIL WELL, OTUABAGI, OLOIBIRI CLAN, BAYELSA STATE, SOUTH-SOUTH, NIGERIA

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ARTICLE INFORMATION ABSTRACT

Submitted 21 June, 2024
Revised 18 July, 2024
Accepted 20 July, 2024

Keywords:

Radiation
well head
crude
dose rates

Individuals who get exposed to radiation stand the danger of experiencing health problems such as skin burn, acute radiation syndrome, cardiac condition. Natural radiation chains exist in nature including oil and gas fields in the ground. Therefore, crude may contain natural radioactivity. In this study, the background ionizing radiation level around the immediate vicinity of Nigeria's first oil well has been measured using the Radalert-100X, a portable radiation detector. The background exposure rate ranges from 0.0095 to 0.0155 mR^h⁻¹ with a mean of 0.0128 mR^h⁻¹. The absorbed dose rate calculated ranges from 82.65 to 156.6 nGy^h⁻¹ with a mean of 109.56 nGy^h⁻¹. The averages of the annual effective dose equivalent ranges from 0.101 to 0.192 mSv^y⁻¹ with a mean of 0.136 mSv^y⁻¹. The calculated averages of ELCR from the study area ranges from 0.359×10^{-3} to 0.670×10^{-3} with a mean of 0.476×10^{-3} . From the evaluation made, the granite area around the well head, has the highest background ionizing radiation value and other parameters compared to results from the well head and the muddy area. Given the values recorded in the study, it is imperative to advise that appropriate precautions be taken, such as adhering to the ALARA principle, to shield the public from radiation related risks.

1.0 Introduction

The level of ionizing radiation in the environment at a specific location that has not been caused by any kind of intentional introduction of radiation sources is known as background radiation.

(Ugwuanyi *et al.*, 2021). Many sources, whether natural, man-made, or both, contribute to background radiation. Normally, this is the scenario when monitoring the ambient dosage for environmental reasons. Ionizing radiation, when present in an environment, has sufficient energy to affect the atom in a living cell and thereby damage the genetic materials (DNA). Fortunately, our body cells are remarkably efficient at fixing the harm (Adrian and Andres, 2020). However, if the damage is not properly repaired, a cell might die or finally become cancerous (Adrian and Andres, 2020; Zhitovovsky and Orrenius, 2010). Human population exposed to radiation is at risk of having health effects like skin burn, acute radiation syndrome and cardiovascular diseases. Studies have shown that exposure to low level radiation in the

environment does not cause immediate health effect but it is a contributor to overall cancer risk (Yasser et al., 2020).

Sedimentary formations, which are good hosts to rocks for uranium deposits, are also generally good reservoir rocks for petroleum crude oil (Soumyajit et al., 2023). Crude itself may contain some level of natural radioactivity, as natural radiation chains, such as those found in underground oil and gas deposits, are present in nature (Ajayi et al., 2009). Atoms in such chains are not stable, radioactive decay process may occur, which leads to release of radiation in the environment and so can enhance the background radiation level of the environment. Mostly, the oil and gas sector use unsealed radioactive solids (powder and granular forms), liquids and gases to look into or track the flow of items (IAEA, 2003). It is at the wellhead that these radiotracers are most often used to assess flow rate for a variety of reasons (IAEA, 2012). Also, in most instances, spillages which could be accidental or otherwise, may occur around oil and gas facilities thus bringing these chains to the surface, thereby increasing the possibility of heightened background radiation levels in the immediate environment.

Nigeria's first oil head, now a national historic site, as a tourist attraction has many people who visit the site for many purposes. There is therefore the need to investigate radiation profile of the immediate environment. A study such as this one to quantify background ionizing radiation level around the immediate vicinity of the well head will not only provide base line data on exposure rate but will also provide data on radiological health effects on population within the site.

The area of study is the immediate surroundings of Nigeria's first oil well. Nigeria's first oil well head is situated in Otuabagi in Oloibiri clan, Ogbia local government area of Bayelsa state. The state is host to one of the country's biggest reserves of oil and gas. The state's population, according to 2022 census is two million, five hundred and thirty seven thousand, four hundred (2,537, 400). The Oloibiri terrain is made up of freshwater wetlands and streams formed by the distributaries of creeks. The region is part of the coastal belt, which is made up primarily of low-lying coastal plains that are structurally related to the Niger Delta's sedimentary layers (Oborie and Oki, 2017). Its geology is made up of fluvial sediments. The region is typified by lowlands and gentle undulating coastal plains, as well as sandbars, tidal basins, mud flats, and swamps (Ononugbo et al., 2015). The area considered for this survey is about 0 – 50 m from the oil well head. The oil well itself though no longer in production, is now a tourist attraction site with some level of construction here and there round the well head. Therefore, for this study, its immediate vicinity was categorized into the well head, muddy, sandy, granites chippings and concrete areas. Figure 1 shows a picture of Nigeria's first oil well head in Oloibiri, Bayelsa State.



Figure 1: Nigeria's first oil well head

2. Materials and method

Radiation alert inspector (Radalert-I00X), a portable radiation detector was used for measuring background ionizing radiation. Radalert has an inbuilt Geiger-Muller tube capable of producing a pulse current when radiation goes through it (Ovuomarie-Kelvin et al., 2018). The pulse produced is automatically sensed then recorded as count. The radiation alert inspector was standardized by the use of ^{137}Cs specific energy source and made to quantify the exposure in milli-Roentgen per hour (mRhr^{-1}) and with a precision of $\pm 15\%$ (Biere et al., 2023). To carry out background ionizing radiation measurement, the area around the oil well head was divided into well head, muddy, sandy, granites chippings and concrete areas. Each segment is about three to four meters wide. Readings were taken linearly starting from the well head to an adjacent road off Ogbia-Nembe road. Average values of readings in each segment were taken and recorded in table. At each measurement point, the radiation meter was positioned 1 m from ground level and its window faced the expected source. The detector was switched on for about 120 s to absorb radiation. The process was repeated in all points of measurement and obtained readings were recorded in mRhr^{-1} .

2.1 Determination of radiological hazards

The background ionizing radiation (BIR) values measured were used to calculate other radiological parameters associated with it.

2.1.1 Absorbed dose rate in air (ADR)

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

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

This can be written as

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

2.1.2 Annual effective dose equivalent (AEDE)

Annual effective dose equivalent. This parameter is employed to calculate the likelihood of long-term health consequence 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 entire hours in one year, CF is dose conversion factor from absorbed dose to effective dose in Sv/Gy. CF = 0.7 Sv/Gy. OF is occupancy factor, probable time that people would spend outdoor in the study area, OF = 0.2 as suggested by UNSCEAR, 2008

2.1.3 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 duration of life) and RF is cancer risk factor expressed in Sv^{-1} . In the scenario of low dose background radiation, anticipated to result in stochastic effects, ICRP 103 stipulates a threshold of 0.05 Sv^{-1} for the public (ICRP, 2007).

3. Results and discussion

Table I presents averages of measured background radiation and calculated radiological parameters associated with the exposure rates within the sections of the ambience of the abandoned oil well. To gain further insight of the variation of the various radiological parameters in the different segments around the well head, the average values obtained in this study have been plotted against their respective world average values. Figures 2 to 5 show the comparison of background radiation, absorbed dose rate, annual effective dose equivalent and excess life time cancer risk with World average.

Table I: Measured and estimated radiological parameters

Data collection points	BIR (mRh^{-1})	ADR ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR ($\times 10^{-3}$)
Well-head area				
average	0.0095	82.65	0.101	0.353
Mudy area				
Average	0.010	87.0	0.107	0.372
Sandy area				
Average	0.011	95.7	0.117	0.409
Granites area				
Average	0.018	156.6	0.192	0.670
Concrete area				
Average	0.0155	134.85	0.165	0.577
Mean	0.0128	109.56	0.136	0.476

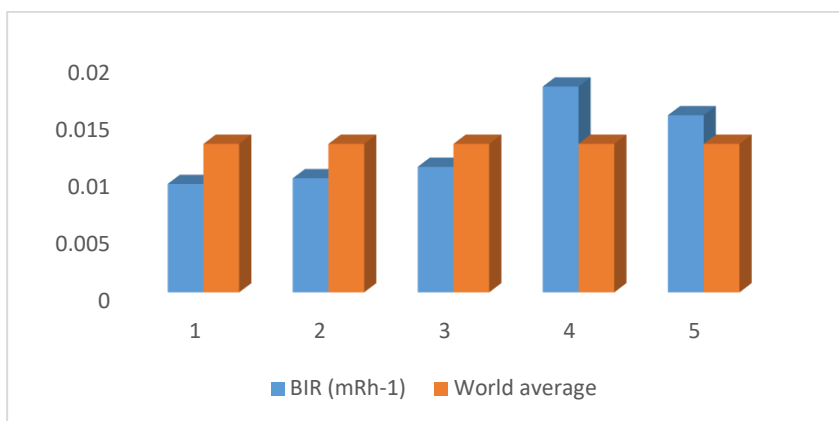


Figure 2: comparison of background radiation mean with world average

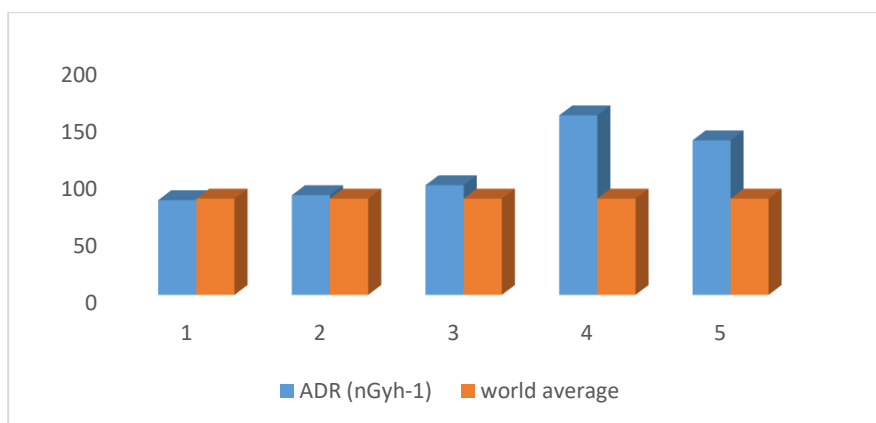


Figure 3: comparison of absorbed dose rate mean with world average

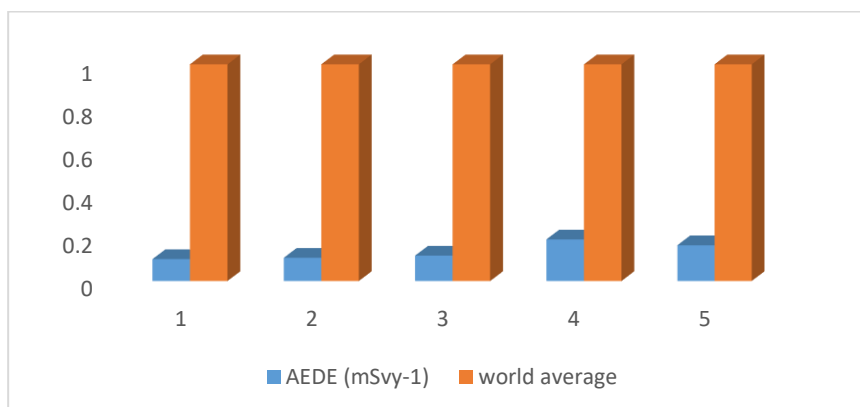


Figure 4: comparison of annual effective dose equivalent mean with world average

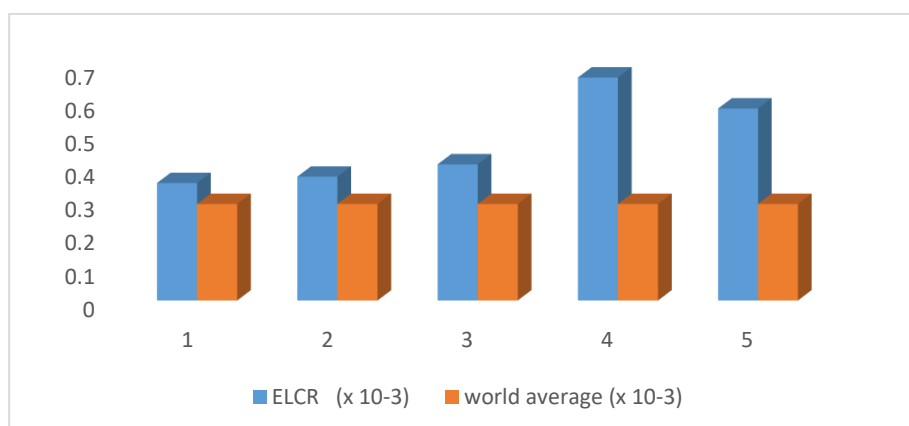


Figure 5: comparison of excess lifetime cancer risk mean with world average

Discussion

Table 1 presents the averages of in-situ measurements of background ionizing radiation in different segments in the immediate vicinity of Nigeria's first oil well. The background exposure rate ranges from 0.0095 to 0.0155 mR^h⁻¹ with a mean of 0.0128 mR^h⁻¹. It is observed that some segments have exposure rate higher than the world permissible limit of 0.013 mR^h⁻¹ (Khamis et al., 2022), this could be attributed to the introduction of some geological materials and manmade activities which could have contribute to the overall radiation level. The mean background exposure rate recorded here falls between the range of the values published by Ovuomarie-Kelvin et al., 2018. However, they are less than the figures Avwiri et al., 2014 reported. Absorbed dose rate calculated ranges from 82.65 to 156.6 nGy^h⁻¹ with a mean of 109.56 nGy^h⁻¹. Mean of the study area is above both the world average of 59.0 nGy^h⁻¹ (Taskin et al., 2009) and 84.0 nGy^h⁻¹ tolerable threshold (Ayua et al., 2017). The high values reported here indicates that there is possibility of radiological contamination of the environment. Which indicates that radiation related health risk could occur in the future if precautions are not taken. The mean absorbed dose rate is above 95.7 nGy^h⁻¹ reported by Ovuomarie-Kelvin et al., 2018, but lower than 203.41 nGy^h⁻¹ reported by Anekwe and Onoja, 2020 for similar environments. Annual effective dose equivalent ranges from 0.101 to 0.192 mSv^y⁻¹ having a mean of 0.136 mSv^y⁻¹ which is above the world average 0.07 mSv^y⁻¹ (Agbalagba et al., 2016; ICRP 2013) but lower than the 1.0 mSv^y⁻¹ recommended threshold for general public (Taskin et al., 2009; UNSCEAR 2008). The average annual effective dose is comparable to those recorded by Ovuomarie-Kelvin et al., 2018. The calculated averages of ELCR from the study area ranges from 0.359×10^{-3} to 0.670×10^{-3} with a mean of 0.476×10^{-3} . This mean exceeds the global average of 0.29×10^{-3} (UNSCEAR 2000). The mean ELCR from the study area is quite high. This indicates the possibility of developing cancer in the future. The mean value reported here is slightly above reported in Ovuomarie-Kelvin et al., 2018.

Figures 2 to 5 show pictorial representation of the obtained results as compared with their respective averages. In Figure 2, the average background ionizing radiation from the well head, muddy and sandy areas are seen to be below the world average while that of the granite and concrete areas are above the world average. In Figure 3, only the average absorbed dose rate from the well head area is slightly below the world average and others are higher. Figure 4 show all averages of annual effective dose equivalent to be far below world average and Figure 5 shows all averages of excess lifetime cancer risk to be above world average.

Conclusion

This study is intended to reveal the level of radiological parameters around the closest proximity of Nigeria's first oil well head which is no longer in use but is now a tourist destination and a historic land mark. The background ionizing radiation has a mean value which is approximately equal to the world average. Mean absorbed dose rate is above the world suggested tolerance level. Mean of annual effective dose equivalent is below the world permissible limit. Mean excess lifetime cancer risk exceeds the global average by a considerable margin. From the evaluation made, the granite area has the highest background ionizing radiation value and other parameters compared to that from the well head and the muddy area. These values were clearly seen to be influenced by the presence of granites spread in that segment around the well head. Nevertheless, as a result of the high values recorded in study, it is necessary to recommend that adequate measures like the ALARA (as low as reasonably

achievable) principle should be taken to protect the general public from any radiation induced hazards.

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