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Estimation of Excess Lifetime Cancer Risks at the Niger Delta University Sculpture Garden, Wilberforce Island, Bayelsa State, Nigeria

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Abstract: The exposure rates at the Niger Delta University sculpture gardens have been measured and excess lifetime cancer risk has also been determined. Measurement of exposure rate was carried out in a total of twenty points around the garden using a portable hand-held radiation detector, radalert 100X. Results show averages of exposure rate, absorbed dose, annual effective dose and excess lifetime cancer risk as 0.012 mRh^{-1}, 107.9 $nGyh^{-1}$, 0.132 $mSvy^{-1}$ and 0.162 x 10^{-3} respectively. All averages, except for absorbed dose rate, were below world average. The results show low radiation level in the materials used in sculptures at the garden. However, this low level can pose specific health risks after prolonged exposure. There is the need to begin to apply caution in the consideration of materials used for building the sculptures so as to avoid the introduction of radioactive elements into the garden. Conclusively. the study suggests that the Niger Delta University sculpture garden is relatively safe for public use.

Keywords: exposure rate, sculpture garden, excess lifetime cancer risk.

I. Introduction

Ionizing radiations like alpha, beta particles, x-rays as well as gamma rays, possess enough energy to ionize atoms or molecules by detaching electrons from them, which can lead to significant alterations in their chemical structure. This process of ionization can cause serious biological damage, including DNA mutations, cellular dysfunction, and even cell death, which underscores the importance of studying this type of radiation (Baeyens, *et al.* 2023; Tuan, *et al,* 2023; Buciuman, *et al*, 2024). Unlike alpha and beta particles, gamma rays are not particles but high-energy photons, meaning they can travel long distances and penetrate most materials, including human tissue (IAEA, 2004; Tabrah, 2010; IAEA, 2024). Because of their high penetration capability, gamma rays are used extensively in medical imaging and cancer treatment, where they can be precisely targeted to destroy malignant cells (Hosam and Amal, 2023). However, their ability to penetrate deeply into the body also makes them particularly dangerous, as they can ionize atoms within living cells even at lower energy levels, potentially leading to mutations, cancer, and other health issues (Mavragani, *et al*., 2019; Omoruyi, *et al*., 2023). Research has consistently shown that exposure to elevated gamma radiation intensity can potentially cause acute radiation syndrome, with symptoms ranging from nausea and vomiting to severe, life-threatening organ damage (ICRP, 2019). Radiation is everywhere in the environment and in the things that make up the environment.

Sculpture as an expressive medium that involves the manipulation of materials such as stone, metal, wood, or clay to create a tangible artistic representation in the environment (Nithiku, 2010; Gilmore, 2020;). Sculpture gardens, often celebrated for their artistic and aesthetic appeal, provide a serene environment where art and nature coexist. However, beneath the beauty and tranquility, there exists a potential radiation risk to human health, particularly through prolonged exposure to certain materials used in sculptures. The estimation of excess lifetime cancer risk in a sculpture garden is a significant concern that arises from the potential exposure to harmful substances that may be associated with certain sculptural materials and their degradation over time. Studies such as those by Akpoveta and Osakwe (2010) and Ogbodo *et al.,* (2023) have highlighted the general environmental health concerns in the Niger Delta but have not addressed the particular risks posed by localized and culturally significant spaces like the Sculpture Garden. This gap in research necessitates an investigation into excess lifetime cancer risks that may be associated with the unique environmental factors present in the Sculpture Garden at Niger Delta University.

Study area

The garden is located at main campus, Niger Delta University, Yenagoa, Bayelsa State, Nigeria. It is specifically located at the Fine and Applied Art Department in the Faculty of Arts, the main campus of the university, it is known as the sculpture garden, and it consists of different sculptures and materials. It is an outdoor space specifically designed to showcase sculptures and artworks in a natural setting. The sculptures are made up of different materials like stone, metals, wood, and even glass and are exposed to all elements of weather such as rain, wind, and sunlight which can gradually wear down the sculpture over time. The university campus itself is situated on the edge of Nun River Forest Reserve, nestled within a humid tropical rainforest marked by

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heavy rainfall periodic flooding, and multilayered flora (Mohammed *et. al,* 2007). In this region, pockets of sandstone exist between diapiric structures towards the delta or (base of coastal slope), this alternating sequence of sandstones and shale progressively transition to basically sand-stone (Dorrik and Melissa, 2000; Worden and Burley, 2009; Beck *et. al*., 2024). The primary real risk in the Niger Delta is the interceded shale within the Agbada formation. Below are pictures showing sections of the sculpture garden.

Plate 1

Plate 2

Plate 3

Plates 1, 2 and 3 are pictures of sections of the sculpture garden

II. Material and method

The material used in the course of this research is the radiation alert inspector, the Radalert 100X, a factory-calibrated radiation detection instrument, to measure x-rays, beta, alpha and gamma radiation (Omojola, *et. al*., 2021; Ononugbo and Anekwe, 2020). This device features an audible alarm for radiation levels exceeding the set threshold, enabling the screening of environmental contamination and radioactivity sources. Data logging and computer connectivity allow for efficient data recording and analysis. Utilizing a Geiger tube and mica window, the Radalert 100X detects ionizing radiation displays results on an LCD screen. The garden was divided into two sections for the purpose of this study. One section has more sculptures than the other. Measurement was performed at 20 points, 10 points a section. The meter was turned on and positioned at waist level for 120 seconds during each measurement after which the radiation counts were recorded in mRh^{-1}.

III. Calculation

Equations 1, 2, and 3 were used to convert exposure rate, ER to absorbed dose (Rafique et. al, 2014), then to annual effective dose (Aluko, *et. al*., 2023) then eventually to excess lifetime cancer risk (Biere *et. al*., 2024) respectively.

$$I\ mRh^{-1} = 8700\ nGyh^{-1} \qquad (1)$$

$$AEDE = D \times 8760\ h \times 0.7\ SvGh^{-1} \times 0.2 \times 10^{-3} \qquad (2)$$

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ELCR = AEDE x DL x RF 3

Where D is the absorbed dose rate in $nGyy^{-1}$, 8760 h is the total hours a year, CF is the dose conversion factor from the absorbed dose to effective dose in Sv/Gy. CF = 0.7 Sv/Gy. OF is the occupancy factor, OF = 0.2 as put forward by UNSCEAR, 2008. AEDE is annual effective dose equivalent. DL is duration of life (55.2yrs) in Nigeria (WHO, 2018) and RF is risk factor for low-level background radiation, thought to cause stochastic effects, ICRP 103 assigns 0.05 Sv^{-1} for public exposure (ICRP, 2007).

IV. Results

Table 1: Radiological values in section with more sculpture in the garden

S/N	**ER (mRh^{-1})**	**D ($nGyh^{-1}$)**	**AEDE ($mSvy^{-1}$)**	**ELCR x 10^{-3}**
1	0.012	104.4	0.128	0.157
2	0.011	95.7	0.117	0.144
3	0.012	104.4	0.128	0.157
4	0.016	139.2	0.171	0.209
5	0.016	139.2	0.171	0.209
6	0.017	147.9	0.181	0.222
7	0.023	200.1	0.245	0.301
8	0.011	95.7	0.117	0.144
9	0.017	147.9	0.181	0.222
10	0.023	200.1	0.245	0.301
Average	**0.015**	**137.5**	**0.168**	**0.206**

Table 2: Radiological values in section with less sculpture in the garden

S/N	**ER (mRh^{-1})**	**D ($nGyh^{-1}$)**	**AEDE ($mSvy^{-1}$)**	**ELCR x 10^{-3}**
1	0.009	78.3	0.096	0.118
2	0.009	78.3	0.096	0.118
3	0.012	104.4	0.128	0.157
4	0.006	52.2	0.064	0.079
5	0.006	52.2	0.064	0.079
6	0.009	78.3	0.096	0.118
7	0.012	104.4	0.128	0.157
8	0.007	60.9	0.075	0.092
9	0.009	78.3	0.096	0.118
10	0.011	95.7	0.117	0.144
Average	**0.009**	**78.3**	**0.096**	**0.118**

Table 3: Grand average of all parameters in the sculpture garden and world average

S/N	ER (mRh^{-1})	D ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR x 10^{-3}
Average (more sculptures)	0.015	137.5	0.168	0.206
Average (few sculptures)	0.009	78.3	0.096	0.118
Grand average	0.012	107.9	0.132	0.162
World average**	**0.013**	**59.0**	**1.0**	**0.29**

* UNSCEAR, 2000

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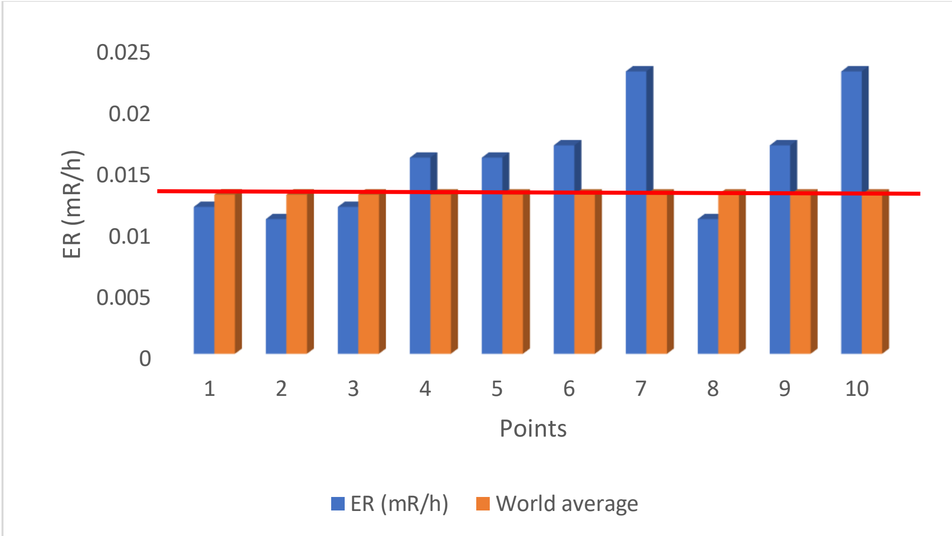

Figure 1: exposure rate in area with more sculptures versus world average

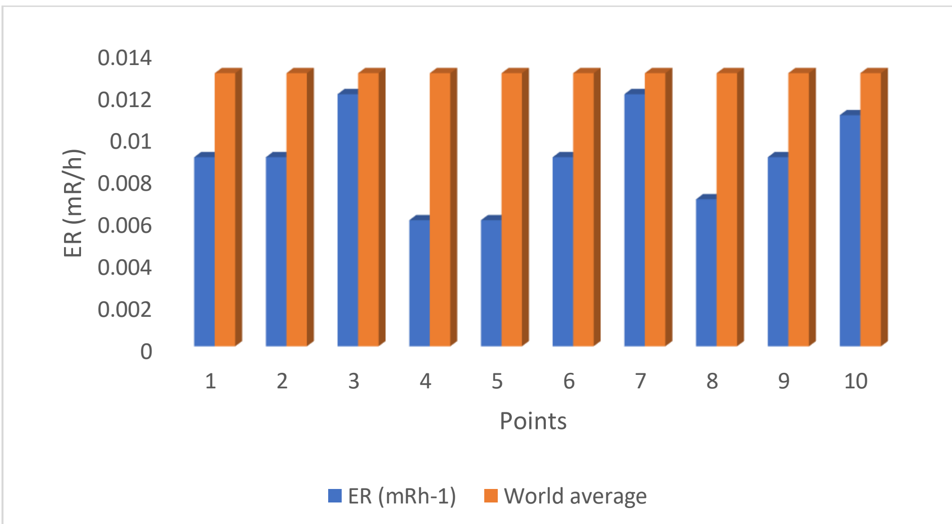

Figure 2: exposure rate in area with less sculptures versus world average

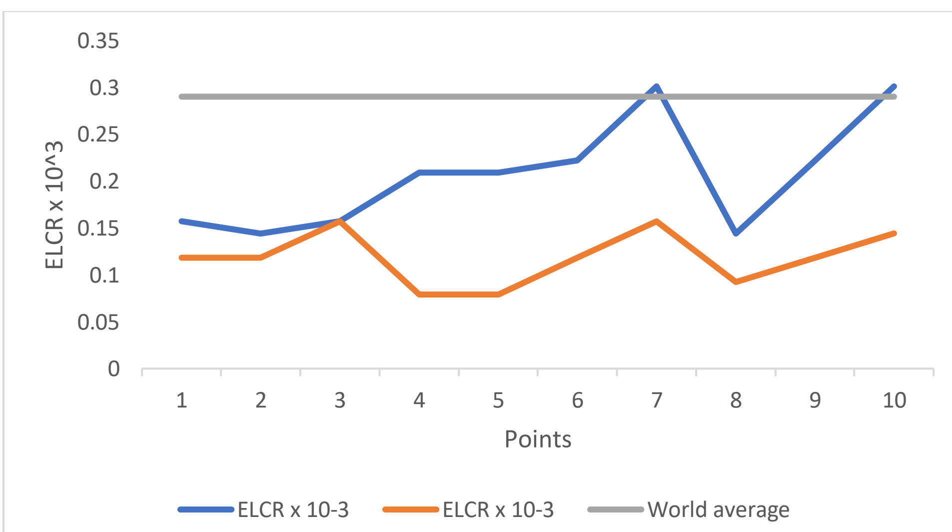

Figure 3: graph of ELCR averages versus World average

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V. Discussion

In the section with more sculptures, average ER recorded is 0.015 mRh^{-1}, with a minimum of 0.011 mRh^{-1} and a maximum of 0.023 mRh^{-1}, indicating relatively low exposure rate within the area. However, the slight variation suggests potential exposure risks that warrant further monitoring, especially at points where ER reaches the maximum level. Absorbed dose D, values range from (95.7 - 200.1) $nGyh^{-1}$, with an average of 137.5 $nGyh^{-1}$. This range indicates variability in radiation exposure within the measured locations, which could be influenced by local geological conditions or anthropogenic activities. The average D is above acceptable limits compared to global standards (UNSCEAR, 2008); the higher readings indicate the need for targeted studies to ascertain the sources of increased radiation. AEDE values averaged 0.168 $mSvy^{-1}$, with a minimum of 0.117 $mSvy^{-1}$ and a maximum of 0.245 $mSvy^{-1}$. These effective doses suggest that the radiation exposure is relatively low but still significant enough to raise health concerns if sustained over long periods (UNSCEAR, 2008). The ELCR values range from (0.14 - 0.30) x 10^{-3}, with average 0.21 x 10^{-3}. While these values are indicative of potential risk, they fall within acceptable limits for radiation exposure, however, they highlight the importance of continues assessment, particularly for vulnerable populations in densely populated areas.

In the section with fewer sculpture, ER averaged at 0.009 mRh^{-1}, indicating a relatively low level of radiation exposure in that section of the sculpture garden. The minimum recorded value of 0.006 mRh^{-1} and maximum of 0.012 mRh^{-1} suggest a consistency in low radiation levels, which is beneficial for both the environment and public health, as excessive exposure can lead to harmful biological effects. Absorbed Dose D, shows an average of 78.3 $nGyh^{-1}$, with a minimum of 52.2 $nGyh^{-1}$ and a maximum of 104.4 $nGyh^{-1}$. The average value fall within acceptable limit for natural background radiation, reinforcing the safety of this area for recreational activities and gatherings. Annual Effective Dose Equivalent (AEDE) averaged 0.096 $mSvy^{-1}$, but ranged (0.064 - 0.128) $mSvy^{-1}$ indicating that individuals in this area receive a relatively minor effective dose from environmental radiation sources. This low dose is critical in assessing potential health risks associated with prolonged exposure. The Excess Lifetime Cancer Risk (ELCR) value averages 0.118 x 10^{-3}, with a range from (0.079 - 0.157) x 10^{-3}. The values indicate very low cancer risk. Table 3, shows the grand total of all measured parameters which indicates relatively low levels, implying that the risks remain within a manageable threshold. Figure 3 shows all excess lifetime cancer risk obtained in the whole garden to be less than the world average, except for two points in the section which has more sculpture.

Conclusion

The measurement of exposure rate in the Niger Delta University sculpture garden has been done. Results show averages of exposure rate, absorbed dose, annual effective dose and excess lifetime cancer risk as 0.012 mRh^{-1}, 107.9 $nGyh^{-1}$, 0.132 $mSvy^{-1}$ and 0.162 x 10^{-3} correspondingly. All values determined are less than world average values except for absorbed dose rate. This suggests that the sculpture garden is generally safe for public use. However, fluctuations observed in readings highlight the fact that radiation level across the garden is not evenly distributed with the section with more sculptures having relatively higher values. Thus, the necessity for continuous monitoring. The ELCR values, although within acceptable limits with only about 20% of obtained values above world average, 0.29 x 10^{-3}, indicate a slight increase in excess lifetime cancer risk and underscoring the importance of protecting vulnerable populations who may be exposed frequently to these environments. The results have shown minimal elevation radiation levels, in environmental materials used in sculptures present in the garden. This low level can pose specific health risks such as skin damage, eye irritation, and potential long-term effects like an increased risk of cancer due to prolonged exposure. Therefore, caution should be taken to avoid the introduction of radioactive elements in relaxation areas like the sculpture garden.

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