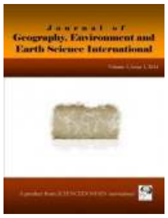

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Measurement of Outdoor Ambient Radioactive Radiation and Evaluation of Radiation Indices and Excess Lifetime Cancer Risk within Uyo, Unity Park, Uyo, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SEE and AAE designed the study, wrote the first draft of the manuscript and managed the literature searches. Author OEA performed the statistical analysis and managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

In this paper, the first result of outdoor ambient radioactivity measurement and evaluated radiation indices and excessive lifetime cancer risk factor within Uyo, Unity Part Uyo, Nigeria (Latitude 5.0281°, Longitude 7.9734° and Latitude 5.0466° and Longitude 7.9869°) are presented. Overall mean equivalent dose rate of 0.116µSv/yr and mean ELCR of 0.449 x 10^{-3} were recorded for the park. The mean annual equivalent dose is less than the ICRP annual recommended limit. The values here are less than those reported for most other locations by other researchers.

Keywords: Uyo Unity Park; radioactive radiation; equivalent dose; effective dose; excessive lifetime cancer risk factor.

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1. INTRODUCTION

Environmental safety is a matter of universal concern. It is ranked with availability of water, food and air. Polluted and unsafe environment leads to polluted and unsafe air, water and food, leading to poor/bad health conditions. It is in the light of this that [1] says "In our safer society, the public's demand for ever more safety is undiminished." Currently, there has been keen interest in measurement and evaluation of gamma radiation which the general public is exposed. The environmental radiation comprises the natural radiation found in the ground, the cosmic radiation together with the background radiation from nuclear tests and accidents [2]. [3] summarily attributes the presence of radiation in our environment to cosmic, anthropogenic and primordial sources, observing that primordial radioactivity is widespread in the earth environment while the contribution of the other two to the total environment radioactivity is negligible. Supporting this, [4] report, explain that level of primordial radioactivity concentration depends on geological conditions and geographical location of the area. This is further supported by [5,6] and [7].

In addition [8] and [9] assert that the high ambient ultraviolet (UV) levels and a predominantly fair skinned population, combined with an emphasis on an outdoor incidence rate of non-melanoma skin cancer in the world.

For a given radiation dose there is a risk of tumor induction with children being generally at more risk than adults. The rate of radiogenic tumor induction is termed radiation sensitivity with regard to cancer induction [4].

Terrestrially, gamma radiation from 238U, 232Th series and 40 K are predominant and irradiates the human body from external sources. According to [10] exposure to radioactive radiation has high health risk, which include chromosomal transformation, hence, gene mutation. This has led to the practice of keeping one's exposure to ionizing radiation to as low as reasonably achievable, known by the agronomy ALARA principle. This therefore makes

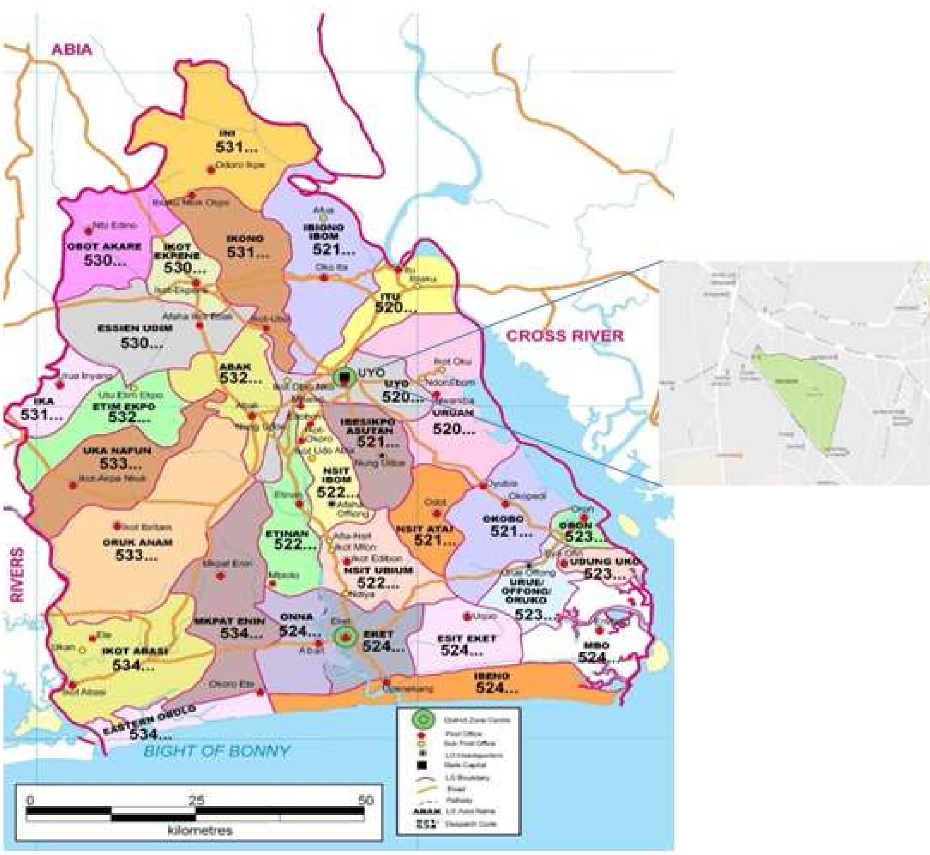

Fig. 1. Showing the Study area in map of Akwa Ibom State Nigeria

estimation of ambient and background radiation, a matter of serious concern to environmental scientists, regulatory agencies and public health managers ([4,11]).

Studies on radioactivity level and radiation activity have however been copiously reported in some locations within Niger Delta Region of Nigeria such as the work of; [12-27] and others embarked on similar studies elsewhere, yet no studies has been reported on our present chosen study location, the Uyo Unity Park. It becomes expedient to carry out investigation and radioactivity level, evaluation of radiation indices and excessive lifetime cancer risk factor within the park for future radiation impact assessment, protection and control as recommended by [28].

1.1 Study Area

The study was carried out at the Unity Park, Uyo, Akwa Ibom State, Nigeria, located within latitude 5.0281 and longitude 7.9734 and latitude 5.0466 and longitude 7.9869.

Unity Park, a recreation center, located at Uyo, the state capital of Akwa Ibom state, within the Niger Delta region of Nigeria is an establishment of the government of Akwa Ibom State, Nigeria. It covers a vast landmark with grass planted and shrubs with Indian bamboo. The park is an open field where people go for recreational purposes. It has water ponds and a few hurt. The park provides sit out for inhabitants as well as visitors coming into the city who sometimes sit there for many hours. The park is often used for film shutting, public rallies, political and religious purposes and circular pursuits.

The study site is within the Niger Delta Region of Nigeria where oil and gas exploration is continuously carried out. The choice of this study site is informed by the fact that large population of people stay longer at the site for recreational purpose at one time and other programs at another coupled with the fact that no study had ever been carried out for environmental monitoring and control or impact assessment purposes.

2. MATERIALS

A portable inspector Alert TM Nuclear radiation monitor (Model GLR 61-6AM6-9V serial number 33333 Quality 1 made in USA by International Medcom) having a GM tube with a fragile window, was used for the detection and measurement of the radiation equivalent dose. The instrument was first switched on and calibrated to detect and measure equivalent dose in µSv/hr. The instrument has provision for wide variety of digital displayed readings in MR/hr, CPM, CPS and µSv/hr with a switch for setting to the unit required for measurement. It has provision for audio alert in addition to the digital display with total/timer setting. The radiation was set to µSv/hr range for the purpose of the study. A global positioning system (GPS) meter (GPS) was equally used for the geographical identification of the study location in terms of Latitude, Longitude and Altitude. In all, calibration was carried out before use as stipulated by [29].

3. METHODS

In situ measurement of outdoor radioactive levels, equivalent dose per hour were carried out at 24 locations within the study area. The calibrated portable inspector Alert was set to µSv/hr position for the measurement of the equivalent dose, while the GPS meter was calibrated and set to position for determination of actual geographical study position in terms of longitude, latitude and altitude. The inspector alert was held above the terrestrial level with the window facing down 1m above the ground level. 500 measurements were taken in each of the 24 locations and recorded as raw data. The primary data was taken to the laboratory office and processed for mean and standard error and other radiation indices evaluated from the data for the locations and the study area, using the equations stipulated under the data analysis.

4. DATA ANALYSIS AND RESULTS

The processed raw data gotten under method were analyzed here and other radiation indices calculated, using established mathematical equations. 3D wire surface graph are drawn using the calculated values for the locations within the study area.

4.1 Equivalent Dose

The data obtained from the in situ measurement for each location within the study area were processed for mean value by adding up all the raw data obtained for each location and divided by the number of data taken to get the mean value for the location. Standard error for each of the location was also calculated using simple statistical formula that abounds in most statistics textbooks.

The result is as shown in Table 1 for the outdoor location invested, while Fig. 2 is a 3D wire surface box diagram for the outdoor equivalent dose rate HT measured within the location.

4.2 Annual Equivalent Dose

The mean equivalent dose rate in µSv/hr obtained from the processing of the in situ measurement was used to calculate the corresponding annual equivalent dose rate in mSv/yr using the mathematical relation given by [30], [12] as:

$$HT_{ann} = \delta \times \mu \times 24 \times 365 \times 10^{-3} \tag{1}$$

Where

$\delta = {HT}/{Q}$ known as the absorbed dose

HT is equivalent dose in µSv/hr
HT_{amm} is annual equivalent dose in mSv/yr
µ is the occupancy factor, indicating the proportion of the total time which an individual is exposed to radiation. [4] recommend 0.2 for outdoor and 0.8 for indoor.
Q is the quality factor equal to unity.

For outdoor equivalent dose rate a simplified version of equation 1 given as

$$HT_{ao} = 1.752 \times HT \tag{2}$$

Was employed for the calculation of annual outdoor equivalent rate HT_{ao} in mSv/yr. Standard error was equally calculated from the quotient of the difference between the maximum value and the minimum value calculated for a location and the number of reading taken for that location.

That was done for each of the locations. The result of the analysis is as seen in Table 1. Whereas a 3D wire surface box diagram is as seen in Fig. 3.

4.3 Annual Outdoor Effective Dose (E_O)

Annual outdoor effective dose (E_o) was calculated using outdoor external dose D_o, occupancy factor or proportion of the total time in the outdoor which an individual is exposed to the radiation μ_o= 0.2 of 8760 hr within a year and $0.7SvGy^{-1}$ being the conversion factor (CF) for converting the absorbed dose in air to effective dose. The mathematical relation given by [31] and [3] thus:

$$E_O = D_O(nGyhr^{-1}) \times 0.2 \times 8760hr \times 0.7SvGy^{-1} \times 10^{-3} \tag{3}$$

where, $$D_o(nGyhr^{-1}) = \frac{HT_o(\mu Svhr^{-1})}{Q} \times 10^{-3} \tag{4}$$

the calculated mean values for the annual outdoor effective dose are seen in Table 1, Fig. 4 is a 3D wire surface box diagrams representation of the Annual Outdoor Effective Dose for the study location.

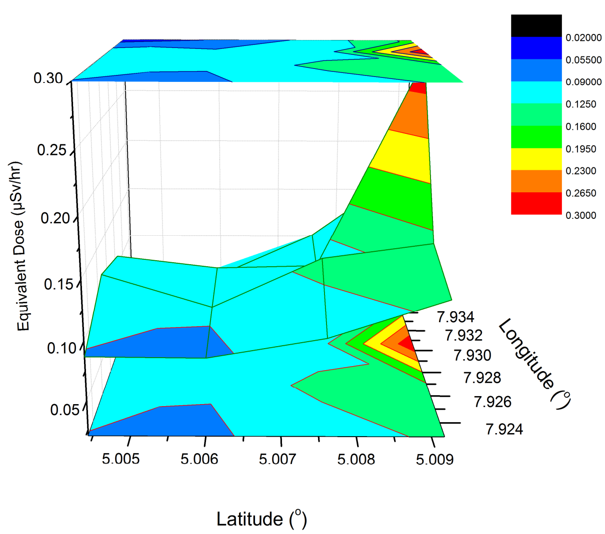

Fig. 2. 3D wire surface box diagram for the outdoor equivalent dose rate

Table 1. Mean outdoor radiation indices and excess life cancer rate estimation at Uyo Unity Park

Location	Latitude (°)	Longitude (°)	Altitude (m)	HT (µSv/hr)	Ht_{ann} (mSv/yr)	D_o (nG/hr)	E_o (mSv/yr)	ELCR x 10^{-3}
O1	5.0083	7.9231	69.1	0.1163	0.2038±0.0262	0.000116	0.1426	0.4992
O2	5.0075	7.9278	70.9	0.1247	0.2185±0.0310	0.000125	0.1529	0.53519
O3	5.0081	7.5944	71.1	0.1183	0.2073±0.0165	0.000118	0.1451	0.50793
O4	5.0092	7.9275	69.6	0.1289	0.2258±0.0146	0.000129	0.1580	0.55313
O5	5.0089	7.9283	69.1	0.0895	0.1567±0.0231	0.000090	0.1097	0.38396
O6	5.0089	7.9286	68.0	0.1253	0.2196±0.0351	0.000125	0.1537	0.53795
O7	5.0086	7.9294	69.0	0.1154	0.2021±0.0222	0.000115	0.1415	0.49524
O8	5.0088	7.9302	71.6	0.1828	0.3203±0.0337	0.000183	0.2242	0.78479
O9	5.0081	7.9308	72.0	0.1060	0.1857±0.0257	0.000106	0.1300	0.45495
O10	5.0069	7.9300	68.5	0.1010	0.1769±0.0306	0.000101	0.1238	0.43335
O11	5.0061	7.9297	73.1	0.1017	0.1781±0.0290	0.000102	0.1247	0.43634
O12	5.0068	7.9289	70.4	0.0895	0.1568±0.0288	0.000090	0.1098	0.38425
O13	5.0069	7.9283	61.2	0.1182	0.2071±0.0228	0.000118	0.1450	0.50749
O14	5.0064	7.9278	68.0	0.1105	0.1936±0.0213	0.000111	0.1355	0.47437
O15	5.0053	7.9283	70.6	0.1038	0.1819±0.0245	0.000104	0.1273	0.44563
O16	5.0050	7.9292	76.2	0.1035	0.1813±0.0268	0.000104	0.1269	0.44424
O17	5.0044	7.9289	68.0	0.1199	0.2101±0.0224	0.000120	0.1471	0.51463
O18	5.0056	7.9275	62.6	0.0923	0.1618±0.0266	0.000092	0.1132	0.39631
O19	5.0067	7.9272	61.2	0.1279	0.2241±0.0269	0.000128	0.1569	0.54912
O20	5.0069	7.9264	74.6	0.1165	0.2042±0.0293	0.000117	0.1429	0.50019
O21	5.0078	7.9267	68.8	0.1374	0.2407±0.0276	0.000137	0.1685	0.58972
O22	5.0089	7.9261	65.0	0.1130	0.1980±0.0166	0.000113	0.1386	0.48516
O23	5.0081	7.9253	61.9	0.1361	0.2384±0.0262	0.000136	0.1669	0.58409
O24	5.0081	7.9236	67.1	0.1117	0.1957±0.0335	0.000112	0.1370	0.47956
			Mean	0.1163	0.2037±0.0253	0.000116	0.1426	0.499
			Minimum	0.0895	0.1567±0.0146	0.000090	0.1100	0.384
			Maximum	0.1828	0.3203±0.0351	0.000183	0.2240	0.785

4.4 Excess Lifetime Cancer Risk (ELCR)

Excess lifetime cancer risk (ELCR) factor, which owes its dependence on annual effective dose (E) value, was calculated for the study locations within the study area using the equation generally expressed by [32,27] and [3] as

$$ELCR = E \times LE \times RF \tag{5}$$

Hence, for the calculation of ELCR in outdoor locations we have

$$ELCR = E_o \times LE \times RF \tag{6}$$

Where E_O is the outdoor annual effective dose, LE is life expectancy (70years), and RF is fatal risk factor which is kept at 0.05 per Sievert ([33]).

The result for the estimated level of this radiological hazard, Excess Lifetime Cancer Rate, (ELCR) is also shown in Table 1, where Fig. 5 shows the 3D wire surface box diagram for the Excess Lifetime Cancer Risk.

5. DISCUSSION

This research paper presents the results of radiological investigation carried out at Uyo Unity Park, a vast and frequently patronized recreation park located within A mean minimum equivalent dose rate of 0.0895 µSv/hr was recorded, with a mean maximum equivalent dose rate of 0.1828 µSv/hr and overall mean of 0.116 µSv/hr for the study location. The mean annual equivalent dose rate for the location is 0.143 µSv/hr, which is 0.857 mSv/hr less than the ICRP recommended permissible limit of 1mSv/hr for members of the public [34]. The mean value of annual equivalent dose in this work, when compared with the values reported for other locations within the Niger Delta Region, is generally lower, for instance, 0.745 mSv/hr for upland campus environment 0.690 mSv/yr for rural riverine communities and 1.270 mSv/yr for industrial zone, all within River State [18] a range of 0.943 – 1.755 mSv/yr reported by [35] for Nigeria environment, 0.532 mSv/hr for Ughelli region of Delta State [23], among others.

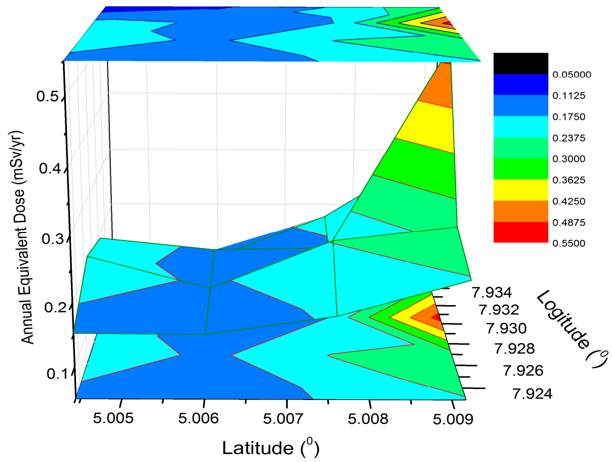

Fig. 3. 3D wire surface box diagram for the annual outdoor equivalent dose

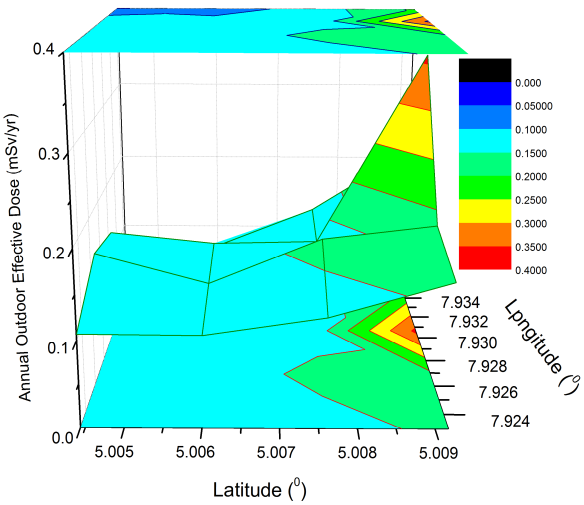

Fig. 4. 3D wire surface box diagram for the Annual Outdoor Effective Dose

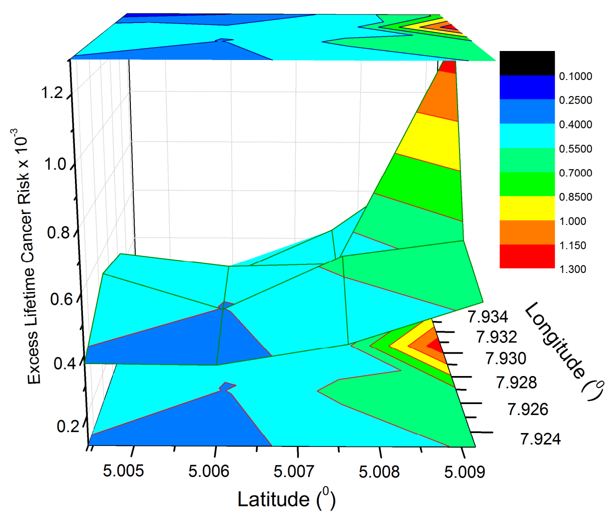

Fig. 5. 3D wire surface box diagram for the Excess Lifetime Cancer Risk

The overall mean outdoor annual effective dose for the study environment is shown to be 0.143 mSv/hr which is 0.073 mSv/hr higher than the world's average of 0.07 mSv/yr [3].

The effect of gamma radiation in relation to Excess Lifetime Cancer Risk factor has currently attracted the attention of environmental researchers, medical physicists, medical and community health practitioners the world over. Such include the work of [3]. In this present investigation, the mean Excess Lifetime Cancer Risk (ELCR) factor for the outdoor environment was seen to be 0.449×10^{-3} about 1.55 times the world's average of 0.29×10^{-3} ([36,3]). The location at latitude 5.008750° and 7.930167° with 0.785×10^{-3} has the highest excessive lifetime cancer risk factor more than any other location within the area investigated. The mean value of ELCR factor in our report here is 0.001×10^{-3} less than the value reported by [32] as 0.50×10^{-3} for Kirklareli in Turkey; 0.299×10^{-3} higher than 0.20×10^{-3} reported by [37] for river sediments of Tamilnadu and Karnataka, India; 1.201×10^{-3} les that the value 1.7×10^{-3} reported by [38] for Kerala in India; 0.329×10^{-3} higher than 0.17×10^{-3} reported by [39] for soil sample in Tulkarem in Palestine. Our ELCR value of 0.543×10^{-3} reported by [40] for Jhelum valley.

Considering the above comparison of our results with those of other locations reported by other researchers as indicated above, it is obvious that though the mean value for excessive cancer risk factor in this report is seen to be higher than the world's average, it is also less than the values recorded for most of the reported locations, hence safer than those locations. It is, however, assumed that exposure to radiation for a long time has a risk of causing cancer. Men, are by the report of Surveillance, Epidemiology, and End Results (SEER) cancer statistics, have a higher percentage lifetime cancer risk than women. The statistics of cancer risk of men to women in America according to the report is 44% to 38% ([41]).

The differences in our values with those of others reported elsewhere may be due to differences in the geological content as well as the geographical location of the environments investigated. The area investigated in this work has 76.2 m as the highest altitude and 6.12m as its minimum. It is covered with green grass and stands of Indian bamboo with four natural ponds, few hurts, unequipped museum building and a cenotaph built with rocks, tiles and marble. The highest value of equivalent dose rate were recorded at the cenotaph and the museum buildings. This indicates that the rocks, titles and marbles used for the construction plausibly contribute to the raised value of equivalent dose rate than locations with ordinary green grass, Indian bamboo and natural ponds. There is however no known artificial source of radioactivity within the vicinity studied. However, from the 3D wire surface box diagram it can be deduced that the trends are the same, that is the highest points are in the North Eastern part and lowest points are in the Central part of the of the study location for outdoor equivalent dose rate, annual outdoor equivalent dose rate, annual outdoor effective dose rate and excess lifetime cancer risk as shown in Figs. 2 to 5.

6. CONCLUSION

In the light of the present result data, this situation does not seem to be acute or stochastic. The main conclusion of this paper is that the activity concentration present within the Uyo Unit Park is below the ICRP annual recommended limit, hence the accepted interval. However further studies should be carried out at locations within the park and its environment for the purpose of control and to ascertain the long term effect of natural radioactive effect in the population regularly patronizing the park.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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