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Assessment of Radiological Risks in Sections of Niger Delta University campus, Bayelsa State, Nigeria

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Abstract

This paper presents an assessment of background radiation levels within the Niger Delta University campus, Bayelsa State Nigeria. A portable Geiger-Muller tube (Radiation Alert) was used to detect the background ionizing radiation within a temperature range of -100 ℃ to 500 ℃. Results of absorbed dose rate in air in the main campus, open field and new campus vary from 104.4 nGy/h to 278.4 nGy/h with an average of 156.6 nGy/h, 34.8 nGy/h to 174.0 nGy/h with an average of 95.7 nGy/h and 69.6 nGy/h to 174.0 nGy/h with an average of 113.1 nGy/h respectively. The annual effective dose estimates ranged from 0.160 mSv/y to 0.427 mSv/y with an average of 0.024 mSv/y, 0.053 to 0.267 mSv/y with an average of 0.147 mSv/y and 0.107 to 0.267 mSv/y with a mean of 0.173 mSv/y in the main campus, open field and new campus respectively. The excess lifetime cancer risks ranged from 0.442 to 01.174 x 10^{-3} with a mean of 0.663 x 10^{-3}, 0.146 to 0.736 x 10^{-3} with an average of 0.405 x 10^{-3} and 0.295 to 0.736 x 10^{-3} with average 0.479 x 10^{-3} in main campus, open field and new campus respectively. The estimated averages of absorbed dose rates in the air within Niger Delta University were above the world average of 57 nGy/h. Annual Effective Dose Equivalent (AEDE) are below the safe limit of 1 mSv/y for humans. The results of this study provide baseline information on the background ionizing radiation and can be referenced for future works in the area.

Keywords: Background radiation level; Absorbed dose rate; Geiger muller counter.

I. Introduction

All living things have been exposed to radiation from the start of life on Earth. There are chiefly two sources of radiation, artificial and natural sources [1]. Artificial radiation could originate from radionuclides such as ^{95}Zr, ^{131}I and ^{137}Cs which are introduced by human activities like nuclear weapon testing, normal discharges and emission/effluence from nuclear reactors and accidental discharges, medicine, agriculture and industry. Other artificial sources of radiation include X-ray machines lantern-mantle. Natural radiation sources, on the other hand, are either due to cosmogenic radionuclides or primordial radionuclides [2]. Cosmogenic radionuclides are formed unceasingly by the contact of cosmic rays and matter in the sky. Many of the radionuclides like ^{7}Be, ^{3}H, ^{14}C, as well as ^{22}Na, result from these continuous bombardments. Primordial radionuclides are long-lived radionuclides, which were formed at the beginning when the elements that constituted the universe were created. Examples of primordial radionuclides are ^{238}U, ^{232}Th and ^{40}K. These primordial radionuclides elements have always existed in various degrees in the earth's crust and atmosphere, as well as every element that made up the earth, the human body included, being a product of the environment [3, 4]. Igneous rocks have largely been linked with high concentrations of the primordial radionuclides, resulting in elevated background radiation levels, whereas, sedimentary rocks, except a few shales and phosphate rocks, are linked to lower concentrations of radionuclides resulting in low levels of radiation [5]. Also, when rocks at a particular location erode, their particles are carried away by runoffs and are dumped in other locations. The characteristics of the deposited rock particles may then be different from those of the underlying host rock. Radiation can be advantageous and detrimental. Effects of radiation that are detrimental include cancer, mutation of genes, deterioration of bones, destruction of blood cells, and cataracts. Radiation exposure could lead to death of humans [6]. Radiation exposure is principally due to the release of radon gas from the decay chain of radioactive thorium (^{232}Th) and uranium (^{238}U), which exist in soil layers and construction materials mostly granite [7, 8]. A global annual equivalent dose rate exposure limit to ionizing radiation of 1 $mSvy^{-1}$ was set by the International Commission on Radiation Protection (ICRP) in 1990, for the safety of wildlife and human population [9]. Furthermore, the United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR), sets an average effective dose rate limit of 2.4 $mSvy^{-1}$ for indoor facilities like lecture venues, laboratories, offices and conference halls [5]. The amount of background radiation in a location to a level is subject to man's activities like construction and soil use. Accordingly, the soil of a barren area should show different radioactivity when compared to that of a cultivated area. Investigation of radiation levels in the living or work environment is essential, due to its health implications on human life. Studies on background radiation have been carried out using several methods. These methods include using suitable chambers, hand-held dosimeters, airborne scintillation counters, in-situ gamma spectrometry and laboratory-based gamma spectrometry [10, 11]. An increase in human activities as well as an influx of different rock types due to an increase in construction works in the Niger Delta University, has necessitated this study.

A. Study Area

The Niger Delta University is situated between latitude 4 $97° N - 4.99° N$ and longitude $6.09° E - 6.11° E$. Niger Delta University is on the Wilberforce Island, Bayelsa state, Nigeria. It is a multi-campus, state government-funded university that was established in 2000. The area of study is inside the lower segment of upper flood plains deposits of the subaerial Niger Delta. Its underlying Agbada formation differs in size from 300 meters to 4500 meters. It is made up of mostly unconsolidated pebbles and rough-to smooth-grained sand units. [12]. The map of the study area is depicted in Fig. 1.

II. MATERIALS AND METHODS

A. Materials

A well-standardized nuclear radiation monitoring meter was used to measure the radiation exposure rate in this study. The detector is a Geiger-Muller tube (Radiation Alert) which can detect background ionizing radiation (BIR) within the temperature range of -10 ℃ to 50 ℃ [13]. The meter was calibrated using a 137Cs source, with specific energy to quantify the exposure rates in milli Roentgen per hour (mRh^{-1}) and an accuracy of ±15%.

B. Methods

1) Sample Collection

The campus was divided into three locations, the old campus, the open field, located between the old and new campus, and the new campus. Measurements were carried out in a total of 60 points, 20 per location. At each point, the detector was held at a height, of 1 m from the ground while making its window to face the supposed source for actual detection [14]. It was switched on to measure absorbed radiation for about two seconds, and the highest steady reading was recorded. The process was repeated at each point and two consecutive readings were obtained at each location and an average value in milli Roentgen per hour (mRh^{-1}) was recorded.

2) Absorbed Dose Rate

Absorbed dose rate gives a measure of radiation energy which may be absorbed by likely unprotected persons. Detected outdoor background exposure levels were changed to radiation absorbed dose rate, using (1).

$$1\mu Rh^{-1} = 8.7\ \eta Gyh^{-1} = \frac{8.7 \times 10^{-3}}{(1/87600y)} nGyh^{-1}$$
$$1mRh^{-1} = 8.7\ nGh^{-1} \times 10^{3} = 8700\ nGyh^{-1} \quad (1)$$

3) Annual Effective Dose Equivalent (AEDE)

The annual effective dose equivalent is used in radiation evaluation and safety to measure the complete absorbed dose per annum. AEDE is used to determine the possibility of long-term effects that may occur in time to come. AEDE per annum received by the population and workers is determined using (2)

$$AEDE(mSvy^{-1}) = D(nGyh^{-1}) \times 8760 \times CF \times OF \times 10^{-3} \quad (2)$$

Where D is the absorbed dose rate in air, in $nGyh^{-1}$, 8760 h is the total hours in a year, CF is the dose conversion factor from absorbed dose to effective dose in Sv/Gy ($CF = 0.7\ Sv/Gy$), OF is occupancy factor, likely time people may spend within the area of study. $OF = 0.2$ for outdoor as it is probable time humans would spend 20% of their time outdoors [15].

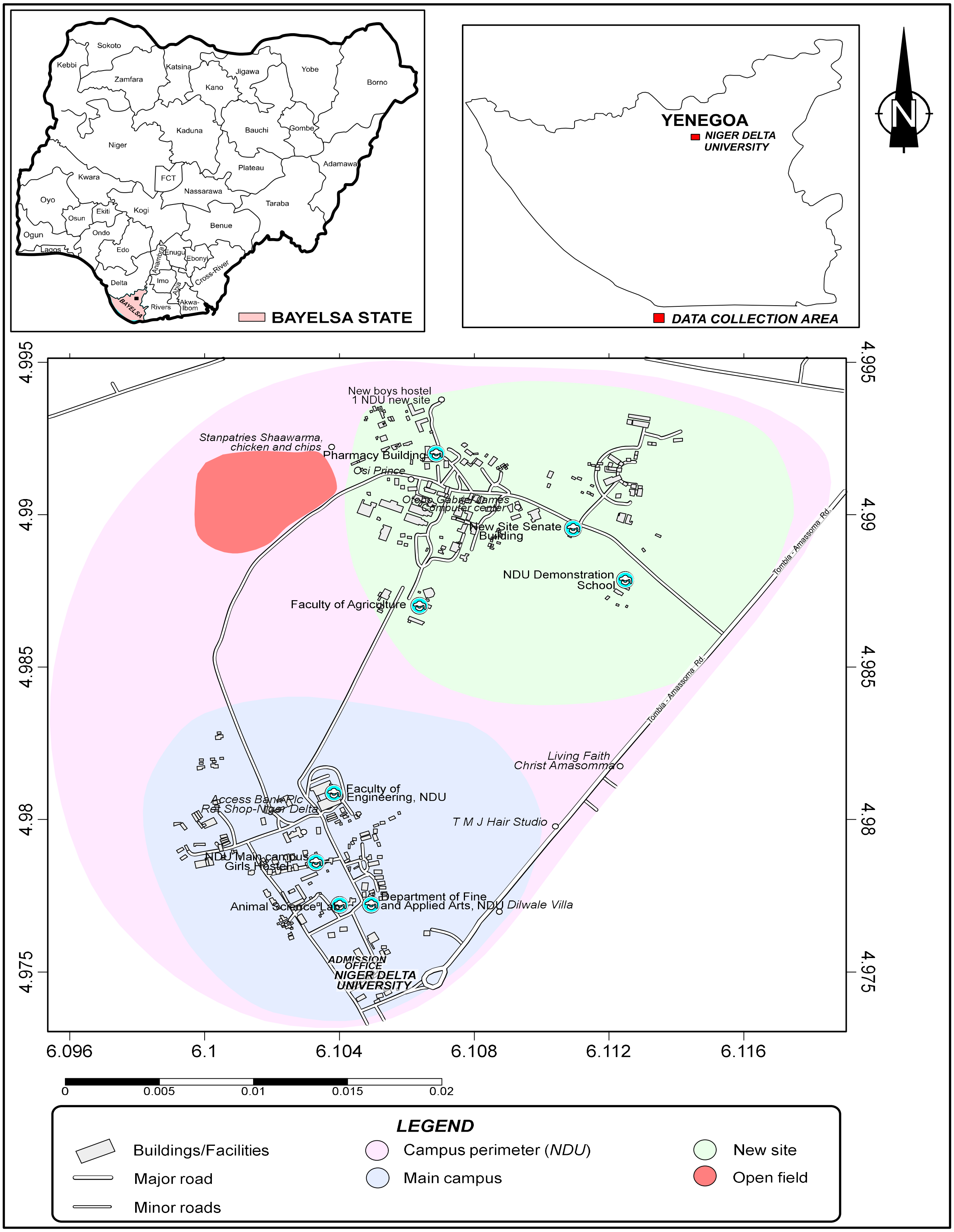

Fig. 1 Map of the Niger Delta University

4) Excess lifetime cancer risk

Excess lifetime cancer risk was evaluated by applying AEDE values using (3).

$$ELCR = AEDE(mSvy^{-1}) \times D\,L \times R\,F \quad (3)$$

Where DL is the average life duration (70 years) and RF is the fatal cancer risk factor per sievert, Sv^{-1}. For low-dose background radiation that can give rise to a stochastic effect, ICRP 103 uses a fatal cancer risk factor of 0.05 for the public [16].

III. RESULTS AND DISCUSSION

Exposure rates measured in three different areas of the university were determined. Table I presents background ionizing radiation (BIR), absorbed dose rate (ADR), annual effective dose equivalent (AEDE) and excess lifetime cancer risk (ELCR) in the main campus of Niger Delta University.

Table I Radiological parameters determined in the main campus

S/N	BIR (mRh^{-1})	ADR ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR × 10^{-3}
1	0.013	113.1	0.173	0.479
2	0.017	147.9	0.227	0.624
3	0.016	139.2	0.213	0.589
4	0.012	104.4	0.160	0.442
5	0.013	113.1	0.173	0.479
6	0.016	139.2	0.213	0.589
7	0.022	191.4	0.293	0.810
8	0.032	278.4	0.427	1.174
9	0.027	234.9	0.360	0.990
10	0.025	217.5	0.333	0.915
11	0.021	182.7	0.280	0.773
12	0.019	165.3	0.253	0.699
13	0.014	121.8	0.187	0.515
14	0.019	165.3	0.253	0.699
15	0.016	139.2	0.213	0.589
16	0.012	104.4	0.160	0.442
17	0.015	130.5	0.200	0.552
18	0.014	121.8	0.187	0.515
19	0.017	147.9	0.227	0.624
20	0.016	139.2	0.213	0.589
AVE	0.018	156.6	0.240	0.663

The absorbed dose rate ranged from 104.4 - 278.4 nGy/h with an average of 156.6 nGy/h. The estimated AEDE ranged from $0.160 - 0.427\,mSv/y$ with an average value of $0.240\,mSv/y$, while the estimated ELCR ranged from $0.442 \times 10^{-3} - 0.174 \times 10^{-3}$ with an average value of 0.663×10^{-3}.

Table II. depicts estimated values of radiological hazards in the open field area. The absorbed dose varies from 34.8 nGy/h to 174.0 nGy/h with an average value of 95.7 nGy/h, annual effective dose equivalent ranged from $0.053\,mSv/y$ to $0.267\,mSv/y$ with an average value $0.147\,mSv/y$ and excess lifetime cancer risk ranged from $0.146 \times 10^{-3} - 0.736 \times 10^{-3}$ with an average value of 0.405×10^{-3}.

Table II Radiological parameters determined in open field readings

S/N	BIR (mRh^{-1})	ADR ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR × 10^{-3}
1	0.012	104.4	0.160	0.442
2	0.015	130.5	0.200	0.552
3	0.009	78.3	0.120	0.332
4	0.011	95.7	0.147	0.405
5	0.008	69.6	0.107	0.295
6	0.016	139.2	0.213	0.589
7	0.006	52.2	0.080	0.222
8	0.009	78.3	0.120	0.332
9	0.004	34.8	0.053	0.146
10	0.006	52.2	0.080	0.222
11	0.011	95.7	0.147	0.405
12	0.008	69.6	0.107	0.295
13	0.004	34.8	0.053	0.146
14	0.009	78.3	0.120	0.332
15	0.016	139.2	0.213	0.589
16	0.013	113.1	0.173	0.479
17	0.012	104.4	0.160	0.442
18	0.015	130.5	0.200	0.552
19	0.013	113.1	0.173	0.479
20	0.020	174.0	0.267	0.736
AVE	0.011	95.7	0.147	0.405

Table III. depicts estimated values of radiological hazards in the new campus of the Niger Delta University. The absorbed dose varies from 69.6 - 174.0 nGy/h with an average value of 113.1 nGy/h, AEDE varies from 0.107 - 0.267 mSv/y with a mean value of 0.173 mSv/y and excess lifetime cancer risk varies from $0.295 \times 10^{-3} - 0.736 \times 10^{-3}$ with a mean value of 0.479×10^{-3}.

Fig. 1, 3 and 4 show the distribution of BIR in the main campus, open field and new campus as shown in tables I, II and III respectively. Fig. 5 shows the comparison of BIR values of the study area in percentage. The main campus contributes the highest exposure rate of 43% followed by the new campus 31% and the Open field contributes the lowest exposure rate of 26%. Fig. 6 compares average absorbed dose rate values obtained in the Niger Delta University with the world average value.

Table III Radiological parameters determined in new campus readings

S/N	BIR (mRh^{-1})	ADR ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR × 10^{-3}
1	0.015	130.5	0.200	0.552
2	0.008	69.6	0.107	0.295
3	0.017	147.9	0.227	0.624
4	0.016	139.2	0.213	0.589
5	0.012	104.4	0.160	0.442
6	0.009	78.3	0.120	0.332
7	0.016	139.2	0.213	0.589
8	0.017	147.9	0.227	0.624
9	0.009	78.3	0.120	0.332
10	0.015	130.5	0.200	0.552
11	0.009	78.3	0.120	0.332
12	0.014	121.8	0.187	0.515
13	0.008	69.6	0.107	0.295
14	0.009	78.3	0.120	0.332
15	0.009	78.3	0.120	0.332
16	0.012	104.4	0.160	0.442
17	0.014	121.8	0.187	0.515
18	0.015	130.5	0.200	0.552
19	0.008	69.6	0.107	0.295
20	0.020	174.0	0.267	0.736
AVE	0.013	113.1	0.173	0.479

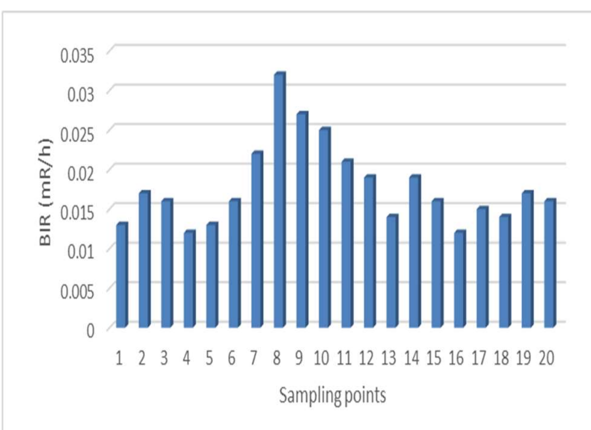

Fig. 2 Main campus exposure rate

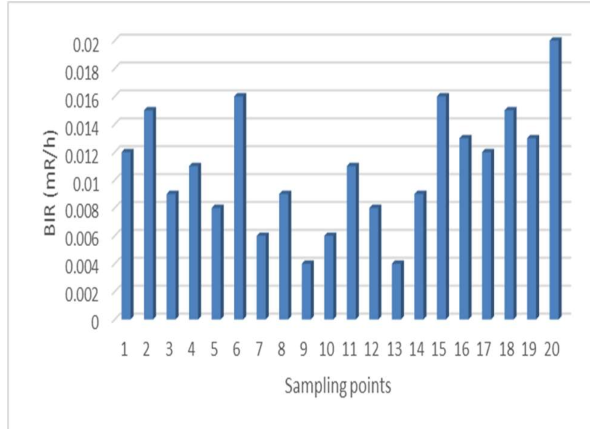

Fig. 3 Open field exposure rate

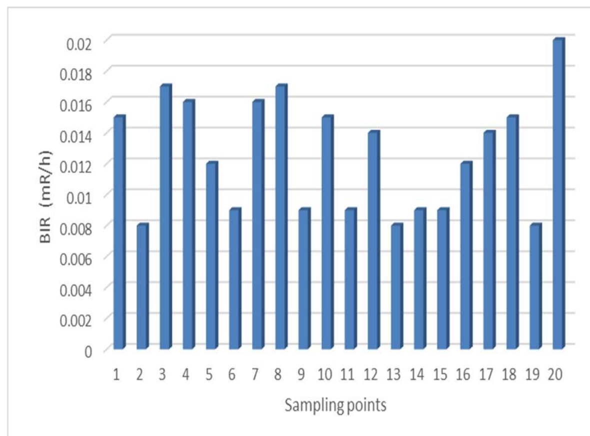

Fig. 4 New campus exposure rate

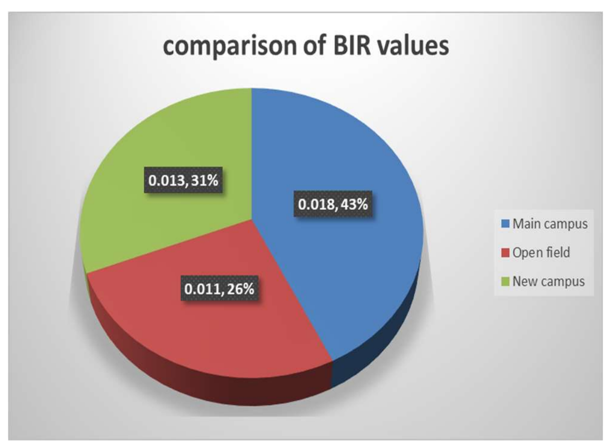

Fig. 5 Comparison of BIR values

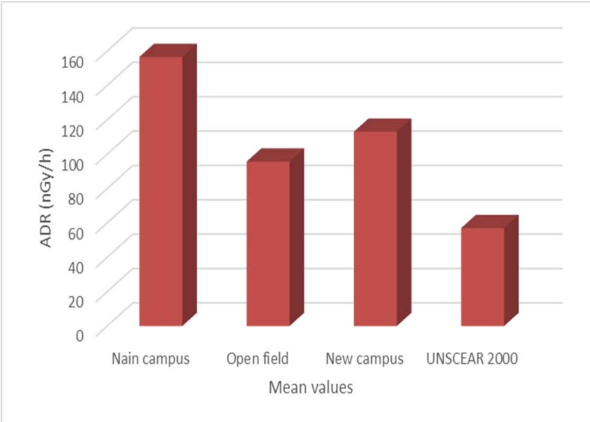

Fig. 6 Comparing absorbed dose rates mean with UNSCEAR 2000

From the results, the main campus contributes the highest BIR. The average value of absorbed dose rate in the open field is least compared to both the main campus and the new campus. All average values of AEDE obtained from the current study were lower compared to the world average of 0.48 mSv [5].

IV. CONCLUSION

Background ionizing radiation level in sections of the Niger Delta University has been evaluated using a calibrated radiation monitor. The calculated mean of absorbed dose rate in the air within Niger Delta University, is above the world average of 57 nGy/h, while the calculated AEDE are below the 1 mSvy-1 safe limit for the public. All averages of ELCR calculated in the study were above the world standard of 0.29×10^{-3}. Thus, the result obtained from this study suggests that the probability of people living within the study area developing cancer, mutation of genes, deterioration of bones, destruction of blood cells and cataracts due to exposure to natural radioactivity is quite significant. This study presents baseline information on background ionizing radiation which can be as referenced for future works in the area.

Reference

[1] N. O. Hashim, I. V. S. Rathore, A. M. Kinyua and A. O. Mustapha. "Natural and Artificial Radioactivity Levels in Sediments Along the Kenyan Coast", *Radiation Physics and Chemistry*. Vol. 71, pp. 805 – 806, 2004.

[2] UNEP, "Final Review of Scientific Information on Lead", United Nations Environment Programme. Chemical Branch, DTIE, pp. 332, 2010.

[3] D. Otwoma, J. P. Patel, S. Bartilol, and A.O. Mustapha. "Radioactivity and Dose Assessment of Rock and Soil Samples from Homa Mountain, Homa Bay County", Kenya.XI *Radiation Physics and Protection Conference*, Nasr City-Cairo, Egypt. 2012.

[4] U. K. Mayeen, J. J. Panakal and A. K. Hasan. "Determination of Primordial Radionuclides in Natural Samples Using HpGe Gamma-Ray Spectrometry", *APCBEE Procedia*. Vol. 1, pp. 187 - 192, 2012

[5] UNSCEAR, "Sources and effects of ionizing radiation". United Nations Scientific Committee on Effects of Atomic Radiation, New York. USA: United Nations publication, 2000.

[6] P. E. Ogola, W. M. Arika, D. W. Nyamai, K. O. Osano, H. O. Rachuonyo, J. R. Wambani, R. C. Lagat, S. M. Njagi, S. W. Mumenya, A. Koteng, M. P. Ngugi and R. O. "Oduor Determination of Background Ionizing Radiation in Selected Buildings in Nairobi County, Kenya", *J. Nucl. Med. Radiat. Ther.* Vol. 7, no. 3, pp. 1 – 7, 2016.

[7] E. H. El-Araby, D. H. Shabaan and Z. Yousef. "Evaluation of Radon Concentration and Natural Radioactivity Exposure from the Soil of Wadi Hodein Region, Egypt", *Int. J. Radiat. Res*. Vol. 19, no. 3, pp.719-727, 2021.

[8] C. P. Ononugbo and F. U. Nte. "Measurement of outdoor ambient radiation and evaluation of the radiological risk of coastal communities in Ndokwa East, Delta State Nigeria", *Advances in Research*, vol. 9, no. 6, pp. 1-11, 2017.

[9] ICRP, "Age-Dependence Dose to the members of the public from intake of radionuclides" International Commission on Radiological Protection Publication, Part 1, Pergamon Press Oxford, 1990

[10] E. E. Sunday, G. J. Nyakno, E, E. Ime and S. C. Nwokolo. "Assessment of Radiation Exposure Levels Within Ikot Akpanden Campus of Akwa Ibom State University, Nigeria", *IOSR Journal of Applied Physics*, vol. 7, no. 3. Pp. 86-91, 2015.

[11] A. O. Mustapha, P. E. Biere, A. E Ajetunmobi and J. O. Aina. "Applying in-Situ and Laboratory Based Gamma Spectrometry to Determine Activity Concentration and Distribution of 40K, 226Ra and 232Th in Abeokuta, Southwest Nigeria", *Jordan Journal of Physics*, vol. 14, no. 4, pp. 321-329, 2021.

[12] K. S. Okiongbo and E. Odubo "Geoelectric Sounding for the Determination of Aquifer Transmissivity in Parts Bayelsa State, South-South Nigeria", *Journal of Water Resource and Protection*, vol. 4, pp. 346-353, 2012.

[13] U. L. Anekwee and S. O. Ibe. "Estimation of radiation risk due to exposure to terrestrial radiation", *Archives of Current Research International*, vol. 9, no. 4, pp. 1-10, 2017.

[14] H. Taskin, M. Karavus, P. Ay, A. Topuzoghu, S. Hidiroglu and G. Karahan.."Radionuclide Concentration In Soil And Lifetime Cancer Risk Due To Gamma Radioactivity in Kirklareli, Turkey", *Journal of Environmental Radioactivity.* Vol. 100, no. 1, pp. 49-53, 2009.

[15] UNSCEAR, "Sources and effects of ionizing radiation report to the general assembly with

scientific annexes", New York, United Nations Scientific Committee on Effects of Atomic Radiation, vol. 1, pp. 235 – 236, 2008.

[16] ICRP, "Recommendations of the International commission on radiological protection", ICRP Publication 103, 2007.