Radioactivity Risk of Dump-Site Exposure to Students at Daniel Hall in Covenant University

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Abstract— **A radiometric assessment of the activity concentrations of ^{238}U, ^{235}Th and ^{40}K was conducted in Covenant University dump site located about 200-400 meters behind Daniel hall. For this study the RS-125 Super Spec hand held radiation detector was used alongside a GPS to take down location coordinates. Fifteen stations were measured, in the dump site, some meters away from the dumpsite, by the sides and in front of Daniel hall. The activity concentration of radionuclides varies from 11.42 ± 0.3 to 44.76 ± 0.2 Bqkg^{-1} with a mean value of 27.31 Bqkg^{-1} for ^{238}U, 33.29 ± 0.8 to 213.96 ± 0.4 Bqkg^{-1} with a mean value of 69.14 Bqkg-1 for ^{252}Th and 31.3 ± 0.2 to 1017.25 ± 0.6 Bqkg^{-1} with a mean value of 275.96 Bqkg^{-1}for ^{40}K. The absorbed gamma dose rates exposed to students around the area varies from 81.56 to 442.31 ± 2.2 nGry^{-1} with a mean value of 152.25 ± 2.2 nGry^{-1}.The annual outdoor and indoor effective dose equivalent was 0.18 mSv and 0.274 mSv respectively. Comparing the radiological health risks from the present study with the average world standard by ICRP (International Commission on Radiological Protection) and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR,2000) recommended standard values of 1 mSv, it is within the range. This study revealed that the risk exposure to the students at Daniel Hall may not be from the dump-site, rather, the granitic crushed rocks used for constructions near Daniel Hall may be the risk implication.**

Keywords— Dump-site, Activity concentration, Radiological assessment, Radionuclides

I INTRODUCTION

The presence of ionizing radiation in natural Environment was noted in 1899 and was assumed to originate from radioactivity in environmental materials like rivers, groundwater, soils and rocks. Ionizing radiation is an inseparable part of the living environment.

Naturally occurring radioactive materials (NORM) are found throughout the earth's crust, and they form part of the natural background radiation to which all humans are exposed. Natural radiation is of two origins extraterrestrial and terrestrial.

Extraterrestrial radiation originates from outer space as primary cosmic rays. Their interactions with earth's atmosphere give rise to secondary cosmic rays to which living beings on earth are exposed to. The dose rate from cosmic rays varies with latitude and altitude. There is little that can be done about exposure to cosmic rays since it readily penetrates ordinary buildings.

Terrestrial radiation is emitted from radioactive nuclides present in varying amounts of all soils, rocks, the atmosphere and the hydrosphere and from radionuclides that are transferred to man through food chains or by inhalation and deposited in his tissues. Terrestrial radiation leads to internal and external radiation. The presence of these (NORM) in soil, rocks, water, and air, along with cosmic radiation result in continuous and unavoidable internal and external radiation exposures of all human [7]

More than 200 types of atomic nuclei that are radioactive and are sources of alpha, beta and gamma radiation are known in nature. The most important elements contained in rocks that cause gamma radiation are uranium, thorium and potassium which concentrate in the near-surface layer 150 mm thick. These radiations are exposed to inhabitants of Earth which requires immediate attention [2].

In groundwater, uranium and other toxic elements are present in particulate and dissolved form due to certain minerals such as uranite, pitchblende and conalite or as secondary mineral in form of complex oxide of silicate, phosphate, validates lignite and monazite sands.

Human activities such as industrialization is the main cause of man's exposure to radiation cosmic ray contribute just a little. The global average annual effective dose arising from natural source of radiation is 2.4mSv [7].Studies on radiation level and radionuclide distribution in the environment provide vital radiological baseline information on human exposure to NORM which may be relevant to radiation protection. X-rays used in hospitals are the most recognized source of artificial radioactivity. A chest x-ray for instance would a dose equivalent to the lungs of about 0.1 mSv. Radionuclides are also administered to patients for diagnostic and therapeutic purposes such as treatment of cancer.

Radiation exposure can also be as a result of large scale production of electric power by nuclear fission. The nuclear fuel cycle includes mining and production of the uranium ore, fuel fabrication and enrichment, power production in the reactors and finally the reprocessing of the spent fuel. Selfluminous wrist watches and color televisions also emit radionuclides as they x-rays.

II GEOLOGY AND GEOGRAPHIC LOCATION OF THE STUDY AREA

Covenant University is in Ota, Ogun State, which falls within the Eastern Dahomey (Benin) Basin of south-western Nigerian that stretches along the continental margin of the Gulf of Guinea. Rocks in the Dahomey basin are Late Cretaceous to Early Tertiary in age [3]. The stratigraphy of the basin has been classified into Abeokuta Group, Imo Group, Oshoshun, Ilaro and Benin Formations. The Cretaceous Abeokuta Group consist of Ise, Afowo and Araromi Formations consisting of poorly sorted ferruginized grit, siltstone and mudstone with shale-clay layers.

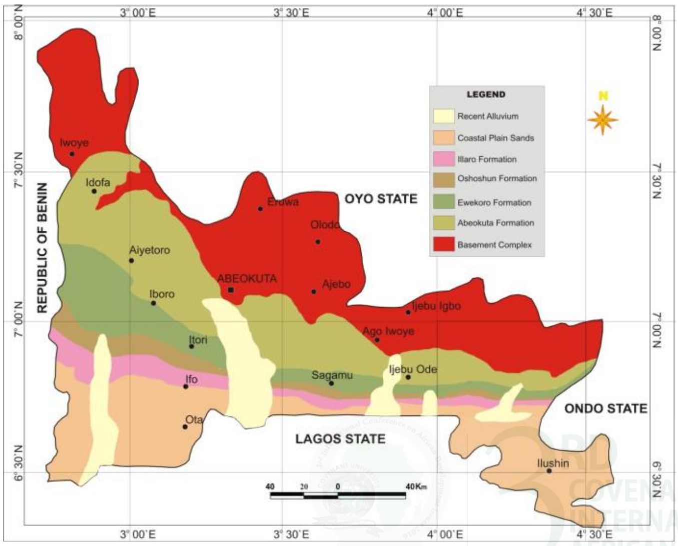

Figure 1 shows Geological Map of Ogun State Gotten from Geological Survey Agency Abuja.

III MATERIALS AND METHODS

Gamma radiation (GR) dose rates were measured 1 m above the soil from various locations at the dump-site. The measurement points were chosen based on the level of waste deposits and the Students Hostel which is the target of assessment of the area avoiding cliff and non-arable land. The GR dose rates were measured at each point using a gamma-ray detector, and the coordinates (latitude and longitude) of each surveying point were recorded with a Global Positioning System made of (Garmin :GPSmap 72H) .An average value was recorded from four measurements around each point. The detector used was model (Super SPEC RS-125), manufactured by Canadian Geophysical Institute. It has high accuracy with probable measurement errors of about 5%. It offers an integrated design with a large detector, direct assay readout, data storage and high sensitivity. The assay mode of RS-125 Super SPEC provides sample concentration analysis with direct data display of K (%), U (ppm) and Th (ppm). It uses sodium iodide (NaI) crystal doped with thallium [Tl] as activator. The approximate linear energy of the detector falls between 0.80 and 1.2 MeV, this range covers the majority of significant gamma-ray emissions from terrestrial sources. The detection of gamma-rays from cosmic rays is negligible due to the detector's low response to high-energy gamma radiation (6, 5). The instruments reading was in parts per million (ppm), the mean results were obtained and then converted to Becquerel per kilogram (Bqkg-1) with the conversion factor by (2). Microsoft excel software was used for the conversion analysis. The RS-125 spectrometer is calibrated on 1m X 1m test pads manufactured by Dr. R. L. Grasty et al, fully described in Geological Survey of Canada (1991) Report No.90-23. The calibration process utilizes 5 minutes spectra accumulation on K, U, Th pads and 10 min accumulation on the Background (BG) pad according to Canadian Geophysical Institute.

I Calculating the Radiation hazard indices

The radiation hazard indices obtained in this study includes:

(i) The annual effective dose outdoors (AEDEout), which took into account the conversion coefficient (0.7 Sv Gy−1) from the absorbed dose in air to effective dose, and the outdoor occupancy factor (~ 20 %) was calculated using Equation (1) according to [7] :

$$AEDE_{out}\,(\mathrm{mSv}) = D(\mathrm{nGy\,h^{-1}}) \times 8760\,(\mathrm{h}) \times 0.2 \times 0.7\,(\mathrm{Sv\,Gy^{-1}}) \qquad (1)$$

(ii) The radium equivalent activity (Raeq) which assesses the gamma radiation hazards associated with materials that contain 238U, 232Th and 40K was calculated using Equation (2) according to [7]:

$$Raeq = (AK \times 0.077) + ARa + (ATh \times 1.43) \qquad (2)$$

where ARa, ATh and AK are specific activity concentrations of 238U, 232Th and 40K, respectively, in Bq kg^{-1}. The recommended level of Ra_{eq} is 370 Bq kg^{-1}.

(iii) The external hazard index or outdoor radiation hazard index denoted by Hex was calculated using Equation (3) according to [7]:

$$H_{ex} = \frac{C_U}{370} + \frac{C_{TH}}{259} + \frac{C_K}{4810} \leq 1mSvy^{-1} \qquad (3)$$

Where Cu, C_{Th} and C_K are the specific activity concentrations of 238U, 232Th and 40K in dump-site and Daniel Hall, respectively, in Bq kg^{-1}. The value of this index should be less than 1, for the radiation hazard to be considered acceptable to the public [7].

IV RESULTS AND DISCUSSION

I Activity Concentrations of ^{238}U, ^{232}Th and ^{40}K in the Study Area

Table 1 below presents the activity concentrations of naturally occurring radionuclides of varying concentrations. Considering the activity levels of radionuclides (238U, 232Th and 40K) in the study area, it varies from 11.42 ± 0.3 to 44.76 ± 0.2 Bqkg-1 with a mean value of 27.31 Bqkg-1 for 238U, 33.29 ± 0.8 to 213.96 ± 0.4 Bqkg-1 with a mean value of 69.14 Bqkg-1 for 252Th and 31.3 ± 0.2 to 1017.25 ± 0.6 Bqkg-1 with a mean value of 275.96 Bqkg-1 for 40K. The highest activity level of all the nuclides were found at station 13 with values of 37.67 ± 0.03 Bqkg-1 , 213.96± 1.05 Bqkg-1 and 1017.25 ± 6.5 Bqkg-1 for 238U, 232Th and 40K, respectively. This effect of higher values found outside the dump-site nearer Daniel Hall may be attributed to the imported building materials used for fillings and granites used for the construction of car packs. It can be observed that the major radionuclide that is most abundant in the area is 40K whereas the lowest in abundance is 238U. It may be that 40K contributed the highest exposure to the surrounding considering how richly found at the site of study. 238U and 232Th have lower radiation effects to the environment when compared to their 40K counterpart.

Table 1 Activity concentrations of naturally occurring radionuclides of varying concentrations.

Stations	U(Bq.kg^-1)	Th(Bq.kg^-1)	K(Bq.kg^-1)
1	23.77 ± 0.02	48.72 ± 0.24	54.78 ± 0.35
2	23.77 ± 0.02	48.42 ± 0.24	31.30 ±0.20
3	27.48 ± 0.02	44.96 ± 0.22	46.95 ±0.30
4	24.08 ± 0.02	39.89 ± 0.12	62.60 ±0.40
5	27.17 ± 0.02	34.92 ± 0.17	93.90 ±0.60
6	26.24 ± 0.02	35.63 ± 0.18	86.08 ±0.55
7	23.77 ± 0.02	33.29 ± 0.16	101.73 ±0.65
8	23.16 ± 0.02	38.47 ± 0.19	31.30 ±0.20
9	15.13 ± 0.01	49.63± 0.25	281.70 ±1.80
10	40.45 ± 0.03	120.48 ± 0.59	469.50 ±3.00
11	44.77 ± 0.04	108.81 ± 0.54	555.58 ±3.55
12	37.67 ± 0.03	112.67 ± 0.56	563.40 ±3.60
13	37.67 ± 0.03	213.96± 1.05	1017.25 ± 6.5
14	11.42 ±0.01	46.49 ± 0.23	367.78 ± 2.35
15	23.16 ± 0.02	60.90 ± 0.30	375.60 ± 2.40

II External Gamma Radiation (Gr) Dose Rates Assessments

Total number of fifteen (15) stations of external gamma dose rates were measured 1 m above the ground in the study area, with 10 stations within the dump site and 5 stations outside the dump site (Daniel hall) . The external gamma dose varies from 81.56 ± 2.25 to 442.31 ± 2.2 nGry-1 with a mean value of 152.25 ± 2.2 nGry-1. Comparing the mean value of gamma dose rate obtained in this present study with the world average value, it is approximately three times the world average value of 59 nGy h−1. The highest value of 442.31 ± 3.67 nGy h−1 was noted close to the hostel, about 58 m away (station 13), which is approximately eight times the world average standard but noticed that the effect of higher such value was from crushed granites composed of igneous rocks that have crystallized from molten magma, which usually results in higher gamma dose rate values [4, 6], used for road and car park constructions at the Daniel Hall. Table2 shows the mean values of GR dose rates for each sample station.

Table2 Mean values of GR dose rates for each sample station

Stations	Dose rate $nGry^{-1}$
1	99.16 ± 4.53
2	96.63 ± 2.77
3	95.92 ± 2.99
4	86.95 ± 4.36
5	82.72 ± 3.70
6	88.99 ± 1.63
7	81.56 ± 2.25
8	85.58 ± 1.88
9	102.2 ± 1.63
10	258.0 ± 13.3
12	252.45 ± 5.34
13	442.31 ± 3.67
14	112.58 ± 3.67
15	145.31± 2.92

The GR dose rate in the study area was plotted against station points as shown in Figure 2 below, for easy location peak level that poses higher exposure value to the environment. It can be noted that station 13 has the highest GR dose rate exposure to the students at Daniel Hall which was attributed to the granitic materials imported for building/construction purposes at the car park. The least value was observed at the entrance of the dump-site (station 1).

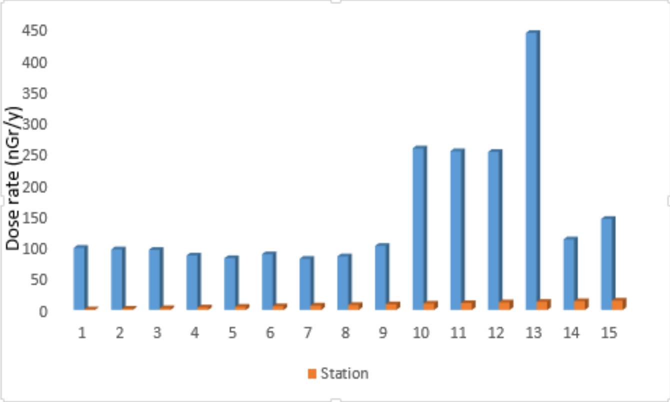

Figure 2 : Graph of Gamma Dose Rate against Stations in the Study Area.

II Calculation Of Radiological Effects

Radium Equivalent Uranium (Req)

From the results obtained in activity concentration of 238U, 232Th and 40K, radiation hazard indices associated with this study for radium equivalent uranium using Equation (2) was 147.45 ± 0.6 Bqkg-^{1} . This result when compared with the International standard value of 370 Bq kg^{-1}, it was lower by a factor of 2.5.

III External Hazard Index (Hex)

External hazard index was determined from the Radiation exposure due to 238U, 232Th and 40K according to Beretka and Matthew 1985. For calculating external hazard index, the formula below was used. In the study area, the value obtained for the external hazard index is 0.39. Comparing the present work with the international standard value of 1 and the considered acceptable level to the general public [1, 3 7], it can be noted that the present work is below with a factor of 2.5. The external hazard index may not have any health risk to the students in Daniel Hall

IV Annual Effective Dose Equivalent (AEDE)

The AEDE was calculated using the dose conversion factor of 0.7 Sv/Gy for the absorbed dose in air [7], the world average occupancy factor for outdoor is 0.8 and 0.2 respectively [7]. Daniel hall boys spend almost six (6) hours outdoors and eighteen (18) hours indoors. AEDE is determined using the following equations (1). The AEDE for outdoor obtained in this present study is 0.18 mSv. Comparing this value with the International Reference Standard value of 0.07 mSv according to [7], it can be observed from Figure 3 below that this present work is twice higher than the standard value.

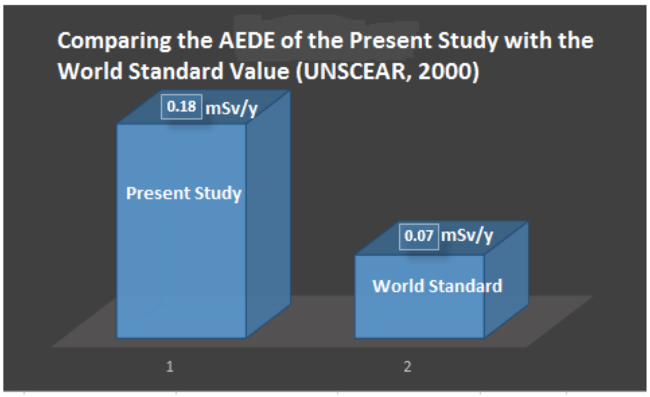

Figure 3. Comparison of the AEDE of the Present Study with the International Standard Value [7]

V CONCLUSION

The natural radioactivity from the waste materials at the dump-site and the related radiological health implication in the environmental of Daniel Hall were obtained. The mean gamma dose rate was found to be 152.25 ± 2.2 nGry-1, which gives the AEDE outdoors of 0.18 mSvy-1 was measured. These values are three times more than the world average values of 59 nGy h−1 and 0.07 mSv, respectively. Few areas of enhanced activity were noted in the Dump-site and Car park in front of Daniel Hall. These areas at the Daniel Hall are predominantly covered with granitic crushed materials used for constructions. These areas have the highest values for activity concentrations of radionuclides. The radium equivalent activities (*R*eq) and external hazard index (*H*ex) were below the recommended values of 370 Bq kg^{-1} and 1, respectively according to [7]. Further research on soil geochemistry and indoor gamma dose rate and radon assessment in Daniel Hall is highly recommended so as to draw a conclusion on the cancer fatal risks level.

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