ASSESSMENT OF GAMMA RADIATION DUE TO TERRESTRIAL SOURCES IN SOUTH WESTERN NIGERIA.

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ABSTRACT

The activity concentration of naturally occurring radionuclides in twenty one (21) soil samples from selected areas in south western Nigeria has been determined using the $7.6 \times 7.6\, cm$ NaI(Tl) detector. The average activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Ibadan areas were 19.57 ± 6.84, 51.44 ± 20.94 and 97.06 ± 32.90 Bqkg^{-1} respectively, ranging from 10.1 to 31.7, 17.9 to 81.0 and 55.1 to 133.7 Bqkg^{-1} respectively while the average activity concentrations in Lagos study areas were 17.8 ± 10.16, 32.21 ± 13.16 and 166.73 ± 33.03 Bqkg^{-1} respectively, ranging from 5.3 to 33.5, 17.7 to 53.2 and 121.7 to 211.4 Bqkg^{-1} respectively and the average activity concentrations of radionuclides in Ohunbe study areas were 29.17 ± 9.31, 13.03 ± 7.68 and 55.96 ± 11.76 Bqkg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K respectively, ranging from 19.2 to 44.5, 3.4 to 19.4 and 40.6 to 71.3 Bqkg^{-1} respectively. The absorbed dose and effective doses were also calculated. The effective dose in all sites were lower than the permissible limit of 1 mSv/yr, hence the possibility of radiological hazard is low.

Keywords: activity concentration, absorbed dose, effective dose

INTRODUCTION

Nigeria consists of thirty-six states comprising six geopolitical zones which includes South west. Generally, the area covered by the south western Nigeria lies between latitude 7^0N and 10^0N and longitude 2^0E and 7^0E (Faleyimu et. al., 2013). Southwest Nigeria is bounded in the west by Benin republic, in the south by the gulf of Guinea, in the north by the North Central and in the east by the South south Nigeria. The climate of south western Nigeria is tropical in nature and it is characterized by wet and dry seasons. The temperature range between 21 and 34°C while the annual rainfall range between 150 and 3000 mm. Three cities were selected for the purpose of these research; two urban (Lagos and Ibadan) and one rural area (Ohunbe study areas). Lagos is famously regarded as the most populated city and Ibadan is the largest as regards land mass in the south west Nigeria while Ohunbe is rural area in Ogun state.

Exposure to ionizing radiation from natural sources is a continuous and unavoidable feature of life. Human beings are exposed to natural background radiation every day from the soil, rock, water, building materials, air, food, outer space, and even elements in their own bodies. Gamma radiation emitted from primordial radionuclide and their progeny is one of the main external sources of radiation exposure to the humans (UNSCEAR, 2000). Terrestrial radioactivity and the associated external exposure due to gamma radiation, depend primarily on the geological formation and soil type of the location; and these factors (geology and soil type) greatly influence the dose distribution from natural terrestrial radiation (UNSCEAR, 2010). Since natural radiation is the largest contributor of external dose to the world population, assessment of gamma radiation dose from natural sources is of particular importance. The concentrations of ^{232}Th, ^{226}Ra and ^{40}K vary widely depending on the location. Majority of the external gamma dose rate above typical soils (95%) arises from primordial radionuclides incorporated in the soil. In addition, soil acts as a source of transfers of radionuclides through the food chain depending on their chemical properties and the uptake process by the roots to plants and animals (Muneer A. S., 2013) hence, it is the basic indicator of the radiological status of the environment.

MATERIALS AND METHODS

Sample Collection

Twenty (21) soil samples were collected randomly from the selected sites. Seven (7) soil samples were collected each from Lagos, Ibadan and Ohunbe respectively. The samples were air dried in the laboratory to remove moisture. The dry soil samples were homogenized and sieved through 2mm sieve. Two hundred grams (200g) of each of the prepared samples were weighed into 0.3 litre plastic containers, sealed and left for about 30 days. This was done to enable the short lived decay products of ^{222}Rn reach secular radioactive equilibrium with ^{226}Ra prior to gamma spectroscopy (Bello et. al., 2014).

Analysis

The spectrometry analysis of the samples was carried out using a gamma spectrometry system consisting of a Sodium Iodide activated with Thallium [NaI(Tl)] detector, Model 802 (7.6 cm x 7.6 cm) coupled to a Canberra series 100 multichannel analyzer (MCA) through a photomultiplier tube/preamplifier/amplifier base. The detector was placed in 10cm thick lead shield to reduce the effects of natural background radiation. The detector has a resolution of 8% Full Width at Half Maximum (FWHM) at ^{137}Cs energy of 0.662, which is capable of distinguishing the gamma-ray energies of interest in this study. The activity concentration of ^{214}Bi (determined from its 1.760 MeV gamma-ray peak) was chosen to provide an estimate of ^{226}Ra in the sediment samples, while that of the daughter radionuclide ^{208}Tl (determined from its 2.615 MeV gamma-ray peak) was chosen as an indicator of ^{232}Th. ^{40}Kwas determined by measuring the 1.460 MeV gamma-rays emitted during its decay. These transition gamma-ray peaks of the higher energies chosen for the determination of concentrations of ^{226}Ra, ^{232}Th and ^{40}K in the sediments were sufficiently separated such that the contribution of background continuum in their peak areas determination was very low.

The activity concentrations of the radionuclides in the samples were obtained using Eq. (1).

$$C(\mathrm{Bq\ kg^{-1}}) = kC_n \qquad (1)$$

Where C is the specific activity concentration of the radionuclide in the sample in Bqkg^{-1}, C_n is the count rate under the corresponding peak, k is the probability constant which is the multiplicative factor which is constant for each radionuclide at constant geometry.

$$k = \frac{l}{\varepsilon P_r M_s} \qquad (2)$$

Where P_r is the absolute transition probability of the specific gamma ray. M_s is the mass of sample in Kg. ε is the detector efficiency at the specific gamma energy.

The absorbed dose rate (D) is a measure of the amount of energy from an ionizing radiation deposited in a mass of some material or tissue at 1 m above the ground. This was calculated from the specific activities of ^{226}Ra, ^{232}Th, and ^{40}K in the samples from the study areas. Contributions from other radionuclides to total dose from environmental background were neglected in this calculation since they were assumed to be very insignificant. D was calculated from equation 3 (Jibiri and Okeyode , 2012):

$$D(nGyh^{-1}) = 0.462\,A_{Ra} + 0.604\,A_{Th} + 0.0417\,A_K \qquad (3)$$

Where A_{Ra}, A_{Th}, and A_K are the respective activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Bqkg^{-1}. 0.462, 0.604 and 0.0417 nGyh^{-1} per Bqkg^{-1} are the dose conversion factors (UNSCEAR, 2010) for ^{226}Ra, ^{232}Th, and ^{40}K, respectively.

The mean annual effective dose to man was calculated using equation 4. The conversion factor of 0.7 SvG/yr for dose rates in air and an outdoor occupancy ratio of 0.2 (UNSCEAR, 1988) were used.

$$AED(mSvy^{-1}) = D(nGyh^{-1}) \times 8760(hy^{-1}) \times 0.7(SvGy^{-1}) \times T \times 10^{-6} \quad (4)$$

Results and Discussion

The 21 study sites are shown in table 1. The activity concentration of ^{226}Ra, ^{232}Th and ^{40}K, the calculated absorbed dose rates and the annual effective dose for Ibadan study areas, Lagos study areas and Ohunbe study areas are presented in Table 2, Table 3 and Table 4 respectively.

Table 1: The study sites

S/N	Location	S/N	Location	S/N	Location
1	Omi Adio	8	Kola	15	Ibayun
2	Sango	9	Alakuko	16	Oke Oyinbo
3	Soka	10	Oke Ira	17	Oke Imedu
4	Idiroko	11	Aguda	18	Igbeme
5	Oluloyo	12	Iju isaga	19	Oko Epo
6	Jegede	13	Fagba	20	Pedepo
7	Ifelodun	14	Agbado	21	Sawmill

Table 2 shows that the average activity concentrations of radionuclides in the soil samples of Ibadan study areas were 19.57 ± 6.84, 51.44 ± 20.94 and 97.06 ± 32.90 $Bqkg^{-1}$ for ^{226}Ra, ^{232}Th and ^{40}K respectively, ranging from 10.1 to 31.7, 17.9 to 81.0 and 55.1 to 133.7 $Bqkg^{-1}$ respectively. The absorbed dose rate and effective dose ranged from 19.29 to 63.76 $nGyh^{-1}$ and 0.02 to 0.08 $mSvy^{-1}$ with average values of 44.13 ± 17.85 and 0.06 ± 0.02 respectively.

Table 2: Actvity Concentration, Absorbed Dose and Effective dose in Ibadan Study areas

Location	^{226}Ra (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Absorbed Dose ($nGyh^{-1}$)	Effective Dose ($mSvy^{-1}$)
1	10.1	17.9	99.3	19.29	0.02
2	21.4	44.1	70.3	39.45	0.05
3	14.2	37.2	55.1	31.33	0.04
4	17.8	59.3	72.5	47.43	0.06
5	18.9	51.4	141.3	45.66	0.06
6	31.7	69.2	133.7	62.02	0.08
7	22.4	81.0	107.2	63.76	0.08
Mean	19.57 ± 6.84	51.44 ± 20.94	97.06 ± 32.90	44.13 ± 17.85	0.06 ± 0.02
Range	10.1 – 31.7	17.9 – 81.0	55.1 – 133.7	19.29 – 63.76	0.02 – 0.08

Table 3 shows that the average activity concentrations of radionuclides in the soil samples of Lagos study areas were 17.8 ± 10.16, 32.21 ± 13.16 and 166.73 ± 33.03 $Bqkg^{-1}$ for ^{226}Ra, ^{232}Th and ^{40}K respectively, ranging from 5.3 to 33.5, 17.7 to 53.2 and 121.7 to 211.4 $Bqkg^{-1}$ respectively. The absorbed dose rate and effective dose ranged from 25.80 to 48.57 $nGyh^{-1}$ and 0.03 to 0.06 $mSvy^{-1}$ with average values of 34.34 ± 16.57 and 0.04 ± 0.01 respectively.

Table 3: Activity Concenration, Absorbed Dose and Effective Dose in Lagos Study areas

Location	^{226}Ra (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Absorbed Dose ($nGyh^{-1}$)	Effective Dose (mSv/yr)
8	24.6	53.2	121.7	48.57	0.06
9	15.9	19.7	157.2	25.80	0.03
10	13.2	34.8	189.9	35.87	0.04
11	23.6	17.7	183.4	30.00	0.04
12	8.5	45.1	176.7	34.41	0.04
13	33.5	23.2	211.4	38.80	0.05
14	5.3	31.8	126.8	26.95	0.03
Mean	17.8 ± 10.16	32.21 ± 13.16	166.73 ± 33.03	34.34 ± 16.57	0.04 ± 0.01
Range	5.3 – 33.5	17.7 – 53.2	121.7 – 211.4	25.80 – 48.57	0.03 – 0.06

Table 4 shows that the average activity concentrations of radionuclides in the soil samples of Ohunbe study areas were 29.17 ± 9.31, 13.03 ± 7.68 and 55.96 ± 11.76 $Bqkg^{-1}$ for ^{226}Ra, ^{232}Th and ^{40}K respectively, ranging from 19.2 to 44.5, 3.4 to 19.4 and 40.6 to 71.3 $Bqkg^{-1}$ respectively. The absorbed dose rate and effective dose ranged from 12.62 to 33.98 $nGyh^{-1}$ and 0.02 to 0.04 $mSvy^{-1}$ with average values of 23.68 ± 6.36 and 0.03 ± 0.01 respectively.

Table 4: Activity Concentration, Absorbed Dose and Effective Dose in Ohunbe Study areas

Location	^{226}Ra (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Absorbed Dose ($nGyh^{-1}$)	Effective Dose (mSv/yr)
15	30.2	13.2	55.3	24.23	0.03
16	44.5	17.3	71.3	33.98	0.04
17	28.3	9.2	69.2	21.52	0.03
18	19.2	3.4	40.6	12.62	0.02
19	37.7	11.9	61.5	27.17	0.03
20	23.9	19.4	43.7	24.57	0.03
21	20.4	16.8	50.1	21.66	0.03
Mean	29.17 ± 9.31	13.03 ± 7.68	55.96 ± 11.76	23.68 ± 6.36	0.03 ± 0.01
Range	19.2 – 44.5	3.4 – 19.4	40.6 – 71.3	12.62 – 33.98	0.02 – 0.04

Table 2-4 show that Ibadan has the highest average value of absorbed rate and Effective dose (44.13 ± 17.85 and 0.06 ± 0.02 respectively) while Ohunbe has the lowest (23.68 ± 6.36 and 0.03 ± 0.01 respectively) and is presented in figure 1 below.

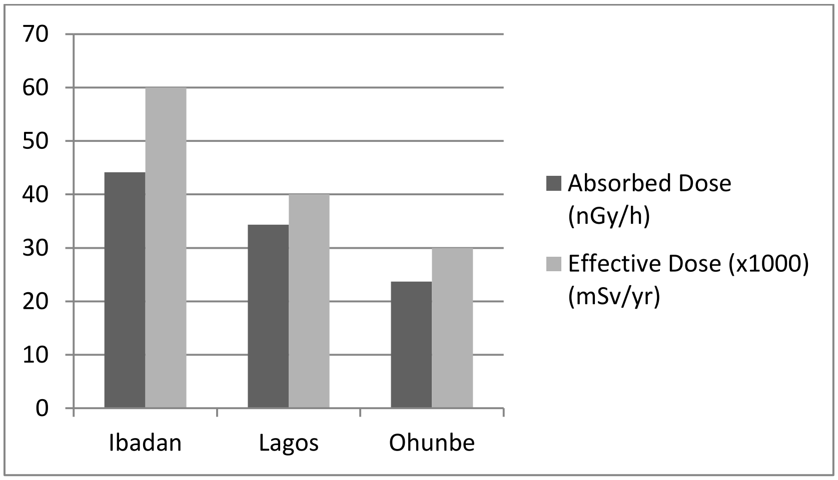

Figure 1: Absorbed dose and effective dose Average in the surveyed locations.

Conclusion

The average activity concentration of ^{226}Ra, ^{232}Th and ^{40}K in all the study sites were lower than the world average 40, 35 and 400 $Bqkg^{-1}$ (UNSCEAR, 2000) respectively except for Ibadan that has an average activity concentration of ^{232}Th of 51.44 $Bqkg^{-1}$ which is higher than its respective average. The mean absorbed dose rate in all the study areas were lower that the world average of 58 nGy/h. The average effective dose in all the study areas were lower than 1 mSv/yr which is the maximum permissible for the general public (ICRP, 1999). Hence the occurrence of any radiological hazard is low. The data can also be used as baseline for other epidemiological studies.

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