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Research Article

Gamma Emitting Radionuclides in Soils from Selected Areas in Douala-Bassa Zone, Littoral Region of Cameroon

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A study of natural radioactivity levels in some composites of eighteen soil samples selected within Douala-Bassa zone of Littoral Region has been evaluated. The samples were analysed using gamma spectrometry based broad energy germanium detector (BEGe 6350). The activity profile of radionuclide shows low activity across the studied areas. The obtained mean values of ^{226}Ra, ^{232}Th, and ^{40}K in the two campuses were 25.48 Bq/kg, 65.96 Bq/kg, and 39.14 Bq/kg for Campus 1 and 24.50 Bq/kg, 66.71 Bq/kg, and 28.19 Bq/kg for Campus 2, respectively. In terms of health analysis, some radiation health hazard parameters were calculated within the two campuses. The mean values of radium equivalent activity were 122.81 Bq/kg and 122.08 Bq/kg, absorbed dose rate in air was 99.13 nGy/h and 98.18 nGy/y, annual outdoor effective dose was 0.12 mSv/y and 0.12 mSv/y, and external health hazard index was 0.34 and 0.33 in Campus 1 and Campus 2, respectively. These health hazard parameters were seen to be below the safe limit of UNSCEAR 2000 except the absorbed dose rate in air and the annual outdoor effective doses which are relatively high compared to the values of 60 nGy/h and 0.07 mSv/y. These results reveal no significant radiological health hazards for inhabitance within the study areas.

1. Introduction

Gamma radiation emitted from naturally occurring radioisotopes, also called terrestrial background radiation, represents the main source of radiation of the human body. Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions and appear at different levels in the soils of each region in the world [1, 2]. Only radionuclides with half-lives comparable with the age of the earth or their corresponding decay products existing in terrestrial materials such as ^{232}Th, ^{238}U, and ^{40}K are of great interest. Abnormal occurrences of uranium and its decay products in rocks and soils and thorium in monazite sands are the main sources of high natural background areas that have been identified in several areas of the world [3]. Outdoors exposure to this radiation originates predominantly from the upper 30 cm of the soil [1]. According to the literature of natural radioactivity in soil, there is lack of information on natural radioactivity levels in soils from various living sites in Cameroon. Radionuclides in soil generate a significant component of the background radiation exposure to the population [3].

The knowledge of specific activities or concentrations and distributions of the radionuclides in soil is of great interest for many researchers throughout the world and serves as the reference in documenting changes to environmental radioactivity due anthropogenic activities or any release of radioactive elements [4, 5]. Monitoring of radioactive materials is therefore of primary importance to humans,

organisms, and environmental protection. The accumulation of such radioactivity may substantially contribute to collective radiation dose received by the local population living within this particular environment. Radiation exposure can damage living cells, causing death in some of them and modifying others.

There have been many surveys to determine the background levels of radionuclides in soils, which can in turn be related to the absorbed dose rates in air. All of these spectrometric measurements indicate that the three components of external radiation field, namely, from the γ-emitting radionuclides in the ^{238}U and ^{232}Th series and ^{40}K, made approximately equal contributions to the externally incident γ-radiation dose to individuals in typical situations both outdoors and indoors. Since 98.5% of the radiological effects of the uranium series are produced by radium and its daughter products, the contribution from the ^{238}U and other contributions of ^{226}Ra precursors are normally ignored.

The aim of the present study tends to assess the specific activity and examine radiation hazard indices of the naturally occurring radionuclides (^{226}Ra, ^{232}Th, and ^{40}K) in soil samples from the two campuses of the University of Douala-Cameroon using broad energy gamma-ray spectrometry based high purity germanium detector.

1.1. Overview of the Study Area. The field experiment was carried out at the two campuses of the University of Douala-Cameroon (04°03′14.8″–04°03′29.7″N and 09°44′00.1″–09°44′45.2″W). The studied sites are located within the Douala-Bassa zone where the geology of the region is compromised by the sedimentary rocks, namely, by the tertiary to quaternary sediments as seen in Figure 1. These sedimentary rocks found in the Douala-Bassa zone (within the Douala basin) consist of poorly consolidated grits and sandstones that occasionally display bedding with a few intercalations of limestone and shale. Soils in Douala-Bassa zone vary from yellow through brown to back, freely drained, sandy ferralitic [6].

1.2. Samples Collection and Preparation Techniques. Composites of eighteen soil samples were randomly chosen from the two campuses of University of Douala (seven from small area coverage of Campus 1 ESSEC situated at Angel-Raphael and eleven from large area coverage of Campus 2 located at Ndong-Bong Douala-Bassa). The vertical or near vertical surface was dressed (scraped) to remove smeared soil. This was necessary to minimize the effects of contaminant migration interferences due to smearing of material from other levels. Each composite sample was a mixture of five samples collected within an area of 5 m^2 separated from each other by a distance of 300 m to cover the study site and to observe a significant local spatial variation in terrestrial radioactivity. Each sampling point was marked using a global positioning system (GPS). Four samples were collected at the edges (end corners) and one at the centre. These five samples collected at a depth of approximately 20 cm from the top surface layer were mixed thoroughly to form a composite sample and packed into a polyethylene bag to prevent contamination. The samples were transferred into the laboratory after they were labelled accordingly.

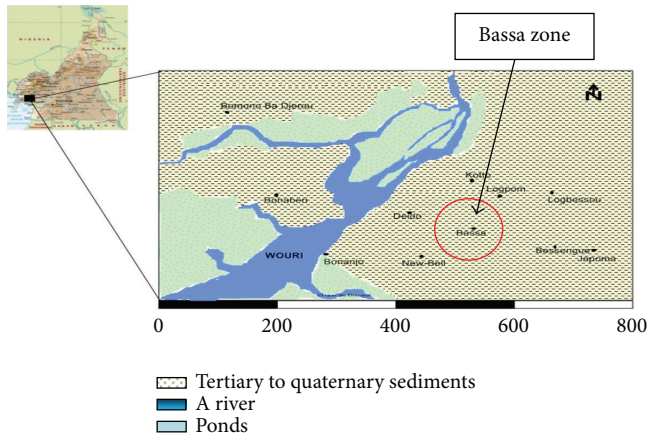


FIGURE 1: Map indicating the study area.

At the laboratory, the samples were air-dried for a week then oven-dried at 105°C for 24 hours. The dried samples were grinded into powder and sieved through a 2 mm wire mesh to obtain a uniform particles size. In order to maintain radioactive equilibrium between ^{226}Ra and its daughters, the soil samples were then packed in a 360 mL air tight polyethylene cylindrical container, dry-weighed, and stored for a period of 32 days for equilibrium between the long-lived parent and daughter nuclides.

2. Experimental

Each sample was subjected to a coaxial gamma-ray spectrometer consisting of broad energy germanium detector (BE6530) manufactured by Canberra Industries. The resolution of this detector is 0.5 keV at 5.9 keV for ^{55}Fe, 0.75 keV at 122 keV for ^{57}Co, and 2.2 keV at 1332 keV for ^{60}Co. The detector is placed in a low-level Canberra Model 747 lead shield with thickness of 10 cm.

The energy distributions of the radioactive samples were generated by the computer inbuilt Multiport II Multichannel Analyzer (MCA). Each sample was counted for 86400 seconds for effective peak area statistics of above 0.1%.

Following the sample analysis process, the specific activity concentration in Becquerel per kilogram (Bq·kg^{-1}) for each radionuclide was calculated after background separation using the Genie-2000 software incorporated with cascade summing correction coefficient.

Assuming a state of secular equilibrium between ^{238}U and ^{232}Th and their respective decay daughter products, the following relatively intense gamma-ray transitions were used to measure the activity concentrations for the above-mentioned radionuclides.

(a) ^{226}Ra concentration was calculated as a weighted mean of the activity concentrations of the gamma-rays of ^{214}Pb (295.1 keV, 351.9 keV), ^{214}Bi (609.3 keV and 1120.29 keV), and its specific gamma-ray at

186.2 keV. Interference correction due to the presence of 185.7 keV energy peak of ^{235}U has been taken into account and subtracted accordingly.

(b) The gamma-ray photopeaks used for the determination of the ^{232}Th contents were 338.4 keV, 911.2 keV, and 969.11 keV of ^{228}Ac and 238.6 keV of ^{212}Pb.

(c) ^{40}K was directly determined by using 1460.8 (10.7%) gamma-ray.

2.1. Health Hazard Parameters

2.1.1. Absorbed Dose Rate in Air (D). A direct connection between radioactivity concentrations of natural radionuclides and their exposure is known as the absorbed dose rate in the air at 1 metre above the ground surface. The mean activity concentrations of ^{226}Ra (of the ^{238}U series), ^{232}Th, and ^{40}K (Bq·kg^{-1}) in the soil samples were used to calculate the absorbed dose rate using the following formula provided by UNSCEAR [7] and European Commission [8]:

$$D\left(\text{nGy}\cdot\text{h}^{-1}\right) = 0.92A_{\text{Ra}} + 1.1A_{\text{Th}} + 0.08A_{\text{K}}, \quad (1)$$

where D is the absorbed dose rate in nGy·h^{-1} and A_{Ra}, A_{Th}, and A_{K} are the activity concentrations of ^{226}Ra (^{238}U), ^{232}Th, and ^{40}K, respectively. The dose coefficients in units of nGy·h^{-1} per Bq·kg^{-1} were taken from the UNSCEAR (2000) report [7–9].

2.1.2. Annual Effective Dose Equivalent. The absorbed dose rate in air at 1 metre above the ground surface does not directly provide the radiological risk to which an individual is exposed [10]. The absorbed dose can be considered in terms of the annual effective dose equivalent from outdoor terrestrial gamma radiation which is converted from the absorbed dose by taking into account two factors, namely, the conversion coefficient from absorbed dose in air to effective dose and the outdoor occupancy factor. The annual effective dose equivalent can be estimated using the following formula [7, 11]:

$$\text{AEDE}\left(\mu\text{Sv}\cdot\text{y}-1\right) = D\left(\text{nGy}\cdot\text{h}^{-1}\right) \times 8760\,\text{h} \times 0.2 \times 0.7\,\text{Sv}\cdot\text{Gy}^{-1} \times 10^{-3}. \quad (2)$$

The values of those parameters used in the UNSCEAR report (2000) are 0.70 Sv·Gy^{-1} for the conversion coefficient from absorbed dose in air to effective dose received by adults and 0.20 for the outdoor occupancy factor [7].

2.1.3. Radium Equivalent Activity. As a result of nonuniform distribution of natural radionuclides in the soil samples, the actual activity levels of ^{226}Ra, ^{232}Th, and ^{40}K in the samples can be evaluated by means of a common radiological index called radium equivalent activity (Ra_{eq}) [10, 12]. It is the most widely used index to assess the radiation hazards and can be calculated as given by Beretka and Mathew [10, 12]:

$$\text{Ra}_{\text{eq}}\left(\text{Bq}\cdot\text{kg}^{-1}\right) = A_{\text{Ra}} + 1.43A_{\text{Th}} + 0.077A_{\text{K}}, \quad (3)$$

where A_{Ra}, A_{Th}, and A_{K} are the activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in Bq·kg^{-1}, respectively.

The maximum permissible value of the radium equivalent activity is 370.00 Bq·kg^{-1} [7, 10]. This value corresponds to an effective dose of 1 mSv for the general public and radiation dose rate of 1.50 mGy·y^{-1} [7, 13].

2.1.4. External and Internal Hazard Indices. Many radionuclides occur naturally in terrestrial soils and rocks and, upon decay, these radionuclides produce an external radiation field to which all human beings are exposed. In terms of dose, the principal primordial radionuclides are ^{232}Th, ^{238}U, and ^{40}K. The decay of naturally occurring radionuclides in soil produces a gamma-beta radiation field in soil that crosses the soil-air interface to produce exposures to humans. The main factors which determine the exposure rate to a particular individual are the concentrations of radionuclides in the soil and the time spent outdoors. To limit the radiation exposure attributable to natural radionuclides in the samples to the permissible dose equivalent limit of 1.00 mSv·y^{-1}, the external hazard index based on a criterion has been introduced using a model proposed by Krieger (1981) which is given by [7, 14]:

$$H_{\text{ex}} = \frac{A_{\text{Ra}}}{370} + \frac{A_{\text{Th}}}{259} + \frac{A_{\text{K}}}{4810} \leq 1. \quad (4)$$

In order to keep the radiation hazard insignificant, the value of external hazard index must not exceed the limit of unity. The maximum value of H_{ex} equal to unity corresponds to the upper limit of radium equivalent activity of 370.00 Bq·kg^{-1} [15, 16].

In addition to the external hazard, radon and its short-lived products are also hazardous to the repository organs. To account for this threat, the maximum permissible concentration for ^{226}Ra must be reduced to half of the normal limit (185.00 Bq·kg^{-1}). The internal exposure to carcinogenic radon and its short-lived progeny is quantified by the internal hazard index (H_{in}) given by the expression [17].

3. Results and Discussion

The activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in soil samples from the University of Douala-Cameroon have been measured and presented in Table 1 with the geological coordinates of each sampling point. The radiological health hazards indices in the investigated soil samples have been calculated and displaced in Table 2. The comparison of specify activities of ^{226}Ra, ^{232}Th, ^{40}K in soil samples from the University of Douala-Cameroon with data from other countries is reported in Table 3.

For Campus 1, in Tables 1 and 3, the activity concentrations of ^{226}Ra varied from 21.99 ± 0.68 to 29.17 ± 0.87 Bq/kg with an average of 25.48 Bq/kg. The activity concentrations of ^{232}Th and ^{40}K ranged from 59.14 ± 1.41 to 65.88 ± 1.55 Bq/kg with an average value of 65.96 Bq/kg and from 13.93 ± 2.88 to 70.89 ± 3.70 Bq/kg with a mean of 39.15 Bq/kg, respectively.

For Campus 2, in Tables 1 and 3, the activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K ranged from 21.99 ± 0.68 to

Table 1: Specify activities of ^{226}Ra, ^{232}Th, and ^{40}K in soil samples from Campuses 1 and 2 of the University of Douala.

Sampling sites	Sample ID	Latitude	Longitude	Specific activity (Bq/kg)		
				^{226}Ra	^{232}Th	^{40}K
Campus 1	UD01	04°03′20.8″N	09°43′57.6″W	26.70 ± 0.76	65.88 ± 1.55	32.56 ± 3.22
	UD02	04°03′25.1″N	09°44′00.1″W	28.95 ± 0.84	80.03 ± 1.87	13.93 ± 2.88
	UD03	04°03′22.6″N	09°44′07.1″W	21.99 ± 0.68	59.14 ± 1.41	70.89 ± 3.70
	UD04	04°03′19.7″N	09°44′04.1″W	25.44 ± 0.77	63.27 ± 1.52	38.01 ± 3.38
	UD05	04°03′17.2″N	09°44′02.9″W	23.27 ± 0.71	59.78 ± 1.42	44.03 ± 3.29
	UD06	04°03′14.8″N	09°44′08.0″W	29.17 ± 0.87	71.06 ± 1.71	21.82 ± 3.09
	UD07	04°03′16.7″N	09°44′11.0″W	22.82 ± 0.69	62.57 ± 1.48	52.80 ± 3.12
	Minimum			21.99 ± 0.68	59.14 ± 1.41	13.93 ± 2.88
	Maximum			29.17 ± 0.87	65.88 ± 1.55	70.89 ± 3.70
	Average values ± standard deviation			25.48 ± 2.92	65.96 ± 7.39	39.15 ± 19.14
Campus 2	UD08	04°03′29.7″N	09°44′26.5″W	22.27 ± 0.68	52.60 ± 1.27	44.70 ± 3.27
	UD09	04°03′31.0″N	09°44′30.3″W	27.68 ± 0.80	62.79 ± 1.51	16.76 ± 3.06
	UD10	04°03′22.0″N	09°44′30.0″W	24.94 ± 0.73	72.50 ± 1.66	14.68 ± 2.76
	UD11	04°03′25.1″N	09°44′36.8″W	21.99 ± 0.68	63.93 ± 1.49	11.89 ± 2.66
	UD12	04°03′21.5″N	09°44′39.0″W	22.89 ± 0.69	64.46 ± 1.51	15.82 ± 2.90
	UD13	04°03′16.5″N	09°44′39.8″W	25.87 ± 0.76	74.12 ± 1.71	15.10 ± 2.96
	UD14	04°03′18.4″N	09°44′37.5″W	23.84 ± 0.71	63.27 ± 1.48	80.76 ± 2.80
	UD15	04°03′16.8″N	09°44′35.5″W	26.74 ± 0.80	78.99 ± 1.83	18.29 ± 3.21
	UD16	04°03′24.9″N	09°44′42.2″W	24.64 ± 0.76	71.66 ± 1.69	29.94 ± 3.24
	UD17	04°03′21.2″N	09°44′45.2″W	24.98 ± 0.74	72.39 ± 1.66	19.84 ± 1.81
	DU18	04°03′18.2″N	09°44′42.7″W	23.67 ± 0.71	57.20 ± 1.36	42.26 ± 3.18
	Minimum			21.99 ± 0.68	52.60 ± 1.27	11.89 ± 2.66
	Maximum			27.68 ± 0.80	78.99 ± 1.83	80.76 ± 2.80
	Average values ± standard deviation			24.50 ± 1.80	66.72 ± 7.91	28.19 ± 20.72
Worldwide (UNSCEAR 2000)						
Range				17.00–60.00	11.00–68.00	140.00–850.00
Average				35.00	30.00	400.00

27.68 ± 0.80 Bq/kg with an average value of 24.50 Bq/kg, from 52.60 ± 1.27 to 78.99 ± 1.83 Bq/kg with a mean of 66.72 Bq/kg, and from 11.89 ± 2.66 to 80.76 ± 2.80 Bq/kg with an average value of 28.19 Bq/kg, respectively.

The distributions of radioactivity measured in both studied sites are present in Figures 2(a) and 2(b). As shown in the figures, the radioactivity concentration slightly varied from one point to another. These variation observed in both studied sites may result from the nonuniform distribution of radioactivity contents present under the earth crust. It is generally considered that igneous rocks contain higher levels of radioactivity than sedimentary rocks. The areas under study are part of the Littoral Region observed to be the major sedimentary basin of Cameroon [6]. This formation has variations in sediments, limestone, shale, and clay. From the recorded activities of ^{226}Ra, ^{232}Th, and ^{40}K in the present study, it can be noticed that the obtained average value of ^{232}Th in both locations was observed to be comparably higher than both of ^{226}Ra and ^{40}K in almost all the soil-sampling locations. This could be due to the high content of thorium present in sedimentary rocks.

Comparing the average activity values of ^{226}Ra, ^{232}Th, and ^{40}K obtained in both studied sites, as shown in Figure 3(a), it can be seen that the obtained average values of ^{226}Ra, ^{232}Th, and ^{40}K in the analyzed soil samples from both studied sites were relatively the same with the exception of the ^{40}K average value which was slightly higher in Campus 2 than in Campus 1. The observed similar variation range in activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K is due to the fact that both studied sites are closed to one another and the soil samples collected in both sites originated from the same geology formation. The slight difference in activity concentration average value of ^{40}K is also due to the irregular distribution of uranium, thorium, and potassium contents present in the studied soils.

The calculated average activity values of ^{226}Ra, ^{232}Th, and ^{40}K in both studied sites were compared with the established worldwide ones by UNSCEAR [7] as represented in Figure 3(b). It can be observed that the values obtained in both studied sites are comparably lower that the recommended worldwide values with the exception of the ^{226}Ra values.

The observed activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in the present work were compared with other published values obtained from the literature of radioactivity in soil by many authors as dispatched in Table 3. The obtained average

Table 2: The radiological health hazard parameters due to the activity contents of ^{226}Ra, ^{232}Th, and ^{40}K in soil samples.

Sampling site	Sample ID	Ra_{eq} (Bq/kg)	Absorbed dose (nGy/h)	Outdoor annual effective dose (mSv/y)	External health hazard index (Hex)
Campus 1	UD01	123.41	99.63	0.12	0.34
	UD02	144.46	115.78	0.14	0.40
	UD03	112.01	90.95	0.11	0.31
	UD04	118.84	96.04	0.12	0.33
	UD05	112.14	90.68	0.11	0.31
	UD06	132.47	106.75	0.13	0.36
	UD07	116.36	94.05	0.12	0.32
Minimum		116.36	90.95	0.11	0.31
Maximum		144.46	115.78	0.14	0.40
Average val. ± DS		122.81 ± 11.90	99.13 ± 9.21	0.12 ± 0.01	0.34 ± 0.03
Campus 2	UD08	100.92	81.92	0.10	0.28
	UD09	118.75	95.87	0.12	0.33
	UD10	129.75	103.88	0.13	0.35
	UD11	114.32	91.50	0.11	0.31
	UD12	116.28	93.23	0.11	0.32
	UD13	133.02	106.53	0.13	0.36
	UD14	120.53	97.99	0.12	0.33
	UD15	141.11	112.96	0.14	0.39
	UD16	129.42	103.89	0.13	0.35
	UD17	130.02	104.19	0.13	0.35
	DU18	108.71	88.07	0.11	0.30
Minimum		100.92	81.92	0.10	0.28
Maximum		141.11	112.96	0.14	0.39
Average val. ± SD		122.08 ± 11.80	98.18 ± 9.11	0.12 ± 0.01	0.33 ± 0.03
Worldwide (UNSCEAR 2000)					
Range			18.00–93.00		
Average		370.00	60.00	0.07	<1.00

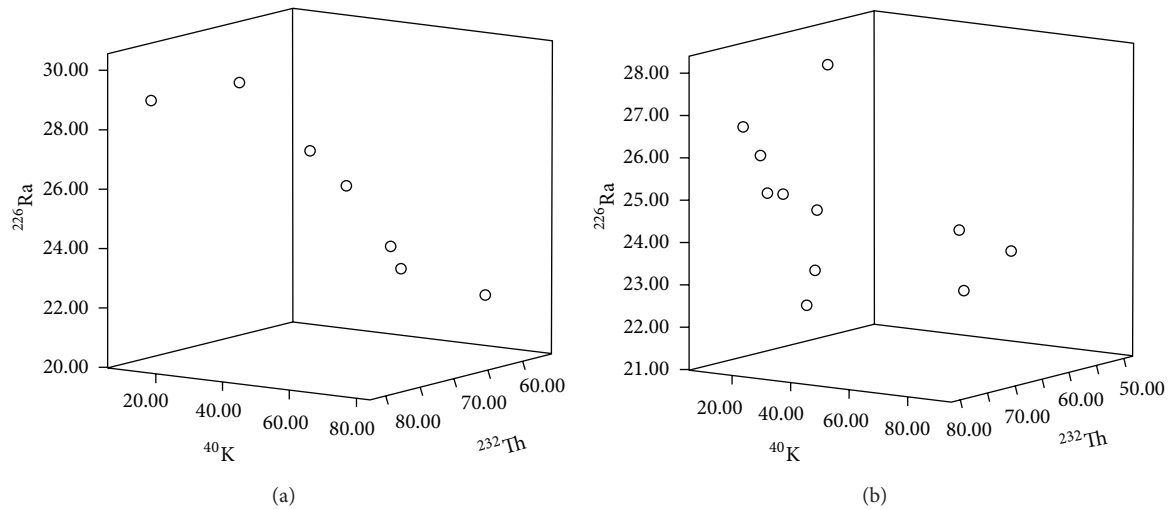
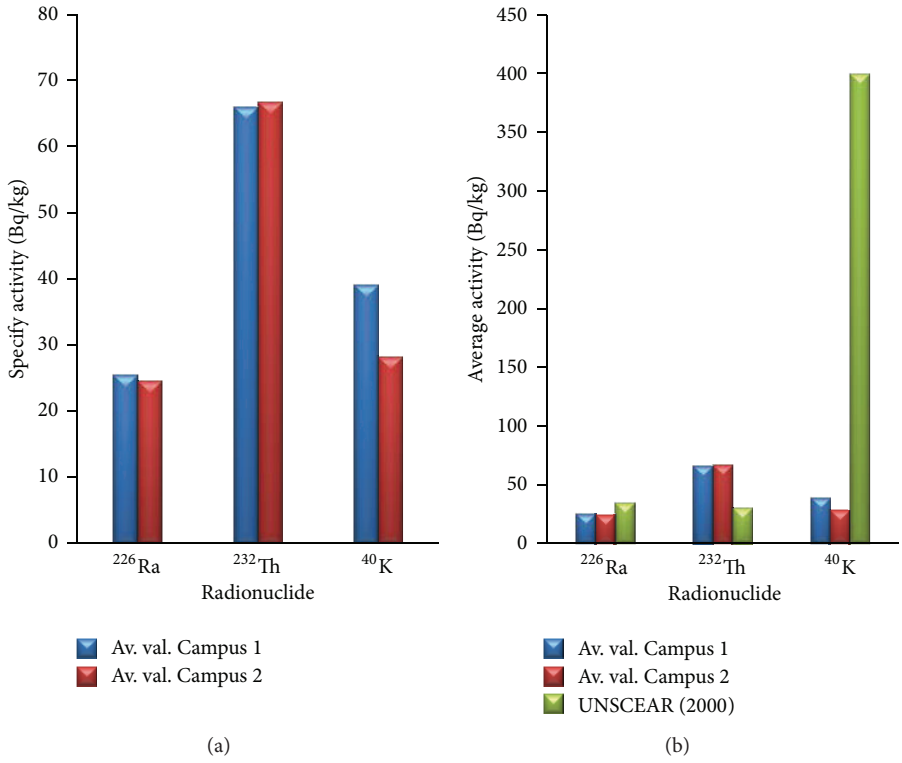


Figure 2: (a) Distribution of specific activities of ^{226}Ra, ^{40}K, and ^{232}Th in soil samples from Campus 1. (b) Distribution of specific activities of ^{226}Ra, ^{40}K, and ^{232}Th in soil samples from Campus 2.

Table 3: Comparison of specific gamma activities (Bq/kg) in soil with that of other countries.

Country	Activity concentration (Bq/kg) ^{226}Ra	^{232}Th	^{40}K	Reference
China (Xiaz-hung area)	40.20–442.00 (112.00)	32.60–88.10 (71.50)	440.00–913.00 (672.00)	[18]
Botswana	6.10–97.40 (34.80)	7.40–110.00 (41.80)	33.50–1085.70 (432.70)	[19]
Ghana (Great Accra)	2.40–62.70	3.2–145.7	91.10–1395.90	[20]
India (Himwchal Pradesh)	42.09–79.63 (57.34)	52.83–135.75 (82.22)	95.33–160.30 (135.75)	[21]
Italy (Southern)	57.00–71.00	73.00–87.00	580.00–760.00	[22]
Namibia	4.50–48.00 (31.00)	3.00–38.00 (32.00)	42.00–1100.00 (480.00)	[23]
Nigeria (Lagos)	3.00–43.00	5.00–76.00	40.00–354.00	[24]
Nigeria Delta	11.00–40.00 (18.00 ± 3.40)	12.00–40.00 (22.00 ± 4.40)	69.00–530.00 (210.00 ± 49.00)	[25]
Cameroon	*21.99–29.17 (25.48) **21.99–27.68 (24.50)	*59.14–65.89 (65.96) **52.60–78.99 (66.72)	*13.93–70.89 (39.15) **11.89–80.76 (28.19)	This Work

*Campus 1; **Campus 2; ( ): average value.



(a) (b)

Figure 3: (a) Comparison of the mean specific gamma activities in soil from both studied sites. (b) Comparison of the mean specific gamma activities in soil samples with the worldwide value.

activity concentrations of ^{226}Ra and ^{40}K in both studied sites were comparably lower than the values published by other authors with the exception of the recorded values of ^{226}Ra in Nigeria Delta published by Agbalagba and Onoja [25] which were relatively low. Similar observations were observed for ^{232}Th as recorded in the activity concentration in this work. It can be seen that the average values of ^{232}Th recorded in the present study were slightly lower than the published values recorded in China (Xiaz-hung area), Ghana (Greater Accra), and India (Himwchal Pradesh) [18, 20, 21] and higher than the recorded and published average values in Namibia and Nigeria Delta [23, 25]. The present values were compared favourably with the recorded average values published by other countries selected from the worldwide investigation of natural radioactivity in soils.

Uniformity with respect to exposure to radiation defined in terms of radium equivalent activity to compare the specific activity of geological materials contain in different amounts of ^{226}Ra, ^{232}Th, and ^{40}K. This was calculated and the results were presented in Table 2. It can be seen that values ranged from 116.36 Bq/kg to 144.46 Bq/kg with an average of 122.81 Bq/kg in Campus 1 and from 100.93 Bq/kg

to 141.11 Bq/kg with a mean value of 122.08 Bq/kg in Campus 2. The obtained values of radium equivalent in the present investigation are comparably less than the safe limit (370.00 Bq/kg) recommended by UNSCEAR [7].

The ionising radiation affects the biological systems and it depends, along with the other factors, on the time and place of exposure and population involved. In most cases, the risk appears to be higher outdoors than indoors. As shown in Table 2, the calculated absorbed dose in air is in the range of 90.95 nGy/h to 115.77 nGy/h with a mean of 99.13 nGy/h in Campus 1 and from 81.92 nGy/h to 112.96 nGy/h with an average of 98.18 nGy/h in Campus 2. The estimated annual outdoor effective dose in the present study varies from 0.11 mSv/y to 0.14 mSv/y with a mean of 0.12 mSv/y and from 0.10 mSv/y to 0.14 mSv/y with an average of 0.12 mSv/y in Campuses 1 and 2, respectively. The external health hazard index calculated in the present study ranges from 0.31–0.40 with a mean of 0.34 and from 0.28–0.39 with an average of 0.33 in Campuses 1 and 2, respectively. The obtained values of the absorbed dose rate in air and the annual outdoor effective dose in the present investigation are comparably higher than the recommended values of 18.00–93.00 (60.00) nGy/h and 0.07 mSv/y UNSCEAR [7], whilst those of external health hazard index obtained are comparably less than the unity.

4. Conclusion

The natural radioactivity levels of ^{226}Ra, ^{232}Th, and ^{40}K have been measured in soils from the selected areas within the Douala-Bassa zone in the Littoral Region of Cameroon using gamma spectrometry based broad energy germanium detector (BE6530). The recorded mean values of ^{232}Th in both studied sites were relatively high than those of ^{226}Ra and ^{40}K. Considering the nonuniform distribution of radioactivity in geological materials, the radium equivalent was calculated and observed to be lower than the recommended safe value (370.00 Bq/kg) by UNSCEAR. The radiological health hazards parameters calculated in the present work were comparably higher than the recommended safe limit of the absorbed dose rate in air, the annual outdoor effective dose, and external health hazard index by UNSCEAR except those values of the external health hazard index which were less than unity.

The results obtained in this work have established baseline information on natural radioactivity in the two campuses of the University of Douala-Cameroon. It is expected that the results obtained may be used as baseline data for future work.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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