Available online at www.elixirpublishers.com (Elixir International Journal)

Nuclear and Radiation Physics

Elixir Nuclear & Radiation Phys. 78 (2015) 29989-29992

ISSN: 2229-712X

Analysis of ^{238}U, ^{235}U, ^{137}Cs and ^{133}Xe in soils from two campuses in university of douala-cameroon

M.M. Ndontchueng[1,2], R. L. Njinga[1], E.J.M. Nguelem[1,2] and A. Simo[1]

[1]National Radiation Protection Agency of Cameroon, Box 33732, Yaounde, Cameroon.

[2]Department of Physics, Faculty of Science, University of Douala, P.O. Box 24157, Douala, Cameroon.

ARTICLE INFO

Article history:

Received: 26 November 2013;

Received in revised form:

11 January 2015;

Accepted: 26 January 2015;

Keywords

Radionuclides,

Absorbed dose rate,

Outdoor effective dose,

Gamma spectroscopy.

ABSTRACT

An evaluation of ^{238}U, ^{235}U, ^{137}Cs and ^{133}Xe in soils from two campuses in university of Douala-Cameroon using gamma spectroscopy based Broad Energy Germanium Detector (BEGe6530) has been performed. The mean activities in soils from Campuse 1 were 40.16±8.98 Bq/kg for ^{238}U, 3.39±0.33 Bq/kg for ^{235}U, 0.46±0.33 Bq/kg for ^{137}Cs and 0.14±0.16 Bq/kg for ^{133}Xe. In Campus 2, the mean activities in soils were 31.45±12.24 Bq/kg, 3.02±1.00 Bq/kg, 0.30±0.26 Bq/kg and 0.35±0.24 Bq/kg for ^{238}U, ^{235}U, ^{137}Cs and ^{133}Xe respectively. Using the *In situ* survey meter, the mean values of the absorbed dose rate measured was 71.43 nGy/hr for Campus 1 and 62.72 nGy/hr for Campus 2. The evaluated average outdoor effective dose for Campus 1 and 2 were 87.60 µSv/yr and 76.93 µSv/yr respectively. The overall results obtained in this work were generally low compared to that of UNSCEAR.

Introduction

Natural radionuclides occur naturally in terrestrial soils and rocks and in building materials. Upon decay, these radionuclides produce an external radiation field to which mankind are exposed. Studies and survey of these radioactive elements in our living environment are of great importance and interest in health physics not only for many practical reasons but for more fundamental scientific reasons. The progressive development of radiation and radioactive isotopes in industries and other contaminating technologies necessitate the evaluation of background dose rate to detect humanly manufactured contamination to protect the population and the environment [1].

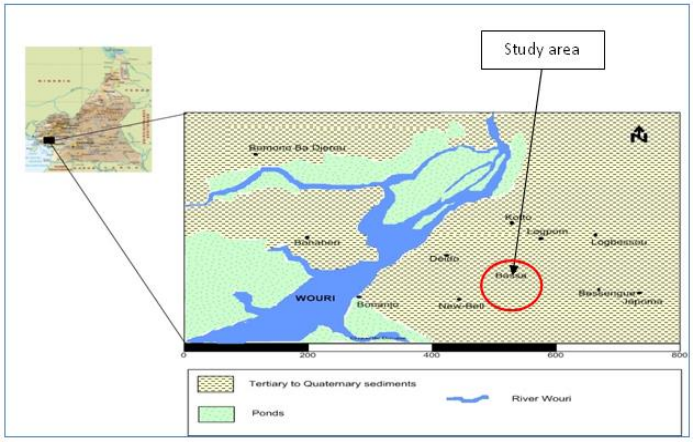
Soil radionuclide activity concentration is one of the mains determinants of the natural radiation background [2]. Soil is mineral deposits formed through the weathering and erosion of rocks. The deposits found at different trace levels within the soil contain natural radionuclides that contribute to external gamma radiation. The distributions of these radionuclides in various soils are related to the nature of the parent rock from which the soils are derived and the processes through which the soils are concentrated [3, 4]. In addition to the natural sources, soil radioactivity may also be affected by man-made radionuclide such as ^{137}Cs, ^{134}Cs, ^{90}Sr etc resulting from nuclear weapon atmospheric weapons testing conducted in the past century and nuclear accidents [2]. External exposure to high level of these non-natural radionuclides can result in malignant tumors and shortening of life. Nonetheless, NORM concentration in soil can also be increased above average natural background level through specific industrial activities, including waste products from the companies.

The aim of the present study tends to determine the specific activity of ^{235}U, ^{238}U, ^{137}Cs, ^{133}Xe using high purity germanium HPGe detector and measurement of dose rate due to γ-rays using an *In situ* survey meter of the soils samples obtained from two campuses of University of Douala-Cameroon.

The Study Area

The field experiment was carried out at the two campus 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 below. 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. It is sand at the top and sandy clayey at the subsoil [5].

The climate of Douala metropolis is uniform and is described as a particular equatorial type called “Cameroonian” marked by lengthy rainy season (at least nine months), abundant rainfall (about 4000 mm per annum), high and stable average annual temperatures (26.7°C). The main relative air humidity remains high throughout the year with a mean value of 82.6%.



Tele:

E-mail addresses: ndomomau@yahoo.fr

Samples Collection and Preparation Techniques

Eighteen soil samples were randomly chosen for all over the two campus of the University of Douala (seven from Campus 1 ESSEC situated at Ange-Raphael and eleven from Campus 2 located at Ndong-Bong Douala-Bassa). Each soil samples was collected from five subsamples in an area of approximately $1m^2$ and up to a typical depth of about 20 cm from the top surface layer. The subsamples were mixed thoroughly to make a composite sample and packed into its own secure polyethylene bag to prevent contamination. In order to cover the study site and to observe a significant local spatial variation in terrestrial radioactivity, the sampling points at each site of the study area were selected at a minimum distance of 300 m from one another. Each sampling point was marked using a global positioning system (GPS) as shown in Table 1. The samples were transferred into the laboratory after they were labelled accordingly.

At the laboratory, the samples were air dried in an oven for 24 hours at a temperature of 105^0C. 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 32 days to attain secular equilibrium between the long-lived parent and daughter nuclides.

Table 1: Sampling Locations Marked using GPS

Sample ID	Longitude	Latitude
C1-01	04°03'20.8"	09°43'57.6"
C1-02	04°03'25.1	09°44'00.1"
C1-03	04°03'22.6"	09°44'07.1"
C1-04	04°03'19.7"	09°44'04.1"
C1-05	04°03'17.2"	09°44'02.9"
C1-06	04°03'14.8"	09°44'08.0"
C1-07	04°03'16.7"	09°44'11.0"
C2-08	04°03'29.7"	09°44'26.5"
C2-09	04°03'31.0"	09°44'30.3"
C2-10	04°03'22.0'	09°44'30.0"
C2-11	04°03'25.1"	09°44'36.8"
C2-12	04°03'21.5"	09°44'39.0"
C2-13	04°03'16.5"	09°44'39.8"
C2-14	04°03'18.4"	09°44'37.5"
C2-15	04°03'16.8"	09°44'35.5"
C2-16	04°03'24.9"	09°44'42.2"
C2-17	04°03'21.2"	09°44'45.2"
C2-18	04°03'18.2"	09°44'42.7"

Experimental

Each sample was counted for 86400 sec. 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 automatically by Genie-2000 software based on the following equation:

$$A_{sp} = \frac{CR}{\varepsilon(E_i) \times P_{\gamma_i} \times M_S \times C} \quad (1)$$

$$CR = \frac{N_S}{t_s} - \frac{N_B}{t_B} \quad (2)$$

where CR=count rate, N_s = net counts of the radionuclide in the samples; N_B = net counts of radionuclide in the background; $P_{\gamma i}$ = gamma emission probability (gamma yield); $\varepsilon(E_i)$ = peak efficiency of the detector at energy Ei; t_s = sample counting time; t_B = background measuring time; M_s = mass of the sample (kg) and C = 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) ^{238}Uspecify activity was calculated using the gamma-ray line 1001.03 keV of ^{234m}Pa

b) ^{235}U was determined using its direct gamma-rays photopeak 185.71 keV. Interference correction due to the presence of 186.2 keV energy peak of ^{226}Ra has been taken into account and subtracted accordingly.

c) ^{137}Cs was directly determined by using 661.66 keV gamma-ray line.

d) ^{133}Xe was determined using its direct gamma-rays photo-peak 81.00 keV

Annual Effective Dose Equivalent

The absorbed dose rate in air at 1 metre above the ground surface was measured. In Situ measurement does not directly provide the radiological risk to which an individual is exposed [7]. The absorbed dose can be considered in terms of the annual effective dose equivalent from outdoor terrestrial gamma radiation which is converted based on;

- conversion coefficient from absorbed dose in air to effective dose and
- outdoor occupancy factor.

The annual effective dose equivalent was evaluated based on the published work by [8, 9].

Results and Discussions

The activity concentrations of ^{238}U, ^{235}U, ^{137}Cs and ^{133}Xe in soil samples from the University of Douala-Cameroon have been measured and presented below in Table 2.

In Campus 1, the specific activities concentration of ^{238}U and ^{235}U varied from 29.53±11.66 Bq/kg (C1-02) to 58.08±11.92 Bq/kg (C1-04) with an average of 40.16 Bq/kg and 3.02±0.25 Bq/kg (C1-04) to 3.98±0.33 Bq/kg (C1-01) with average value of 3.39 Bq/kg respectively. In the studies of the specific activities of the two isotopes, the noble gas xenon-133 (^{133}Xe) and the aerosol-bound caesium-137 (^{137}Cs), which have very different release characteristics as well as behavior in the atmosphere, ^{133}Xe was observed to vary from 0.13±0.08 Bq/kg (C1-07) to 0.45±0.09 Bq/kg (C1-05) with an average value of 0.14 Bq/kg and ^{137}Cs was 0.28±0.06 Bq/kg (C1-07) to 1.01±0.09 Bq/kg (C1-06) with an average value of 0.46 Bq/kg respectively.

$$SD = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(x_i - \bar{x}\right)^2}$$

where SD= Standard Deviation, N= number of sample, x_i = specific activity of i^{th} radionuclide and $\bar{x}$ = average activity concentration.

In Campus 2, the specific activity concentration of ^{238}U, ^{235}U, ^{137}Cs and ^{133}Xe ranged from 22.16±10.53 Bq/kg (C2-14) to 42.82±10.41 Bq/kg (C2-12) for ^{238}U with an average value of 31.45 Bq/kg; 0.72±0.44 Bq/kg (C2-08) to 3.74±0.33 Bq/kg (C2-18) for ^{235}U with a mean of 3.02Bq/kg; 0.17±0.05 Bq/kg (C2-09) to 0.95±0.08Bq/kg (C2-18) for ^{137}Cs with an average value of 0.30 Bq/kg and 0.02±0.04 Bq/kg (C2-14) to 0.76±0.11 Bq/kg (C2-13) with a mean value of 0.35 Bq/kg respectively.

It can be seen from the Table 2 above that the specific activity of ^{238}U in all measured soils samples from campus 1 & 2 is compared to be higher than those of ^{235}U.

Table 2: Specify activities of ^{238}U, ^{235}U, ^{137}Cs and ^{133}Xe in soil samples from Campus 1 and 2 of the University of Douala

Sample ID	Specific Activity (Bq/kg)				Radiological health parameters	
	^{238}U	^{235}U	^{137}Cs	^{133}Xe	AD (nGy/h)	AEDE (µSv/y)
C1-01	41.45±6.97	3.98±0.33	0.56±0.06	ND	60.00	73.58
C1-02	29.53±11.66	3.24±0.17	ND	ND	80.00	98.11
C1-03	33.96±9.74	3.16±0.29	0.39±0.12	0.24±0.04	60.00	73.58
C1-04	58.08±11.92	3.02±0.25	0.31±0.06	ND	60.00	73.58
C1-05	41.38±11.61	3.38±0.30	0.70±0.13	0.45±0.09	70.00	85.85
C1-06	39.45±10.42	3.69±0.32	1.01±0.09	0.18±0.08	80.00	98.11
C1-07	37.27±12.42	3.27±0.03	0.28±0.06	0.13±0.08	90.00	110.38
Av. Val.±SD	40.16±8.98	3.39±0.33	0.46±0.33	0.14±0.16	71.43	87.60
C2-08	28.05±9.08	0.72±0.44	ND	0.35±0.09	60.00	73.58
C2-09	ND	3.79±0.33	0.17±0.05	0.09±0.06	70.00	85.85
C2-10	37.27±10.15	1.53±0.89	0.27±0.06	0.44±0.10	70.00	85.85
C2-11	40.60±10.60	2.84±0.23	0.46±0.06	0.27±0.04	60.00	73.58
C2-12	42.82±10.41	3.63±0.29	0.32±0.06	0.32±0.09	50.00	61.32
C2-13	34.66±11.46	3.52±0.32	0.33±0.06	0.76±0.11	60.00	73.58
C2-14	22.16±10.53	3.22±0.29	0.34±0.06	0.02±0.04	50.00	61.32
C2-15	34.83±13.46	3.63±0.32	0.21±0.06	0.50±0.04	70.00	85.85
C2-16	39.73±10.99	2.93±0.29	0.22±0.06	0.64±0.12	60.00	73.58
C2-17	27.00±12.63	3.62±0.32	ND	0.38±0.08	80.00	98.11
C2-18	38.82±11.25	3.74±0.33	0.95±0.08	0.05±0.02	60.00	73.58
Av. Val.±SD	31.45±12.24	3.02±1.00	0.30±0.26	0.35±0.24	62.72	76.93
UNSCEAR	33	-	-		60.00	70.00

Val = Value, ND = Not Detected, C1= Campus 1, C2 = Campus 2

These differences in the content of ^{235}U and ^{238}U in the collected soil samples is attributed to the abundances of both isotopes in the entire earth i.e. ^{235}U (0.75%) and ^{238}U (99.28%). However, the mean specify activity of ^{238}U obtained in campus 1 is high compared to the established value of UNSCEAR [6]. The mean value of ^{238}U obtained in Campus 2 is observed to be slightly lower than the safe value of UNSCEAR [6]. Even though the collected soil samples in both sites originate from the same geological formations as shown on the geology map represented in figure 1, the high content of ^{238}U in sample from campus 1 compared to the ^{238}U content found in sample from campus 2 may result from the irregularities in the distribution of the uranium rock matrices. This might also depend on the structural and geochemical composition.

The aerosol-bound caesium-137 (^{137}Cs) and the noble gas xenon-133 (^{133}Xe) were found to be low in the collected samples from the two campuses of the University of Douala-Cameroon. However, the presence of these trace amount of radionuclides in the studied soil samples might be as result of human anthropogenic activities since these sites were used in the past as a dumping ground of residues from HYSACAM industry before the construction of the University of Douala. Another attributes for the presence of the trace ^{137}Cs and ^{133}Xe in the soils samples might result from the fallout of the nuclear weapon testing that might have travelled long distances due to some of the atmospheric activities.

In terms of the ionising radiation affects as shown in Table 2, the measured absorbed dose using the *In Situ* survey meter ranged from 60 90 nGy/h to 90 nGy/h with a mean of 71.43 nGy/h in Campus 1 and from 5090 nGy/h to 80 nGy/h with an average of 62.72 nGy/h in Campus 2. The estimated annual outdoor effective dose obtained from the direct absorbed dose measured in the present study varies from 73.36 µSv/y to 110.38 µSv/y for Campus 1 with a mean of 87.60 µSv/y and 61.32 µSv/y to 98.11 µSv/y for Campus 2 with an average of 76.93 µSv/y. The obtained values of the absorbed dose rate in air measured *In Situ* in the present investigation are comparably low than the recommended values of 18.00 nGy/h to 93.00 nGy/h (average value of 60 nGy/h) by UNSCEAR [6]. The estimated average annual outdoor effective dose obtained from the absorbed dose rate measured *In Situ* in the present study is compared to be slightly high in Campus 1 than the safe limit of 70µSv/y by UNSCEAR [6] whilst the value obtained in Campus 2 is comparably the same with the safe limit value. These variations are due to due to the variation of the background radiation in the investigated areas.

Conclusion

The natural and anthropogenic radioactivity concentrations of ^{238}U, ^{235}U, ^{137}Cs and ^{133}Xe have been determined in soils samples from two campuses of University of Douala. The observed specify activities due to ^{238}U in all samples from both campuses were relatively higher compared to specify activities due to ^{235}U due to the irregular distribution of these radionuclides in soil matrices. The trace amount of ^{137}Cs and ^{133}Xe were observed in the investigated soil samples to emanate from the human anthropogenic activities and dumping residues from HYSACAM industry in the past before the construction of the University. The measured average absorbed dose rate in air is relatively high in Campus 1 and low in Campus 2. The average annual outdoor effective dose from the absorbed dose

rate measured was slightly higher in Campus 1 than the safe limit of 70 μSv/y by UNSCEAR whilst in Campus 2 was comparably the same with the safe limit value by UNSCEAR [6].

Acknowledgement

The authors are grateful for the support and technical cooperation provided by the National Radiation Protection Agency of Cameroon in granting access to the facilities to successfully complete this study. The authors also appreciate the administrations committee of the University of Douala and their vicinity for the understanding during sampling period.

References

1-A.I. Abd El-mageed, A.H. El-kamel, A. Abbady, S. Harb, A.M.M. Youssef and I.I. Saleh. Assessment of natural and anthropogenic radioactivity levels in rocks and soils in the environs of Juban town in Yemen. Tenth Radiation Physics and Protection conferences, 27-30 November 2010, Nasr city, Cairo, Egypt.

2-W.M. Badawy, S.V. Mamikhin. Radioactivity measurement and dose rate calculation due to γ-ray of soil from Chashmikovo-Russia. Arab Journal of Nuclear Sciences and Applications, 45(2) 270-282(2012)

3-Tzortzis M., Svoukis, E. and Tsetos, H. **2004** A Comprehensive Study of Natural Gamma Radioactivity Levels and Associated Dose Rates from Surface Soils in Cyprus. *Radiation Protection Dosimetry*, *109*(3), 217–224.

4-Rani A, Singh S. Natural radioactivity levels in soil samples from some areas of Himachal Pradesh, India using γ- ray spectrometry. Atmospheric Environ. 2005; 39:6306–14.

5-Asaah A. Victor, Akinlolu F. Abimbola and Cheo E. Suh. Heavy metal concentrations and distribution in surface soils of the Bassa Industrial zone 1, Douala, Cameroon. The Arabian Journal for Science and Engineering, vol. 3(2A):147-158 (2006).

6-United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Effects and Risks of Ionizing Radiation, Report to the General Assembly. New York: United Nations; 2000.

7-Turhan, S. and Gundiz, L (2008). "Determination of Specific Activity of ^{226}Ra, ^{232}Th and ^{40}K for Assessment of Radiation Hazards from Turkish Pumice Samples", Journal of Environmental Radioactivity, 99:332-342

8-Xinwei L (2004). Natural Radioactivity in some building materials of Shaanix, China. J. Radioanaly. Nucl. Chemi., 262:775-777.

9-Jibiri, N. N., Farai, IP. and Alausa, SK (2007). "Estimation of Annual Effective Dose due to Natural Radioactive Elements in Ingestion of Foodstuffs in Tin Mining Area of Jos-Plateau, Nigeria", Journal of Environmental Radioactivity 94:31-40.