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Quantitative Determination of ^{226}Ra and ^{228}Ra in Reservoir and Tap Water in Yaounde Area, Cameroon

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Abstract: Activities of ^{226}Ra and ^{228}Ra derived from the decay of their naturally occurring parent radionuclides ^{238}U and ^{232}Th respectively, have been investigated in this study for reservoir and tap water collected during the dry and the rainy seasons respectively in december 2002 and july 2003.Using a well calibrated Canberra NaI(Tl) detector system, it was possible to determine the average specific activity of ^{226}Ra and ^{228}Ra in water samples.

Key words: Water · Reservoir · Tap · NaI(Tl) detector

INTRODUCTION

There are different forms (isotopes) of uranium but ^{238}U is the predominant contributor to natural radioactivity[1]. Enhanced levels of uranium, thorium and their daughter products might be present in water in areas that are rich in natural radioactivity. As groundwater moves through fractures in the bedrock that contain these deposits radioactive minerals can leach out into the groundwater system [2]. Uranium isotopes (^{238}U, ^{235}U and ^{234}U) have a non-negligible radiotoxicity. Several radionuclides in the radioactive decay chain starting from ^{238}U and ^{235}U are highly radiotoxic [3]. The most radiotoxic and most important among them is radium, which is a known carcinogen and exists in several isotopic forms. The predominant radium isotopes in ground water are ^{226}Ra, an alpha emitter with a half-life of 1600 years and ^{228}Ra, a beta emitter with a half-life of 5.8 years [4]. When radium is taken into the body, it's metabolic behavior is similar to that of calcium and an appreciable fraction being distributed almost uniformly in soft tissues [5].

The objective of this work was to determine the activities of ^{226}Ra and ^{228}Ra in the reservoir and tap water of Yaounde town, capital city of Cameroon, respectively during the dry and the rainy seasons.

MATERIALS AND METHODS

The study was conducted over the Yaounde area which lies at the latitude of 3°52'00''N and longitude of 11°31'30''E, covering a total area of 297 km^2, with an average altitude of 740 m. The study area was partitioned into 12 units. The sampling locations shown in Fig. 1. Locations 1, 2 and 3 are reservoirs. Location 4 - 12 are taps whose water is used for drinking, washing of clothes, cleaning of food, for irrigation and for various domestic uses. The water taps were first turned on at full capacity for several minutes to purge the plumbing system of any water which might have been there for some time. The taps were turned down to a low rate to reduce turbulence and, thus, reduce radon loss [6]. After the water samples were collected as mentioned above, they were transfered to 1 litre kegs prior to processing for γ-spectometry analysis. All the samples of water were acidified with 11 M of (H_3O^+, Cl^-) at the rate of 10 ml per litre of sample as soon as possible after sampling to avoid absorption of radionuclides on to the walls of the containers [7]. Marinelli beaker of 1 litre volume capacity previously washed, rinsed with a dilute sulfuric acid and dried to avoid contamination were filled with known volume of the various water samples and later firmly sealed for, at least, four weeks to ensure that no loss of radon occurs thereby ensuring a state of secular equilibrium to be reached between radium isotopes and their respective daughters. From each location, four samples were made from water collected.

The Gamma-counting equipment was a canberra sodium iodide thallium activated NaI(Tl) crystal detector. The detector is coupled to a photomultiplier tube, which converts the small visible light flashes produced in the NaI(Tl) crystal into amplified electrical pulse that are fed into a suitable pulse height analyser system. The energy

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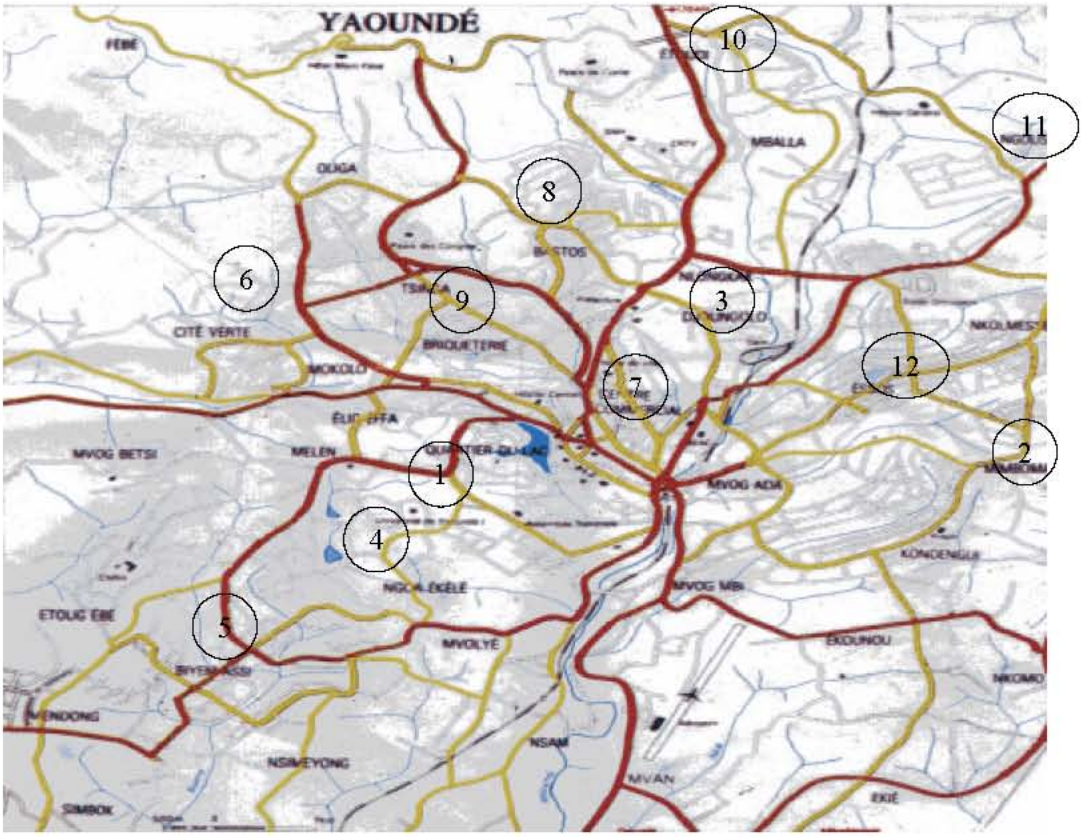

Fig. 1: Sampling locations

and efficiency calibrations were done using a well calibrated standard water sources supplied by the International Atomic Energy Agency (IAEA), Vienna, Austria. The techniques used are well described elsewhere [7]. The quantification of ^{226}Ra and ^{228}Ra present in water sample was obtained through accurate energy and efficiency calibrations of the gamma-counting systems since the accuracy of the results depend on the accuracy of the system's calibration.This was done by the use of decay data obtained from IAEA. The system above is coupled at end to a Canberra multichannel analysing (MCA) computer system. The MCA was calibrated so as to display gamma photopeaks in the energy range of 200-1500 keV, which covering all the gamma energies of radionuclides of interest. The photopeaks observed in the water samples were identified to belong to the naturally occuring series decay radionuclides headed by ^{238}U and ^{232} Th,. The characteristics of the selected gamma-emitting radionuclides used as monitor lines for this work are as documented in an publicaiton [8].

The activity concentrations of ^{226}Ra and ^{228}Ra were obtained indirectly from the γ-rays emitted by their progenies which were in secular equilibrum with them. ^{226}Ra concentration was determined by measuring the 609,3 keV γ-rays from ^{214}Bi. The 583.0 keV γ-rays of ^{208}Tl was used to determine that of ^{228}Ra. The gamma spectroscopy analysis was carried out by a spectra-analysis program, SAMPO 90, which matched γ-energies at various energy levels to a library of possible isotopes. This data analysis routine substracted a linear background distribution from the pulse-height spectra of both the sample and the background in addition to the net background peak area being subtracted from the corresponding net peack area for a particular radionuclide. The activities of the radionuclides were calculated from the difference between net peak and net background araes, accumulation time, absolute peak efficiency, absolute γ-ray emission probability (γ-ray intensity) and the sample volume.Triplicate analysis were conducted on all the water samples to check on the reproducibility of results and the stability of the counting system.

RESULTS AND DISCUSSIONS

Table 1 shows the summary of the ^{226}Ra and ^{228}Ra concentrations in sampled reservoir and tap water

Table 1: Activity contents($Bq.L^{-1}$) in reservoir and tap water in Yaounde area

		^{226}Ra		^{228}Ra	
Type of Water sample	No. of Samples	Range	Mean	Range	Mean
Reservoir water(dry season)	12	6.20 - 10.09	8.73 ± 3.50	0.37 - 0.78	0.57 ± 0.28
Reservoir water(rainy season)	12	6.09 - 10.98	8.54 ± 3.68	0.57 - 0.66	0.61 ± 0.26
Tap water (dry season)	36	8.41 - 13.82	11.40 ± 3.71	0.32 - 1.59	1.02 ± 0.31
Tap water(rainy season)	36	4.29 - 12.24	9.14 ± 3.50	0.23 - 1.06	0.68 ± 0.26

collected during the dry and the rainy seasons. The overall uncertainty in the measured concentrations was estimated from the parameters contained in the above mentioned relation, the calibration procedure, the peak area determination and the background.

Although the mean concentration of ^{226}Ra agreed with a range of values obtained by many investigators namly Mc Curdy, R. Buchli, W. Burkart and P.L. Dana, 10.1 - 43.1 $Bq.L^{-1}$, 0.081 - 36.4 $Bq.L^{-1}$ in imported bottled water and 1.56 - 123.80 $Bq.L^{-1}$ in public water supplies in North Carolina. The ^{228}Ra concentrations recorded for this work fell within the wide range of values 0.054-4.600 $Bq.L^{-1}$ quoted for the USA's imported bottled water [9]. The concentration values are relatively low during the rainy season. This could be due to the dilution effets of rain water since the river nyong, where reservoir and tap water studied comes. The lowest concentration was recorded in reservoir water due to treatment. The mean specific activity of uranium in this type of water samples is lower than the results (10.40 ± 1.70 $Bq.L^{-1}$) of P.Tchokossa, J. B Olomo and O.A. Osibote (1998) in the reservoir water of mukuro [10]. ^{228}Ra activity is not too different to the result (620 ± 10 $mBq.L^{-1}$) obtained by O.K. Hakam (2001) in the drinking water from Fez locality in Morocco [11]. While They are higher than 0.20-135 $pCiL^{-1}$equivalent to 0.007 - 0.05 $Bq.L^{-1}$,obtained by N.K. Ahmed (2004) in tap water from Qena locality in Egypt [12]. They are still within the range of 0.00-8.75 $Bq.L^{-1}$ reported by David et al in 1981 for domestic bottled water marketed and consumed in USA.

The specific activity due to natural thorium is relatively low in all the water samples investigated; this is because ^{238}U is very mobile than ^{232}Th [13]. Slight variation in the radioactivity content in water of the same type and from the same source can be observed in different locations and even worldwide, mainly due to potential changes occurring in the pipe during distribution, the oxidation state of the water, the concentration of suitable complexing agents which can increase the solubility of uranium or thorium [14-16].

CONCLUSION AND RECOMMENDATIONS

The results of the study has indicated that the average specific activity concentrations of ^{226}Ra and ^{228}Ra in the reservoir and tap water in this area have consistent values with those reported for many other countries in the world. These observations demonstrate that the radionuclide concentrations are a function of the geology of the area and it could be greatly influenced by the water transportation. People can then filter this water before consumption, because by filtrating, the radioactive substances that couldn't be dissolved have been eliminated.

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