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^{226}Ra, ^{232}Th and ^{40}K analysis in sand samples from some beaches of Great Vitória, Espírito Santo, Brazil: Preliminary results.

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ABSTRACT

The natural radioactivity in superficial beach sand samples of 7 beaches of Great Vitória, metropolitan region of the State of Espírito Santo, southeast Brazil, was determined from the ^{226}Ra, ^{232}Th and ^{40}K contents. The assessed beaches were Manguinhos, Camburí, Praia do Canto, Curva da Jurema, Itapuã, Setibão and Areia Preta. Three samples of each beach were sealed in standard 100 mL polyethylene flasks and stored in order to obtain secular equilibrium in the ^{238}U and ^{232}Th series. All samples were measured by high resolution gamma spectrometry and the spectra were analyzed with the WinnerGamma software. The ^{232}Th concentration was determined from the average concentrations of ^{228}Ac, ^{212}Pb and ^{212}Bi and the ^{226}Ra concentration was determined from the average concentrations of ^{214}Pb and ^{214}Bi. Preliminary results show concentrations varying from 9 Bq.kg^{-1} to 6035 Bq.kg^{-1} for ^{232}Th, from 4 Bq.kg^{-1} to 575 Bq.kg^{-1} for ^{226}Ra and from 13 Bq.kg^{-1} to 142 Bq.kg^{-1} for ^{40}K. Areia Preta beach shows the highest values for ^{232}Th, while the highest value for ^{226}Ra was observed for Camburí beach. High values of ^{40}K were observed for Curva da Jurema beach.

1. INTRODUCTION

The main external source irradiation to the human body are the naturally occurring radioactive elements in the soils and rocks, namely ^{40}K and the radionuclides from the ^{238}U and ^{232}Th series originated in the earth's crust, present everywhere in the environment [1].

Great Vitória is the metropolitan region of the State of Espirito Santo, southeast Brazil, with an approximated extension of 90 km, that includes the capital Vitória itself and its surroundings Fundão, Serra, Vila Velha, Cariacica, Viana and Guarapari, whose several beaches, containing monazitic ((Ce, La, Nd, Th)PO_4) and ilmenitic ($FeTiO_3$) sands are well-known for their high background radiation and silica group sands(SiO_2) [2]. Due to the warm weather during the entire year, these beaches are constantly frequented by the general public. Also, some of these sands are used, on an unofficial base, as building material by people living in the area. So, it is very important to know the radioactivity content of these sands, in order to evaluate the radiation hazard in these areas.

The aim of this work is to determine the concentration of natural radionuclides in several beach sands in the Great Vitória region, Curva da Jurema beach, Manguinhos beach, Itapuã beach and others neglected in earlier studies by other researchers.

2. MATERIALS AND METHODOLOGY

2.1. Sampling Collection and Preparation

In the sampling process, the locations had been selected following the human concentration criterion and the mineral composition of the sands samples throughout the coast of the region of the Great Vitória. It was observed that the disposal of these minerals is approximately the same for all beaches, but for the regions of higher ilmenitic mineral concentration with dark tonalities in sands (as "Areia Preta" beach, meanning "Black Sand"). Monazitic sands possess a variation of tonality between the colored and brown tones (not black as it is believed) [2].

Superficial beach sand samples with a depth of about 2 cm, from 7 beaches of Great Vitória region (Camburí, Praia do Canto, Curva da Jurema, Setibão, Areia Preta, Manguinhos and Itapuã), were collected at a distance of 3 m of the sea line. The samples location are show in Fig.1. Each sample was sealed in a standard 100 mL polyethylene flask and stored for approximately 4 weeks before counting, in order to allow the reaching of secular equilibrium in the ^{238}U and ^{232}Th series [3]. For each location, the samples were prepared in triplicate.

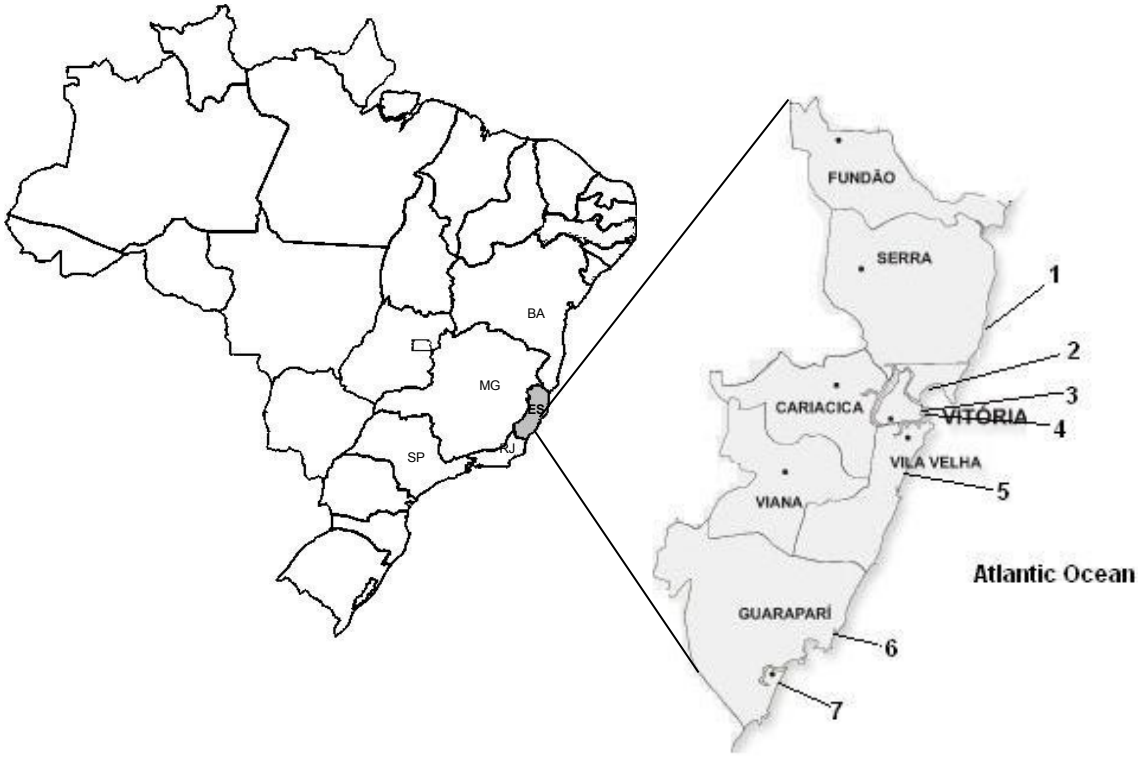

Figure 1. Map of Great Vitória region and this geographic location on the coast of Espírito Santo state, Brazil. The numbers (1-7) represent the ID beach location of the collected samples (see Table 2).

2.2. Measurements

The samples were measured by high resolution gamma spectrometry [4] with a 15% HPGe ORTEC EG&G detector with conventional electronics and a 919 ORTEC EG&G Spectrum Master 4k multichannel analyzer. The HPGe detector and the samples were placed inside a conventional lead shield, with 10 cm of thickness.

In order to establish the counting time, a fast screening was performed for each sample. All samples, but Areia Preta beach samples, were measured during 150000 s. The Areia Preta beach samples, with higher radioactivity levels, were measured for only 3000 s. For each location three samples were measured.

All spectra were analyzed with the WinnerGamma software [5]. The detector efficiency curve was determined with a multielement gamma standard solution [6], for the same geometry as the sample. The background radiation was determined by measuring a deionized water sample in the same geometry as the beach samples. The software output represents already the radionuclide concentration.

The ^{232}Th concentration was determined from the average concentrations of ^{228}Ac, ^{212}Pb and ^{212}Bi. The ^{226}Ra concentration was determined from the average concentrations of ^{214}Pb and ^{214}Bi and the concentration of ^{40}K is determined directly by its gamma transition. The gamma transitions were choosed by their highest intensities as showed in Table 1.

Table 1. Gamma transitions used for determination of radionuclide concentration.

Radionuclide	Progeny	Gamma transition energy (keV)	Gamma transition intensity (%)
^{226}Ra	^{214}Pb	295.21	18.7
		351.92	35.8
	^{214}Bi	609.32	45
^{232}Th	^{212}Pb	238.63	43.5
		300.09	3.25
	^{212}Bi	727.33	6.6
	^{228}Ac	911.07	27.8
		968.90	16.7
^{40}K	^{40}K	1460.83	10.7

Reference [5]

The concentrations of ^{40}K, ^{232}Th and ^{226}Ra were determined by the arithmetic mean of the triplicate samples. Also, the standard deviation for each location was calculated.

3. RESULTS AND DISCUSSION

3.1. Activity Concentration in Beach Sands of Great Vitória

The average concentrations values of ^{40}K, ^{232}Th and ^{226}Ra are shown in Table 2.

Table 2. ^{232}Th, ^{226}Ra and ^{40}K concentrations in several beaches of Great Vitória surroundings (Values in parentheses represent the standard deviation from the mean)

Municipality		This work (mean of 3 measurements			Literature values [7]		
ID	Location	^{232}Th ($Bq.kg^{-1}$)	^{226}Ra ($Bq.kg^{-1}$)	^{40}K ($Bq.kg^{-1}$)	^{232}Th ($Bq.kg^{-1}$)	^{226}Ra ($Bq.kg^{-1}$)	^{40}K ($Bq.kg^{-1}$)
Serra							
1	Manguinhos*	92(14)	27(2)	< 40	-	-	-
Beach not identified by the author		-	-	-	1330(1599)	116(95)	127(63)
Vitória							
2	Camburi	3129(299)	575(11)	< 86	236(200)	49(40)	27(3)
3	Praia do Canto*	39(8)	13(1)	92(3)	-	-	-
4	Curva da Jurema*	670(91)	172(19)	142(31)	-	-	-
Vila Velha							
5	Itapuã*	13(2)	5(1)	48(11)	-	-	-
Beach not identified by the author		-	-	-	77(67)	34(25)	41(19)
Guarapari							
6	Setibão*	9(1)	4(1)	13(2)	-	-	-
7	Areia Preta	6035(181)	509(29)	< 318	55537(20816)	4043(1664)	63(32)

* New values

Measurements with 68% (± 1σ) confidence level, k=1

The results of our work are summarized in Fig. 2, for easier contemplation.

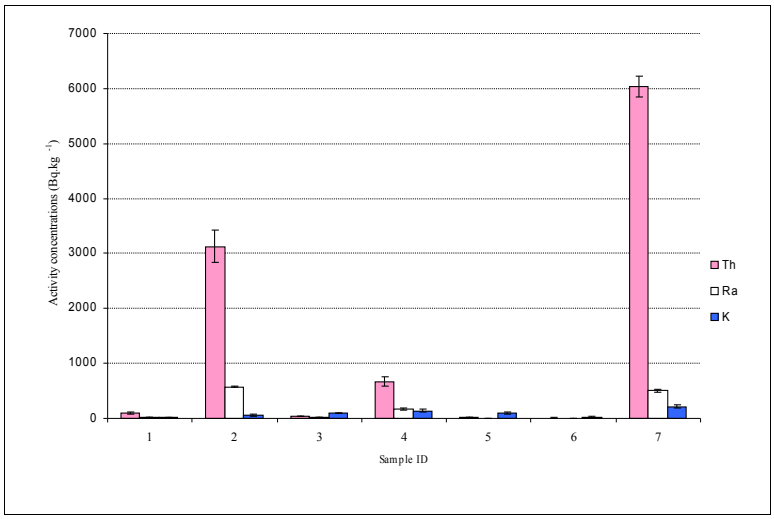

Figure 2. Bar diagram showing activity concentration of ^{232}Th, ^{226}Ra, and ^{40}K, at different sampling sites (sample ID).

As can be seen from Table 2, it is difficult to compare our results with literature values, as, for two regions, the authors present values without major considerations about a specific beach and, in general, their standard deviations are higher when compared with the mean values, probably because a NaI(Tl) detector with poor resolution was used.

The highest ^{232}Th concentration was found for the Areia Preta beach and the lowest for Setibão beach, both in the same municipality of Guarapari.

The highest ^{226}Ra concentration was found for Camburí beach and the lowest one for Setibão beach.

The highest ^{40}K concentration was found for Curva da Jurema beach and the lowest one for Setibão beach. It must be pointed that, for beaches with high thorium content, as Areia Preta and Camburí, the potassium concentration determination was difficulted by the interference of the ^{228}Ac 1458 keV gamma transition with the ^{40}K 1460 keV gamma transition. For future assessment of the radium equivalent activity, those samples will be measured for shorter counting times for the determination of the^{40}K only.

From Fig. 2, it can be observed that there is no regular trend in the variation of radioactivity concentrations from Manguinhos beach to Areia Preta beach. The higher values for ^{232}Th, ^{226}Ra and ^{40}K concentration were found for Camburí beach and Curva da Jurema beach, both belonging to the municipality of Vitória and for Areia Preta beach from the municipality of Guarapari.

4. CONCLUSIONS

The concentration of ^{226}Ra, ^{232}Th and ^{40}K in beach sand samples from 7 beaches of Grande Vitória Region, Espírito Santo State, southwest of Brazil, were investigated by high resolution gamma-ray spectrometry. The activities ranged from 9 to 6035 Bq.kg^{-1} for ^{232}Th, from 4 to 575 Bq.kg^{-1} for ^{226}Ra and from 13 to 142 Bq.kg^{-1} for ^{40}K.

As a new approach of the Great Vitória beaches, the outstanding is the study of the Praia do Canto beach, Curva da Jurema beach and Setibão beach, not assessed before the present work.

The next step is the assess of the radium equivalent activity (Ra_{eq}) and the external hazard index due to the natural radioactivity in those beach sands. However, it was observed that several samples present apparent densities around 2 g.cm^{-3}, so, before calculating the Ra_{eq} and the gamma activity concentration index, it will be necessary to correct the activities for self-attenuation, as the concentrations should be higher than the values from Table 2.

The high-resolution gamma-ray spectrometry is a powerfull tool for natural radioactivity studies and elemental concentrations determination in sand samples.

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