Determination of the concentration of natural and artificial radionuclides in the soil of the Campus of the Federal University of Sergipe

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Natural radionuclides are not only found scattered in the earth's crust but in all environments on the planet: soil, water and atmosphere, and leading from the natural radioactive series of ^{238}U and ^{232}Th, and the ^{40}K. However, the artificial radionuclides in the vast majority produced since the 40's and released into the environment by nuclear tests, were spread throughout the globe by the process known as "fallout." In view of the lack of geochemical data in the state of Sergipe, this work was done in order to analyze the activity of radionuclides in the soil of the Federal University of Sergipe, located at the city of São Cristovão. The collection of samples was performed at five points on the campus of the university, which were sent to the Eletronuclear's Environmental Monitoring Laboratory, located in Paraty - RJ, and analyzed by gamma spectrometry, thereby obtaining the radioactive elements present in samples.
Keywords: artificial radionuclides, ^{238}U, concentration.

1. INTRODUCTION

In due to the influence of surface geochemistry has on the biosphere is important to know where and how the elements are distributed in their natural state and which may have been redistributed by man. The natural abundance of elements on the surface can vary with the product range of geological processes, environmental and soil [1].

A geochemical database as well and its representation on a map form has a direct impact on the human occupation and in the exploration of terrestrial surface. The necessity of an adequate geochemical database increases with the population. In the next 50 years the worldwide population may exceed 8 million people, the one that would correspond an increase of about 50% relatively to the current numbers. Inevitably this expansion of the world population will cause an increase in the need for exploitation of mineral resources, the areas for planting and cattle, forestry, water and living space and since most people aspire to a standard of living each even better, the pressure on these resources will increase further [1]. So that humanity anticipates to these problems, and makes it on a rational form, it will be essential to establish a database that says respect to all the types of resources, as well as the all the aspects related with the environment. Currently the geochemical database, that is incomplete and without a uniform criterion systematized, which could lead to significant facts are not considered related to environmental science and political decisions are inadequate.

Among the various agents in the environment that may expose humanity to various risks and effects, there are the ionizing radiations, whose knowledge of their dose it is of fundamental importance for the effective control and prevention of their possible damage to humans and the environment.

Therefore, had to some superficial tests with nuclear bombs [2, 3], that had been carried through the decades of 40 and 70, and also the secondary radiation produced by the constant interaction of the cosmic rays with the terrestrial atmosphere, radioactive elements are present in all the globe through fallout (denomination of the phenomenon in which the dispersion of the radioactive material, taken for the winds, and posterior precipitation of the same occurs). It

exists, then, the concern to verify the levels of contamination of the ground, the water and foods since the harvest (rude foods) until the consumption for the man (fine foods) [4].

There are few references in the literature on these types of studies; the majority of the references are destined to the north hemisphere, for being the region more affected by the nuclear tests. About the south hemisphere, there are few studies, mainly in Brazil. In particular, for the state of Sergipe there is no data about the Sergipe's environment regarding the levels of radiation.

The objective of this study is to evaluate the activity of radionuclides in the soil of the Federal University of Sergipe Campus. Thus the first technical-scientific experimental evidence regarding the level of environmental dose in the State of Sergipe will be presented.

2. MATERIALS AND METHODS

Basically the gamma spectrometry was the technique used in laboratory to determine the radionuclides of the samples [5]. The detection of radiation occurs when a photon of radiation reaches the detector transferring all or part of its energy to the crystal by means of known processes of interaction of radiation with matter which are mainly, the photoelectric effect, Compton effect and the production of pairs [6].

The scintillator crystal has the property to produce a pulse of light or peak when the radiation passes through it. In the case of a detector of intrinsic germanium HP (GE), when the ionizing radiation reaches the matrix of the crystal forms pairs electron-hole generating a pulse or electric signal. In these detectors, the charge carriers are the holes that are the positions where the electrons are missing. They behave as if they were positively charged and can move through the crystalline matrix when an electric field is applied [7].

The amplitude of the electric signal is in general proportional to the energy of the gamma photon incident in the material. An electronic arrangement allows discriminating the tension pulses distributing it in windows or channels corresponding to energies of radiation emitted by various elements, generating the spectra. The lines or peaks are formed as the counting of the discriminated pulses go accumulating themselves in the respective canals and thus it is possible to relate the energies and the original activity, after appropriate calibrations. The detector's ability to produce these lines is characterized by the width of the peak and the efficiency of detection.

The high-resolution gamma spectrometry has been used widely in the determination of radionuclides in environmental samples, it is possible to determine directly the gamma emitters of the sample, obtaining a qualitative and quantitative identification of the radionuclides present in the sample. The geometry of the sample used in this work was a Marinelli beaker with one-liter volume (Figure 1) manufactured by Ga-Ma & Associates, Inc., of special materials with low background radioactivity [5].

Figure 1- Beaker used in this work – manufactured by Ga Ma & Associates

The activity of a radionuclide is calculated according to the rules of CNEN (National Nuclear Energy Commission) and IAEA (International Atomic Energy Agency), according to the following expression [8, 9]:

$$A = \frac{N_L}{\varepsilon . P_\gamma mt} \quad [1]$$

Where **A** is the activity of the sample in Bq/kg, $\mathbf{N_L}$ is the net number of counts measured in the photopeak, **ε** is the detection efficiency of the system, **Pγ** is the absolute transition probability for decay through the energy range selected for **ε**, **m** is the mass of the sample in kilograms and **t** is the time measured in seconds [10].

The determination of the activities of the samples was performed using a HPGe detector coupled to a 4096 channels multichannel analyzer, standard for gamma spectrometry. The background and samples spectra were taken for a period of 60,000 seconds for each measure, and then found the average result of the measures and their deviations.

For this study were chosen five different points inside the campus, they are: **point 1**, near the Department of Physics, **point 2**, near the Department of Chemistry, **point 3**, near the Rectory, **point 4**, near the Library, and **point 5** , near the soccer field. Collection was held on October 30, 2008 at 15 o'clock and it was collected approximately 2kg of soil from each point. These samples were placed in plastic bags previously identified and sent to the Environmental Monitoring Laboratory (EML) of Eletronuclear, located in Angra dos Reis in Rio de Janeiro. In EML samples were passed in a sieve of 16 mesh, then transferred to a one liter plastic Marinelli's beaker previously weighed. And the set was weighed to determine the mass of the sample, and the beaker was sealed with silicone glue and identified to be analyzed by gamma spectrometry.

3. RESULTS AND DISCUSSION

The results obtained in four of the five samples collected on the campus of the UFS, have only natural radionuclides as shown in the tables below:

Table 1 - Natural radionuclides in point 1.

Radionuclide		Activity (Bq/Kg)
^{40}K	1.000	3.33 ± 0.32
^{211}Bi	0.497	0.50 ± 0.05
^{212}Bi	0.407	1.48 ± 0.04
^{214}Bi	0.598	2.02 ± 0.01
^{212}Pb	0.863	0.11 ± 0.07
^{214}Pb	0.959	0.17 ± 0.08
^{228}Ac	0.349	0.24 ± 0.02
^{235}U	0.620	0.11 ± 0.01

Table 2 - Natural radionuclides in point 2.

Radionuclide		Activity (Bq/Kg)
^{40}K	0.998	0.11 ± 0.84
^{211}Bi	0.540	3.70 ± 0.51
^{212}Bi	0.704	5.61 ± 0.20
^{214}Bi	0.762	6.14 ± 0.30
^{212}Pb	0.884	5.65 ± 0.14
^{214}Pb	0.774	6.10 ± 0.22
^{228}Ac	0.494	1.33 ± 0.01
^{235}U	0.620	0.11 ± 0.01

Table 3 - Natural radionuclides in point 4.

Radionuclide		Activity (Bq/Kg)
^{40}K	0.891	0.22 ± 0.16
^{211}Bi	0595	2.92 ± 0.78
^{212}Bi	0.463	7.83 ± 0.29
^{214}Bi	0.769	6.46 ± 0.34
^{212}Pb	0.894	7.53 ± 0.23
^{214}Pb	0.490	7.02 ± 0.33
^{228}Ac	0.501	0.95 ± 0.13
^{235}U	0.891	0.22 ± 0.16

Table 4 - Natural radionuclides in point 5.

Radionuclide		Activity (Bq/Kg)
^{40}K	0.959	0.22 ± 0.16
^{211}Bi	0.567	4.59 ± 0.91
^{212}Bi	0.390	6.82 ± 0.28
^{214}Bi	0.764	6.61 ± 0.50
^{212}Pb	0.891	7.01 ± 0.24
^{214}Pb	0.339	6.57 ± 0.31
^{228}Ac	0.457	0.89 ± 0.12
^{235}U	0.959	0.22 ± 0.16

The natural radionuclides of terrestrial origin occur in all compartments of the environments, even in living organisms [4, 11]. The external irradiation of the human body due to these factors occurs mainly through the gamma radiation of natural radionuclides of the series of uranium-238 (^{238}U) and Thorium-232 (^{232}Th) and the decay of potassium-40 (^{40}K). Another natural series, the actinium series, begins with ^{235}U with the isotopic composition of 0.71% on that in the ^{238}U is 99.28%. Internally, in addition to gamma radiation, the body is irradiated by alpha and beta particles produced in the decay of these elements. The intake through food and water is the main route of absorption of these radionuclides in the body and depends on dietary habits, the type of soil and farming practices of a given population [2, 5]. As a general rule, the radioisotopes are behaving the same way as their non-radioactive isotopes with respect to absorption by the roots of the plants and even do not have metabolic function, may be present in plant tissues.
In the sample of point 3 in addition to the natural radionuclides, which exists in other places, checked the activity of cesium-137 (^{137}Cs), as described in Table 5.

Table 5 - Radionuclides in point 5.

Radionuclide		Activity (Bq/Kg)
^{40}K	0.999	0.33 ± 0.15
^{211}Bi	0.537	8.32 ± 0.67
^{212}Bi	0.828	0.13 ± 0.28
^{214}Bi	0.987	0.12 ± 0.28
^{212}Pb	0.986	0.13 ± 0.26
^{214}Pb	0.947	0.15 ± 0.27
^{228}Ac	0.524	2.39 ± 0.13
^{235}U	0.997	0.18 ± 0.07
^{137}Cs	0.999	0.33 ± 0.15

The ^{137}Cs is an artificial radionuclide which was produced in thermonuclear surface's tests during the period from 1945 to 1970 and distributed globally in the stratosphere and deposited by precipitation and wet or dry. When deposited on soil, the ^{137}Cs is absorbed by organic and inorganic components of the soil matrix. These components have high affinity for ^{137}Cs, and the clays have a great capacity to absorb and retain ^{137}Cs. In mineral soils, the ^{137}Cs is fixed on hydrous mica. In flooded organic soils, the ^{137}Cs is fixed by a simple process of exchange of ions and can be displaced by cations with higher affinity for adsorption positions or by cations present in higher concentrations [10].

4. CONCLUSIONS

The soil analysis of the UFS in points 1, 2, 4 and 5 had only natural radionuclides with an activity below the limit of the standard CNEN-NE-3.01. In point 3, were the same natural radionuclides present in other places, and it was an important concentration of artificial radionuclide ^{137}Cs. The activity found in ^{137}Cs was 0.18 ± 0.07 Bq/kg and comparing the values of activity found for the ^{137}Cs with the values established by the standard CNEN-NN-3.01, we see that the activity of ^{137}Cs in 3 is less than 10% of the maximum recommended.

The radioactive pollution has become of great concern since the last world war, once their effects may cause serious harm to people, plants and animals in different regions of the Earth. The radioactive materials dispersed in the environment by anthropogenic sources (nuclear

detonations, nuclear accidents, use of radioactive sources in medicine etc.) can be transported by various processes, be they atmospheric, aquatic or terrestrial.

The radioactive elements, however, when properly handled, can be very useful to man. For example, the ^{137}Cs and ^{60}Co are used in medicine for treatment of cancer or in the large radiators for the sterilization of products that are used by humans, such as packaging for food and also the ^{241}Am in smoke detectors.

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