Poster Presentation

RADIONUCLIDES OF NATURAL ORIGIN IN FOOD AND WATER FROM A HIGH BACKGROUND RADIATION AREA IN SOUTH-EASTERN BRAZIL

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Abstract

Food consumption is one of the main entry routes of radionuclides into the human body. Concentrations of radionuclides of natural origin vary according to several factors such as local geology, climate and agricultural practices. High background radiation areas have attracted much interest from a radiation protection point of view. The Poços de Caldas Plateau is located in south-eastern Brazil and is regarded as a high background radiation area. The situation of the resident population in the region of Poços de Caldas is of special interest for public health surveillance. The activity concentrations of radionuclides of natural origin in 19 groups of food and drinking water were determined. These radionuclides were quantified using gamma spectrometry, ultra low level alpha and beta total counting, and alpha spectrometry, after group preparation and/or radiochemical separations. The results of this study showed that the food groups analysed give rise to a low effective ingestion dose. Calculations were performed using the total radionuclide concentration in each food group, the mass consumed per day by each population group, the total time considered, and the dose intake of each radionuclide. The average annual effective dose received by members of the urban population on the Poços de Caldas plateau was 0.555 mSv.

1. INTRODUCTION

Radionuclides are naturally present in the environment and in all living things, food and water. All beings are exposed to natural radiation (also called background radiation) on a day to day basis [1]. The radiation originates from radionuclides of natural origin found in soil, water and air. Radioactivity can be detected in food and water, and the radionuclide concentration varies according to several factors such as local geology, climate and agricultural practices [2]. Radioactive material is transferred into the food chain in the same way as non-radioactive material. The degree of harm to human health depends on the type of radionuclide and the period of exposure [1]. High background radiation areas (HBRAs) have attracted much interest from the point of view of radiological protection. Studies that evaluate the biological harm in humans exposed to radionuclides in the ^{238}U and ^{232}Th series, which have long half-lives, are very important [3]. Among the HBRAs, the Poços de Caldas plateau, located in south-eastern Brazil, is known worldwide for exhibiting several radioactive anomalies. The situation of the population residing in the cities affected by the volcanic region of Poços de Caldas is of special interest for public health surveillance related to physical factors, presenting a rich framework for studies that improve the knowledge about the long term exposure to natural radioactivity in regions with geological anomalies with high concentrations of radioactive minerals. The World Health Organization recommends the ‘total diet study’ (EDT) as the most appropriate method for estimating the intake of contaminants and nutrients for a country or large population groups [1] .The use of the ‘family budget researches’ (POFs) of the Brazilian Institute of Geography and Statistics (IBGE) is one of the ways to determine the food consumption data for use in EDTs. The objective of this work is to determine which of the radioactive elements ^{40}K, ^{210}Pb, ^{210}Po, ^{226}Ra, ^{228}Ra, ^{232}Th, ^{230}Th, ^{228}Th, ^{234}U, ^{235}U and ^{238}U are radiologically relevant and present in the diet of the population in the HBRA of south-eastern Brazil.

2. METHODS

The sampling and preparation of food were carried out using the groups described in the 2008–2009 IBGE POF [4], and each group was regarded as a composite, with a total of 83 types of food divided into 20 groups. The composites were prepared according to the food as they are consumed. The food eaten after cooking was prepared without the use of spices, condiments, oils and fats, and other ingredients were not introduced during the preparation, except for the addition of distilled water [5]. After preparation, each composite was homogenized manually or using a home processor, then the composites were dried at 75°C, crushed, dissolved with nitric acid and perchloric acid, and forwarded for radiometric analysis.

2.1. Gamma spectrometry

One of the advantages of gamma spectrometry is the ability to determine radionuclides without the need for chemical separation and acid dissolution. The equipment has a semiconductor detector of high purity germanium (HPGe), which has a good energy resolution and is connected to multi-channel analysers and the appropriate software for identification and quantification of radionuclides. This methodology was used for the determination of ^{40}K.

2.2. Alpha spectrometry

This method is used to determine the alpha radiation emitting isotopes previously isolated from the matrix and purified by radiochemical separation. The source for the measurement of isotopes is extremely thin, and in this work it was obtained by the methods of electroplating and spontaneous deposition. This technique was used in this work for the determination of ^{210}Po, ^{228}Th, ^{230}Th, ^{232}Th, ^{234}U, ^{235}U and ^{238}U.

2.3. Alpha and beta total counting

This method is used for the determination of the radionuclides ^{210}Pb, ^{226}Ra and ^{228}Ra, and is based on chemical separation from the other elements present in the sample, using a purification technique with selective co-precipitation. It is an indirect method of determination based on the short half-life progeny of the radionuclides to be quantified. This technique has an advantage over gamma spectrometry, as it presents a low natural radiation and consequently has also a very low detection limit for these same radionuclides.

3. RESULTS AND DISCUSSION

The reference material IAEA-327-Soil was analysed in order to validate the methodologies used for the radionuclide determinations and quality control of the results. The matrix used for the validation was a soil, which could be considered a more complex matrix than food. The activity concentrations of ^{40}K, ^{210}Pb, ^{210}Po, ^{226}Ra, ^{228}Ra, ^{228}Th, ^{230}Th, ^{232}Th, ^{234}U, ^{235}U and ^{238}U showed that the methods used to determine these radioisotopes are reliable and accurate. The doses received by food intake by population groups can be calculated as follows:

$$E_A = \sum_j \sum_f C_{j,f} \times M_{j,A} \times T \times h_{j,A} \quad (1)$$

where:

E_A is the effective dose absorbed per group (mSv),

$C_{f,j}$ is the average radionuclide concentration in the food (Bq/kg),

$M_{j,A}$ is the mass consumed by group A (kg/d),

T is the total length of time considered (d).

$h_{j,A}$ is the ingestion dose coefficient for the radionuclide for Group A (mSv/Bq).

The risk associated with the ingestion of radionuclides by humans is proportional to the total ingested dose of radionuclides. In general, it is assumed that the stochastic effects increase linearly with dose and the effective dose is usually used to define such risk. Table 1 presents the total contribution of each radionuclide to the total annual effective dose.

TABLE 1. EFFECTIVE DOSE

	Dose coefficient (mSv/Bq)	Effective dose (mSv/d)
K-40	6.20×10^{-6}	7.53×10^{-4}
Pb-210	6.80×10^{-4}	4.18×10^{-4}
Po-210	2.40×10^{-4}	6.26×10^{-5}
Ra-226	2.80×10^{-4}	4.41×10^{-5}
Ra-228	6.70×10^{-4}	2.24×10^{-4}
Th-228	7.20×10^{-5}	1.54×10^{-5}
Th-230	2.10×10^{-4}	9.99×10^{-7}
Th-232	2.20×10^{-4}	9.79×10^{-7}
U-234	4.90×10^{-5}	8.28×10^{-7}
U-235	4.60×10^{-5}	2.63×10^{-8}
U-238	4.40×10^{-5}	5.42×10^{-7}
Total		1.52×10^{-3}
	Total effective dose in a year (mSv)	0.555

Note: The dose coefficients are those for ingestion by adults, as published in 2012 by the International Commission on Radiological Protection.

In order to verify the radiological dietary safety of the population of an HRBA in Nigeria (Bitsichi, Jos Plateau), activity concentrations of ^{226}Ra, ^{228}Th and ^{40}K in food samples and soil of the region were analysed. The dose rates that were found ranged from 0.50 to 1.47 μSv/h. However, the values obtained suggested that the dose of these radionuclides in food intake was low and that detrimental health effects were not expected [6]. The values found for this Nigerian study were much higher than the total annual effective dose determined in the present work (0.555 mSv/a, implying a dose rate of 0.06 μSv/h), indicating that doses received by ingestion are not harmful to the health of the Poços de Caldas Plateau population. The measurement of radioactivity in the total diet food groups is extremely important for monitoring the radiation levels to which humans can be directly or indirectly exposed, in particular the determination of radionuclides of the ^{238}U and ^{232}Th series, as presented to the population of Pocos de Caldas, a city with high natural radioactivity.

4. CONCLUSION

The total annual effective ingestion dose received by the urban population on the Pocos de Caldas plateau was determined to be 0.555 mSv. This does not give rise to any health concern.

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