DOSE EVALUATION DUE TO INGESTION OF FOODSTUFFS CONTAINING NATURAL URANIUM AND ^{226}Ra CULTIVATED IN THE PHOSPHATIC REGION OF PERNAMBUCO/BRAZIL.

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Abstract.

This paper aims to evaluate the dose to the population living in the phosphatic region of Pernambuco, Brazil, due to the ingestion of natural uranium and ^{226}Ra found in foodstuffs forming the principal ingredients of their diet. Only foods cultivated in the area and grow around the year were included in the investigation. Uranium concentrations were determined though the fluorophotometric technique, while ^{226}Ra was determined through the radon emanation method. The results indicate the annual individual dose to bone and to the whole body, derived from the ingestion of ^{226}Ra could reach 7.6 and 0.76mSv/year, respectively. The estimated doses to the kidneys and to the whole body, resulting from the ingestion of natural uranium were 1.3x10^{-3} and 3.1x10^{-4}, respectively.

1. Introduction.

Today there is much concern with the evaluation of human exposure to naturally occurring radionuclides and its contribution to the overall dose received by the population, especially in areas with high background radiation. This is because natural radioactivity is responsible for approximately 70% (2.4 mSv/year) of the overall dose received by the population of the planet [1].

Most of the exposure derived from natural terrestrial sources comes from the radionuclides in the uranium series, which is headed by the long-lived isotope ^{238}U. In the decay chain of ^{238}U one finds ^{226}Ra, which is of great importance in the field of radiation protection, due to its chemical similarity with calcium. Uranium is also important in light of its chemical toxicity.

Radium-226 occurs with its parent ^{238}U as trace constituents in granitic and metamorphic rocks, and as a sedimentary deposit in phosphate mineralizations [2]. The source of uranium in phosphate-bearing rocks is considered to be redeposition of uranium dissolved in the waters of ancient oceans from which the phosphate mineralization was derived [3,4]. The variability in the ^{226}Ra content of soils is due to the geochemistry of the uranium, which may be remobilized by surface or ground water, adsorbed to clays, reduced by iron or organic matter, or scavenged by iron precipitation [2].

Studies carried out in Brazil, concerning the internal dose received by the population living in regions with high background radiation, have focused attention only in the area of the Pocos de Caldas Plateau, in the State of Minas Gerais. However, there is little or no information related to the impact of the presence of abnormally high levels of uranium and radium associated with phosphate deposits known to exist in the Northeast of Brazil. The mineralized area, located in the coastal region of the States of Pernambuco and Paraiba, is partially occupied by industries, small farms, and houses, being fairly populated.

Agricultural activities developed in the mineralized area comprehend the production of foodstuffs such as, fruits (bananas, mangoes, cashews), roots and tubers (sweet potatoes, cassava, yam), and grains (beans, corn). These produce are consumed by the local population leading, probably, to a higher than normal ingestion of uranium and radium present in the soil that overlays the phosphate deposit.

The objective of this paper is to evaluate the dose due to the ingestion of natural uranium (Unat) and ^{226}Ra present in agricultural products cultivated in the phosphatic region of the State of Pernambuco, Brazil.

2. Methodology.

As the phosphatic region of Pernambuco is extense, an area of about 40 km^2 including part of the cities of Paulista, Abreu e Lima, Cruz de Reboucas, and Igarassu was selected for the purpose of dose assessment.

For this study, the produce grown in the area and that are of daily consumption were used. Those foods whose consumption is restricted to one season per year, such as the majority of fruits, were not considered. The foods were grouped in three broad categories according to their similarities.

For the determination of uranium levels in the samples, the fluorimetry technique was used. The ^{226}Ra levels were determined using the radon emanation technique (Lucas method). Dose calculations were performed in order to evaluate the contribution of the ingestion of uranium and radium to the radiation dose due to their presence in fruits, grains, tubers and roots cultivated in the phosphatic region under study. The annual dose equivalent, Hr,y was used to quantify the potential exposure of the population that live in the region. The average concentration of each of the nuclides in the particular crop was used, and the dose was calculated through the equation [5]:

$$H_{r,y} = (Ug \cdot C_r g + Uf \cdot C_r f + Ut \cdot C_r t) \cdot FCD_{r,y} \quad (1)$$

where,

Hr,y annual dose resulting from the ingestion of nuclide r in organ y in Sv/year;

FCDr,y dose conversion factor (in Sv/Bq) for the ingestion of nuclide r for organ y;

Ug,f,t amount of food (in kg) ingested per year in terms of grains (g), fruits (f), tubers and roots (t);

Crg,f,t concentration of nuclide r (in Bq/kg) in grains, fruits, tubers and roots.

3. Results and Discussion

The average concentrations of natural uranium and ^{226}Ra in vegetables grown in the phosphatic region under investigation are given in Table 1 [6].

The annual intake of each radionuclide (Table 3) was calculated by combining the average concentration of each radionuclide to data for the average annual food consumption for the standard man [7], given in Table 2.

The annual doses to the kidneys, bone and whole body, resulting from the ingestion of Unat and ^{226}Ra, are shown in Table 4. They were obtained by entering the data for radionuclide concentration (Table 1), and average annual produce consumption (Table 2) in Eq. 1, and applying the appropriate dose conversion factors [5].

The calculated annual dose to the whole body is higher than the one found by Amaral [8] who reported a total dose (due to the contribution of uranium and radium) of 8.7×10^{-2}mSv/year, from the ingestion of produce grown in the Pocos de caldas Plateau, Minas Gerais, Brazil. The calculated annual doses are also well above the values reported by Watson et al. [3], for an average adult exposed to a diet of foods grown in a reclaimed area in the Florida phosphate region. The reported values were 0.53 mSv/year to the bone and 0.042 mSv/year to the whole body.

4. References.

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Table 1. Uranium and radium concentrations in selected groups of edible vegetables cultivated in the phosphate region of Pernambuco.

Concentration (mBq/kg of wet weight)

Food Group	U_{nat} Range	U_{nat} Average[3]	Radium-226 Range	Radium-226 Average[3]
Roots and Tubers	14- 88	39	114-2209	456
Fruit	21-214	102	149- 540	263
Grains	15-137	70	120- 784	453

Table 2. Average annual consumption for the standard man.

Produce	Average annual consumption (kg)
Tubers and roots	87
Grains	96
Fruit	27

Table 3. Annual intake of Unat and ^{226}Ra associated with edible crops.

Average annual intake (Bq)

Food Group	Natural Uranium	Radium-226
Tubers and roots	3.4	39.7
Grains	6.7	6.7
Fruit	2.8	7.1

Table 4. Annual dose due to the intake of Unat and ^{226}Ra.

Average annual intake (Bq)

Organ or tissue	Dose convertion		Dose (mSv/year)	
	Unat	^{226}Ra	Unat	^{226}Ra
Kidneys	1.0×10^{-7}		1.3×10^{-3}	
Bone	5.1×10^{-7}	8.4×10^{-5}	6.6×10^{-3}	7.6
W. Body	2.4×10^{-8}	8.4×10^{-6}	3.1×10^{-4}	0.76