URANIUM AND ^{226}Ra CONCENTRATIONS IN SOILS AND VEGETABLES IN THE PHOSPHATE DISTRICT OF NORTHEASTERN BRAZIL

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Abstract.

A sampling and analytical program is under way in the Nuclear Energy Department, Federal University of Pernambuco (DEN/UFPE), to determine radionuclides concentration in water, soil, and plants in a phosphate-rich area located in the Northeast of Brazil. In this study, the concentration of natural uranium and ^{226}Ra in soil, as well as, in locally grown vegetables was determined. The uranium content of the soil was determined through the fluorophotometry technique. Radium-226, on the other hand, was determined through the radon emanation method. Maximum measured uranium concentrations were 102 mBq/kg of wet weight for vegetables and 148 Bq/kg (dry) for soils. Maximum ^{226}Ra concentrations, on the other hand, were 2209 mBq/kg of wet weight for vegetables and 207 Bq/kg (dry) for soils.

1. Introduction.

The distribution of alpha emitters in soils and plants has been the subject of many investigations. Of special concern are the members of the ^{238}U series, which are the major source of exposure to man. Studies have been centered in areas where higher than normal concentration of natural uranium has been detected. One of these regions, located in the Northeast of Brazil, is known for its urano--phosphate deposits. The mineralized area comprehends a 4-km wide land strip in the coastal region of the States of Pernambuco and Paraiba, with U_3O_8 soil contents ranging from 150 to 300 ppm. The area is occupied by houses, industries, and small farms, being fairly populated. Vegetables cultivated in the area include fruit (bananas, mangoes, cashews), tubers and root vegetables (sweet potatoes, yam, cassava), and grains (brown beans, corn).

This study aims to determine the concentration of natural uranium (Unat) and ^{226}Ra in soil, as well as, in locally grown vegetables, which are part of the diet of people who live in the region.

2. Methodology.

The selection of vegetables for this study was based on their importance in the local diet. Only those vegetables that grow around the year were chosen, neglecting those whose crop is restricted to one season, such as most of the fruit. Vegetables were cleaned and peeled as for human consumption. They were cut in small pieces, weighed, dried in a heating plate, and ashed at 5000 C. Soil samples were grabbed in the same spots where vegetables were harvested. They were taken from different horizons to detect possible variations in the concentration of radionuclides as a function of depth in the soil. Samples were collected with a manual boring tool from depths ranging from 0 to 120 cm. Samples were air-dried, weighed, and coarse-screened in 2 mm sieves. Both, the fine and the coarse portions were weighed to determine the fractions of fines from that soil.

The uranium content of vegetables was determined through the fluorophotometric technique. It consists in the extraction of uranium with an organic extractor (TOPO), followed by deposition on NaF/LiF disks previously prepared in platinum crucibles. The uranium spiked disks were then fused at 9000C and cooled according to the procedure given by Price et al. [1]. The fluorescence of each disk was measured in a fluorimeter (Jarrel-Ash Mod. 27-000) and related to the uranium content of the sample, through a previously prepared calibration curve. Radium-226 concentration in vegetables, was determined through the radon emanation technique. Radium was concentrated and scavenged by co-precipitation with a barium carrier. The precipitate was dissolved with EDTA reagent to end up with a volume of approximately 16mL. The solution was transferred to a radon bubbler, de-emanated by passing compressed air through the bubbler, and stored to allow ingrowth of ^{222}Rn. At the end of the storage period each sample was de-emanated into an evacuated scintillation cell attached to the bubbler. After waiting for one hour at least to ensure equilibrium between radon and its short-lived progeny each cell was counted for 10 minutes in a radon counter. Uranium and ^{226}Ra concentrations in soil samples, on the other hand, were determined by gamma spectrometry with a Ge(HP) detector.

3. Results and Discussion.

Tables 1 and 2 give the range and average concentration of Unat, and total and exchangeable 226Ra, respectively, in soils sampled from different depths. The data on Table 1 show that the uranium content of soil samples taken from the same horizon varies by an order of magnitude, and that there are no significative discrepancies between samples collected from different soil depths. The results obtained for total and exchangeable radium (Table 2) show a similar pattern. Again, no significant differences in radium concentration were detected between samples grabbed from either superficial or more deeper soil layers.

The distribuiton of uranium and radium in vegetables grown in the phosphate-rich area is presented in Table 3. To facilitate data presentation vegetables were grouped in three broad categories, namely, roots and tubers (sweet potato, cassava, yam), fruits (banana, cashew, mango), and grains (beans, corn). The results show that fruit present the highest uranium concentration among vegetables, followed by grains, and roots and tubers. The highest concentration for ^{226}Ra, on the other hand, was found in roots and tubers, followed by grains, and fruit. Among the species included in the fruit group, cashew samples showed an unusualy high uranium concentration, and consequently shifting the average concentration to a higher value. If cashew samples are excluded from the group, the average uranium concentration falls to 42.4 mBq/kg of wet weight.

Table 4 shows, for the sake of comparison, results obtained by other investigators for uranium and radium concentrations in beans, which was selected with basis on both, its abundance in the region and its importance in the dietary habits of the local population. The data on Table 4 show that measured 226Ra concentrations in beans are of the same order of magnitude than those found by Vasconcellos et al. [2] in Pocos de Caldas, Minas Gerais, an alkaline igneous intrusion in which several radioactive anomalies exist. They are, however, one order of magnitude higher than those measured by Fisenne and Keller [3,4]. On the other hand, all of the measured Unat concentrations in beans were above the average value reported by Fisenne et al. [4].

These results support the importance ongoing investigations in the phosphatic region of the Northeast of Brazil. They will be used in further studies aiming to assess the potential ingestion dose due to the consumption of locally grown edible crops.

4. References.

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Table 1. Uranium concentrations in soils from three different horizons.

Sampling Position		Uranium Concentration (mBq/kg dry)	
Horizon	Depth	Range	Average
A	0 - 40 cm	12 - 148	77
B	41 - 80 cm	10 - 112	75
C	81 - 120 cm	32 - 114	77

Table 2. Total and exchangeable radium concentrations in soils from three different horizons.

Radium Concentration (mBq/kg dry)

Sampling Position		Total		Exchangeable	
Horizon	Depth	Range	Average	Range	Average
A	0 - 40 cm	33 - 207	106	2.2-42.9	11.2
B	41 - 80 cm	27 - 198	103	3.9-43.7	12.5
C	81 - 120 cm	39 - 200	119	4.3-22.1	11.7

Table 3. 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	Unat		Radium-226	
	Range	Average[3]	Range	Average[3]
Roots and Tubers	14 - 88	39	144 - 2209	456
Fruit	21 - 214	102	149 - 540	263
Grains	15 - 137	70	120 - 784	453

Table 4. Values reported in the literature for uranium and ^{226}Ra concentrations in beans.

Source	Concentration Range (mBq/kg of wet weight) Unat	Radium-226
This work	77 - 137	724 - 771
(Ref. 2)	-	166 - 840
(Ref. 3)	-	26 - 178
(Ref. 4)	60*	56.8*

* Average value