

Pre-operational Monitoring Program of Ra-226 in Biological Material in Uranium Mining and Milling Areas

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Abstract. The environmental licensing processes of 'Santa Quitéria' uranium mining and milling unit are being carried out nowadays. The pre-operational radiological environmental monitoring program is part of those processes, which has the objective of determining the background for further comparisons and evaluation of radiological environmental impact of the operation unit. This work shows the results of Ra-226 determination in the most consumed farm products of the region, which are black beans, corn and milk. These data are compared with data available in the literature. Measurement results of Ra-226 in black beans vary from 3.3×10^{-2} Bq/Kg to 9.1×10^{-2} Bq/Kg; in corn, the results vary from 8.0×10^{-3} Bq/Kg to 4.6×10^{-2} Bq/Kg; in milk the results vary from 1.0×10^{-3} Bq/Kg to 7.0×10^{-3} Bq/Kg that represents the smallest variation range. All of these results are in good agreement with literature reported data.

KEYWORDS: Ra-226, monitoring program, NORM, Santa Quitéria

1 - Introduction

The environmental licensing processes of a uranium mining and milling unit at Santa Quitéria (Brazil, CE) are underway nowadays. Thus, following Brazilian norms, a pre-operational radiological environmental monitoring program must be undertaken [1]. This program is being carried out to establish the background (BG), aiming further estimation of the environmental impact of the plant.

Thus, Ra-226 was chosen as the critical radionuclide and the chosen critical way was the ingestion of agricultural produce (black beans, corn and milk). Ra-226 was selected for being considered as the most radiotoxic radionuclide from the uranium series [2, 3]. This results from its chemical similarities with calcium, being therefore accumulated in the bones, where its alpha radiation irradiates the bone marrow, a highly radio-sensible tissue [2], and also from its long physical half-life (1600 years), resulting in an activity that is supported over long periods [3].

In addition, the choose of Ra-226 was supported also by previous studies [4-6] that identified this radionuclide as the major contributor to the committed effective dose by ingestion of vegetal derived aliments in another uranium mining site situated in the same semi-arid region of northeastern Brazil (Caetité, BA) where similar environmental conditions are observed.

The present work intends to identify the activity concentrations of Ra-226 in agricultural produce important for the region of Santa Quitéria (black beans, corn and milk) and to compare these concentrations with literature data.

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2 - Methodology

2.1 – Studied area

The radioactive anomaly of Santa Quitéria is localized in the interior of the state of Ceará, in the semi-arid region of northeastern Brazil. The typical vegetation is known as caatinga (steppe); pluviometry varies from 550 to 960 mm/year, and the rainy season goes from January to March.

2.2 –Critical radionuclide

Ra-226 was analyzed both by radiochemical processes and by total alpha radiometry, following Godoy et al. (1994) [7]. Ra-226 was co-precipitated as Ba(Ra,Pb)SO₄ by adding H₂SO₄ and BaCl₂ to the sample solution. The obtained mixed sulfates were washed and dissolved with nitrilotriacetic acid (NTA). Barium (radium) sulfate was re-precipitated by adding acetic acid until pH 4.5-5.0; in such conditions, lead remains in the aqueous phase. The aqueous and solid phases were separated, and Ba(Ra)SO₄ was purified by dissolution in an ethylene diamine tetra-acetic acid (EDTA) solution at pH 10. Then the sulfate mixture was re-precipitated with acetic acid (pH 4.5-5.0). The precipitate was filtrated and, after left aside for 1 month allowing the growth of Rn-222 and his short-lived progeny. Ra-226 was determined by gross alpha counting.

2.3 - Analyzed Material

Milk, corn (*Zea mays* L.) and black bean (*Phaseolus vulgaris* L.) were chosen for the analysis for being the agricultural produce that exhibited the highest radioactive concentrations of Ra-226 in another uranium mining area with similar environmental characteristics [5]. These three farm products are entirely produced and consumed in the region and are considered the most important foods locally consumed [8].

2.4 - Material Collection and Preparation

Approximately 5 kg (wet weight) of corn grains and beans were collected. This material was dried at constant weight and calcined at 450°C until a clear residue was formed. In the case of milk, approximately 5 liters were collected, dehydrated and the residue calcined at 450° C until a clear residue was obtained.

3 - Results and Discussion

Radioactive concentrations of Ra-226 found in this work are summarized in Table 1. Observed values are at least one order of magnitude higher than those reported for a similar semi-arid region in the state of Pernambuco (Brazil), where a phosphate anomaly with uranium impurities is reported (Table 1, Amaral et al 2005) [9].

Similarly, our results are at least ten times higher than data reported for the city of New York (Table 1, Fissenne et al 1987) [10], for the United States (Table 1, Tracy et al 1983) [12], and also for the uranium mining and milling area of Caldas (Brazil, MG) (Table 1, Vasconcelos et al 1986) [11].

On the contrary, our data are of the same order of magnitude than values reported by Santos et al (2002) (Table 1, Santos et al 2002) for the city of Rio de Janeiro [13], and are at least ten-fold lower than data reported by us in a previous paper for the area of Caetité where a uranium mining facility is operating (Table 1, Pereira and Py Júnior 2002) [5].

Table 1 - Values reported in the literature for Ra-226 concentration in different samples.

Source	Concentration range (mBq/Kg)
This work	
Bean	33.6 – 91.3
Corn	8.28 – 46.0
Milk	1.62 – 6.60
Amaral et al 2005 [9]	
Bean	0.709 – 0.784
Corn	0.092 – 0.179
Fisenne et al 1987 [10]	
Corn	0.003 – 0.185
Vasconcelos et al 1986 [11]	
Bean	0.163 – 0.840
Corn	0.070 – 0.229
Tracy et al 1983[12]	
Bean	0.248 ¹
Corn	0.070 ¹
Santos et al 2002 [13]	
Bean	34 – 298
Corn flour	6 – 36
Milk	2.2 – 27
Pereira and Py Junior 2002 [5]	
Bean	570 ¹
Corn	130 ¹
Milk	100 ¹

¹ arithmetic mean

4 - CONCLUSIONS

Comparing the radioactivity concentrations of Ra-226 in corn, black beans and milk, obtained in the present study, with those reported in the literature for high background areas, our data are one order of magnitude higher than those of the former uranium mining area of Caldas (Minas Gerais, Brazil) and of the phosphate anomaly region in Pernambuco (Brazil), but are one order of magnitude lower than values reported by us for the uranium anomaly at Caetité.

Comparing with urban areas, our data are one order of magnitude higher than data for New York City, and of the same order of magnitude as data recorded for the city of Rio de Janeiro.

As final conclusion, it can be stated that the values found in the present work are in good agreement with the distribution of the radioactive concentrations of Ra-226 as reported in the literature for beans, corn and milk samples.

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