Cultural inputs of ^{226}Ra and ^{228}Ra in tropical agricultural environments

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Abstract. In this work, soil to plant transfer factor of ^{226}Ra and ^{228}Ra obtained in areas of traditional agricultural practices varied as a function of the considered cultivated species, but little variation was observed as a function of the soil type. Beans and soybeans presented a more important absorption than cereals (corn, rice and wheat). Values of transfer factor of the legumes (beans and soybeans) were about an order of magnitude greater than the average obtained in areas of high natural radioactivity, while the results for the cereals did not presented such clear differences. Cultural inputs of ^{226}Ra and ^{228}Ra are occurring in agricultural areas, but few species can demonstrate it. Soil to plant transfer factor values for ^{226}Ra and ^{228}Ra, obtained in agricultural areas seem more applicable in models of risk evaluation.

1. INTRODUCTION

The use of regional values of parameters in the modelling can contribute to improve the environmental radiological impact assessment. In the absence of regional values of parameters, many of these values are generally obtained in manuals of the International Atomic Energy Agency or in the specialised literature, which is not always applicable.

Values of soil to plant transfer factor of radionuclides are still rare in the specialised literature for the tropical region. The existence of several types of soils and vegetation results in a great dispersion of the values of soil to plant transfer factor for a single radionuclide. Moreover, regional agricultural practices as manure, liming or irrigation, further increase this variability, once they influence in the root uptake processes [1, 2].

For ^{137}Cs, the values of coefficients of soil to plant transfer obtained in tropical soil can get to be up to 2 orders of magnitude superior to the values found in literature for temperate climate [3]. Experimental studies show that ^{137}Cs remains mainly associated to iron oxides and the availability for plants has not decreased due to fixation processes on clays, as it happens in soils of temperate climate [4, 5, 6].

Lima [7], through the results of chemical sequential extraction, concluded that the ^{226}Ra was also associated to the iron oxides in oxisol artificially contaminated. It has been observed that cultural contributions would happen in more labile forms, that would favour root uptake processes, when compared with the transfer observed in original soils of areas of high natural radioactivity where radium appears incorporated into the soil matrix. Besides this, the chemistry of the soils is complex and the transfer processes of radionuclides are dependent of its origin and chemical forms, as well as the physical and chemical properties of the soil and the plant metabolism [8, 9, 7, 10]. Intensive application of phosphates fertilisers in agricultural areas can increase the concentrations of natural radionuclides in the soils, but few background levels of these radionuclides data are available in tropical soil agro-systems, therefore evaluation of the impact of fertiliser in this systems is difficult.

Concentration of natural radionuclide established for soils from a certain agricultural area, are not necessarily applicable to other areas, because the radionuclides concentrations in fertilisers depend on the concentrations found in the origin rocks [11] and its application rate varies according to the several types of soils and cultures.

In Brazil, the soil to plant transfer factor values for natural radionuclides are based on results from areas of elevated natural radioactivity (e.g.[12, 13, 14 and 15]). These values do not necessarily reflect the influence of cultural contributions and they can underestimate the soil transfer. The use of these values in the evaluation of environmental radiological impact can contribute to increase its uncertainty.

It seems clear that the use of regional values of parameters allows to reduce the uncertainty associated with radioecological modelling and to the dose calculations, since it better express physical, chemical and/or biological processes occurring in a specific scenario [16]. On the other hand the determination of regional values of parameters generally involves long term experiments, high cost and high risk, which not always is justified in countries with restricted applications of the nuclear energy.

The present study proposes to obtain regional soil to plant transfer factor values for ^{226}Ra and ^{228}Ra in traditional agricultural areas, to be applied in radioecological models. These values will make possible a first approach of background levels of these radionuclides in tropical agro-systems, as well as a preliminary evaluation of the influence of agricultural practices in the plant concentration of ^{226}Ra and ^{228}Ra.

2. MATERIALS AND METHODS

Samples of rice (*Oriza sativa*, L.), corn (*Zea mays*, L.), wheat (*Triticum vulgare*), beans (*Phaseolus vulgaris*, L.), soybeans(*Glycine max*) and soils were collected in agricultural areas in the state of Rio de Janeiro (RJ), Minas Gerais (MG) and Goiás (GO) with poor or normal fertiliser contribution in the culture of corn or/and beans; areas with high rate of use of fertilisers in the culture of soybeans, rice and wheat in Paraná (PR) and in Rio Grande do Sul (RS); and areas with no fertilisers contribution as corn in the Amazonian Forest (AM)

In the laboratory, plants were analysed by radiochemical methods for natural radionuclides. The soils were dry and the natural radionuclides analysed by gamma spectrometry.

The Transfer Factor was calculated according to recommendations of IUR [17]:

$$TF = A_p / A_s$$

Where,

A_p = Activity of the edible part of the plant (Bq kg^{-1} dry weight).

A_s = Activity of the soil (Bq kg^{-1} dry weight).

In this work TF values obtained in elevated natural radioactivity areas (ENR) refers to those obtained in reference [14].

3. RESULTS AND DISCUSSIONS

Some examples of soil to plant transfer factor values for natural radionuclides in soils of tropical climate are presented in the table 1. Data obtained in tropical areas can be at least an order of magnitude larger than those recommended by the International Union of Radioecologia [17] that should be used in the absence of regional data.

The values presented in the table 1 show that the transfer values for ^{226}Ra vary as a function of the type of plants. Legumes presented larger absorption than the cereals. The transfer value obtained by Lima [7] for beans cultivated in Oxisol artificially contaminated with ^{226}Ra, it was about an order of magnitude greater than the values recommended by IUR. Some values obtained in agricultural areas can also get to be an order of magnitude larger than the values recommended by IUR. These results indicate that cultural contribution of radionuclides can be happening.

In agricultural areas of Paraná, Rio Grande do Sul and Rio de Janeiro, the soils present lower concentrations of ^{226}Ra and ^{228}Ra and larger availability for the legumes, while the opposite happens in soils of areas High Natural Radioactivity (ERN). These behavior suggest that cultural contributions can be happening, since although the total concentrations of ^{226}Ra and ^{228}Ra in soils of agricultural areas are low, mobility is higher compared with areas of Elevated Natural Radioactivity, where the origin is predominantly mineralogical (Figures 1 and 2).

Table 1. Soil to plant transfer factor values for natural radionuclides in soils of tropical climate compared with International Union of Radioecologists (IUR) data.

Radionuclide- plant-place	TF	IUR *
^{226}Ra - beans Campos (RJ)	1.4 E-02	7.0 E-03 [3.5E-2 – 1.4E-3] (n=8)
^{228}Ra - beans Campos (RJ)	8.0 E-03	7.0 E-03 [3.5E-2– 1.4E-3] (n=8)
^{226}Ra - beans Experimental (8) **	6.6 E-02 [1.2E-2 - 9.1E-2] (n = 4)	7.0 E-03 [3.5E-2– 1.4E-3] (n=8)
^{226}Ra - soybeans Paraná and Rio Grande do Sul	5.6 E-02 [1.2E-1 - 1,6E-2] (n=5)	7.0 E-03 [3.5E-2– 1.4E-3] (n=8)
^{228}Ra - soybeans Paraná and Rio Grande do Sul	5.1 E-02 [1.7 E-1 - 1.8E-2] (n=5)	7.0 E-03 [3.5E-2– 1.4E-3] (n=8)
^{226}Ra - corn - Campos and Rio Grande do Sul	2.2 E-03 [8.3E-3 - 6.0E-4] (n=2)	1.2 E-03 [6.0E-3– 2.4E-4] (n=11)
^{226}Ra - rice - Campos and Rio Grande do Sul	8.1 E-03 [1.3E-2 – 5.0E-3]	1.2 E-03 [6.0E-3– 2.4E-4] (n=11)
^{228}Ra - rice Campos and Rio Grande do Sul	8.2 E-03 [1.0E-2 – 6.4E-3] (n=2)	1.2 E-03 [6.0 E-3 – 2.4E-4] (n=11)

***IUR generic data for cereals and legumes.**
****^{226}Ra soil concentration: 740 Bq/g d.w..**

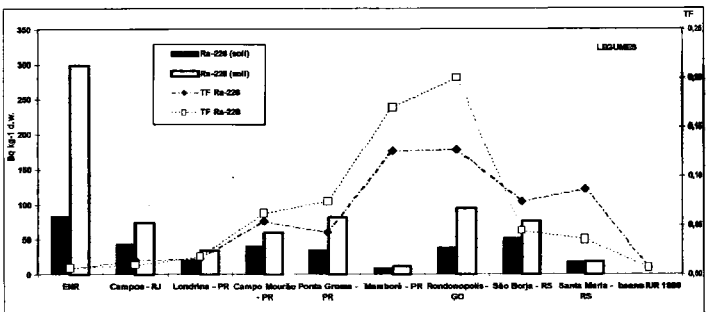

Figura1: Concentration of ^{226}Ra and ^{228}Ra in soils of agricultural areas, Elevated Natural Radioactivity areas (ERN) and soil to plant transfer factor (TF) including values recommended by IUR for legumes.

The results presented in the figure 2 show that in agricultural areas the soils presented smaller concentrations of ^{226}Ra and ^{228}Ra and larger availability for the plants, while the opposite happened in soils of areas High Natural Radioactivity (ERN). However, the soil-plant factors of transfer obtained for cereals they don't differ significantly of the values recommended by IUR for cereals.

The major nutrient need for corn and wheat is about 40 kg per each produced ton, while the soybeans and the beans need 103 kg and 81 kg of major nutrient respectively for each produced ton [18]. The corn usually needs less major nutrient per cultivated area than the soy, but its production is larger than the one

of the soy, what promotes a relative dilution of elements from phosphated fertilisers in its grains. The Figures 3 and 4 present the values of concentration of ^{226}Ra and ^{228}Ra in legumes and cereals, respectively. Figures 3 and 4, show that legumes concentrate more ^{226}Ra and ^{228}Ra than the cereals. These results indicate that the beans and soybeans, can contemplate better than the corn, the influence of the use of phosphated fertilisers s in a certain place. The differences that exceptionally were observed among the soil-plant transfer of ^{226}Ra and ^{228}Ra are mainly due to the origin of these elements: both elements are present in several minerals occurring in Brazilian soils, however the variability on total concentration and bio-availability depends on pedogenetic processes.

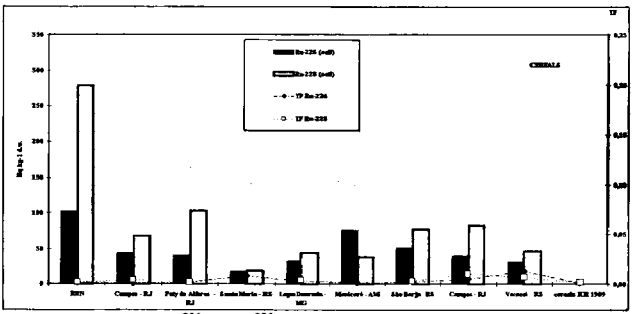

Figure 2: Concentration of ^{226}Ra and ^{228}Ra in soils of agricultural areas and Elevated Natural Radioactivity areas (ERN) and transfer factor soil-plant (Ft) including the values recommended by IUR for cereals.

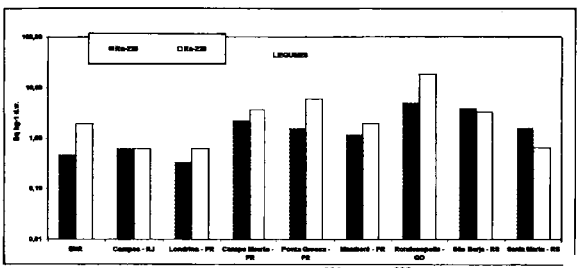

Figure 3: Values of concentration of ^{226}Ra and ^{228}Ra in legumes.

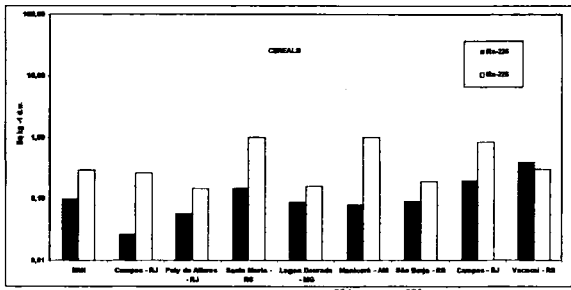

Figure 4: Values of concentration of ^{226}Ra and ^{228}Ra in cereals.

4. CONCLUSIONS

Soil to plant transfer factor for ^{226}Ra obtained in tropical agro-systems were similar to those obtained experimentally by artificial contamination and about an order of magnitude greater than values observed in elevated natural radioactivity areas.

For the values presented in this work, it was noticed that to establish background values for ^{226}Ra and ^{228}Ra is a delicate task, since the mineralogical origin seems be expressive in almost all the soils and the cultural contributions are times many too low to be detected by the current methodologies. However, as the radiological risk exists mainly associated to materials that suffered physical or chemical alterations, values of Transfer factors obtained in agricultural areas that portrayed larger mobility seem to be more coherent for use in risk analyses than those coming of areas with high background.

Acknowledgement: This work was partially supported by the International Agency of Atomic Energy under contract. BRA 10456/RO. The authors thanks the Division of Environmental Analyses of IRD for the radiochemical analyses.

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