JAP&T
TPA-Timişoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2012, *18* (1), 35-37

Journal of Agroalimentary Processes and Technologies

Soil to plants transfer factor for ^{226}RA and ^{235}U in Caras Severin area

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Received: 16 November 2011; Accepted: 19 March 2012

Abstract

The radionuclides released into the environment can give rise to human exposure by the transport through the atmosphere, aquatic systems or through soil sub-compartments. The exposure may result from direct inhalation of contaminated air or ingestion of contaminated water, or from a less direct pathway, the ingestion of contaminated food products. The samples were collected from a zone located at 20 km from the dump of the waste rock of the mine EM, Caras-Severin Country, Romania. In all of the samples, the activity concentration of 226Ra, and 235U were determined.

Keywords: natural radionuclides, soil, plants, transfer

1. Introduction

Radiation of natural origin at the earth's surface consists of two components namely cosmic rays and terrestrial radiation. The latter component mainly originates from the primordial radioactive nuclides that were originated in the early stage of formation of the solar system.

Natural environmental radioactivity and the associated external exposure due to the gamma radiation depend primarily on the geological and geographical conditions [8].

The naturally occurring radio nuclides present in the soil, rocks and water are not uniformly distributed all over the world. Radio nuclides present in the environment may enter human body through air, food and water and may adversely affect human health at higher radiation dose levels [6,4]. Humans and other living organisms are continuously exposed to ionizing radiations from natural and anthropogenic sources which are present everywhere in the environment.

The level of background radiations vary significantly from area to area and hence radiation doses to be received by the general public [1,5].

The soil-to-plant transfer factor is one of the important parameters widely used to estimate the internal radiation dose from radionuclides through food ingestion. In general, transfer factors show a large degree of variation dependent upon several factors such as soil type, species of plants and other environmental conditions [2,9].

Due to a predicted long-term transfer of radionuclides in the environment, an understanding knowledge of the geochemical and ecological cycles is also needed as they relate to the behavior of not only radionuclides but also associated elements. In addition, the distribution of radionuclides in plant components is beneficial in understanding the dynamics of radionuclides in an agricultural field. Because non-edible parts of agricultural plants are returned to the soil, they may again be utilized in the soil-plant pathway [3,7].

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As a case study, in this work has been considered the uranium waste dump reservoir from the mining perimeter of Ciudanovita., Caras- Severin.

2. Materials and methods

The environmental samples like soil and plants was collected from a zone located at 20 km from the dump of the waste rock of the mine EM, Caras-Severin Country, Romania, in order to evaluate soil to plant radionuclide transfer factors (TF). The definition of TF is:

$$TF = \frac{\text{concentration of radionuclide inplant } (Bq \cdot kg^{-1} \text{ dry crop mass})}{\text{concentration of radionuclide in soil } (Bq \cdot kg^{-1} \text{ dry soil mass in the upper 20cm})}$$

The plants samples at each point were collected from the surface at which the soil sample had to be removed. In all cases, only the aerial fraction was sampled. The samples were carefully washed in the laboratory in order to remove all the adhered soil particles. Fifteen sampling campaigns (soil, grass, carrots and potatoes) were performed during a one-year period (2009-2010) in order to take the variability in meteorological conditions into account. The isotopes selected were ^{226}Ra and ^{235}U. Content of ^{226}Ra and ^{235}U from the solid waste, grass, carrots, potatoes samples were determined by means of the spectrometric gamma measurement chain HPGe-Oxford, with 40% efficiency.

3. Results and Discussion

Table 1 shows values of the activity concentrations (Bq·kg^{-1} dry weight) of ^{226}Ra in soil and grass, carrots, potatoes and the values of soil to plant radionuclide transfer factors (TF) for the ^{226}Ra.

Table 2 shows values of the activity concentrations (Bq·kg^{-1} dry weight) of ^{235}U in soil, grass, carrots, potatoes and the values of soil to plant radionuclide transfer factors (TF) for the ^{235}U in 15 sampling points.

Radium is the last member of the alkaline earth metals, a group of metals whose lighter members (Ca and Mg) play a very important role in plant growth and nutrition. The TF values show a very wide variability for ^{226}Ra. The results have been obtained for radium in grass, with a range between 0.26-0.87, carotts 0,21-0,78 and potatoes 0,21-0,78 (see Table 1).

The statistical analysis of the results indicates that the TF values corresponding to the ^{235}U are statistically indistinguishable (see Table 2).

At a 95% confidence level, and considering all the sampling points, the TF values obtained for the ^{235}U are indistinguishable statistically, with mean values of 0.06-0.66 for grass, 0.06-0.43 for carottes and 0.06-0.62 for potatoes. On the other hand, the TF corresponding to ^{226}Ra (see Table 1) can be considered, at a 95% confidence level, higher than 235 uranium isotopes studied.

Table 1. Means values of the activity concentrations (Bq· kg^{-1} dry weight) of ^{226}Ra in soil, grass, carrots, potatoes and the values of soil to plants radionuclide transfer factors (TF) for the ^{226}Ra

Sampling point	**Activity concentration ^{226}Ra [Bq·kg^{-1}]**				**TF grass**	**TF carrots**	**TF potatoes**
	Soil samples	**Grass samples**	**Carrots samples**	**Potatoes samples**			
1	30.1	17.8	12.9	10.6	0.59	0.42	0.35
2	153	110.1	123.5	120	0.71	0.80	0.78
3	113	98.5	98.1	83	0.87	0.86	0.73
4	108	66.8	56.4	74.5	0.61	0.52	0.68
5	93	34.2	65.9	42.4	0.63	0.70	0.45
6	96.3	7.5	48.4	41.9	0.07	0.50	0.43
7	71	14	44.6	23.6	0.19	0.62	0.52
8	46	13.6	26.1	13.5	0.29	0.56	0.29
9	16.7	5.6	3.8	9.4	0.33	0.22	0.56
10	54.6	14.5	31.4	14.6	0.26	0.57	0.26
11	86.7	29.8	26.7	20.9	0.34	0.30	0.24
12	90.8	37.5	17.4	40.1	0.41	0.19	0.44
13	109.3	46.7	23.6	45.3	0.42	0.21	0.21
14	36.7	14.7	22.5	17.7	0.40	0.61	0.48
15	84.5	29.8	35.3	36.9	0.35	0.41	0.43

Table 2. Means values of the activity concentrations (Bq· kg^{-1} dry weight) of ^{235}U in soil and grass and the values of soil to plant radionuclide transfer factors (TF) for the ^{235}U

Sampling point	Activity concentration ^{235}U [$Bq \cdot kg^{-1}$]				TF grass	TF carrots	TF Potatoes
	Soil samples	Grass samples	Carrots samples^C	Potatoes samples			
1	30.1	12.2	10.1	7.8	0.40	0.33	0.25
2	153	10.8	9.4	9.7	0.07	0.06	0.06
3	113	13.7	10.5	9.9	0.12	0.09	0.08
4	108	7.5	4.6	6.7	0.06	0.04	0.06
5	93	7	5.3	7.6	0.07	0.05	0.08
6	96.3	11.4	8.7	6.5	0.11	0.09	0.06
7	71	6.3	2.5	5.4	0.08	0.03	0.07
8	46	30.5	20.1	14.2	0.66	0.43	0.30
9	16.7	8.3	5.7	10.4	0.49	0.34	0.62
10	54.6	12.6	9.8	11.3	0.23	0.17	0.20
11	86.7	15.3	11.4	12.2	0.17	0.13	0.14
12	90.8	17.5	14.5	13.2	0.19	0.15	0.14
13	109.3	11.9	8.4	8.5	0.10	0.07	0.07
14	36.7	9.3	5.2	7.7	0.25	0.14	0.20
15	84.5	14.8	7.6	8.9	0.17	0.08	0.10

The excess of ^{226}Ra in plants versus ^{235}U must be explained by the higher absorption of radium.

From the comparison between the TF values corresponding to the two elements studied (uranium, and radium), we conclude that the uranium (^{235}U is statistically indistinguishable, whereas the uptake for radium is higher than for the other once element. The fact that uranium is both actinides may explain their more analogous chemical behavior, whereas this argument cannot be extended to radium which is an alkaline-earth.

This general result is in agreement with other affirmation [3] that TF values for elements in oxidation state +II are almost always greater than for those elements in oxidation state +IV.

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