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INVESTIGATION OF TRANSFER FACTORS OF NATURAL RADIONUCLIDES FROM SOIL TO FODDER IN KARS, TURKEY

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ABSTRACT

In this research work, the activity concentrations of ^{40}K, ^{232}Th and ^{226}Ra in fodder plant samples such as wheat, barley, oats, corn slices, sainfoin and vetch grown in Kars region used for animal feeding have been determined. For this purpose, fodder samples were taken from different agricultural fields in Kars region, where the cows, sheep and poultry breeding were made. All samples were analyzed by means of gamma-ray spectrometer using NaI(Tl) detector. The average activity concentrations of ^{40}K, ^{232}Th and ^{226}Ra were found to be 484.25±23.2, 35.25±7.2 and 28.95±7.0 Bqkg^{-1}, respectively, in soil samples. In the fodder samples examined according to soil samples, the average activity concentration of ^{40}K, ^{232}Th and ^{226}Ra were found to be 463.94, 20.60 and 16.20 Bqkg^{-1}, respectively. The mean soil to plant transfer factors of these natural radionuclides for fodder samples were determined as 0.95, 0.62 and 0.55, respectively.

Key Words: Kars, fodder, natural radioactivity, transfer factor.

INTRODUCTION

The natural radionuclides found in the soil are found in different concentrations throughout the world, and their distribution varies according to geological conditions. Natural radionuclides taken from soil by plants are directly redistributed into food chains by human food or animal feed (Harb et al., 2010). Concentration of radionuclides in soil is an important factor affecting concentration in plants. Therefore, it is important to investigate the distribution of radionuclides in plants and associated soils, along with long-term behavior of radionuclides such as mobility, transfers and translocation, to provide adequate protection for all living organisms in the environment (Al-Masri et al., 2008).

In this study; fodder plants (such as wheat, barley, oats, sainfoin, corn silages, and vetch) were collected from different villages of Akyaka, Arpaçay, Selim and Susuz in Kars. It is aimed to determine the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in these fodders used for animal feeding. Since the dairy products and meat of the animals growing in the region are consumed by people living in both the local and other cities of the country, the activity levels of the natural radionuclides must be known in terms of environmental health.

MATERIALS AND METHODS

Sample collection and preparation

The study area chosen in this work lies between the longitudes of 40° 27′ - 40° 50′ N and 42° 47′ -43° 37′ E. The population of the city is 296466 as of 2016. It has 8 districts and 384 villages. 180 soil samples and 120 samples of fodder plants in the north-eastern part of Turkey's selected were collected from 35 different stations in four districts (Figure 1) The local people provide their source of income by livestock breeding, and in order to feed their animals in the long and difficult winter conditions, they grow a variety of feed crops in a wide range of land in this region. Approximately 2 kg of soil samples were taken from five single subdivisions at selected stations. The samples were taken with a sample collection tool at a depth of 13 cm from the surface by cleaning the soil surface. The samples were cleaned from foreign objects such as stone, grass and crust, and then placed in labeled nylon bags and transferred to the laboratory.

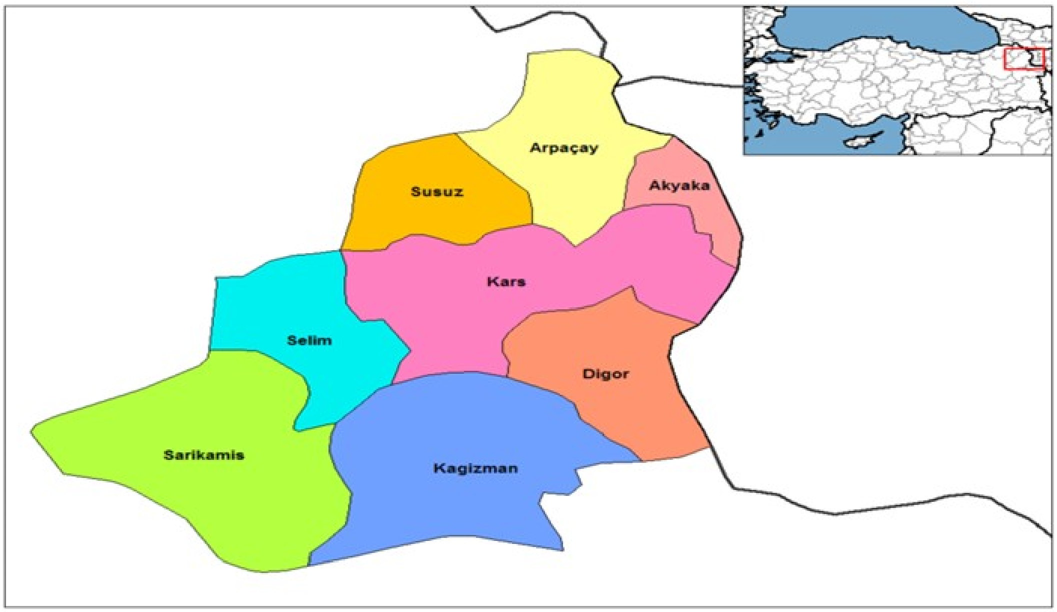

Figure 1 The map of the study area

Approximately 2.5 kg of fodder plants were collected from the stations where soil samples were taken. Fully matured forage plants collected from five subdivisions of each selected station were combined into a composite sample. The samples in the labeled nylon bags were cleaned from the soil residue and foreign bodies in the laboratory. All samples were dried in an electric oven at 105 °C for 15 hours to obtain a constant dry weight. The samples were homogenized by grinding and sieving with a mesh of 1 mm. Once the sieved samples were weighed, they were held in airtight cylindrical plastic containers of uniform size for 45 days for allowing equilibrium to develop ^{226}Ra and its short-lived decay products.

Activity determination

The prepared samples were measured by a NaI(Tl) scintillation detector based on a gamma-ray spectrometer system. The spectrum was analyzed using a PC (Personal Computer) based an MCA (Multi Channel Analyzer) system and Maestro software. The energy calibration and the relative efficiency calibration of the gamma spectrometer were performed with standard calibration material (IAEA-375). The activity concentrations in the soil samples and fodder samples were determined using the total net count under the selected photopeaks at several energies, the sample weight, the gamma intensity and the measured photo-peak efficiency. The counting time for each sample was 86400 seconds. The activity concentrations of ^{40}K was evaluated from the 1460.8 keV gamma line. ^{226}Ra concentration was found out by measuring the 609.3, 1120.3 and 1764.5 keV gamma-rays from ^{214}Bi. Similarly, 583 keV and 2614.5 keV gamma-rays from ^{208}Tl were used to indicate the activity concentration of ^{232}Th. The net count rate under the most significant photo peaks of all radionuclides daughter peaks were determined by subtracting the background spectrum corresponding to the same count time. Afterwards the activity of radionuclide the background subtracted area, is calculated from the significant gamma ray energies (Bilgici Cengiz, 2013). After used background and self-absorption corrections, the natural radionuclide (^{226}Ra, ^{232}Th and ^{40}K) concentrations were obtained for each sample. (San Miguel et al., 2004)

Soil-to-plant transfer factor (TF), which represents the transfer mechanism of radionuclides, is commonly used to describe the uptake of radionuclides from soil to plant. The activity concentrations of the radionuclides in the fodder plants and the corresponding soil are assumed to be linear and used to calculate TF according to the following equation (Alharbi et al., 2013; Kritsananuwat et al., 2017).

$$TF_{soil-plant} = \frac{A_{plant}(Bqkg^{-1}, dry\ weight)}{A_{Soil}(Bqkg^{-1}, dry\ weight)} \quad (1)$$

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RESULTS AND DISCUSSION

The mean values of activity concentrations of natural radionuclide ^{226}Ra, ^{232}Th and ^{40}K in 180 soil samples collected from the four study districts in Kars region are summarized in table 1. Considering the average radioactivity concentrations, the lowest concentrations of ^{232}Th (23.3 ± 4.8 Bq kg^{-1}) and ^{40}K (383.5 ± 19.3 Bq kg^{-1}) were found in the samples collected from the Arpaçay district. Also in the soil samples of Selim district, the lowest concentration of ^{226}Ra (19.9 ± 7.5 Bq kg^{-1}) was found. The highest activity concentrations of ^{226}Ra (37.7 ± 6.8 Bq kg^{-1}) were determined in the Akyaka district. On the other hand, the highest activity values of ^{232}Th and ^{40}K were found to be (57.9 ± 14.6 Bq kg^{-1}) and (562.0 ± 32 Bq kg^{-1}), respectively, in soil samples collected from Selim district. The mean activity concentrations of ^{232}Th (35.25 ± 7.2 Bq kg^{-1}), ^{40}K (484.25 ± 23.2 Bqkg^{-1}) and ^{226}Ra (28.95 ± 7.0 Bqkg^{-1}) were found to be in agreement with world average values of 30, 400 and 35 Bqkg^{-1}, respectively (UNSCEAR, 2000).

Table 2 shows the concentrations of ^{226}Ra, ^{232}Th and ^{40}K in fodder plant samples from Kars region. The mean and range of the concentrations of ^{226}Ra, ^{232}Th and ^{40}K were 14.0 ± 1.4 (9.69± 1.1 –20.80± 2.3), 20.60 ± 6.4 (14.50± 4.9 – 25.70± 9.8) and 463.16 ± 18.38 (313.0± 15.0 –589.0± 33.2) Bq kg^{-1}, respectively. When we compare the results obtained from similar studies in the literature, it is found that the average activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K are higher than the values of 0.7±0.1, 1.1±0.02 and 102.±9.8 Bq kg^{-1} respectively, found in the studies of Pulhani et al. on wheat grains. However, the results we obtained were found to be higher than those of 1.62±0.11, 0.23±0.04 and 195.26±6.36 Bq kg^{-1}, respectively, which Harb et al. found in his studies on fodder mixture (Harb et al., 2010; Pulhani et al., 2005).

The values of transfer factors (TF) of ^{226}Ra, ^{232}Th and ^{40}K from soil to fodder plants were calculated by using the ratio of the radionuclide concentration in plant (Bqkg^{-1}, dry weight) to its concentration in soil (Bqkg^{-1}, dry weight). The obtained TF values for ^{226}Ra, ^{232}Th and ^{40}K from soil to the grain of the fodder samples in Kars region are shown in Table 3.

Table 1. Activity concentrations of studied soil samples (Bq kg^{-1} dry weight)

Location	Number of Station	Number of Sample	^{40}K	^{226}Ra	^{232}Th
Akyaka	5	25	483.7±20.5	37.7±6.8	29.9±4.8
Arpaçay	4	20	383.5±19.3	28.9±6.5	23.3±4.5
Selim	18	99	562±32.0	19.9±7.5	57.9±14.6
Susuz	8	36	510.4±21.0	37.7±7.3	29.8±5.0
Mean	**35**	**180**	**484.25±23.2**	**28.95±7.0**	**35.25±7.2**

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Table 2. Activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in fodder samples (Bq kg^{-1} dry weight)

Sample	^{40}K	^{232}Th	^{226}Ra
Wheat	357.0±16.0	19.17±4.3	10.53±1.2
Barley	313.0±15.0	16.87±5.5	9.71±1.1
Oats	531.0±26.5	25.70±9.8	20.80±2.3
Corn Silages	589.0±33.2	25.60±5.7	16.66±1.8
Sainfoin	444.0±16.6	21.75±6.2	9.69±1.1
Vetch	545.0±19.6	14.50±4.9	16.66±1.0

The TF values for the ^{226}Ra values are 0.34 for barley and 0.72 for oats. The lowest values of ^{232}Th radionuclide TF were estimated to be 0.47 (barley) and the highest 0.80 (sainfoin). As shown in Table 3, the TF factor of ^{40}K in corn silage (1.22) is higher than the TFs of ^{40}K of all other fodder plants. In this study, the mean TF value of ^{40}K for feed plants was found to be 0.55, which is higher than the values found in studies conducted on wheat grains (0.015) in India and wheat grains (0.10) in Egypt. (Alharbi et al., 2013; Pulhani et al., 2005). The ^{232}Th transfer factors average value observed in present study is higher than the TF average values of ^{232}Th reported in literature in some plants such as grass, alpina galangal, vegetables and wheat (Kritsananuwat et al., 2017; Pulhani et al., 2005; Chakraborty et al., 2013; Tome et al., 2003; Keser et al., 2011). The obtained the mean transfer factor for ^{40}K value is lower than the values reported in the studies in Thailand and Turkey (Kritsananuwat et al., 2017; Keser et al., 2011).

Table 3. Transfer ratios from soil to fodder plants

Sample	^{40}K	^{232}Th	^{226}Ra
Wheat	0.69	0.53	0.36
Barley	0.62	0.47	0.34
Oats	1.11	0.75	0.72
Corn Silages	1.22	0.65	0.69
Sainfoin	0.98	0.80	0.61
Vetch	1.10	0.48	0.59

CONCLUSIONS

In this study, the levels of radionuclides and transfer factor (TF) from soil to fodder plants were evaluated in soil and fodder plants, collected from four different districts of Kars, Turkey. The ^{40}K TFs are higher than ^{226}Ra and ^{232}Th TFs in all fodder plants. The values for ^{232}Th transfer factor are similar to ^{226}Ra transfer factor in corn silages. Also the ^{226}Ra transfer factor value is the lowest in all feed plants. As a result of evaluating the studies conducted for the monitoring of the environmental radiation in Kars province and its surroundings, no situation which could affect the human health and the environment in terms of radiology has been determined. The results of this study can be used as the basis for future studies on environmental radiation levels and radionuclide distribution.

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