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REGULARITIES OF THE DISTRIBUTION OF RADIONUCLIDES IN SOIL SAMPLES AND TOBACCO PLANTS IN THE SHEKI-ZAGATALA ZONE OF THE REPUBLIC OF AZERBAIJAN

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Abstract: The results of the distribution of U (Ra), Th and K radionuclides in soils, as well as in different parts of the tobacco plant in the Sheki-Zagatala zone of the Azerbaijan Republic are presented. It was revealed that the specific activity of these radionuclides corresponds to sanitary standards and does not exceed the maximum permissible values.

Key words: gamma-spectrometer, radionuclides, tobacco, specific radioactivity

1. Introduction

The main sources of radioactive contamination of the soil and plant complex are global radioactive fallout from the atmosphere of long-lived radionuclides during nuclear tests, as well as air emissions of technogenic radionuclides associated with the operation of nuclear fuel cycle enterprises and enterprises working with hazardous substances. Therefore, at present there is an acute problem of ecological safety of the environment, ecologically safe use of natural resources with increasing anthropogenic loads. The soil-plant-water system is polluted by various chemical substances [1-3]. Mainly solid, liquid, and gaseous industrial wastes, fuel products, etc., lead to a change in the chemical composition of soils. Emissions of radionuclides into the natural environment in a number of the earth's surface significantly exceed natural norms.

The most important pollutants in the atmosphere are dust, carbon monoxide and carbon dioxide, sulfur, and nitrogen oxides, hydrocarbons and, to a lesser extent, radionuclides. The behavior of radionuclides in the soil is regulated by the processes of changing the mobility of their physicochemical properties. The transformation of the forms of radioactive elements is based on sorption interactions in combination with the migration of soil particles and the movement of solutions. The heavy natural radionuclides found in the soil pass into plants and are included in the biological cycle. In living matter, some accumulation of natural radionuclides - potassium and partly radium, and only extremely weak - uranium is found [4-5].

The literature provides a lot of information about the content of natural radionuclides in the bark of plants growing in areas with an increased amount of radioactive elements [6-7]. Radioactive isotopes accumulating in the bark of plants remain in them until the end of plant life. The radionuclides in leaves and needles periodically return to the soil. The radioisotopes accumulated by grasses, after they die off, practically completely pass into the soil. The level of radioactivity in soils depends on the content of natural radionuclides in the parent rocks. The maximum radioactivity is found in soils formed on acidic igneous rocks, and the highest concentration of radionuclides is observed in the finely dispersed fraction of soils - in clay particles. Besides, the level of radioactivity in soils depends on the landscape, climatic conditions, processes of vertical and horizontal migration in soils, their biological accumulation, etc. [1-2,8].

The purpose of this work is to identify patterns of distribution and migration of radionuclides in soils and tobacco plants in the Sheki-Zagatala zone of the Republic of Azerbaijan.

2. Experimental part

Determination of the radionuclide composition by instrumental gamma spectrometry was carried out in the laboratories "Radioecology", the Institute of Radiation Problems, and the Institute of Geology and Geophysics of ANAS. To determine the radionuclide composition, a gamma spectrometric method was used, based on the measurement of gamma radiation from the studied soil, and plant samples. The measurements were carried out on three semiconductor detectors with different parameters: coaxial GEM-2018 “Ortec”, wide-range GX-1520 “Canberra” and planar “Canberra” BE-3830 [8-9].

Wide-range and planar detectors have thin entrance windows made of weakly absorbing soft gamma radiation material (beryllium and carbon composite, respectively). Samples of soils and tobacco plants selected for analysis were dried, homogenized by grinding to a size of 150-200 microns in a ball mill, and analytical samples weighing -100 grams were taken from the obtained material by quartering. Before measurements, weighed portions of the samples were placed in Petri dishes with a diameter of 70 mm with a bottom made of polyethylene film 100 microns thick. All samples for measurement were placed directly on the entrance window of the detector. The measured spectra were processed using a software package for gamma spectrometric analysis, which included a program for processing complex gamma and X-ray spectra using an algorithm based on the nonlinear least squares method and an analytical description of the instrumental line shape. This method provides the smallest possible error in determining the area of the total absorption type and, therefore, the maximum analysis sensitivity. Another program of this package made it possible to calculate the absolute efficiency of registration of gamma radiation depending on the geometric dimensions and material of the detector sample and possible absorbers between them.

The activities of radionuclides were calculated from three natural radioactive series - uranium, thorium, as well as the activity of the natural radionuclide ^{40}K, caused by global fallouts. The list of determined radionuclides was limited to those nuclides, gamma lines, which had a quantum yield of more than 4% [8-9].

3. The discussion of the results

The dominant part of the natural radioactivity of soils is associated with radioisotopes, which form three radioactive families - uranium, actinium, and thorium. The long-lived radioactive isotope ^{40}K ($T_{1/2} = 1.3 \cdot 10^9$ years) makes a significant contribution to the natural radioactivity of soils [2]. As shown in recent literature, the dynamics of the profile migration of radionuclides was described by an exponential relationship of the form [9]:

$$C = C_0 e^{-\lambda x}$$

where C_0 - is the concentration of the radionuclide on the surface (Bk/kg); λ - is a constant characterizing the migration capacity of a radionuclide and depending on the physicochemical properties of soils; a positive value characterizes a decrease in the radionuclide concentration along with the profile, a negative value - an increase in the content; x - soil profile (cm).

The behavior of radionuclides in the soil is regulated by the processes of changing the mobility of their physical and chemical properties. The transformation of the forms of radioactive

elements is based on sorption interactions in combination with the migration of soil particles and the movement of solutions. Sorption, on the one hand, ensures the existence of a long-term source of radionuclides for entering plants, on the other hand, it limits the biological availability of elements.

The results reflecting the level of content of natural radionuclides - radium (uranium) -226, potassium-40, thorium-232 in the soils of the Sheki-Zagatala regions of Azerbaijan are given in Table 1.

As can be seen from Table 1, the average specific radioactivity in the soils of the Sheki and Zagatala regions is 36,41 and 54,80 Bk/kg, respectively. And the average value of the radionuclides ^{238}U, ^{232}Th, ^{40}K in the soil of Sheki is 3,105; 8,580; 294,42 Bk/kg and for Zagatala 22,86; 5,14; 321,41Bk/kg. In addition, the average values of Th and K radionuclides in the soils of the Sheki and Zakatala regions are not so different. The average value of the specific activity of the ^{238}U radionuclide in the soils of Zagatala is 7 times higher than that of Sheki. In our opinion, the specific activity of ^{238}U depends on the type of soil on which the plant grows. The maximum concentration of ^{238}U was noted in tobacco plants growing on mountain forest soils, and the minimum - on yellowish soils.

Table 1

Natural radionuclides in tobacco soils in Sheki and Zagatala regions of Azerbaijan

Place of sampling of soil samples	**Depth, cm**	**Specific radioactivity**	**^{238}U(Ra)**	**^{232}Th**	**^{40}K**
		Bk / kg			
Sheki region	0-20	34,51	3,89	2,90	342,08
	20-40	44,76	2,32	13,92	308,70
	40-60	29,96	-	8,92	232,47
mean		36,41	3,105	8,580	294,42
Zagatala region	0-20	57,99	36,55	1,57	247,10
	20-40	54,85	16,24	4,76	412,94
	40-60	51,56	15,79	9,10	304,19
mean		54,80	22,86	5,14	321,41

In recent years, interest in the problems of migration in the system soil (root) -different parts of tobacco plants (stem-leaves) of heavy natural radionuclides U (Ra), Th, K, and their decay products have noticeably increased.

As can be seen from tables 2 and 3 the ^{238}U concentration, depending on the plant variety, varies from 0,50 to 13,10 Bk/kg for the Sheki region. For the Zagatala region, this value varies from 1,2 to 18,30 Bk/kg. Different plant varieties are capable of accumulating elements to varying

degrees. The maximum concentration of uranium is observed in the Dubeki-Zakatalsky leaves, which is 18,30 Bk/kg.

As mentioned above, the specific radioactivity of nuclides depends on the type of soil and the zones of the regions in which the plants grow. The maximum concentration of ^{238}U is noted in the soil with a depth of 0-20 cm in the Zagatala region and is equal to 57,99 Bk/kg. Certain relationships between the accumulations of plant radionuclides and their concentrations in soils are not observed. In the case of ^{238}U, the concentration of radionuclides in plants practically does not exceed their content in the soil.

Table 2

Distribution of natural radionuclides in different parts of the plant and different varieties of tobacco in Sheki region

Plant	**Plant parts**	**Specific activity, Bk / kg**		
	Depth	**U(Ra)-226**	**Th-232**	**K-40**
The soil	0-20cm	11,60+5,36	29,51+7,20	619,00+133,00
	20-40cm	11,90+5,05	27,85+6,65	567+122,00
	40-60cm	9,48+4,84	28,85+6,78	602,00+128,00
Dubek Zagatalinsky	Root	11,80+16,90	7,30+19,00	365,00+199,00
	Stem	9,10+19,30	5,80+19,60	927,600+313,00
	Leaves	1,00+13,00	22,80+14,10	338,60+90,30
Zagatala-67	Root	6,40+16,80	1,90+18,40	393,00+204,06
	Stem	13,10+18,00	3,80+20,00	1064,00+327,00
	Leaves	6,68+8,72	0,38+9,42	990,0+237,00
Trapezond-15	Root	0,50+17,10	9,90+18,40	335,00+195,00
	Stem	1,20+18,30	0,30+19,50	705,00+266,00
	Leaves	11,91+9,49	2,40+10,20	983,00+240,00

Thorium belongs to sedentary elements, weak and very weak biological uptake. At the same time, its clarke in the biosphere is relatively high – 30,193 Bk/kg. Thorium forms fairly stable complexes and organic compounds, which lead to increased mobility. Plants readily absorb soluble ^{232}Th compounds. According to [10], the accumulation of ^{232}Th by plants is insignificant, but it is higher than ^{238}U. The biological absorption coefficient of thorium is 0,04 [10]. The average content

of ^{232}Th in the soil of the Sheki region, depending on the depth of 0-60 cm, is 8,58, and in the Zagatala region – 5,14 Bk/kg, respectively. The maximum level of specific radioactivity ^{232}Th is 13.92, and the minimum values are 1,57 Bk/kg. The average content of ^{232}Th in plants for Zagatala is 5,39 + 19,9 Bk/kg.

Table 3

Distribution of natural radionuclides in different parts of the plant and different varieties of tobacco in the Zagatala region

Plant	Plant parts	Specific activity, Bk / kg		
	Depth	Ra-226	Th-232	K-40
The soil	0-20cm	22,12+5,31	45,23+7,59	737,00+139,00
	20-40cm	17,75+4,86	47,40+7,80	740,00+139,00
	40-60cm	27,75+4,98	18,03+1,62	260,90+11,50
Dubek Zagatalinsky	Root	3,75+9,26	3,90+10,30	321,00+114,00
	Stem	9,40+18,00	4,90+19,50	804,00+282,00
	Leaves	18,30+28,30	9,20+29,60	420,00+293,00
Zagatala-67	Root	1,20+9,39	0,67+9,98	234,00+116,00
	Stem	12,40+18,00	1,80+19,70	835,00+288,00
	Leaves	6,70+26,70	13,20+30,10	676,00+336,00
Trapezond-15	Root	1,30+10,20	6,00+10,80	202,00+117,00
	Stem	5,90+13,90	0,60+15,00	496,00+195,00
	Leaves	10,00+15,90	1,40+17,30	463,00+213,00

Potassium is one of the most consumed chemical elements. In terms of activity, it is one of the main radionuclides in soils and plants. The nature of the intraprofile distribution of ^{40}K in soils is different, which is explained by the formation of these soils on different parent rocks. Most of the potassium in plants is in the ionic form [11]. It easily evaporates from leaves, which lose up to 50% of their elements during rains. A characteristic feature of ^{40}K is its high accumulation in the productive parts of plants. The maximum level of specific radioactivity for varieties Zagatala-67, which is 1064 Bk/kg, and the minimum value is 202 Bk/kg. The average content of 40K in plants for Zagatala-67 is 690,82 Bk/kg. When analyzing the data obtained, it can be noted that the content of ^{40}K, if the average potassium norm of 500 Bk/kg is adopted, then 1,5 times exceeds the maximum permissible level of the average recommended norms and this is quite understandable by the biogenic properties of potassium.

Thus, in the soil and plants of the studied zones, the content of these radionuclides (except for ^{40}K) does not go beyond the norm. Significant heterogeneity in the content of natural radioactive elements in the soils of the Sheki-Zakatala regions of Azerbaijan was revealed, due to the contrast of the parent rocks, the physicochemical properties of soils, the landscape-geochemical conditions of migration and accumulation of elements.

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ЗАКОНОМЕРНОСТИ РАСПРЕДЕЛЕНИЯ РАДИОНУКЛИДОВ В ОБРАЗЦАХ ПОЧВЫ И РАСТЕНИЯХ ТАБАКА В ЗОНЕ ШЕКИ-ЗАГАТАЛА АЗЕРБАЙДЖАНСКОЙ РЕСПУБЛИКЕ

И.Б. Асадова

Резюме: Представлены результаты распределения радионуклидов U(Ra), Th и K в почвах, а также в разных частях растения табака в зоне Шеки-Закатала Азербайджанской Республике. Выявлено, что удельная активности указанных радионуклидов соответствует санитарным нормам и не превышает предельно-допустимых величин.

Ключевые слова: гамма-спектрометр, радионуклиды, табак, удельная радиоактивность

AZƏRBAYCAN RESPUBLIKASININ ŞƏKI-ZAQATALA ZONASINDA TÜTÜNÜN TORPAQ VƏ BITKI NÜMUNƏLƏRINDƏ RADIONUKLIDLƏRIN PAYLANMASI QANUNAUYĞUNLUQLARI

İ.B. Əsədova

Xülasə: Azərbaycan Respublikasının Şəki-Zaqatala zonasında torpaqda, eləcə də tütün bitkisinin müxtəlif hissələrində U(Ra), Th və K radionuklidlərinin paylanmasının nəticələri göstərilmişdir. Müəyyən edilmişdir ki, göstərilən radionuklidlərin xüsusi aktivliyi sanitar normalara uyğundur və verilən hədləri aşmır.

Açar sözlər: qamma-spektrometr, radionuklidlər, tütün, xüsusi radioaktivlik