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DETERMINATION OF RADIONUCLIDES AND WAYS TO REDUCE THEIR IMPACT ON THE ENVIRONMENT

[1]G.M. Allabergenova, [2]U.D., Merkulov., [3]A.M. Muzafarov, [4]I.A. Uruno
[1,3,4] NSMTU Navoi city Uzbekistan
[2]NSPI Navoi city Uzbekistan
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Abstract. *This article presents the results of a study to determine the radionuclides of the uranium decay chain in samples of uranium production and ways to reduce their impact on the environment, namely the values of the specific activity of radionuclides 234U, 230Th, 226Ra, 222Rn, 218Bi, 214Po, etc. taken from uranium waste tailings, off-balance uranium ore dumps and underground uranium leaching sites.*

Keywords: *uranium facility, radiation factors, radioecological problems, uranium production, value of specific activity, radionuclides of the uranium decay chain technogenic uranium facility, uranium waste tailings, off-balance uranium ore dumps, depleted areas of underground uranium leaching, technological solutions, exhaust gases, nitrous oxides uranium.*

Introduction. Among the general radioecological problems associated with the development of uranium production, it especially determines the values of the specific activity of radionuclides 234U, 230Th, 226Ra, 222Rn, 218Bi, 214Po and other uranium decay chains in samples taken from the territories of operating uranium processing plants and their man-made objects [1 -5].. The main technogenic sources of environmental pollution at these facilities are uranium dump tailings, dumps of off-balance uranium ores, spent areas of underground uranium leaching, technological solutions, exhaust gases from the uranium oxide calcination shop, etc. [6-8].

On the basis of the above, the study and determination of the states of man-made objects of uranium production, the specific activities of radionuclides - 234U, 230Th, 226Ra, 222Rn, 218Bi, 214Po and other uranium decay chains in samples of uranium dumps taken from the tailing dump, dumps of off-balance uranium ores, spent areas of underground leaching uranium, process solutions and into exhaust gases from the uranium oxide calcination shop and the issuance of practical recommendations for reducing the impact of these radionuclides on the environment is an urgent task of analytical chemistry, applied nuclear physics and radioecology [9-10].

The goals and objectives of the study were to solve the following:

- study of methodological and metrological characteristics of radiochemical, nuclear-chemical and instrumental radiation analysis of the states of natural and man-made objects of uranium production;

- improvement and implementation of radiometric methods for determining the specific activities of radionuclides to determine the radiation impact of a man-made uranium object on the environment;

- based on the determination of the specific activity of radionuclides of chemical elements - 234U, 230Th, 226Ra, 222Rn, 218Bi, 214Po and other uranium decay chains in samples of uranium dumps taken from the tailing dump, dumps of off-balance uranium ores, spent areas of underground leaching of uranium, technological solutions and waste gases from the uranium oxide

calcination shop to determine the patterns of studying the chemistry and distribution of the migration of these radionuclides:

- issuance of practical recommendations to reduce the impact of radionuclides of chemical elements - 234U, 230Th, 226Ra, 222Rn, 218Bi, 214Po and other uranium decay chains on the environment.

Technique and methodology of physical experiment Determination of the value - specific activity of radionuclides of chemical elements - 234U, 230Th, 226Ra, 218Bi, 214Po, etc. determined by radiometric methods - gamma spectrometry on the device of the brand - "Gamma Progress", the concentrations of total uranium were determined by X-ray fluorescence methods on the devices ARF-7 and EDX-7000 "SHIMADZU", the exposure dose rates of gamma radiation were carried out by direct measurement on the device - DKS-96 .

As is known, the successive transformations of radioactive families of uranium:

$$^{238}U \xrightarrow[4{,}5*10^{9}\,лет]{\alpha} {}^{234}Th \xrightarrow[24{,}1дн]{\beta} {}^{234}Pa \xrightarrow[1{,}2мин]{\beta} {}^{234}U \xrightarrow[2{,}5*10^{5}\,лет]{\alpha} {}^{230}Th \ldots \quad (1)$$

The isotope - 234U and the rest of the radionuclides of the uranium decay chain, formed from - 238U as a result of α - decay [Z-2XA-4] and beta decay, experiences energy recoil.

In the geotechnological method of uranium mining, sites and its local parts of underground leaching of uranium are contaminated with various radionuclides - 234U, 230Th, 226Ra, 218Bi, 214Po, etc. The concentrations of these radionuclides in contaminated soils are determined by measuring their radioactivity values, and their chemical identification is based on measuring the output energy.

The chemical composition of the soil contaminated with radionuclides in the initial samples and samples after the processing of Fig. 1.

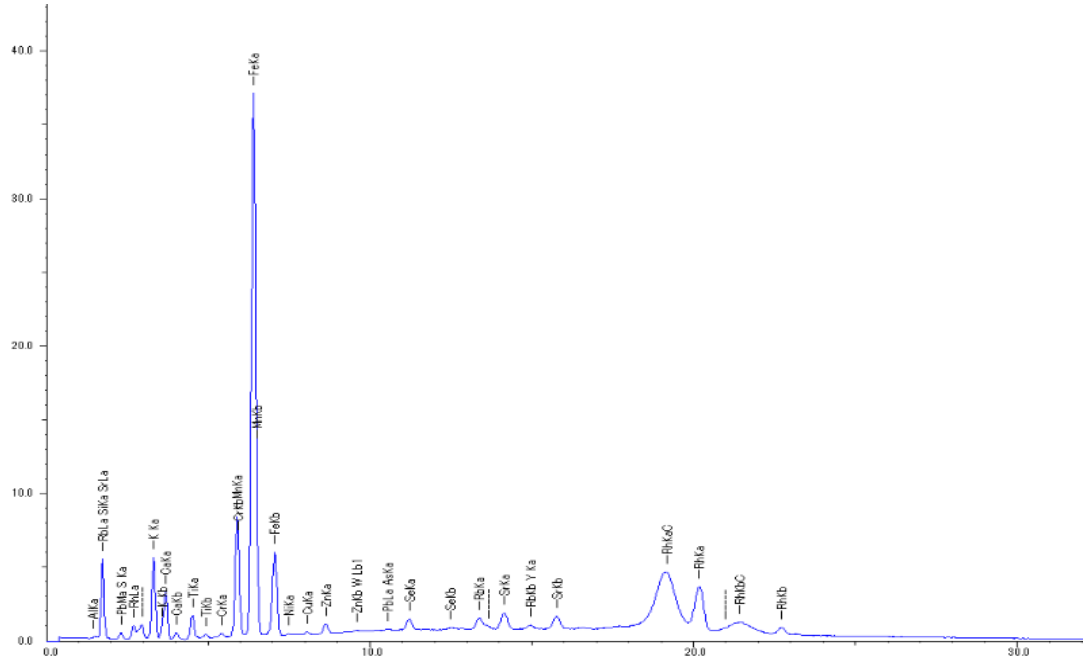

Fig. 1. Dependence of the energy of chemical elements on the number of pulses per minute in soil samples

As can be seen from the dependence shown in Fig. The most important rock-forming chemical element in soils is SiO2.

As can be seen from the results obtained, given in tab. 1, the concentration of most chemical elements such as - Al, Fe, Ti, Ca and S in the process of leaching decreases by half in the spent samples (1*, 2*, 3*) than in the original samples (1, 2, 3) . And the concentration of most chemical elements such as - K, Mn, Sr, etc. do not change during the leaching process. Their concentration remains the same as they were in the original samples. The SiO2 concentration changes only slightly.

Table 1

Results of semi-quantitative analysis of some chemical elements in soil contaminated with radionuclides in initial samples and samples after treatment

Elements	Concentration in initial samples, (%)			Concentration after treatment, (%)		
	1	2	3	1*	2*	3*
Al	3,4	3,2	3,0	2,0	2,0	1,8
Fe	2,3	2,6	2,8	1,6	1,8	1,6
Ti	0,31	0,28	0,29	0,13	0,11	0,14
Ca	0,98	0,81	0,92	0,64	0,61	0,58
S	0,65	0,58	0,71	0,40	0,38	0,43
K	2,3	2,1	2,4	2,4	2,3	2,1
Mn	0,042	0,047	0,040	0,044	0,045	0,042
Sr	0,014	0,018	0,013	0,012	0,014	0,011
Zn	0,013	0,019	0,014	-	-	-
V	0,012	0,016	0,013	-	-	-
Cr	0,012	0,021	0,018	-	-	-
SiO_2	73,2	74,1	70,9	68,8	69,4	69,1

In Table 2 shows the results of measuring DER, specific activity of radionuclides - 234U, 230Th, 226Ra, 218Bi, 214Po of the uranium decay chain in contaminated soils of underground uranium leaching sites.

As can be seen from the tab. 2 the value of the exposure dose rate of gamma cure - EDR of selected soils is directly proportional to the specific activity - radionuclides - 234U, 230Th, 226Ra, 218Bi, 214Po of the uranium decay chain and there is the same dependence on the specific activity of the radionuclide - Ra226, since this radionuclide is the main gamma emitter in the uranium decay chain.

During acid underground leaching, the vast majority of radium (99.3-99.6%) does not dissolve and remains with solid ore residue in the bowels of the Earth during underground leaching. A little more radium is dissolved in the process of carbonate leaching (up to 1.5-2.2%). In this case, the concentration - 226Ra and 230Th in waste solutions reaches the following values: 226Ra - 35 * 10-6 μKu / ml; 230Th- 22 * 10-6 μCu / ml, which is 10 times higher than the maximum allowable standards for discharge into open water bodies (for both isotopes).

Table 2

Results of measurement of DER, specific activity of radionuclides - 234U, 230Th, 226Ra, 218Bi and 214Po

№ проб	DER , (mkR/h)	Soil specific activity , (Bk/kg)				
		^{234}U	Ra^{226}	Th^{230}	^{218}Bi	^{214}Po

1	15,1-23,4	473	705	8	7	8
2	14,9-27,2	603	417	25	5	7
3	13,5-20,8	460	270	19	6	9
4	13,6-20,1	509	243	25	5	7
5	12,4-28,3	445	406	17	7	7
6	12,0-21,3	529	169	22	5	8
7	11,9-20,1	563	110	29	6	9
8	11,1-19,3-	558	57	22	7	10
9	343,1-840,1	2282	21020	288	5	8
10	298,2-610,7	2200	13010	183	5	8
11	271,4-312,5	1932	8609	161	6	6
12	261,7-332,0	369	8756	25	5	7
13	15,1-23,4	273	829	6	6	6
14	25,8-89,3	105	1534	4	7	9
15	33,5-68,8	343	1348	15	5	8
16	25,0-91,0	180	1492	6	6	6
17	44,2-60,6	562	1249	19	5	9
18	37,1-72,3	384	1504	16	6	6
19	25,0-65,1	383	1088	17	6	6
20	47,7-60,6	323	1173	6	4	10

The values of the specific activity of radionuclides - 234U, 230Th, 226Ra, 218Bi, 214Po varies in a wide range, that is, for the radionuclide - 234U - from 105 Bq / kg to 2282 Bq / kg, for the radionuclide - 230Th - from 4 Bq / kg to 288 Bq /kg, for the radionuclide - 226Ra - from 57 Bq / kg to 21020 Bq / kg, for the radionuclide -218Bi, from 4 Bq / kg to 7 Bq / kg. and for the radionuclide - 214Po from 6.0 Bq/kg to 10 Bq/kg.

Conclusion Thus, the main pollutants of the region were identified as radionuclides - 234U, 230Th, 226Ra, 218Bi, 214Po present in samples of off-balance dumps, areas of underground uranium leaching and uranium waste tailings. To improve the radioecological state in this region, it is recommended to process off-balance uranium ores by geotechnological methods (vat or heap leaching), carry out reclamation work and cover the places where spent uranium wastes are deposited - with gold-bearing ores processing waste or fertile soil.

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