RADIOISITOPIC PARAMETERS OF WATER OF THE SYRDARYA RIVER BASIN IN TERRITORY OF THE KYRGYZ REPUBLIC

I. A. Vasiliev, V. M. Alekhina, S. Mamatibraimov, S. Idrisova, T. Orozobakov

Institute of Physics of National Academy of Science, Kyrgyz Republic, Bishkek

Introduction

Solution of atomic problem, which comprises atomic weapon creation, required intensive exploration and extraction of radioactive raw material, uranium ores in the first place, as well as other important metals for this purpose. Practical realization of these problems led to formation of many storages of wastes (tail storages) and dumps of mining production. In this connection the problems of the environmental protection from contamination by radioactive and other unhealthy metals appeared.

As a result of mining and processing of radioactive and other raw material, which are necessary in atomic industry, a series of tail storages and dumps appeared in the Kyrgyz Republic. The largest of them are the Kara-Balty, Mailuu-Suu, Kavak, Kadamjai and other tail storages of uranium production.

Toxic ingredients of the tail storages migrate together with the natural waters. However the regularities of their migration in space and time are studied insufficiently. By this reason it is almost impossible forecasting radiative and other ecological hazard.

As an assessment of the measure of migration from territories of uranium plants only summarized the content of the uranium in underground waters, without natural and technogenic (man-caused) component separation is used at present time, though it is obvious, that just a technogenic component must characterize hazard. For solving this problem the discovery "Phenomenon of uranium-234 and uranium-238 natural separation" [1-3] and different degree of ^{234}U and ^{238}U fractioning in natural conditions and during technological processes were used.

Essence of the discovery consists in that at transition of uranium from solid uranium-containing formations in liquids (comprising natural waters), which do not dissolve these formations, the enrichment of isotopic mixture by uranium-234 occurs. As a result of this natural waters and hydrogenic uranium derived from them have a surplus of ^{234}U toward ^{238}U.

In technological cycle when deriving the uranium-element from uranium ores and other mineral raw material by dissolving, the correlation between mentioned uranium isotopes holds true. During the derived technological process uranium is without surplus of ^{234}U toward ^{238}U. It is stipulated by the mechanism of pointed phenomenon [4].

Thus, there is a real possibility to distinguish by magnitude of ratio of activities $^{234}U/^{238}U=\gamma$ the uranium of natural waters ($\gamma>1$) from technogenic (man-caused) uranium of tail storages and leaches of uranium dumps ($\gamma=1$), that in turn allows outlining areas of technogenic uranium distribution in waters.

In frameworks of International cooperative program of transboundary river monitoring between the Republics of Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan and the United States of America ("Navruz", the ISTC project KR-850) the isotopic composition (ratio of activities $^{234}U/^{238}U=\gamma$) and uranium content (C_U) in water of the rivers, forming the Syrdarya, the largest in Central Asia river, were defined by the Kyrgyz Republic. The samples were selected in 15 locations (the table below) twice a year: quiet phase – in autumn, and a phase of high water –in spring.

Periodical sampling has begun in autumn of 2000 and continues till now. To define these parameters up to 20 liters of water were taked from every location. The samples were measured using known methods [5]. The ratio of activities $^{234}U/^{238}U$ and the uranium content were defined on ionization α-spectrometers in Radiometric laboratory of Institute of Physics of National Academy of Sciences of the Kyrgyz Republic [6]. The obtained data are given in Table 1.

Table 1. Ratio of activities and uranium content in waters of the Naryn and Mailuu-Suu rivers

Samples №	Sampling location	Quiet phase		Phase of high water	
		$^{234}U/^{238}U(\gamma)$	$C_U \cdot 10^{-6}$ g/l *	$^{234}U/^{238}U(\gamma)$	$C_U \cdot 10^{-6}$ g/l *
1	The Chong Naryn river	1.53±0.05	0.90	1.53±0.03	3.9
2	The Kichi-Naryn river	1.52±0.05	1.2	1.47±0.02	3.3
3	The Naryn river before Naryn town	1.86±0.05	0.5	1.56±0.03	2.8
4	The At-Bashy river before falling into the Naryn	1.69±0.05	0.8	1.53±0.02	2.6
5	The Naryn after confluence with the At-Bashy river	1.61±0.05	0.8	1.65±0.02	3.3
6	The Naryn before the Toktogul reservoir	1.70±0.02	1.9	1.62±0.02	5.7
7	The Chichkan before falling into the Toktogul reservoir	1.27±0.03	1.3	1.28±0.02	4.0
8	The Toktogul reservoir	1.86±0.02	1.0	1.59±0.02	3.8
9	The Naryn after the Toktogul reservoir	1.77±0.02	1.0	-	-
10	The Naryn river on boundary with Uzbekistan	1.88±0.02	0.9	1.53±0.02	3.0
11	The Mailuu-Suu river on boundary with Uzbekistan	1.32±0.02	1.8	1.12±0.02	3.2
12	The Mailuu-Suu river after Mailuu-Suu town	1.06±0.04	2.1	1.09±0.02	2.9
15	The Mailuu-Suu river	1.39±0.07	0.4	1.39±0.04	0.8
14	Right tributary of the Mailuu-Suu	1.31±0.04	1.2	1.29±0.03	1.4
13	The Mailuu-Suu river in Mailuu-Suu town near the Transformer plant	1.05±0.02	3.1	1.06±0.02	4.3

* - Errors of the uranium content definition make around 5 %.

The outcomes can be commented as follows.

The Chon-Naryn and the Kichi-Naryn rivers at confluence form the Naryn river. Isotopic parameters found for these rivers are close. Ratio of activities $^{234}U/^{238}U$ is equal within the limits of measuring errors, and uranium content differs less than by 40%. The isotopic composition in sample 3 (the Naryn river before Naryn town) is higher than in the rivers Chon-Naryn and Kichi-Naryn, and the uranium content is lower. There are no plants of uranium processing there, therefore the change of the water radioisotopic parameters can be explained by dilution of the Naryn waters by the Orto-Kura, Bash-Kura, and other tributaries, in which the uranium concentration is possibly lower and ratio of activities $^{234}U/^{238}U$ - higher.

However this explanation is unconvincing, because the discharges of the above rivers are considerably more, than the pointed tributaries have, that conflicts with earlier opinion about γ stability along riverbed flow [7]. Additional sampling in the left tributary of the Naryn river [8] confirmed the fact that the isotopic composition is close to a value of these parameters in the rivers Chon-Naryn and Kichi-Naryn. This effect can be explained by intensive processes of uranium sorption and desoption in mountain rivers. Further the isotopic parameters change slightly up to the exit of the Naryn river beyond boundaries of the Republic. The greater interest is represented by outcomes of defining ratio of activities $^{234}U/^{238}U$ and uranium content in the Mailuu-Suu river Basin (samples 11-15 in Table1).

The analysis of obtained outcomes brings about the following conclusion. Least contents of uranium and maximum ratio of activities $^{234}U/^{238}U$ were observed in water of the Mailuu-Suu upper industrial complex and tail storage of Mailuu-Suu town. The water in the river are diluted by a right tributary (sample 14). Then waters of the Mailuu-Suu are enriched by technogenic uranium (ratio of α-activities $^{234}U/^{238}U=1$) by 70% (samples 13 and 12), after this the uranium content reduces by 60%, and a ratio of activities $^{234}U/^{238}U$ reaches practically its initial value. This fact can be explained first by contamination of the river water by technogenic uranium (ratio of α-activities $^{234}U/^{238}U=1$), then – by sorption of technogenic uranium by the riverbed rocks and desorption of natural uranium (with $\gamma \approx 1,4$) and (or) additional dilution by waters with high ratio of activities $^{234}U/^{238}U$ and low uranium concentrations. But the Mailuu-Suu river in territory of the Kyrgyz Republic has no large tributaries, therefore a factor of dilution is not decisive.

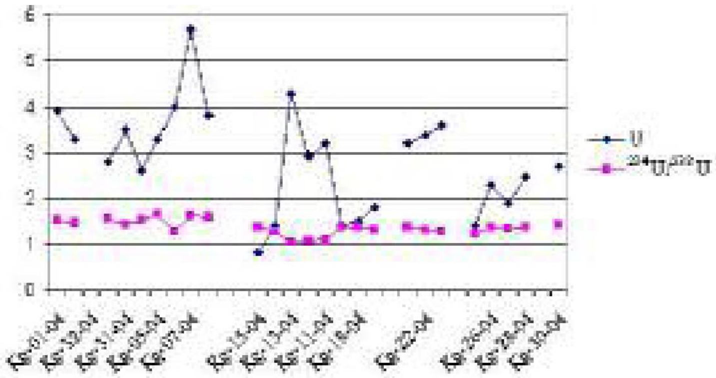
During a phase of high water the suspended soil and mountain rock particles are transported by river waters, therefore the additional uranium dilution (with $\gamma \approx 1$) by river waters occurs. It brings about a raise of uranium concentration in water and a little diminution of ratio of activities $^{234}U/^{238}U$. Since 2003 the area under study was expanded for searching possible contamination of other rivers, which form the Syrdarya. Sampling locations and outcomes of ratio of activities $^{234}U/^{238}U=\gamma$ and uranium content (C_U) definition are given in Table 2.

Table: 2. Ratio of activities and the uranium content in river waters of locations under study

№ of samples	Sampling location	$^{234}U/^{238}U=\gamma$	C_U 10^{-6} g/l*
16.	River Kara-Kul before falling into the Naryn	1.38±0.03	1.4±0.1
17.	Right tributary of the Kara-Darya in area of Massy village	1.37±0.06	1.5±0.1
18.	River Kara-Unkur	1.33±0.02	1.8±0.1
19.	Tributary of the Kegart in 10 m from the road	1.38±0.03	3.2±0.2
20.	The Kegart before confluence with the tributary	1.33±0.06	3.4±0.2
21.	The Changet river	1.28±0.06	3.6±0.2
22.	The Zarger before confluence with the Jassy river before falling into Andizhan reservoir	1.35±0.03	2.4±0.1
23.	The Jassy before confluence with the river before falling into Andizhan reservoir	1.23±0.05	1.4±0.1
24.	The Kara-Darya after confluence with the rivers Kara-Kulja and Tar	1.37±0.03	2.3±0.1
25.	The Kara-Kulja before confluence with the Tar	1.35±0.03	1.9±0.1
26.	The Tar before confluence with the Kara-Kulja	1.37±0.02	2.5±0.1
27.	Tributary of the Tar in Ylai-Talaa village	-	-
28.	The Kurshab river	1.44±0.03	2.7±0.1
29.	The Naryn river before the At-Bashy inflow	1.44±0.03	3.5±0.2
30.	The Naryn river after the Kichi-Naryn and Chong-Naryn confluence	1.48±0.02	3.3±0.2

In given results it is visible that the ratio of activities $^{234}U/^{238}U$ for those samples varies within small limits: from 1.23 in the Jassy river to 1.44 in the Kurshab, and at modification of uranium content in waters - from 1.4 in the Jassy to 3.6 in the Changet river. The content of uranium in rocks, washed by river waters, varies from 18 to 40 Bq/kg and radium – from 30 to 65 Bq/kg [8]. The information on uranium content and ratio of α-activities $^{234}U/^{238}U$ are given in Figure1.

Fig 1. The uranium content and ratio of α-activities $^{234}U/^{238}U$ for the rivers, forming the Syrdarya



Conclusions

1. The uranium content in water of all sampling locations does not exceed $5{\cdot}10^{-6}$ g/l, that is by one order lower, than in waters of the Chu valley and significantly lower than limited-admissible concentration (LAC).
2. The isotopic composition (ratio of activities $^{234}U/^{238}U=\gamma$) in rivers, forming the Syrdarya, varies from 1.2 to 1.8, that points to the waters different genetic origin.
3. In upper flow of the Mailuu-Suu river the uranium concentration is $0.4{\cdot}10^{-6}$ g/l (during high water $0.8{\cdot}10^{-6}$ g/l), in Mailuu-Suu town (after the tail storage) – $3.1{\cdot}10^{-6}$ g/l (during high water $4.3{\cdot}10^{-6}$ g/l), i.e. in 5-8 times higher, and on boundary with Uzbekistan – $1.8{\cdot}10^{-6}$ g/l (during high water $3.2{\cdot}10^{-6}$ g/l), i.e. in 1.3-1.7 times lower in comparison with the town. Respectively occur modifications of ratio of activities – from 1.39 (in upper flow) to 1.05 (in the town) and close to the initial – on boundary with Uzbekistan. These circumstances point first to enrichment of the river water by technogenic uranium by 70% (γ=1) with consequent sorption of the uranium (up to 60%) by riverbed rocks.
4. The obtained outcomes on modification of uranium concentration in waters, bottom sediments and coastal locations of rivers under study point to the lack of the uranium transboundary transference from Kyrgyz territory.
5. Hazard can represent mudflows and provoked by modification of landscape as a result of raw material processes and dumps.

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