ISOTOPE COMPOSITION AND URANIUM CONTENT IN THE RIVERS NARYN AND MAILUU-SUU

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To solve the atomic problem, including the creation of an atomic weapon, one must embark on an intensive exploration and mining of radioactive raw materials, first among which uranium, together with other materials and metals.

The acquisition of all these materials has thus been accompanied by the creation of a great deal of production and storage wastes and other refuse from plants, leading to many problems of protecting the environment from radioactive and other hazardous metals and materials.

And so, as a result of the extensive mining and processing of radioactive and other raw materials that had been necessary for the atomic industry, in locations like Kara-Balty, Mailuu-Suu, Kavak, Kadamzhay and other places, a series of radioactive and hazardous tailings and dumps has been generated in the Kyrgyz Republic.

The toxic ingredients from the dumps migrate and mix together with the ground waters that leach the tailings. However, how these waters migrate both in space and time have not been sufficiently studied; and, so, in general, we cannot forecast the propagation of these hazards.

In the usual estimation of the scale of migration from uranium plants, only the total uranium content in the ground water is used. But this does not show natural or technogenic components; and it is obvious that the danger from the plants need only be characterized by the technogenic components. To solve this problem, one can employ the phenomenon where there is a natural separation in the fraction of ^{234}U and ^{238}U present in nature and as a result of technological processes [1-3]. The essence of this understanding is that, as uranium transitions from solid form into a liquid, such as its dissolution in ground water, it undergoes isotope enrichment, i.e. hydrogenic uranium is enriched with ^{234}U compared to ^{238}U.

In the technological cycle, during the extraction of the uranium element by dissolution from uranium ore (or from any other mineral raw material), the proportion between the uranium isotopes does not change. That is, the technological process does not lead to the enhancement of one uranium isotope over another (see [4]). So, there is some real possibility that, by measuring the magnitude of $\gamma = {}^{234}U/{}^{238}U$ in various environments, one can discern technogenic uranium (where $\gamma = 0$) from the uranium leached into ground waters from dumps and tailings (where $\gamma > 0$).

In this work we attempted to utilize this effect for the purpose of defining the technogenic fraction of uranium in the waters of the Naryn and Mailuu-Suu rivers. To measure uranium content C_U and isotopic concentration ratio γ, samples were taken from these rivers at locations shown in Figure 1. The sampling was performed within the framework of Project "Navruz"—an international program of collaboration for the trans-boundary monitoring of rivers, sponsored by the Republics of Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan and the United States of America. Further information about this project can be found on this web site: http://www.cmc.sandia.gov/Central/centralasia.html.

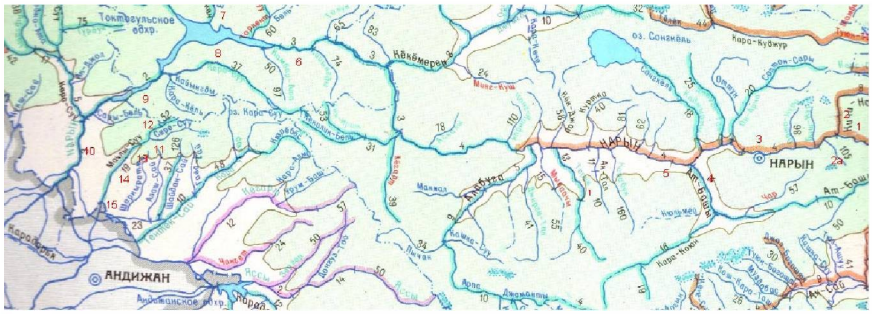

Figure 1. Sites of sample collection from the Naryn and Mailuu-Suu rivers

Twenty liters of water was sampled from every location. Sample preparation was carried out by a well-known method [5]. Uranium content and the concentration ratio $^{234}U/^{238}U$ were determined using ionization α-spectrometers at the Radiometric Laboratory of the Institute of Physics of the National Academy of Sciences of the Kyrgyz Republic [6]. The obtained results are reduced in Table 3.

Table 3.Ratio of activities and uranium content in waters of the Naryn and Mailuu-Suu rivers

№ of samples	Location of selection of samples	$^{234}U/^{238}U=\gamma$	$C_U \cdot 10^{-6}$ g/l*
1	The river Chong-Naryn	1.53±0.05	0.90
2	The river Kichi-Naryn	1.52±0.05	1.24
2a	The left tributary of the Naryn after confluence of the Chong-Naryn and Kichi-Naryn	1.29±0.05	0.36
3	The Naryn river before town Naryn	1.86±0.05	0.54
4	The At-Bashy river before its falling into the Naryn	1.69±0.05	0.85
5	The Naryn river after confluence with At-Bashy river	1.61±0.05	0.85
6	The Naryn river before the Toktogul reservoir	1.70±0.02	1.9
7	Chichkan river before its falling into Toktogul reservoir	1.27±0.03	1.29
8	Toctogul reservoir	1.86±0.02	1.0
9	The Naryn river after Toctogul reservoir	1.77±0.02	1.0
10	The Naryn river on boundery with Uzbekistan	1.88±0.02	0.9
11	The Mailuu-Suu river	1.39±0.07	0.37
12	The right tributary of the Mailuu-Suu river	1.31±0.04	1.2
13	The Mailuu-Suu river in Mailuu-Suu town near Transformer plant	1.05±0.02	3.1
14	The Mailuu-Suu river after Mailuu-Suu town	1.06±0.04	2.1
15	The Mailuu-Suu river on border with Uzbekistan	1.32±0.02	1.8

* Uranium content inaccuracies are approximately 5%.

The results can be characterized as follows.

The rivers Chon-Naryn and Kichi-Naryn combine to form the river Naryn. The isotope parameters of these river waters are similar. The activity ratio $^{234}U/^{238}U$ was found identical within measuring inaccuracies, while the uranium content differed by less than 40%. The isotopic composition in sample 3 (from the Naryn River, upstream from the city Naryn) is higher than those from the rivers Chon-Naryn and Kichi-Naryn, and the uranium content is lower. There are no uranium processing plants at these locations; therefore the variations among the radioisotopic water parameters can be explained by dilution of the Naryn river waters by tributaries Orto-Kura, Bash-Kura, among others, in which the uranium content is probably lower and $^{234}U/^{238}U$ concentration ratios are higher. This explanation, however, is not sufficient, because the discharge from the river is much more than the tributaries, contradicting the earlier-stated opinion about the stability of γ along river-bed flow [7]. Additional sampling in the left tributary of the river Naryn (sample 2a) has affirmed that the isotopic composition is close to the magnitudes of these parameters in the rivers Chong-Naryn and Kichi-Naryn. This effect can be explained by intensive uranium adsorption and desorption processes in the mountain rivers. The isotopic parameters scarcely vary before the river Naryn oversteps of the Republic limits. Consider Figure 2, which graphically shows uranium content (blue line, $\times 10^{-6}$ g/l) and activity ratio $^{234}U/^{238}U$ (red line) as a function of sample location, which roughly corresponds to positions along the river Naryn. One can see in the figure that, below a certain location, there is a decrease in the activity ratio.

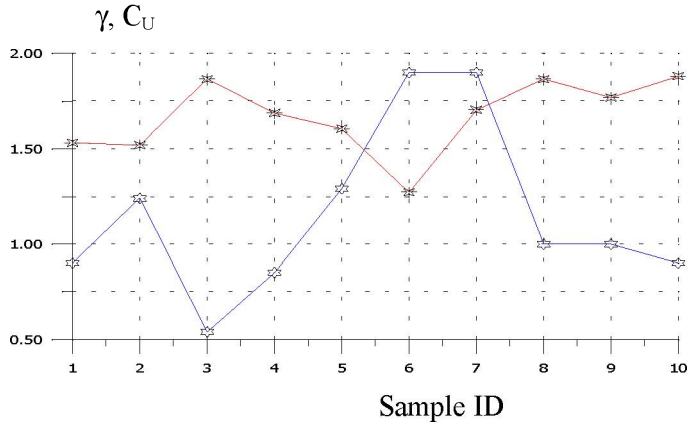

Figure 2. $^{234}U/^{238}U$ activity ratios and uranium content in the Naryn river basin.

The result for the definition of the $^{234}U/^{238}U$ activity ratio and uranium content in the basin of the Mailuu-Suu River (samples 11-15 in Table 3, Fig. 3) are of great interest. It is possible to summarize these results as follows. The least uranium content and maximum $^{234}U/^{238}U$ activity ratio (red line) was observed in waters of the river Sere-Suu, which flows from above the industrial town of Mailuu-Suu town. The waters of the river are then diluted by the right tributary (sample 12). The waters of the Mailuu-Suu River are enriched by technogenic uranium (α-activities ratio $^{234}U/^{238}U = 1$) by 70% (samples 13 and 14), after which the uranium content decreases to 60%, and ratio of activities $^{234}U/^{238}U$ practically reaches its primal value. This fact can be explained by the contamination of the waters with technogenic uranium (ratio of α-activities $^{234}U/^{238}U = 1$), then by absorption of technogenic uranium into the rocks of the river bed and by desorption of natural uranium (with $\gamma \approx 1.4$) and/or by additional dilution with waters having a high $^{234}U/^{238}U$ activity ratio and low uranium concentration. However, the Mailuu-Suu River does not have large tributaries on Kyrgyzstan territory (see Fig. 1.), so this factor is not decisive.

It is necessary to note that the uranium content in all analyzed water samples does not exceed maximum allowable concentrations (MAC), but the fact of the Mailuu-Suu water enrichment by technogenic uranium puts one on guard and can have considerable consequences. One time sampling during dry period could not answer the questions: if the enrichment is stable, how does it depend on weather conditions and other factors? Therefore, it is considered expedient to carry out the further operations, including periodic measurement of the water discharges at the indicated locations, to continue definition of radioactive and other toxic metals.

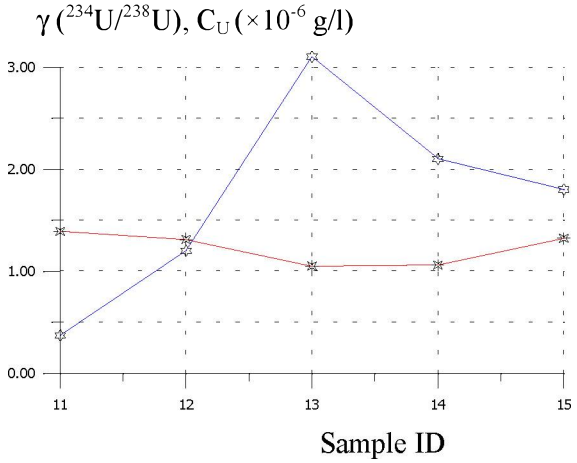

Figure 3. Ratio of activities γ and uranium content C_U in the Mailuu-Suu River.

CONCLUSIONS

1. The uranium content in all locations of sampling did not exceed $3 \cdot 10^{-6}$ g/l, i.e. a concentration significantly lower than the maximum allowable concentration (MAC).
2. The isotopic composition (ratio of activities $^{234}U/^{238}U = \gamma$) in the Naryn River ranges from 1.25 to 1.8, indicating different origins of the river water.
3. In the head waters of the Mailuu-Suu, uranium content is $0.37 \cdot 10^{-6}$ g/l; in the town of Mailuu-Suu (after passing through the tailings), the concentration is $3.1 \cdot 10^{-6}$ g/l, i.e. nearly an order of magnitude higher; and on the border with Uzbekistan the concentrations is $1.8 \cdot 10^{-6}$ g/l, i.e. 1.7 times lower than samples from the town. Activity ratios varied from 1.39 at the riverhead, to 1.05 in the town, to 1.32 on the border with Uzbekistan. The data indicates enrichment of river waters by technogenic uranium to 70% (with $\gamma = 1$), with subsequent absorption of the uranium to 60% by the riverbed.

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