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URANIUM AND OTHER TOXIC ELEMENTS IN TRANSBOUNDARY WATERS NEAR KAMYSHANOVSKY DEPOSIT

Abstract. The paper is devoted to revealing the signs of negative impact from the territory of the Kamyshanovskoye deposit (Kyrgyzstan) on the level of contamination with uranium and other hazardous elements in transboundary water bodies, in the first place in the Shu River. For this, six control points along the irrigation canal at this territory were chosen together with 9 control points along the Shu river within the area. The elemental composition of water samples was studied employing MS-ICP and OES-ICP; concentration values of 22 elements were determined. The calculations were performed based on the obtained contents of toxic elements of the 1st and 2nd classes. Corresponding sanitary standards exceed the corresponding values by 1.5 – 6.7 times. At that, uranium makes the main contribution to the toxicity level of the studied water in the Shu River (46%) and in the canal (61%). The toxicity of the water canal is for ~3 times higher than that of the Shu River. The highest toxicity indicator was found in the water delivered to the agricultural irrigation at the territory of the Kamyshanovskoye deposit. This peculiarity and the obtained data may be of interest to the Ministry of Agriculture of the Kyrgyz Republic.

The distribution of chemical elements in water along the irrigation canal and along the Shu River bed was studied. It is established that the canal water do not become contaminated with toxic elements while passing through the deposit lands. It was established in the 3 control points of the Shu River that an increase (by 28 – 130%) in the concentration of Ca, Ni, Li, Sr, U, Mg, Cr, Ba over their concentrations at the control points is higher upstream of this river. The results obtained convincingly indicate the presence of a serious influence of the Kamyshanovskoye deposit territory on the Shu River contamination with these elements. It is unlikely that such significant contamination is caused by the irrigation system discharge waters. One of the possible mechanisms of water contamination in the Shu River in its segment may be the entry of groundwater in contact with the ore body of this deposit.

Key words: uranium deposit, transboundary waters, toxic elements.

Introduction. The uranium deposit Kamyshanovskoye is located on the territory of Kyrgyzstan 45 km from Bishkek and in the immediate vicinity of the border with Kazakhstan. It has been revealed exploring this deposit that uranium is concentrated (up to 0.1%) mainly in peat and silt-peat deposits. Uranium-bearing peat also contains the following chemical elements (including the toxic ones): Mo, Cu, Zn, V, As – n·(0.1-0.01)%; Pb, Co, Ni, Sc, Ga – n·0.001% [1].

In the southern part of this field, the village of Kamyshanovka with a population of about 2.5 thousand people is located. The local population is mainly engaged in cattle breeding and cultivation of vegetables and grain crops. These agricultural works are carried out practically on the entire territory of the field. A complex densely interwoven irrigation system has been created for watering the cultivated products. Water, which is a mixture of many water sources, enters this system through a special hydro-canal. Ultimately, the waters of this system, including all return water from the irrigation fields, are discharged into the riverbed of the Shu River flowing in the northern part of the field along the Kyrgyzstan-Kazakhstan border.

Since virtually any mineral exploration activity or industrial development of mineral deposits affects the environment [2,3], al-Farabi KazNU studied the radionuclide composition and the presence forms of uranium in peat samples from the Kamyshanovskoye deposit and soil taken near the residential village of the same name.

The revealed specific activity of ^{238}U in the studied soil significantly (for about 10 times) exceeded the background value of its activity for the region. This indicates a technogenic impact from the uranium mine. It was also shown that the main part (more than 90%) of uranium contained in the studied soil and peat samples is in geochemically mobile forms [4, 5]. Uranium in such forms, under the influence of various natural factors (rain, wind), can migrate to local water sources and spread over considerable distances. Thus, the situation on the territory of the Kamyshanovskoye deposit, located in close proximity to the transboundary Shu River, represents a potential danger of contamination of this river with uranium (and, possibly, with other toxic elements).

Given the above, we set up a task to study the elemental composition of water samples taken in the Shu River and the hydro-canal in the territory of the Kamyshanovskoye deposit. The purpose of this study is to identify the signs of the negative impact of the above (or other) factors on the contamination with uranium and other toxic elements (TE) of the waters of these transboundary objects, in the first place of the Shu River.

Field work and methods of research. Field work was based on the experience gained in our previous studies of radiation and environmental conditions in the Syr Darya river basin within the framework of the international project "Navruz" (Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan) [6].

Water was sampled as shown in figure 1 from 6 control points (CH-1 – CH-6) along one of the irrigation canals and at 9 control points along the Shu River (SH-1 – SH-9). The vast majority of these samples (14 out of 15) were taken on the territory of Kyrgyzstan. In Kazakhstan, only 1 water sample was taken at the control point (CP) SH-9.

Figure 1 – Water sampling points in the territory of the Kamyshanovskoye field

At each control point, water was sampled at least in 5 points in compliance with the State Standard RK GOST R 51592-2003. So, places free of algae and floating debris were chosen. A water sampling container was immersed to a depth of 50 cm below the surface. The combined 0.25 l water sample was filtered through 0.3 µm membrane filters, preserved at the rate of 3 ml of concentrated HNO_3 per 1 l, and hermetically packed in plastic bottles.

Inductively coupled plasma mass and optical emission spectrometry (MS-ICP, OES-ICP) were used to determine the elemental composition of the taken water samples. MS-ICP analysis was performed at the ELAN-9000 inductively coupled plasma quadrupole mass spectrometer PerkinElmer SCIEX. The OES-ICP analysis was performed on an OPTIMA-8000 inductively coupled plasma optical emission spectrometer, manufactured by PerkinElmer Inc. Each device is equipped with a computer workstation and specialized software. All analyses were carried out according to the standard method "ISO 17294-2.

Part 2: determination of 62 elements." Prior to each measurement series, the sensitivity and stability of the spectrometer system (instrument tuning) was checked using specially prepared (based on standard samples) solutions. Upon obtaining the calibration curves, blank solutions and natural water samples were measured, both initial and (if necessary) diluted 1/10, 1/100, etc. The isotopes for measurement (in the case of IC-ICP) and the emission lines (in the case of OES-ICP) were selected based on a compromising criterion assuring acceptable detection sensitivity, minimal spectral noise and low background. The technique allows to determine concentrations of many elements with the detection thresholds from 0.1 to 10 $\mu g \cdot kg^{-1}$.

The presented technique was tested on various standard samples and has been successfully used in monitoring the transboundary rivers of Kazakhstan and studying the environmental situation in the basins of the most contaminate water objects [6-8].

Results and their discussion. The methods of MS-ICP and OES-ICP were used to study the elemental composition of water samples taken at all 15 CPs. The concentration values (or their threshold values) were determined for the following 27 elements: Ag, Al, As, B, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Fe, Hg, K, La, Li, Mg, Mn, Mo, Ni, Pb, Sb, Sr, Th, U, V. Preliminary analysis of the obtained data showed that the contents of Ag, Be, Cd, Hg and Th in all the studied water samples were below the detection thresholds of the employed analysis methods and the corresponding clark values (world average) for drinking water [9].

Table 1 shows the intervals of the concentration values for the remaining 22 elements and the average values of their concentrations in water at the studied sections of the Shu River and the canal. The table also presents the clark values for all elements, as well as the maximum allowable concentrations values set by WHO (MAC_{WHO}) [10] and (additionally) by Kyrgyz Republic (MAC_{KR}) [11] for drinking water. It should be noted that the values of the MAC_{KR} for Al, Co and Li coincide with the relevant standards set by the Republic of Kazakhstan (MAC_{RK}) [12].

Table 1 – The concentrations of chemical elements in water samples taken along the Shu river and the canal, $\mu g \cdot kg^{-1}$

Element	Object				clark [9]	MAC_{WHO} [10], *MAC_{KR}* [11]
	The canal		Shu River			
	Range	Average	Range	Average		
Al	103 - 179	146±32	35.9 – 88.0	75.4±24.0	50.0	***500***
As	2.45 - 4.50	3.35±0.79	1.70 - 2.13	1.93±0.11	0.20	10.0
B	232 - 452	312±95	60.9 - 149	91.6±30.5	50.0	2,400
Ba	30.2 - 58.1	40.4±12.1	29.3 - 82.3	62.6±15.7	60.0	700
Ca, %	62.3 - 90.1	73.6±11.5	37.1 - 77.0	57.5±10.4	13.4	–
Ce	0.37 - 0.55	0.46±0.09	0.17 - 0.30	0.26±0.07	0.06	–
Co	0.41 - 0.58	0.47±0.07	0.23 - 0.30	0.25±0.02	0.20	***100***
Cr	2.45 - 8.64	4.84±2.42	1.62 - 4.09	2.29±0.67	1.00	50.0
Cu	1.15 - 2.49	1.82±0.59	1.31 - 3.03	2.59±1.87	1.50	2,000
Fe	82.0 - 163	116±43	43.6 – 61.4	58.8±9.6	40.0	2,000
K, %	2.58 - 4.33	3.53±0.74	1.52 - 2.97	2.56±0.44	1.30	–
La	0.19 - 0.28	0.24±0.05	0.14 - 0.19	0.17±0.05	0.04	–
Li	18.3 - 42.8	26.6±11.2	4.93 - 11.4	8.03±1.87	2.50	***30.0***
Mg, %	31.1 - 59.5	40.4±11.4	12.2 - 24.8	17.8±4.4	3.35	–
Mn	5.22 - 16.6	10.6±6.1	3.99 - 10.6	9.13±3.39	8.20	400
Mo	9.09 – 14.7	10.5±2.2	4.92 - 5.76	5.30±0.24	0.50	70.0
Ni	6.16 - 8.60	6.92±0.98	4.15 - 6.58	5.19±0.58	0.50	70.0
Pb	0.40 – 0.62	0.51±0.08	0.30 - 0.60	0.49±0.11	0.10	10.0
Sb	1.06 - 1.84	1.34±0.35	<0.30 - 0.75	0.69±0.21	1.00	20.0
Sr	1107 - 2025	1392±358	529 - 905	650±124	60.0	–
U	82.6 - 114	99.0±14	17.4 - 31.1	24.3±4.7	0.24	30.0
V	7.83 - 14.2	10.4±3.1	2.08 - 2.43	2.19±0.11	1.00	–

The data presented in table 1 indicate that the average concentration of the vast majority of the studied elements (with the exception of Ba and Sb) in the waters taken in the Shu River and in the canal are higher (for many, are substantially higher) than their corresponding clark values. Also, for many of these elements (with the exception of Ba and Cu), the concentrations in the canal are noticeably (for 1.5 – 4 times) higher than those in the river. As it has been mentioned above, the water of the irrigation system on the territory of the Kamyshanovskoye deposit flows into the Shu riverbed. This imposes the risk of the Shu water contamination with chemical elements contained in significant concentrations in these wastewaters. The highest contamination danger exists due to the significant contents of uranium (U is a chemical element of the 1st hazard class), certain elements of the 2nd hazard class (Al, As, B, Li, Mo, and Sr), and salts of calcium, potassium, magnesium.

Table 2 show the calculated values of the total chemical toxicity (the limiting indicator of the harmful effects, K_{LHI}, the limiting hazard indicator) of water at all CPs along the canal and the Shu River. The calculations are performed in accordance with the following expression

$$K_{LHI} = \sum_{i=1}^{n} C_i * \mathrm{MAC}^1$$

where C_i – is the concentration of the elements of the Hazard class 1 or 2. At that, we considered a limited list of elements (those with significant concentrations at all 15 CPs) of the 1st and 2nd hazard classes: Al, As, B, Ba, Li, Mo, Pb, Sr, U. This indicator for drinking water, following the Sanitary Rules of the Republic of Kazakhstan, should not exceed 1.0 [12].

Table 2 – The values of the limiting hazard indicator K_{LHI} for the water samples taken at the control points in the canal and in the Shu River

Sample code	$C_i \cdot MAC_i^{-1}$									
	Al	As	B	Ba	Li	Mo	Pb	Sr	U	K_{LHI}
Canal										
CH-1	0.36	0.39	0.19	0.08	1.43	0.21	0.04	0.29	3.66	6.65
CH-2	0.34	0.32	0.17	0.07	1.25	0.15	0.05	0.22	3.80	6.37
CH-3	0.32	0.25	0.12	0.04	0.68	0.14	0.05	0.18	3.55	5.33
CH-4	0.31	0.28	0.11	0.04	0.67	0.14	0.06	0.18	3.24	5.02
CH-5	0.21	0.32	0.10	0.05	0.61	0.14	0.06	0.16	2.81	4.45
CH-6	0.22	0.45	0.10	0.06	0.69	0.13	0.05	0.17	2.75	4.62
Shu River										
SH-1	0.18	0.21	0.03	0.11	0.23	0.07	0.08	0.08	0.58	1.57
SH-2	0.17	0.20	0.03	0.11	0.24	0.07	0.04	0.08	0.59	1.53
SH-3	0.18	0.20	0.03	0.12	0.24	0.07	0.06	0.08	0.61	1.59
SH-4	0.17	0.20	0.03	0.11	0.25	0.07	0.05	0.08	0.60	1.56
SH-5	0.16	0.21	0.06	0.09	0.38	0.08	0.05	0.13	0.91	2.07
SH-6	0.09	0.18	0.06	0.09	0.37	0.08	0.06	0.12	1.03	2.08
SH-7	0.08	0.18	0.06	0.08	0.35	0.08	0.05	0.12	1.04	2.04
SH-8	0.07	0.17	0.03	0.04	0.16	0.08	0.03	0.08	0.94	1.60
SH-9	0.08	0.18	0.03	0.05	0.19	0.08	0.03	0.08	0.99	1.71
MAC_{WHO}, MAC_{KR}, $\mu g \cdot l^{-1}$	500	10	2,400	700	*30*	70	10	*7,000*	30	

The data presented in table 2 indicate that all the studied waters are characterized by the K_{LHI} values exceeding the sanitary standard of 1.0. At that, the main contribution to the toxicity of the studied waters is made by uranium (an element of the 1st class of chemical hazard): in the Shu River – for 46%, in the canal – 61%. It should also be noted that the toxicity of the cannel waters is significantly (~3 times) higher than that of the river waters (the average value of the K_{LHI} indicator for the canal waters is 5.41 ± 0.91, for the waters of the Shu River – 1.75 ± 0.24). The highest value of this indicator (K_{LHI} = 6.65) was found for water at KP SN-1. This means that water significantly contaminated with toxic elements is supplied to the irrigation system of the agricultural fields on the territory of the Kamyshanovskoye deposit. We believe that this feature and the data obtained may be of interest to the Ministry of Agriculture of the Kyrgyz Republic.

The distribution histograms were made to study the distribution of the studied elements in the waters of the irrigation canal (laid through separate sections of the uranium-bearing peat deposits) and in the waters of the Shu River. Some of them are shown in figure 2 below.

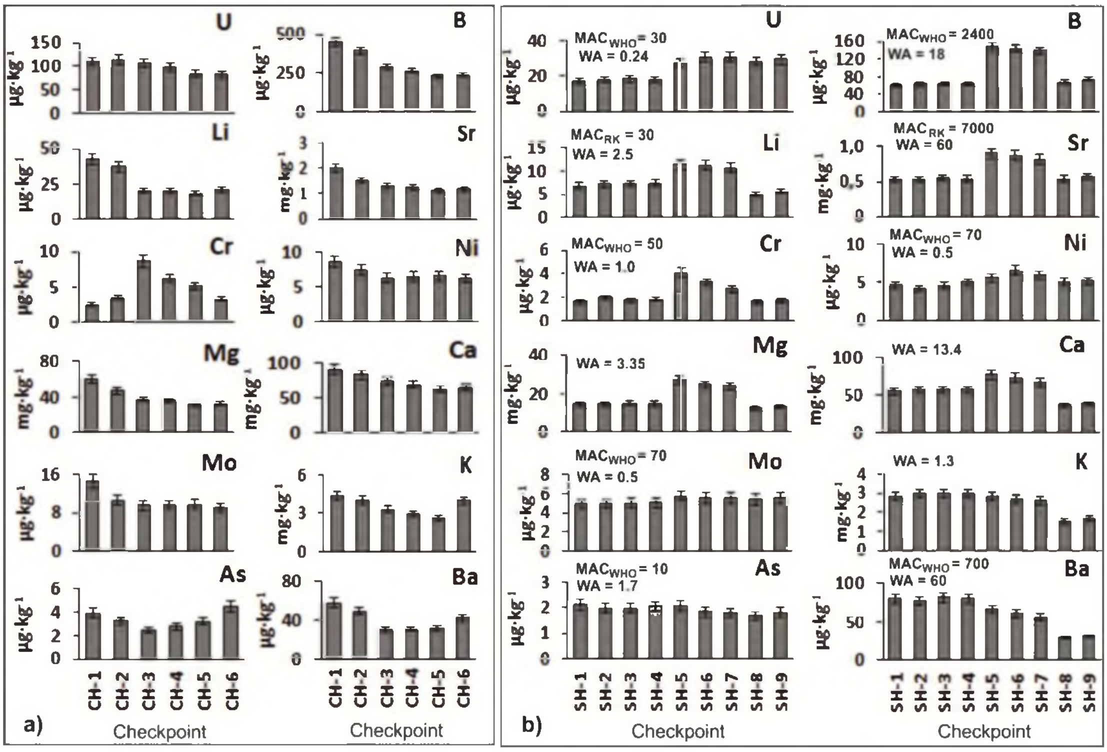

Figure 2 – Distribution of individual elements in the waters along the canal (a) and the Shu river (b)

It follows from figure 2a that the passage of the canal waters through the field does not ultimately lead to their enrichment with the elements presented. Moreover, the concentrations of most of them (U, B, Li, Sr, Ni, Mg, Ca, Mo) in the water at CH-5 are noticeably lower than those at CH-1. At the same time, one should pay attention to the sharp increase in the concentration of Cr in the canal water at the CP CH-3 (probably, due to a local contamination spot), as well as the increased contents of K, As, Ba in the water at the CP CH-6. Additional research is needed to clarify this pattern. It is common for all elements at figure 2b that their concentrations in the Shu River are evenly distributed in the waters taken upstream from the territory of the Kamyshanovskoye deposit at the following CPs: SH-1, SH-2, SH-3, SH-4. Further, their distribution in the waters of this river downstream differs markedly. In accordance with the main objective of this study, the distribution of U, B, Li, Sr, Cr, Ni, Mg, and Ca is of primary interest. The concentrations of each of these elements in water increase sharply (for most of them) or smoothly (for Ni) at SH-5 and remains elevated at the next two CPs SH-6 and CH-7. The excess of the average concentration in waters at these three CPs of each of these elements over the average value of its concentration in waters at the previous 4 CPs has the following value, %: Ca – 28, Ni – 30, Li – 55, Sr – 61, U – 66, Mg – 71, Cr – 86, B – 130. The presented results convincingly indicate the presence of a serious influence of the Kamyshanovskoye deposit territory on the river contamination with these elements. It is unlikely that such significant contamination is caused by wastewater from the irrigation system. This conclusion is supported by the comparison of the concentrations of these elements in the river at the CPs SH-8 and SH-9, in the interval between which the waters of the studied canal flow into this river. An increase in the concentration of these elements in the water on this segment of the Shu River is negligible and ranges from 2.5% (Ni) to 13% (Li). One of the possible mechanisms of water contamination in the Shu River in its segment (SH-5 to SH-7) may be the entry of groundwater in contact with the ore body of this deposit. It should also be added that the revealed contamination with TE, Ca and Mg of the Shu River water is limited to the river section from the CP SH-5 to the CP SH-7. At SH-8, a sharp decrease (with the exception of U) of the concentration of these elements in water is observed. A more detailed study is needed in this place, on a segment of the river from SH-7 to SH-8, to clarify the essence of this phenomenon and its profoundness.

Conclusions. As a result of the present study, the factors of serious environmental concern were identified on the territory of the Kamyshanovskoye uranium deposit. Specific measures are required to clarify their nature and degree of danger to the environment and the health of the local population.

It has been established that the water used for irrigation of agricultural fields in this territory is significantly contaminated with uranium in concentrations of more than 3 times higher than the maximal permissible level for drinking water (MPA_{WHO} = 30 $\mu g \cdot kg^{-1}$) and with other toxic elements. It is necessary to carry out specific studies to reveal the degree of these elements transition to the farmed agricultural products.

It was also established that the concentration of uranium and other TEs in the water of the Shu River in its section located near the ore bodies of this deposit significantly exceed their levels in the upstream waters of this river. The discussed here possible mechanisms of the identified contamination is hypothetical. In order to identify a real source and reveal the mechanism of this contamination, it is necessary to carry out a more detailed study on this section of the deposit territory and the adjacent section of the Shu River.

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КАМЫШАНОВСКОЕ КЕН ОРНЫ МАҢЫНДАҒЫ ТРАНСШЕКАРАЛЫҚ СУДАҒЫ УРАН ЖӘНЕ БАСҚА ДА УЫТТЫ ЭЛЕМЕНТТЕР

Аннотация. Камышановское уран кен орны Қырғызстан аумағында Бішкек қаласынан 45 шақырым қашықта және Қазақстан шекарасына тікелей жақын орналасқан. Бұл кен орнын барлау нәтижесінде уран негізінен шымтезекте және лайлы-шымтезекті шөгіндіде шоғырланғаны (0.1% дейін) анықталды. Сондай-ақ уранды шымтезек құрамында келесі химиялық элементтер (оған қоса уытты) бар: Mo, Cu, Zn, V, As - n·(0.1-0.01)%; Pb, Co, Ni, Sc, Ga - n·0.001%.

Аталмыш кен орны аумағының оңтүстік бөлігінде 2.5~ мыңға жуық халқы бар Камышановка кенті орналасқан. Бұл кент тұрғындары негізінен мал шаруашылығымен, сондай-ақ көгөніс, дәнді дақыл өсірумен айналысады. Бұл ауылшаруашылық жұмыстары іс жүзінде кен орнының барлық аумағында жүзеге асырылады. Өсірілген өнімді суғару үшін бір-бірімен тығыз байланысты суару жүйесі құрылған. Бұл жүйеге су арнайы су арнасы арқылы келеді. Аталған жүйенің суы, оған қоса суармалы алқаптардан кері келетін барлық су, ақыр соңында, Қырғызстан-Қазақстан шекарасы бойындағы кен орнының солтүстік бөлігі арқылы ағып жатқан Шу өзені арнасына жіберіледі.

Әл-Фараби атындағы ҚазҰУ-да Камышановское кен орнынан алынған шымтезек үлгілеріндегі уранның радионуклидтік құрамын және орналасу пішінін, сондай-ақ аттас кенттің жанынан іріктеліп алынған топырақты зерделеу бойынша жұмыстар орындалды. Зерттелген топырақтағы ^{238}U меншікті активтілігі оның аталмыш аймақтағы активтілігінің аялық мәнінен едәуір (шамамен 10 есе) асатыны анықталды. Бұл уран кенішінің техногендік ықпал ететінін көрсетеді. Сондай-ақ, зерттелген топырақ пен шымтезек үлгілеріндегі уранның негізгі бөлігі (90%-тен астамы) геохимиялық-мобильді пішінде екендігі көрсетілген. Осындай пішіндердегі уран әртүрлі табиғи факторлардың (жаңбыр, жел) әсерінен жергілікті су көзіне көшуі және едәуір қашықтыққа таралуы мүмкін. Осылайша трансшекаралық Шу өзеніне жақын жерде орналасқан Камышановское кен орны аумағындағы жағдай осы өзеннің уранмен (мүмкін басқа да уытты элементтермен) ықтимал ластану қаупін төндіреді.

Мақала трансшекаралық су объектілері суының, бірінші кезекте Шу өзенінің уранмен және басқа да уытты элементтермен ластану деңгейіне Камышановское уран кен орны аумағының теріс әсер ету белгілерін анықтауға арналған. Ол үшін осы аумақты суармалау жүйесі арнасының бойындағы 6 бақылау пунктінен, сондай-ақ осы мекенде ағып өтетін Шу өзені арнасының бойындағы 9 бақылау пунктінен су сынамалары іріктеліп алынды. Іріктеліп алынған су сынамаларының элементтік құрамы MS-ICP және OES-ICP әдістерімен зерделенді. 22 элементтің концентрация мәні анықталды. Қауіптілігі 1-ші және 2-топтағы уытты элементтердің мөлшері туралы алынған деректердің негізінде барлық зерделенген судың қосынды химиялық уыттылығының мәніне есептеу жүргізілді. Есептеу нәтижелері осы параметрдің барлық алынған мәні тиісті санитарлық нормативтен 1.5-6.7 есе асатынын көрсетті. Бұл ретте, зерделенген судың уыттылық деңгейіне уранның қосатын үлесі зор: Шу өзенінде - 46%, арнада – 61%. Арна суының уыттылығы Шу өзеніне қарағанда едәуір (~ 3 есе) жоғары. Камышановское кен орны аумағындағы ауыл шаруашылығы алқаптарын суару жүйесіне түсетін судың уыттылық көрсеткіші ең жоғары мәнге ие болды. Осы ерекшелік және алынған деректер ҚР Ауыл шаруашылығы министрлігінің қызығушылығын тудыруы мүмкін.

Химиялық элементтердің суландыру каналы мен Шу өзені арнасында таралу жағдайы зерделенді. Канал суының кен орны аумағы арқылы ағуы олардың уытты элементтермен ластамайтыны анықталды. Кенді шоғыр жанында орналасқан Шу өзені суының үш бақылау пунктінде Ca, Ni, Li, Sr, U, Mg, Cr, Ba концентрациясының осы өзен ағысының жоғарғы бөлігінде орналасқан бақылау пункттеріндегі олардың концентрациясынан едәуір жоғарылағаны (28-130%-ға) анықталды. Алынған нәтижелер Шу өзенінің осы элементтермен ластану деңгейіне Камышановское кен орны аумағының едәуір әсер ететіндігін нақты дәлелдеді. Мұндай айтарлықтай ластанудың суландыру жүйесінің ағынды суынан туындау ықтималдығы аз. Бұл жерде Шу өзенін ластайтын ықтимал механизмдердің бірі оның арнасы арқылы аталмыш кен орнының кенді шоғырымен түйісетін жерасты суының өткенінен болуы мүмін.

Түйін сөздер: уран кен орны, трансшекаралық су, уытты элементтер.

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УРАН И ДРУГИЕ ТОКСИЧНЫЕ ЭЛЕМЕНТЫ В ТРАНСГРАНИЧНЫХ ВОДАХ БЛИЗ МЕСТОРОЖДЕНИЯ КАМЫШАНОВСКОЕ

Аннотация. Месторождение урана Камышановское расположено на территории Кыргызстана в 45 км от г. Бишкек и в непосредственной близости от границы с Казахстаном. В результате разведки этого месторождения установлено, что уран сконцентрирован (до 0.1%), в основном, в торфах и илово-торфяных отложениях. Ураноносные торфы содержат также следующие химические элементы (включая токсичные): Mo, Cu, Zn, V, As - n·(0.1-0.01)%; Pb, Co, Ni, Sc, Ga - n·0.001%.

В южной части территории этого месторождения расположен поселок Камышановка с населением ~2.5 тыс. человек. Жители этого поселка, в основном, занимаются скотоводством, а также выращиванием овощей и зерновых культур. Эти сельскохозяйственные работы проводятся практически на всей территории месторождения. Для полива выращиваемой продукции создана сложная густопереплетённая система орошения. Вода поступает в эту систему по специальному гидроканалу. Воды этой системы, включая все обратные воды с полей орошения, в конечном итоге, сбрасываются в русло р. Шу, протекающей в северной части месторождения вдоль границы Кыргызстан – Казахстан.

В КазНУ им. аль-Фараби выполнены работы по изучению радионуклидного состава и форм нахождения урана в образцах торфа с месторождения Камышановское и почвы, отобранной возле одноименного жилого поселка. Установлено, что удельная активность ^{238}U в изученной почве существенно (примерно в 10 раз) превышает фоновое значение её активности в данном регионе. Это свидетельствует о техногенном влиянии со стороны уранового рудника. Показано также, что основная часть (более 90 %) урана, содержащегося в изученных образцах почвы и торфа, находится в геохимически-мобильных формах. Уран, находящийся в

таких формах, под воздействием различных природных факторов (дождь, ветер), может мигрировать в местные водные источники и распространяться на значительные расстояния. Таким образом, ситуация на территории месторождения Камышановское, расположенной в непосредственной близости от трансграничной р. Шу, представляет потенциальную опасность загрязнения этой реки ураном (возможно, и другими токсичными элементами).

Статья посвящена выявлению признаков негативного влияния территории месторождения урана Камышановское на уровень загрязненности ураном и другими токсичными элементами вод трансграничных водных объектов, в первую очередь – р. Шу. Для этого были отобраны пробы воды на 6-ти контрольных пунктах вдоль канала оросительной системы этой территории, а также на 9-ти контрольных пунктах вдоль русла р. Шу, протекающей в этой местности. Элементный состав отобранных проб воды изучен методами MS-ICP и OES-ICP. Определены значения концентрации 22-х элементов. На основе полученных данных о содержании токсичных элементов 1-го и 2-го классов опасности выполнены расчеты значений суммарной химической токсичности всех изученных вод. Результаты расчетов показали, что все полученные значения этого параметра превышают соответствующий санитарный норматив в 1.5-6.7 раз. При этом основной вклад в уровень токсичности изученных вод вносит уран: в р. Шу – 46%, в канале – 61%. Токсичность вод канала существенно (~ в 3 раза) выше, чем р. Шу. Наиболее высокое значение показателя токсичности установлено для воды, поступающей в систему орошения сельскохозяйственных полей на территории месторождения Камышановское. Эта особенность и полученные данные могут представлять интерес для Министерства сельского хозяйства КР.

Изучено распределение химических элементов в водах вдоль оросительного канала и вдоль русла р. Шу. Установлено, что протекание вод канала через территорию месторождения не приводит к их загрязнению токсичными элементами. В водах р. Шу на трех контрольных пунктах, находящихся близ рудных залежей, установлено значительное повышение (на 28-130%) концентрации Ca, Ni, Li, Sr, U, Mg, Cr, Ba относительно их концентрации на контрольных пунктах, расположенных выше по течению этой реки. Полученные результаты убедительно свидетельствуют о наличии серьезного влияния территории месторождения Камышановское на уровень загрязненности р. Шу этими элементами. Маловероятно, чтобы такое значительное загрязнение было вызвано стоками вод оросительной системы. Одним из возможных механизмов такого загрязнения р. Шу на этом месте может являться поступление в её русло подземных вод, контактирующих с рудными залежами этого месторождения.

Ключевые слова: месторождение урана, трансграничные воды, токсичные элементы.

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