IRSTI 34.49.47 https://doi.org/10.26577/eb.2023.v97.i4.010

A.M. Ganina*, M.M. Bakhtin, E.T. Kashkinbaev, P.K. Kazymbet, D.S. Ibrayeva, M.N. Aumalikova

nJSC "Astana medical university", Institute of Radiobiology and Radiation Protection, Kazakhstan, Astana
*e-mail: anastassiya_smelova@mail.ru

ASSESSMENT OF THE STATE OF THE WATER ECOSYSTEMS OF THE TERRITORIES OF THE TURKESTAN REGION AT THE LEVEL OF "ZERO BACKGROUND", LOCATED IN CLOSE PROXIMITY TO THE NUCLEAR POWER PLANT UNDER CONSTRUCTION IN UZBEKISTAN

The article describes the radiobiological state of open reservoirs, drinking water in the settlements of the Turkestan region, which are potentially affected by the nuclear power plant under construction in Uzbekistan, as well as some biota objects that can serve as indicator organisms. The relevance is due to the fact that the settlements of the Turkestan region of the Republic of Kazakhstan, located near the border with Uzbekistan, fall under the potential impact of the future nuclear power plant. The objects of the study were samples of drinking water from 5 settlements, bottom sediments and hydrobionts (pike-perch – *Sander lucioperca*), carp (*Cyprinus carpi*), lake frog (*Pelophylax ridibundus*), water samples taken from open reservoirs of the Turkestan region. On the basis of an accredited the test laboratory of radiochemistry and radiospectrometry of the Institute of Radiobiology and Radiation Protection conducted tests on the content of radionuclides. The results obtained on the content of radionuclides at the stage of "zero background" before the construction of the nuclear power plant are generally within the normal range, with the exception of samples of drinking water from the village of Zhyly-su , where the total alpha activity exceeds 1.5 times the maximum allowable concentration. The results obtained will allow us to estimate the probable dose loads of the population from the intake of radionuclides through food chains and various scenarios. Data on the content of radionuclides in open water bodies and in drinking water will be used as one of the criteria, for a full assessment of the "zero pho on the territories of the Turkestan region.

Key words: "zero background", drinking water, open reservoir, nuclear power plant, radionuclides.

А.М. Ганина*, М.М. Бахтин, Е.Т. Кашкинбаев, П.Қ. Қазымбет,
Д.С. Ибраева, М.Н. Аумаликова

«Астана медицина университеті» ҚЕАҚ, Радиобиология және радиациялық қорғау институты,
Қазақстан, Астана, қ.
*e-mail: anastassiya_smelova@mail.ru

Өзбекстанда салынып жатқан атом электр станциясына жақын орналасқан Түркістан облысы аумақтарының су экожүйелерінің жағдайын «нөлдік фон» деңгейінде бағалау

Мақалада Өзбекстанда салынып жатқан атом электр стансасынан ықтимал зардап шеккен Түркістан облысының елді мекендеріндегі ашық су қоймаларының, ауыз судың, сондай-ақ индикатор организмдер қызметін атқара алатын кейбір биота нысандарының радиобиологиялық жағдайы сипатталған. Өзектілігі Өзбекстанмен шекараға жақын орналасқан Қазақстан Республикасы Түркістан облысының елді мекендерінің болашақ атом электр стансасының ықтимал әсерінің астында қалуымен байланысты. Зерттеу объектілері ретінде 5 елді мекеннің ауыз суының сынамалары, түбі шөгінділері мен гидробионттары (шортан – *Sander lucioperca*), тұқы (*Cyprinus carpi*), көл бақасы (*Pelophylax ridibundus*), Түркістан облысының ашық су қоймаларынан алынған су үлгілері алынды. Радиобиология және радиациядан қорғау институтының аккредиттелген радиохимия және радиоспектрометрия сынақ зертханасы базасында радионуклидтердің құрамы бойынша сынақтар жүргізілді. АЭС құрылысы басталғанға дейін «нөлдік фон» кезеңіндегі радионуклидтердің құрамы бойынша алынған нәтижелер жалпы алғанда, Жылы-су ауылының ауыз су сынамаларын қоспағанда, қалыпты диапазонда. альфа белсенділігі шекті рұқсат етілген концентрациядан 1,5 еседен асады. Алынған нәтижелер радионуклидтерді қоректік

тізбектер арқылы қабылдаудан және әртүрлі сценарийлер бойынша халықтың ықтимал дозалық жүктемелерін бағалауға мүмкіндік береді. Түркістан облысының аумақтары бойынша «нөлдік фоны» толық бағалау үшін критерийлердің бірі ретінде ашық су айдындарындағы, ауыз судағы және гидробионттардағы радионуклидтердің құрамы туралы деректер пайдаланылады.
Түйін сөздер: «нөлдік фон», ауыз су, ашық су қоймасы, атом электр станциясы, радионуклидтер.

А.М. Ганина*, М.М. Бахтин, Е.Т. Кашкинбаев,
П.К. Казымбет, Д.С. Ибраева, М.Н. Аумаликова

НАО «Медицинский университет Астана», Институт радиобиологии
и радиационной защиты, Казахстан, г. Астана
*e-mail: anastassiya_smelova@mail.ru

Оценка состояния водных экосистем территорий Туркестанской области на уровне «нулевого фона», расположенных в непосредственной близости от строящейся АЭС в Узбекистане

В статье описывается радиобиологическое состояние открытых водоемов, питьевой воды в населенных пунктах Туркестанской области, которые попадают под потенциальное влияние строящейся АЭС в Узбекистане, а также некоторых объектов биоты, которые могут служить индикаторными организмами. Актуальность обусловлена тем, что населенные пункты Туркестанской области Республики Казахстан, расположенные вблизи границы с Узбекистаном, где планируется строительство АЭС. Объектами исследования были пробы питьевой воды 5 населенных пунктов, донные отложения и гидробионты (судак – *Sander lucioperca*), сазан (*Cyprinus carpi*), озерная лягушка (*Pelophylax ridibundus*), пробы воды, отобранные из открытых водоемов Туркестанской области. На базе аккредитованной испытательной лаборатории радиохимии и радиоспектрометрии НАО «медицинский Университет Астана» проведены испытания на содержание радионуклидов. Результаты содержания радионуклидов на стадии «нулевого фона» до строительства АЭС, в целом находятся в пределах нормы, за исключением проб питьевой воды поселка Жылы-су, где общее альфа-активность превышает в 1,5 раза ПДК. Полученные результаты позволят оценить вероятные дозовые нагрузки населения от поступления радионуклидов по пищевым цепям и различным сценариям. Данные о содержании радионуклидов в открытых водоемах, питьевой воде и гидробионтах используются как один из критериев полной оценки «нулевого фона» на территории Туркестанской области перед строительством АЭС на приграничной территории.
Ключевые слова: «нулевой фон», питьевая вода, открытый водоем, АЭС, радионуклиды.

Introduction

In early September 2018, the governments of Uzbekistan and the Russian Federation signed an agreement on cooperation in the construction of nuclear power plants in the territory of the Republic of Uzbekistan. Rosatom State Corporation plans to build a complex of two generation 3+ power units with VVER-1200 reactors. The site near Lake Tuzkan in the Jizzakh region, located 50-80 km from the Zhetysay district of the Turkestan region of the Republic of Kazakhstan, was chosen as the priority site for the construction of the station. In accordance with the IAEA radiation safety requirements and the legislation of the Republic of Kazakhstan, radiation monitoring should be carried out around nuclear power facilities [1-3].

Lake Tuzkan belongs to the Arnasay system of lakes. When using lake water for heat exchange, it can lead to pollution, which is also regulated by the IAEA safety requirements [4]. The specificity of natural water bodies Tuzkan and the chain of lakes Aydarkul, created as a result of recharge and underground water lenses, is such that contamination of water bodies with radionuclides may lead to their spread to the area of underground lenses downstream [5].

Lake Tuzkan in the Jizzakh region, located about 40 km from the Turkestan region, the most densely populated region of Kazakhstan. Near Lake Tuzkan is the Shardara reservoir, a source of drinking water and a reservoir of strategic importance, located on the transboundary Syr Darya River, the longest in Central Asia (flowing into the Aral Sea).

The Shardara reservoir with a capacity of 5.2 billion m3 was put into operation in 1967, it is fed by the Syr Darya, which is used by the agricultural lands of two regions: Turkestan and Kyzylorda [5]. As can be seen from the table 1, the distance from the center of the Jizzakh region to the studied settlements is from 73 to 126 km.

Table 1 – Characteristics of the location of the study and the distance from the NPP under construction

№	Locality name	Location	Note	Distance to the center of Jizzakh region of Uzbekistan
1	Myrzakent settlement	The administrative center of the Maktaaral district of the Turkestan region. 403 km southwest of the city of Turkestan.	The farms of the district contain 12.6% of cattle in the region, the textile and clothing industries are developed.	85,9 km
2	Zhetysay city	The center of the Zhetysay district of the Turkestan region, the distance from Turkestan is 393 km.	There are cotton-cleaning, beer and bread factories in the city; workshop for the production of vegetable and cottonseed oil.	84,3 km
3	Shardara city	The administrative center of the Shardara district of the Turkestan region.	Production of building materials. Food businesses. Shardara HPP.	126,1 km
4	Zhyly-su settlement	A settlement in the Maktaaral district of the Turkestan region of Kazakhstan. It is part of the Zhylysu rural district.	The main occupations of the population are seasonal cotton production and farming.	84,4 km
5	Zh. Kalshoraev settlement	A village in the Maktaaral district of the Turkestan region of Kazakhstan. It is part of the Abai rural district.	The population is engaged in cattle breeding, clothing and textile industries.	73,5 km

Earlier, within the framework of the international project, large-scale studies of the level and nature of pollution of the Syrdarya river basin in the territory of the Republic of Kazakhstan were carried out. The results obtained made it possible to generally characterize the radioecological situation in this region. In the eastern part of the Shardara reservoir, near the territories of the uranium deposit in the Syrdarya River, areas were identified where high concentrations of technogenic radionuclides of the uranium and thorium series were identified. Elevated concentrations of heavy metals were found in the bottom sediments of the Shardara reservoir and in the vicinity of the large cities of Shymkent and Saryagash, which have a negative impact on the state of the water of the Syrdarya River [6-7]. It should be noted that the available data on the pollution of the Syrdarya River must be taken into account in the final formation of data for the "zero background" assessment.

Thus, the purpose of this work is to assess the state of aquatic ecosystems, drinking water in the settlements of the Turkestan region, located in close proximity to the nuclear power plant under construction. This study is part of a comprehensive radioecological monitoring to ensure the radiation safety of the population and comparison of zero background data with data obtained at each stage of the operation of the future nuclear power plant.

Materials and methods

Taking into account the distances of the settlements of Kazakhstan to the priority site of the nuclear power plant under construction, samples of environmental objects (water, bottom sediments) from open reservoirs and drinking water were taken from the settlements of Kalshoraev, Zhetysay, Zhyly-Su, Myrzakent, Shardara of the Turkestan region.

The analysis of literature data on the study of hydrochemical parameters of the Shardara reservoir was carried out.

Water samples were taken in accordance with the guidelines of GOST 17.1.5.05-85 "Nature Protection. Hydrosphere. General requirements for the sampling of surface and sea waters, ice and precipitation" GOST R 51592-2000. "Water. General requirements for sampling". Each sample was taken with a volume of 5 liters. Water samples taken for the determination of radionuclides were filtered, then evaporated, and the dry residue was ashed at a temperature of 350 ^{o}C. Then the method of radiochemical analysis was applied.

When sampling bottom sediments, we were guided by the standards of GOST 17.1.5.01-80. "General requirements for sampling of bottom sediments of water bodies for pollution analysis". Samples were taken with a special sampler at a distance of 5 meters from the shore and a depth of 20–30 cm.

A survey was conducted to determine the food basket of the population. When analyzing personal data, it was found that the main food ration of the inhabitants of the selected territories is: meat, pasta, from cereals: rice, in the summer – vegetables and melons. For residents of the city of Shardara, fish is also included in the diet. In this regard, zander (Sander lucioperca), carp (Cyprinus carpi) from the Shardara reservoir were selected for laboratory analysis. The lake frog (Pelophylax ridibundus) was also taken for laboratory analysis.

Laboratory radiospectrometric and radiochemical research methods.

Laboratory radiochemical and radiospectrometric analyzes of water samples, bottom sediments, biosamples were carried out in the Testing Laboratory of Radiospectrometry and Radiochemistry of the Institute of Radiobiology and Radiation Protection of NJSC "Astana Medical University", which is accredited in the accreditation system of the Republic of Kazakhstan for compliance with the requirements of GOST ISO / IEC 17025-2009 "General requirements to the competence of testing and calibration laboratories".

The determination of the total alpha, beta activity of water samples was carried out in accordance with the "Methodological recommendations for radiation hygiene", as well as "GOST 31864-2012. Drinking water. Method for determining the total specific alpha activity of radionuclides", "ST RK ISO 9697-2006 Water quality".

The total alpha and beta activities of bottom sediment samples were measured using the UMF-2000 low-photon radiometer (No).

Measurement of the specific activity of radionuclides in samples of bottom sediments was carried out using the spectrometric complex "Progress-BG" gamma with beta spectrometric tracts, according to the method "Method of measuring the activity of radionuclides using a scintillation gamma, beta spectrometer with the software" Progress ", No. KZ. 07.00.00303-2004. Before that, the dried sample was crushed, dried and poured into the Marinelli vessel.

Radiochemical analysis to determine the specific activity of ^{137}Cs and ^{90}Sr in drinking water samples was carried out in accordance with the "Methodological recommendations for sanitary control over the content of radioactive substances in environmental objects" approved by the Ministry of Health of the Republic of Kazakhstan MUK No. 5.05.008.99.

The content of uranium in the bones and tissues of bioassays was determined by inductively coupled plasma mass spectrometric method on Agilent-7800 equipment using regulated analysis methods.

Statistical processing of the results was carried out by standard methods using the Student's criterion and a package of documents submitted by Microsoft Excel programs.

The LIETDOS-BIOS software was also used to calculate the oral dose when a person consumes fish from the Shardara reservoir.

Results and discussion

The Shardara reservoir has an important influence in the studied regions. Samples were taken from the left bank (flat, dissected by bays and bays). The total content of dissolved substances showed that the water is brackish [8], with a predominance of sulfates and sodium ions. In the zone of influence of the river flow of the Syr-Darya, the amount of sodium, magnesium, calcium and sulfates slightly increased. The highest concentration of potassium was registered on the left bank of the reservoir. The concentration of biogenic compounds in the water was at a low level and did not exceed the maximum allowable concentration established for fishing in the territory of reservoirs [9]. The content of phosphates in water varied within a small range. Thus, the water in the reservoir can be characterized as slightly alkaline, with a concentration of sodium sulfates, and brackish. These data, in turn, require a detailed study to establish the influence of the above indicators on the degree of impact of the studied radionuclides on biocenoses and biota.

The reservoir is fed from the water of the Syrdarya and Keles rivers. The transparency of the water reached 0.4-3.2 m, the temperature of the surface layers was 25.6-30.7°C, pH was 8.5-8.

The phytoplankton of the Shardara reservoir was studied, which is formed mainly from green and diatom algae (Chlorophyta, Bacillariophyceae), as well as blue-green algae (Cyanobacteria). Phytoplankton was analyzed by comparative floristic similarity of different algae species.

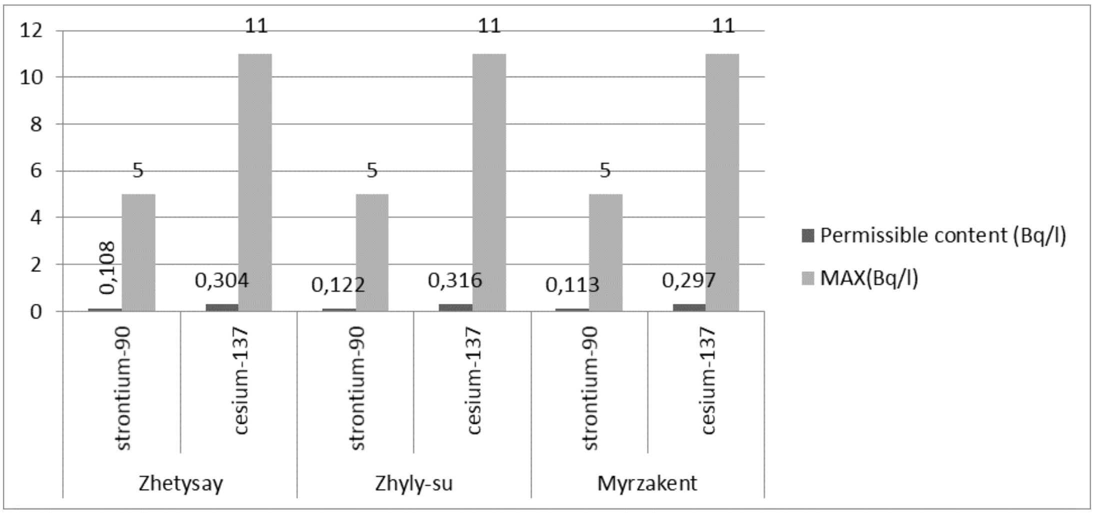
Zooplantcon is mainly represented by rotifers (Synchaeta stylata Wierzejski) [10-11]. Thus, the authors of [10-11] characterize the Shardara reservoir as freshwater, with sources of pollution from rivers and agricultural canals.

According to the research results of the authors [12], salinity increased from depth to the surface of the water due to high evaporation in the arid climate of southern Kazakhstan. The low content of mineral phosphorus in the reservoir is due to regional and climatic features, as in most reservoirs of Kazakhstan, primarily the absence of phosphates in bedrock. Among the analyzed heavy metals, copper and zinc were the most abundant [12].

The data can be used in assessing the environmental conditions of the reservoir to the potential impact of man-made pollutants before the start of operation of the Uzbekistan NPP.

Further, samples of drinking water taken from 3 settlements of the Turkestan region were analyzed and showed that the content of ^{137}Cs and ^{90}Sr was within the acceptable range (Figure 1).

In a sample of drinking water from the Zhyly-su settlement, an excess of the value of the total specific α, β activity by 1.5 times was revealed compared to the permissible intervention level for drinking water (table 2).



* Hygienic standards "Sanitary and epidemiological requirements for ensuring radiation safety", approved by order No. 155 dated February 27, 2015.

Picture 1 – Content of ^{137}Cs and ^{90}Sr in samples of drinking water (Bq/l)

Table 2 – Values of total specific α-, β-activity of water samples (Bq/dm^3)

№	Place of selection, locality	Geographical coordinates	α- activity, (Bq/dm^3)	B- activity, (Bq/dm^3)
1	Zhyly-su column (drinking water)	N 40.4134271 E 68.292789	0,30	0,27
2	Shardara column (drinking water)	N 41.257650 E 67.942733	0,04	0,15
3	Kalshoraev column (drinking water)	N 41.257650 E 67.942733	0,20	0,19
Intervention level (IL) for drinking water [13].			0,20	1,0
4	Shardara, Shardara reservoir	N 41.249764 E 68.017765	0,18	0,27
5	Zhetysay, open reservoir	N 40.4741642 E 68.1914007	0,42	0,01
6	Zhetysay, open reservoir	N 40.464468 E 68.2012736	0,09	0,04
7	Kalshoraev, open reservoir	N 40.4134271 E 68.1738939	0,26	0,05
8	Myrzakent, open reservoir	N 40.403223 E 68.35246	0,52	0,07

This excess is possibly due to the location of uranium deposits in the Shu-Sarysu and Syrdarya provinces.

In terms of hydrogeology, according to G. M. Shor [14], a complex artesian basin (Shu-Sarysu) is formed in this territory, in which several aquifers and aquifers are distinguished, which can contribute to the spread of radionuclides in aquifers.

Based on their literature data, the leading radiation factor in uranium-ore provinces with an industrial type of seam-infiltration uranium deposits is the natural contamination of groundwater of ore-bearing aquifers with uranium series radionuclides.

The assessment of the radionuclide composition of bottom sediments is important not only for assessing the contamination of an open water body, but also for assessing the contamination of groundwater, characterizing the functioning of aquatic ecosystems, given the fact that bottom sediments affect the vital activity of benthic organisms, as well as in assessing the migration of radionuclides. In addition, bottom sediments are more stable in their performance, unlike water masses. Using transfer coefficient calculations, it is possible to establish the degree of transfer of the studied radionuclides from water to bottom sediments. Due to the high absorption capacity and strong fixation of radionuclides in them, bottom sediments precipitate and retain a significant part of the radioactive substances coming with water, becoming the main source of irradiation of benthic organisms [15-16].

Further, the specific activity of radium-226, thorium-232, potassium-40 and cesium-137 in samples of bottom sediments was established (table 3).

Table 3 – Specific activity of radium-226, thorium-232, potassium-40, and cesium-137 in bottom sediment samples of the Shardara Reservoir (Bq/kg)

Sample code	Geocoordinates	^{232}Th	^{226}Ra	^{40}K	^{137}Cs
		Specific activity values			
Sh-DO-1	n.l 41°12’17» e.l 67°55’52»	62,6±26,3	13,5±11,2	178,5±116,2	12,5±9,7
Sh-DO-2	n.l 41°20’449» e.l 67°92’984»	45,4±16,3	15,3±9,26	145,3±99,2	9,5±6,66
Sh-DO-3	n.l 41°20’365» e.l 67°93’036»	61,9±23,9	18,4±7,22	330,4±178,3	13,4±9,56

For a comparative assessment of the specific activity of thorium-232, potassium-40 and radium-226, literature sources on the content of radionuclides in bottom sediments from reservoirs located on the territory of the United Arab Emirates and Ukraine were studied. The first reservoir is located in the background location of the Baraka Nuclear Power Plant (Gulf Coast, UAE). The results of the specific activity of bottom sediment samples had the following values: ^{226}Ra – 4.73±3.1, ^{232}Th – 18.3±1.6, ^{40}K – 130.14±105.2. The calculated concentrations of activity in this study, according to the authors, were lower than the world average and lower than the levels recorded in neighboring countries [17]. Further, information about the Sofievsky reservoir, located in the area of the Ingul River in the Nikolaev region (Ukraine), was considered. In this case, the authors did not exclude the influence of the Chernobyl NPP, but the results indicate the values of the specific activity of radionuclides included in the conditional reference interval: ^{226}Ra – 20.3, ^{232}Th -49.2, ^{40}K – 420.1 [18].

In accordance with the literature sources, the specific contents of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs in our studies are in acceptable values compared to the world values, which are: for 226Ra from 4.9 to 60 Bq/kg, for 232Th from 11 to 64 Bq/kg kg, for 40K from 140 to 1700 Bq/kg, for 137Cs from 5 to 30 Bq/kg. [19, 20, 21].

Based on the reviewed literature data, it can be concluded that the results of the specific content of radionuclides in bottom sediments indicate moderate activity [22].

We have established the total specific activity in samples of bottom sediments of the Shardara reservoir (Table 4).

The result of total specific activity of alpha-emitting radionuclides in bottom sediment samples taken from three different points of the Shardara reservoir ranges from 564,2 Bq/kg to 699,1 Bq/kg.

Analyzing the biological objects of the Shardara reservoir, it is possible to establish the migration of radionuclides along the corresponding food chain. According to the literature data, uranium isotopes are unevenly distributed in the fish body [23]. The highest concentration is observed in the body and head of fish, based on this, tissue samples from the body of fish (Sander lucioperca, Cyprinus carpi) were analyzed for the content of ^{238}U and the following results were obtained (table 5).

Table 4 – Total specific activity of alpha-emitting radionuclides in bottom sediment samples (Bq/kg)

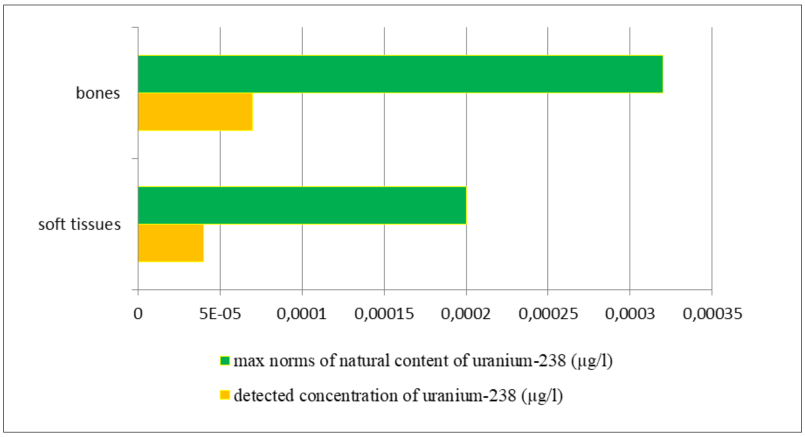
№	Geocoordinates	Sample code	Total specific activity of alpha-emitting radionuclides, Bq/kg
1.	n.l 41°12'17» e.l 67°55'52»	Sh-DO-1	541,4± 107,4
2.	n.l 41°20'449» e.l 67°92'984»	Sh-DO-2	564,2±111,5
3.	n.l 41°20'365» e.l 67°93'036»	Sh-DO-3	526,1±129,6

Table 5 – Content of ^{238}U in fish from the Shardara reservoir

№	Inhabited locality	type of product	^{238}U concentration (ng/l)	^{238}U concentration (mkBq/kg)	Worldwide range* of 238U, µBq/kg
1	Shardara	fish- zander	bones-14,88 meat-1,92	bones-183,768 meat-23,71	100000
2	Shardara	fish- carp	bones-69 meat-6,54	bones-852,15 meat-80,769	

After determining the uranium-238 content, calculations were performed in the LIETDOS-BIOS system for the distribution of preoral dose, the results indicate that the annual effective dose to humans will be only 0.1 µSv, which is typical for background values.

Determination of the content of uranium-238 in the bones and muscles of the lake frog (Pelophylax ridibundus) showed that the results obtained are included in the conditional reference values of the concentration of the natural content of uranium in the body of animals and humans (in terms of mgl/l-0.00033 for bones and 00001- 0.0002 µg/l tissue) [24] (Picture 2). Frogs have thin skin that has good water absorption capacity, thereby being exposed to radionuclides from the environment both inside and outside [24]. Therefore, from a biological and ecological point of view, frogs can serve as a good bioindicator of radioactive contamination.



Picture 2 – The content of uranium-238 in the bones and soft tissues of the lake frog (Pelophylax ridibundus)

The literature indicates that uranium is found in small amounts in many tissues and organs of humans and animals [24-25]. Amphibians and other objects of aquatic fauna can be used as a bioindicator of changes in the radioecological situation in the study area during certain periods of reservoir monitoring.

Conclusion

Based on the results obtained, it can be concluded that most of the water and bottom sediment samples taken from the settlements of the Turkestan region from the Shardara reservoir correspond to the reference values. With the exception of the sample from the Zhyly-su village, where the total alpha activity of drinking water samples exceeds 1.5 times the maximum allowable concentration. This is probably due to the influence of uranium deposits in the Turkestan region (Shu-Sarusuy and Syrdarya uranium-ore provinces). The obtained data will be used for the results of a full assessment of the "zero background" of the territories under the potential influence of the NPP. In addition, at each stage of NPP operation (commencement of operation, annual monitoring, completion of operation), the obtained data can be used for comparative assessment and monitoring. In view of the fact that the Shardara reservoir and the Arnasay system (a priority site for the construction of a nuclear power plant on the shore of Lake Tuzkan) of lakes are connected by a water artery, the established concentrations of radionuclides in water samples, bottom sediments and some objects of aquatic fauna are the key point for further calculations of the intake of radionuclides by food chains. The concentration of uranium-235 in fish (Cyprinus carpi), as well as bones and tissues of a frog (Sander lucioperca, Pelophylax ridibundus) is at the background level.

Taking into account seasonality, it is necessary to monitor water samples from the Shardara reservoir at least 1-2 times a year, with the study of natural (during the pre-operational period) and man-made (operational period) radionuclides. It is also necessary to monitor fish products once a year, because in this region, fish is a product often eaten. If concentrations are found in the fauna of the Shardara Reservoir above the background, measures are necessary to prevent the migration of radionuclides along the associated food chains.

References

1. Actions to protect the public in an emergency due to severe conditions at a light water reactor, International atomic energy agency vienna.2013 P.159

2. Закон РК «О радиационной безопасности населения» (с изменениями и дополнениями по состоянию на 11.04.2019 г., P.23

3. Programmes and Systems for Source and Environmental Radiation Monitoring: Safety Reports Series № 64. — Vienna: IAEA, 2010. P.248.

4. Environmental and Source Monitoring for Purpose of Radiation Protection: IAEA Safety Standarts: Safety Guide RS-G-1.8. – Vienna: IAEA, 2005. — P.136.

5. Верещагина Н., Видинеева Е., Щетинников А., Мухаметзянова А. Основные факторы, влияющие на экологическое состояние Айдаро-Арнасайской системы озер и территории вокруг нее// Экологический вестник. – 2013. – № 8. – С-13.

6. Беркинбаев Г.Д., Федоров Г.В., Бенсман В.А. Радиоэкологическая обстановка в ураноносных регионах юга Казахстана // Экология и промышленность Казахстана. – 2008. – С.1-2.

7. Solodukhin V.P., Poznyak V.L, Kazachevskiy I.V., Knyazev B.B., Lukashenko S.N., Khazhekber S. Some Peculiarities of Pollution by Radionuclides and Toxic Elements of Syrdarya River Basin (Kazakhstan) //7th International Conference on Nuclear Analytical Methods in the Life Sciences, Antalya, Turkey. – 2002. – P.128.

8. Самбаев Н. С. Оценка гидрологического состояния р. Сырдарья в пределах Кызылординской области //Вектор Гео. Наук. – 2018. – Т. 1. – №. 3. – С. 95-100.

9. Barinova S., Krupa E. Bioindication of ecological state and water quality by phytoplankton in the Shardara Reservoir, Kazakhstan //Environment and Ecology Research. – 2017. – Т. 5. – №. 2. – Р. 73-92.

10. Krupa E. et al. Structural indicators of zooplankton in the shardara reservoir (Kazakhstan) and the main influencing factors //Turkish Journal of Fisheries and Aquatic Sciences. – 2018. – Т. 18. – №. 5. – Р. 659-669.

11. Alexyuk M.S. Andrey P., Bogoyavlenskiy A.P., Alexyuk Y.S., Moldakhanov V. E. Berezin V.E. Metagenome Analysis of Surface Waters of the Shardara Reservoir, the Largest Artificial Reservoir in Southern Kazakhstan// ASM Journals Microbiology Resource Announcements. – 2020.- Vol. 9, No. 11. – P.3-7

12. Крупа Э.Г., Баринова С.С., Амиргалиев Н.А. и др. Статистический подход к оценке антропогенных источников потенциально токсичных элементов на Шардаринском водохранилище // Минюст Eco Environ Sci. – 2017. – №2(1). – С.8-14.

13. Об утверждении Санитарных правил «Санитарно-эпидемиологические требования к водоисточникам, местам водозабора для хозяйственно-питьевых целей, хозяйственно-питьевому водоснабжению и местам культурно-бытового водопользования и безопасности водных объектов» от 16 марта 2015 года № 209.Астана.

14. Методическое пособие. Радиогидрогеологические исследования при прогнозировании и поисках урановых месторождений, связанных с зонами пластового окисления // Под ред. Г. М. Шора. Ленинград: Ленинградское отделение «Недра», 1988. P. 97-102.

15. Трапезников А.В., Трапезникова В.Н. Пресноводная радиоэкология. Екатеринбург//Академ Наука. 2012.–С.115–163.

16. Botwe B. O. et al. Radioactivity concentrations and their radiological significance in sediments of the Tema Harbour (Greater Accra, Ghana) //Journal of Radiation Research and Applied Sciences. – 2017. – T. 10. – №. 1. – P. 63-71.

17. Al Rashdi M. R. et al. Radiological baseline around the Barakah Nuclear Power Plant, UAE //Arabian Journal of Chemistry. – 2021. – T. 14. – №. 5. – P. 103-125.

18. Alokhina T., Gudzenko V. Distribution of radionuclides in modern sediments of the rivers flowing into the Dnieper-Bug Estuary //E3S Web of Conferences. – EDP Sciences, 2021. – T. 280. – C. 11003.

19. Tsabaris C. et al. Radioactivity levels of recent sediments in the Butrint Lagoon and the adjacent coast of Albania //Applied Radiation and Isotopes. – 2007. – T. 65. – №. 4. – P. 445-453.

20. Ries T., Putyrskaya V., Klemt E. Long-term distribution and migration of ^{137}Cs in a small lake ecosystem with organic-rich catchment: A case study of Lake Vorsee (Southern Germany) // Journal of Environmental Radioactivity. – 2019. – №198. – P. 89-103.

21. Olszewski G. et al. On the distribution and inventories of radionuclides in dated sediments around the Swedish coast //Journal of Environmental Radioactivity. – 2018. – T. 186. – P. 142-151.

22. Luneva E. V. Radionuclides in Surface Waters, Bottom Sediments, and Hydrobionts in the Neman River //Inland water biology. – 2018. – T. 11. – №. 1. – P. 97-102.

23. Гудыменко В. А. Поведение изотопов урана в модельной системе пресноводного непроточного водоема: дис. канд. биол. наук. –М. – 2014. – P. 65.

24. Барановская Н.В., Игнатова Т.Н., Рихванов Л.П. Уран и торий в органах и тканях человека //Вестник томского государственного университета. – 2010. – № 339. – С. 182-188.

25. Zaghloul A. et al. Biological indicators for pollution detection in terrestrial and aquatic ecosystems //Bulletin of the National Research Centre. – 2020. – T. 44. – №. 1. – C. 1-11.

References

1. Actions to protect the public in an emergency due to severe conditions at a light water reactor, International atomic energy agency Vienna (2013) [Actions to protect the public in an emergency due to severe conditions at a light water reactor]. *International atomic energy agency Vienna*, pp.159.

2. Alexyuk M.S. Andrey P., Bogoyavlenskiy A.P., Alexyuk Y.S., Moldakhanov V. E. Berezin V.E. (2020) [Metagenome Analysis of Surface Waters of the Shardara Reservoir, the Largest Artificial Reservoir in Southern Kazakhstan]. *ASM Journals Microbiology Resource Announcements*. vol. 9, pp. 3-7.

3. Alokhina T., Gudzenko V. (2021) [Distribution of radionuclides in modern sediments of the rivers flowing into the Dnieper-Bug Estuary].*E3S Web of Conferences. – EDP Sciences*, pp. 11003.

4. Al Rashdi M. R. et al. (2021) [Radiological baseline around the Barakah Nuclear Power Plant]. *UAE //Arabian Journal of Chemistry*, no 5, pp. 103-125

5. Baranovskaya N.V., Ignatova T.N., Rikhvanov L.P.(2010) [Uran i torij v organah i tkanyah cheloveka]. *Vestnik Tomskogo gosudarstvennogo universiteta*, no 339, pp.182-188

6. Barinova S., Krupa E. (2017) [Bioindication of ecological state and water quality by phytoplankton in the Shardara Reservoir, Kazakhstan]. *Environment and Ecology Research*, vol 2, no 5, pp.73-92.

7. Berkinbaev G.D., Fedorov G.V., Bensman V.A. (2008) [Radioekologicheskaya obstanovka v urandnosnyh regionah yuga Kazahstana]. *Ekologiya i promyshlennost' Kazahstana*, pp.1-2.

8. Botwe B. O. et al. (2017) [Radioactivity concentrations and their radiological significance in sediments of the Tema Harbour (Greater Accra, Ghana)]. *Journal of Radiation Research and Applied Sciences*, vol 10, no 1, pp. 63-71.

9. Environmental and Source Monitoring for Purpose of Radiation Protection (2005) [IAEA Safety Standarts: Safety Guide RS-G-1.8.], pp.136.

10. Gudymenko V. A. (2014) [Povedenie izotopov urana v model'noj sisteme presnovodnogo neprotochnogo vodoema], pp. 65

11. Krupa E.G., Barinova S.S., Amirgaliev N.A. i dr. (2017) [Statisticheskij podhod k ocenke antropogennyh istochnikov potencial'no toksichnyh elementov na SHardarinskom vodohranilishche]. *Minyust Eco Environ Sci.*, no 2(1), pp.8-14.

12. Krupa E. et al. (2018) [Structural indicators of zooplankton in the shardara reservoir (Kazakhstan) and the main influencing factors].*Turkish Journal of Fisheries and Aquatic Sciences*, vol. 18, no 5, pp. 659

13. Luneva E. V. (2018) [Radionuclides in Surface Waters, Bottom Sediments, and Hydrobionts in the Neman River]. *Inland water biology,* vol. 11, no 4, pp. 97-102.

14. Metodicheskoe posobie Pod red. G. M. SHora. (1988) [Radiogidrogeologicheskie issledovaniya pri prognozirovanii i poiskah uranovyh mestorozhdenij, svyazannyh s zonami plastovogo okisleniya]. *Leningradskoe otdelenie «Nedra»*, pp. 97-102.

15. Ob utverzhdenii Sanitarnyh pravil. (2015) ["Sanitarno-epidemiologicheskie trebovaniya k vodoistochnikam, mestam vodozabora dlya hozyajstvenno-pit'evyh celej, hozyajstvenno-pit'evomu vodosnabzheniyu i mestam kul'turno-bytovogo vodopol'zovaniya i bezopasnosti vodnyh ob"ektov"]. *Prikaz Ministra nacional'noj ekonomiki Respubliki Kazahstan*, no 209.

16. Olszewski G. et al. (2015) [On the distribution and inventories of radionuclides in dated sediments around the Swedish coast]. *Journal of Environmental Radioactivity*, vol. 186, pp. 142-151.

17. Programmes and Systems for Source and Environmental Radiation Monitoring (2010) [Vienna: IAEA]. *Safety Reports Series*, no 64, pp.248.

18. Ries T., Putyrskaya V., Klemt E. (2019) [Long-term distribution and migration of 137Cs in a small lake ecosystem with organic-rich catchment: A case study of Lake Vorsee (Southern Germany)]. *Journal of Environmental Radioactivity*, no 198, pp. 89-103.

19. Sambaev N. S. (2018) [Ocenka gidrologicheskogo sostoyaniya r. Syrdar'ya v predelah Kyzylordinskoj oblasti]. *Vektor Geo. Nauk*. , vol 1, no. 3, pp. 95-100.

20. Solodukhin V.P., Poznyak V.L, Kazachevskiy I.V., Knyazev B.B., Lukashenko S.N., Khazhekber S.(2002) [Some Peculiarities of Pollution by Radionuclides and Toxic Elements of Syrdarya River Basin (Kazakhstan)]. *//7th International Conference on Nuclear Analytical Methods in the Life Sciences, Antalya, Turkey*, pp.128.

21. Trapeznikov A.V., Trapeznikova V.N. [Presnovodnaya radioekologiya]. *Akadem Nauka*, pp.115–163.

22. Tsabaris C. et al. [Radioactivity levels of recent sediments in the Butrint Lagoon and the adjacent coast of Albania]. *Applied Radiation and Isotopes*, vol. 65, no.4, pp. 445-453

23. Vereshchagina N., Vidineeva E., Chetinnikov A., Muhametzyanova A (2013). [Osnovnye faktory, vliyayushchie na ekologicheskoe sostoyanie Ajdaro-Arnasajskoj sistemy ozer i territorii vokrug nee]. *Ekologicheskij vestnik.,* no. 8, pp. 13.

24. Zaghloul A. et al. (2020) [Biological indicators for pollution detection in terrestrial and aquatic ecosystems]. *Bulletin of the National Research Centre*, vol. 44, no. 1, pp. 1-11.

25. Zakon RK (2019) [«O radiacionnoj bezopasnosti naseleniya» (s izmeneniyami i dopolneniyami po sostoyaniyu na 11.04.2019], pp.23.