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Gamma Radiation of Radionuclide in The Mountain Areas of Former Uranium Production Facilities (Kyrgyzstan)

Djenbaev B.M.*, Kaldybaev B.K., Zholboldiev B.T., Karmisheve U.Sh., Shumaliev T. and Dikanov K.

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Biology Institute of National Academy of Sciences Kyrgyz Republic, Bishkek, Kyrgyzstan.

ABSTRACT

In Kyrgyzstan, a number of tailings with radioactive waste from the uranium mining industry of the former Soviet Union have been preserved. Tailing dumps were built without taking into account the climatic conditions of the highlands, resistance to earthquakes, landslides, mudflows. Many of them are located in close proximity to populated areas (Mailuu-Suu, Min-Kush, Kaji-Sai, Ak-Tuz, etc.). The location of tailings in the watersheds of rivers of transboundary nature, in case of emergency situations, may contribute to the expansion of the boundaries of radioactive contamination. The exposure dose rate of gamma radiation on the surface of tailing sites of the natural and man-made province Mailuu-Suu varies from 30-60 μR / hour, in local areas up to 500 μR / hour, in areas where the tail materials reach the surface, the specific activity of radionuclide is increased. On the territory of the uranium natural-technogenic province of Min-Kush, tailing material for processing ore and ash with uranium residues was stored in four tailing sites of the Min-Kush province (Tuyuk-Suu, Taldy-Bulak and Kak Dalniy). Currently, the most dangerous is the Tuyuk-Suu tailing dump, located at the mouth of the Tuyuk-Suu river, where geomorphological processes (landslides) take place. The presented results of radioecological studies have practical application for the purposes of radioecological monitoring of the environment and the radiation safety of mountain ecosystems, the development of measures to reduce radiation risks.

Keywords: Tailing, Radionuclides, Radiation background, Exposure dose, Specific activity

*Corresponding author. E-mail: kg.bek.bm@bk.ru.

INTRODUCTION

The mountains are a large ecosystem of our planet, where the natural landscapes are preserved using traditional land use methods. However, since some years the mining industry has been rapidly developed in many mountainous countries. Thus, mining and transportation of minerals are the most important factors for the destruction of natural mountain ecosystems, which should provide balanced biogeochemical processes and conservation of biodiversity. The mountains of Kyrgyzstan are rich in various types of minerals. Nowadays, more than 300 large and medium deposits of solid minerals were explored and evaluated including gold, silver, antimony, mercury, molybdenum, tin, rare earth metals (U, Th and Ra), non-ferrous metals, coal and non-metallic raw materials (Elyutin et al., 1985).

In the recent past, the country produced uranium oxide, rare-earth metals, semi-finished products for non-ferrous metallurgy (lead, zinc, molybdenum, etc.). From the mid-50s to the present, 20 mining and processing enterprises and 4 extractions and processing of uranium raw materials enterprises have been closed or mothballed in Kyrgyzstan (Djenbaev et al., 2012; Djenbaev and Mursaliev, 2012; Djenbaev et al., 2013).

Long-term and intensive technogenic impacts on the subsoil due to the exploration, mining, processing of mineral resources has led to significant changes in the geological environment in these areas. In some cases, a wide range of potentially dangerous man-made geological processes is continuing to cause significant economic and environmental damage (Torgoev and

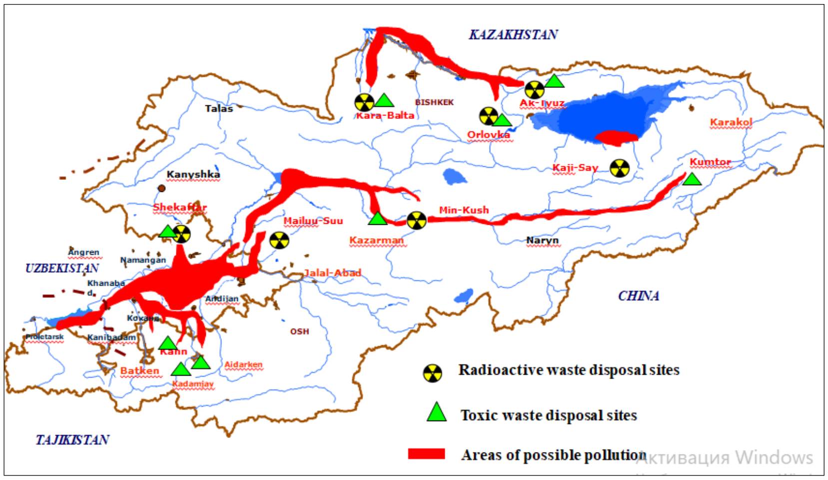

Figure 1. Map of the location of tailings and the area of possible pollution in Kyrgyzstan and transboundary states.

Aleshin, 2009). In complex geo-ecological problems, are the mining and metallurgical industries inherited from the Soviets and acquired after the collapse of the Union of Soviet Socialist Republics.

The problem of safely keeping a large amount of mining waste are raised in the first instance. Due to inefficient processing, minerals were formed in dumps of waste rock, substandard ore, metallurgical slags, tailings and sludge collectors, which not only pollute the environment but also are potentially dangerous sources (Meng, 2000). Tailings are in an especially disadvantaged position special hydraulic structures built from technogenic soils, so-called "tails", obtained as a result of complex and diverse processes of ore processing. Tailing storages are concentrated areas of fine industrial waste and the concentration of radionuclides depends on the processing ore (Mailuu-Suu, Kara-Balta, Min-Kush, Kadzhi-Sai, Ak-Tyuz and Shekaftar). At present, there are 55 tailing dumps in Kyrgyzstan with a capacity of more than 132 million m^3 covering an area of 770 hectares, 85 mining dumps with a volume of 700 m^3 occupying more than 1.500 hectares, including 31 tailing dumps and 25 dumps uranium production waste, with a volume of 51.8 million. m^3 (in 2014 their total radioactivity exceeds 90.000 curies). Unfortunately, the tailings are increasing even more through the development of new deposits (Figure 1). The tailings are occupying large areas and have a negative impact on the environment, as well as at the stage of operation and long periods of time after storage (Bykovchenko et al., 2005). The proximity of radioactive waste tailings to the borders of adjacent states of Central Asia, as well as their location on the catchments of rivers of transboundary nature, water flow, which in the case of emergency situations can contribute to the expansion of pollution boundaries. Particularly relevant is the need for regular monitoring of tailings and dumps of a transboundary nature (Mailu-Suu, Ak-Tyuz and Min-Kush). According to experts, currently there is a high risk of radiation danger for ecological disasters; the areas of possible pollution are the territories of Kyrgyzstan, Kazakhstan, Tajikistan and Uzbekistan, where about 5 million people live (Djenbaev et al., 2013).

MATERIALS AND METHODS

Radioecological researches were conducted in the territories of tailings: “Mailu-Suu”, “Min-Kush”, “Ak-Tyuz”and “Kadji-Sai”. A dosimeter - radiometer DKS-96 of the laboratory of biogeochemistry in the Institute of Biology of the NAS KR was used for the gamma survey of the territories. DKS-96 dosimeter -radiometer is widely used in dosimetry and radiometry. It provides an operative measurement of the basic quantities characterizing the radiation environment and researching sources of ionizing radiation (Figure 2). Measurements of the exposure dose of γ-radiation were carried out in accordance with the instructions of the International Atomic Energy Agency (IAEA) on the ground-based survey of the radiation situation at a height of 0.1 and 1 meter from the surface of the earth. According to the technical instructions of the dosimeters, measurements were carried out at least three times in one point, and then the arithmetic mean values were determined (Guseva at al., 1966). During selecting the soil samples, a map of the soil classification adopted by the Kyrgyz Republic has been used (Mamytov, 1996). Soil sampling was carried out in accordance with the requirements of GOST (2009).

The satellite device (GPS) automatically records the longitude and latitude of the location regularly (Figure 3). Gamma-spectrometric methods using Gamma-spectrometer “Canberra” (model GX4019 with software

Figure 2. DKS-96 dosimeter.

Figure 3. GPS.

Figure 4. Gamma-ray spectrometer

Genie-2000 S 502, S501 RUS) were used for determining the radionuclide concentration, based on the measurement of the gamma radiation of the researched soil samples (Figure 4). The laboratory work was carried out in several stages: (1) Grinding soil samples using a laboratory crusher to a grain size of less than 2 mm. (2) Drying the crushed sample to constant weight in a drying oven at a temperature of 105°C filling the container to the desired volume. The sample mass was determined before and after filling the container using scales. Measurement of gamma spectra of the sample, Identification of radionuclides in the sample and Determination of the peak area of all identified radionuclide, then calculating their specific activity in the sample (Burkuitbaev, 2006).

RESULTS AND DISCUSSION

The uranium natural-technogenic province of Mailuu-Suu

Figure 5. Valley of Mailuu-Suu, showing the former ISOLIT processing plant on the right and the relocated tailings dump no. 3 on the left side/center.

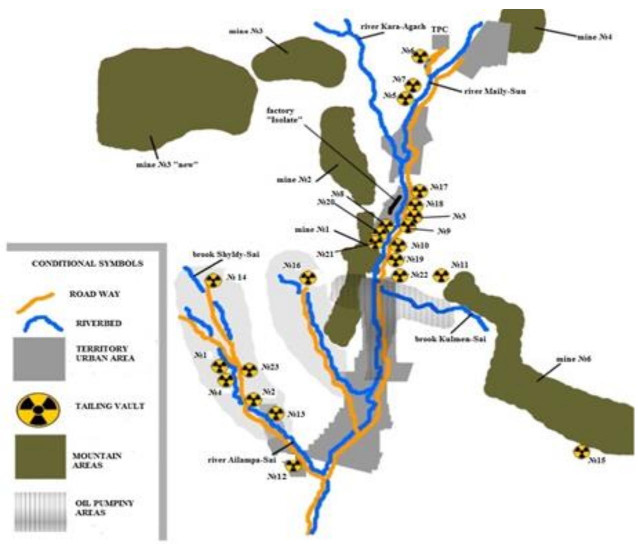

Figure 6. Location of tailing and dumps in Mailuu-Suu.

is located in the western part of the Fergana Range, in the Baubash-Ata Mountains. The Mailuu-Suu river and a number of tributaries originate from a source located in the area of the Baubash-Ata ridge, which is part of the Fergana ridge of the Western Tian-Shan (Figure 5). There are 23 radioactive tailings with a total volume of 1.374 thousand m^3 and 13 mountain dumps of substandard ores of 5845.6 thousand m^3on the territory of the town of Mailuu-Suu, in the floodplain of the Mailuu-Suu river and Kulmen-Sai, Kara-Agach, Aylampa-Sai and Shulda-Sai streams and on the mountain slopes. According to the norms at that time the tailings were mothballed in 1966 to 1973 (Torgoev and Aleshin, 2009). The main waste is a radioactive uranium series of elements from mining and (often poor) processing of uranium-containing ores, which often led to low uranium recovery and thus, increased uranium content of the tailings. Tailing and mountain dumps of the natural and man-made province Mailuu-Suu belong to the Kyrgyz I, II and III categories of danger. Tailing № 1, 2, 4, 12, 13, 14 and 23 are located along the streams of Aylampa-Sai; № 3,5, 6, 7, 8, 9, 10, 18, 19, 20, 21 and 22 of tailings are located in the flood plain of the Mailuu-Suu river (Figure 6). Repairing and service of tailings were done partially and insufficiently over a long period of time. At this time, the average exposure dose rate of gamma radiation is 30 to 60 μR/hour on the surface of tailing; it exceeds 500 μR/h in local areas. Mostly the tailings and dumps are located 900 m above sea level, along the rivers of Mailuu-Suu, Aylampa-Saya, Kulmen-Say and Ashvaz-Say. According to the measurement results, an increased radiation background was observed at the tailings №1, 3, 5, 6, and 13. The exposure dose was more than 800 μR/h at some points before reclamation

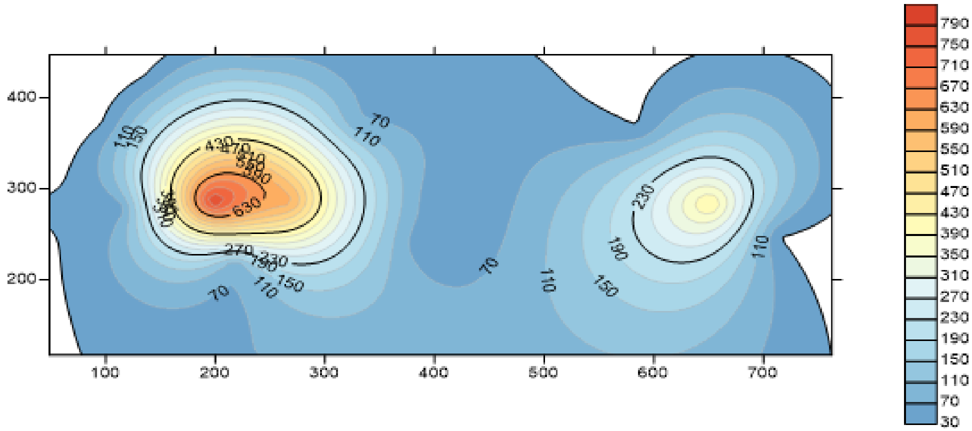

Figure 7. The schematic map of the exposure dose of tailing № 5 (μR/hour).

Table 1. The specific activity of radionuclide in the soils of tailings and dumps of Mailuu-Suu.

№	Place of Selection Sampling	^{238}U	^{232}Th	^{226}Ra	^{210}Pb	^{40}K
		The specific Activity, Bq/kg				
1.	Dam (control)	9.38±1.51	71.00± 8.00	63.78± 7.64	76.56± 10.85	705.00± 12.00
2.	Tailing №1	2044.15±296.51	80.90±9.40	10662.10±592	7065.13±841.19	-
3.	Tailing №3 (relocated)	51.40±11.31	44.15±5.65	137.03±16.09	850.11±107.26	800.00±57.00
4.	Tailing №4	29.60±5.10	26.30±1.35	35.71±1.80	150±70.32	450.70±25.00
5.	Tailing №5	36.26±5.73	52.00±6.60	531.54±58.50	383.66±48.31	926.00±6.37
6.	Tailing №6	38.83±8.33	37.75±4.50	42.27±6.19	193.45±24.29	706.10±35.00
7.	Tailing №7	32.40±5.00	57.80±1.30	31.00±1.20	39.40±2.30	396.20±22.00
8.	Tailing №8	38.20±2.50	22.60±0.70	48.00±1.60	26.30±1.50	454.60±24.80
9.	Tailing №9	28.60±5.00	22.40±1.30	58.50±4.60	474.60±70.00	477.50±30.80
10.	Tailing №13	29.80±5.22	26.00±1.30	34.70±1.80	478.80±70.10	490.10±25.00
11.	Water intake (control)	56.58±7.78	29.26±3.91	20.42±2.16	55.44±7.09	664.90±38.00

at № 3, after completion of work decreased to 175-360 μR/h. At the time the values were high during the transfer from the tailing № 6 to № 3, and then they dropped to 100 to 150 mR/h. The area of № 5 is within the normal range, but at the tailing and the drainage channels and pipes is above - from 120 to 800 μR/h. The exposure dose was slightly increased (from 100 to 300 μR/h) at area № 1 and № 13. According to the results of measurements of the radiation, background was compiled of a schematic map of the exposure dose rate of tailings № 1, №5 and № 6 of Mailuu-Suu, using the Surfer-12 programs (Figure 7).

The soil cover of the Mailuu-Suu river basin in the lower flow is typically gray, in the middle flow is dark grey and further up begins mountain-brown soils. The general characteristics of soil cover are as follows: pH = 8.2 to 8.8; nitrates 13.2 to 25 mg/kg; chlorides 25 to 47 mg/kg; sulfates 240 to 895 mg/kg and petroleum products 18 to 128 mg/kg of dry matter. The physicochemical indicators of the soil cover of the town of Mailuu-Suu (with the exception of the area of technogenic areas) are at a level of or below the Maximum permissible concentrations. The specific activity of radionuclide mostly exceeds the control levels and average background values in the soils of tailings, it is especially in the territory of tailing № 1, where there is an exit of tail materials to the surface: ^{238}U-2044 Bq/kg, ^{226}Ra-10662.1 Bq/kg, ^{210}Pb-7065.13 Bq/kg (Table 1). In recent years, geomorphological processes (landslides and floods) have intensified in this region, therefore, rehabilitation works are needed for tailings and dumps of Mailuu-Suu. The most difficult for the state is to solve the problem of rehabilitation of tailings, dumps and their reburial, which is not possible without the participation of the world community. Due to the fact these places were visited by international experts and representatives of the IAEA, UNDP, TACIS and ROSATOM. For example, rehabilitation works were conducted by the company "Wisutec" (Germany) in dangerous areas from 2007 to 2012, the tailing № 3 was moved to a safer place - tailing № 6. However, rehabilitation work at all tailings and dumps is not completed. In recent years, geomorphological processes (landslides and floods) have intensified in this region, therefore, rehabilitation works are needed for tailings and dumps of Mailuu-Suu. The most difficult for the state is to solve the problem of rehabilitation of tailings, dumps and their reburial, what is not possible without the participation of the world community (IAEA, UNDP, EU/TACIS, World Bank and ROSATOM etc.). For example,

Figure 8. Min-Kush is a uranium natural-technogenic province.

Figure 9. General views of the Tuyuk Suu tailing.

an environmental baseline study was conducted by BGR from 2006 to 2008 and rehabilitation works were conducted by the company "WISUTEC", both Germany, in hazardous areas from 2007 to 2012, the tailing № 3 was moved to a temporarily safer place - tailing № 6 (Jung at al., 2007). However, rehabilitation work at all tailings and dumps is not completed and needs to be continued until sustainable conditions, for example, relocation of all tailings and waste dumps to the remote tailings dump №15 (Jakubick at al., 2015).

Uranium Natural-Man-Made Province of Min-Kush

The former uranium ore deposit of Tuura-Kavak is located near the village of Min-Kush. It was intensively mined from 1953 to 1968. Ore materials and coal concentrating the uranium were processed at a local hydrometallurgical plant after the coal was burned at a combined heat and power plant. The tail material of the processing ore and ash with uranium residues was stored in four tailings of the Min-Kush province (Tuyuk-Suu, Taldy-Bulak and Dalny) with radioactive materials in the volume of 1.15 thousand m^3 in the area of 196.5 thousand m^2. All tailings were mothballed after the closure of uranium production (Torgoev and Aleshin, 2009). Tailings are flat areas of the territory and are located on the slopes of steepness up to 25 to 40° between the mountains. At present, the most dangerous section is the Tuyuk-Suu tailing, it is located at the mouth of the Tuyuk-Suu river, where geomorphological processes (landslides) occur. It is known that the waters from the river Tuyuk-Suu run into the Koko-Meren River and further into the Naryn and Syrdarya Rivers (Figure 8 and 9). According to previously established results, the radiation background of the territory of "Tuyuk-Suu" and "Kak" tailings has

Table 2. The level of radiation background in the natural-technogenic province of "Min-Kush".

№ Places	Location	Height Above Sea Level	Coordinates	Exposure Dose, μR/h
1	Tuyuk-Suu tailing	2104 m	N- 41˚39,531´´ E - 074˚28,050´´	60-65 μR/h, locally 100-150 μR/h
2	Village Min-Kush, 17-territories	2107 m	N- 41˚40,876´´ E - 074˚26,919´´	35-38 μR /h
3	Tailing “Dalniy”	2018 m	N- 41˚ 41,160´´ E - 074˚21,792´´	50-55 μR /h, locally 200-250 μR /h
4	Tailing “Taldy-Bulak”	1926 m	N- 41˚40,922´´ E - 074˚23,734´´	50-55 μR /h
5	Tailing “Kak”	1938 m	N- 41˚41,054´´ E- 0,74˚22,572´´	60-75 μR /h, locally 150-200 μR /h
6	v. Kok-Oi	1562 m	N- 41˚52,828´´ E- 0,74˚25,412´´	18-25 μR /h

Table 3. The concentration of natural radioactive elements in soils.

№	Number of Samples	pH	Specific Activity, Bq/kg			
			^{234}U	^{232}Th	^{226}Ra	^{40}K
1	MST-01	8.20	121.5±15	45.7±3.7	287.6±29.2	418±26
2	MSTB-02	7.85	54.6±7	27.6±1.7	106.2±7.4	590±36
3	MSK-04	8.35	203.3±25	33±2	991.0±31	483±25
4	MSD-04	7.85	210.2±26	40.5±2.2	495.7±22	351±22
5	MSA-05	7.10	37.5±4	32±1.8	47.6± 10	406±25

increased. The exposure dose rate varies in the range of 60 to 65 μR/h at the Tuyuk-Suu tailing and 60 to 75 μR/h on the tailing “Kak” (Table 2). There are medium-strong soils dominate with stony-pebble deposits from a depth of 20 to 50 cm in this province. In this area, the traces of water erosion are noticeable in some places on steep slopes, which arise from the influence of temporary water flows-precipitation and meltwater, which does not have time to be absorbed by the soil.

In general, the soils of the geochemical province of Min-Kush are largely enriched with uranium and the concentration of uranium appears to be 5 to 6 times higher in average than in the soils of other places in Kyrgyzstan. The highest indicator of specific activity of radionuclides ^{238}U, ^{226}Ra was registered at the points MSD-04 (tailing “Dalniy”) and MSK-04 (tailing “Kak”) on the tailings of Kak, Dalnee and Taldy-Bulak, in the tunnels in the residential sites 17 and 21, as well as on the territory of the old factory. The highest indicator was registered ^{40}K in the MST-01 (Tuyuk-Suu tailings) ^{232}Th and ^{226}Ra, and at the point MSTB-02 (Taldy-Bulak tailings), (Table 3). We also investigated the background radiation in some residential houses of the village Min-Kush. The measurement results showed that background radiation is slightly increased (up to 2 times) in residential areas as compared with the maximum permissible concentrations and therefore certain activities are required to reduce it. The main reasons for the slight increase in the background level are due to the fact that slags from local coal were used for construction.

Ak-Tuz

A rare earth-radioactive province of Ak-Tuz is located on the territory of the Chui region of Kyrgyzstan. It is in the upper part of the Kichi-Kemin river valley and in the Chui river basin. The relief is complicated and mountainous, with heights exceeding 2000 m above sea level.

The ore field of this region is characterized by an extremely complex structure and covers about 30 occurrences of lead and rare metals. It is widely developed within the multiplicative and as disjunctive disorders, manifested many times over the entire history of geological development, beginning with the Precambrian. There are developed oxidized and sulfide ores within the deposit. At industrial concentrations was established the presence of Pd, Zn, Sn, Mn and Cu (Vasiliev, 2006). There are 4 tailings in the area of the Ak-Tuz village where 3.9 million m^3 of waste of polymetallic ores was deposited, which occupy 117 thousand m^2. The average recommended gamma background is 60 to 100 μR/hour, whereas in anomalous areas is up to 1000 μR/hour. The supporting work of hydraulic structures was not carried out from 1995 to 1999. In 2000, the supporting work of the hydraulic structures of tailings №1 and №3 were constructed. There is an observed and intensive washout of the protective layer of tailing №1 and wind erosion of the surface of tailing №3 with the destruction of the adjacent territory (Figure 10). According to radiometric measurements, the average exposure dose rate of gamma radiation in Ak-Tyuz is 21.3 to 33.0 μR/h, and around the village is within 1 km to 28.8 μR/ h. Gamma

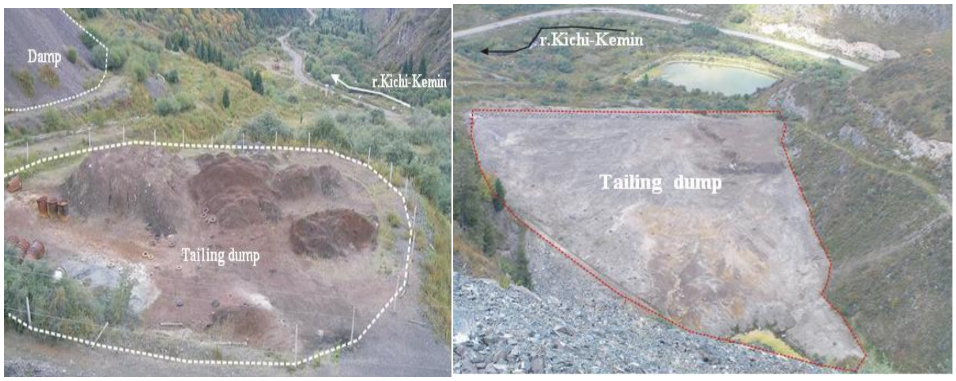

Figure 10. Ak-Tuz tailings №1-4 in the valley of the river Kichi-Kemin.

Table 4. The level of radiation background in the technogenic province of Ak-Tuz.

№ place	Location	Coordinates	Exposure Dose (at a Height of 10 cm From the Ground), md / h
1	Career (mine)	N - 42.860324´ E - 76.118930´´	180-200 μR/h, in some places up to 290 μR/h
2	The road to the career and dump	N- 42.868963´´ E 76.122551´´	110-125 μR/h
3	Tailing №1	N- 41°40,922´´ E - 074°23,734´´	55-65 μR/h
4	Place of the accident, the left bank of the river	N- 42.872439´´ E- 76.120916´´	65-75 μR/h Locally 70-150 μR/h
5	Tailing №2	N- 42.871243 E- 76.107867	46-75 μR/h locally 180-200 μR/h
6	Tailing №4	42. 495431 76. 013400	80-90 μR/h locally 240-260 μR/h
7	Ak-Tuz settlement, Chemical laboratory of Ak-Tuz mine	42°52.581 76°07.490	85.6 μR/h
8	Sump	42. 52.248 76. 07.501	280-320 μR/h, in some places reaches 400 μR/h
9	Mining - Processing factory	42°52.2119 76. 072842	75.4 μR/h
10	On the exits of Ak-Tyuz, 1 km from the center, below the pipeline to the tunnel	42°52.358 76°07.251	30.4 μR/h

background in the area of the processing plant is 75.4 μR/h, in the sump 280 to 320 (in some places up to 400) μR/h, near the mines (quarry)180 to 200 μR/h.

The natural gamma background is up to 30.4 μR/h in the Kichi-Kemin gorges (Table 4). The characteristic of the soil cover of the Ak-Tuz province in the middle mountainous areas of Kyrgyzstan is a mountain-meadow dark soil likes subalpine. The mechanical composition is often medium and heavy loamy. Humus ranging from 4 to 8% in the upper horizons. The reaction of the soil environment (pH) ranges from neutral to slightly acidic (6.5 to 7.0). In the humus horizon, these soils contain up to 0.35% of total nitrogen and 0.15 to 0.30% of phosphorus. Especially it is enriched with potassium and the quantity ranges from 2.2 to 2.6%. The specific activity of U varies in the range of 26 to 131.7 Bq/kg in the soil, increased levels are typical for points: ATP-01-07 - 101.7 Bq/kg; ATP-05-07 - 131.7 Bq/kg, thorium concentration is especially increased at the points of ATP-01-07 - 323.8 Bq/kg and ATP-05-07 - 253.4 Bq/kg (Figure 11 and Table 5). Natural radioactivity is mainly determined by the decay products of uranium-238, uranium-235 and thorium-232, as well as potassium-40. In the areas of the geological environment observed the technogenic impact, there may be an imbalance in the indicated decay chains, as well as significant enrichment for individual isotopes. Increased concentrations of thorium and uranium in the soils of the Ak-Tyuz deposit are probably associated with the intensification of natural geochemical processes as a result of technogenic disruption of the continuity of mountain ranges.

Kaji-Sai

Kaji-Sai tailing is located in the Ton district of the Issyk-Kul region near the village of Kaji-Sai. Close to the

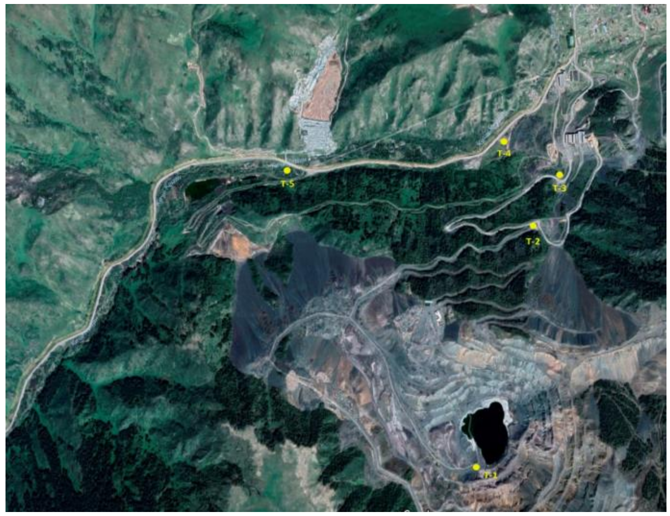

Figure 11. The places of selected sample soil samples on the technogenic province of Ak-Tuz.

Table 5. Specific activity of the radionuclide in the soil of the technogenic province of Ak-Tuz

Place of Selection Sampling	U/^{234}Th	Ra/^{214}Pb	^{232}Th/^{228}Ac	^{40}K	^{137}Cs
	Specific Activity, Bq / kg				
АТП-01-07	101.7±12.6	93.3±28.3	323.8±13.2	382±23.6	2.3±0.07
АТП-02-07	26±3.2	41.2±9.1	132.4±5.3	257±16.7	0.3±0.01
АТП-03-07	50.9±6.3	28.7±9.9	42.8±1.7	492±30.6	0.4±0.01
АТП-04-07	50.8±6.3	28.8±9.9	42.8±1.7	492±30.6	0.4±0.01
АТП-05-07	131.7±16.3	72.1±12.4	253.4±10.1	352±22.5	0.5±0.02

Ministry of Medium Machine Building USSR Mining factory of Kaji-Sai was operating from 1948 to 1969 in order to process uranium ore, which was subsequently transformed into an Electrotechnical factory. Wastes from the production and industrial machinery were buried, creating a tailings pond with a total volume of uranium waste of 400 thousand cubic meters. There is a mixture of uranium enrichment plant waste in this province, coal ash from the former power plant, an empty rock and residues of processing of coal ash, which is extracted from uranium (Djenbaev at al., 2013). It is clear that previous attempts to provide a protective coating over the tailings have been ineffective since the coating is often destroyed by natural phenomena and the local population, which unearths dumps for scrap as a source of income, and others (Figure 12). On the surface of the ground covered with ash dumps and tailings waste in the territory of Kaji-Say, the exposure dose gamma-radiation of the natural and technogenic area is an average of 30 to 60 μR/h. According to our research, the areas with abnormally high levels of exposure dose are 600 to 1500 μR/h (up to15 mSv/h). High levels of radioactivity observed in the field of destruction of the protective coating as a result of the excavations, which are made by locals or by natural factors: rain, water and wind erosion. Areas with elevated background radiation (120 to 200 μR/h) and stored on the territory of the former industrial area and places with storage of ash brown coal, as well as on the sites of the former extraction production. According to the measurements of the field of the protective coating tailing, a diagram was drawn of the spatial distribution of the dose rate of gamma radiation.

This methodological approach is used on researching the areas before and after the restoration of the protective layer by the Ministry of Emergency Situations of the Kyrgyz Republic (Figure 13). Here is shown the state of the province: there is a river bed in the area of the tailings, sedimentation tanks 1 to 3, the industrial site and the area around the tailings pond up to 200 m, the exposure dose to the background level or a little higher, but lower than in the Kyrgyz Republic adopted norma (30 μR/h). Sediment is below the tailings, their condition is satisfactory. The level of background radiation varies from 22 to 40 μR/h (Table 6). We have also studied the total radioactivity of the soil adjacent territory of Kaji-Sai tailings and ^{238}U, ^{234}U, ^{228}Th, ^{228}Ra, ^{230}Th, ^{210}Pb, ^{226}Ra and ^{40}K (Table 7). The table shows that if we compare the concentration of ^{228}Th, ^{228}Ra, and ^{40}K they are at the same level, in all investigated areas in the tailings area in relation to the ^{228}Th and ^{228}Ra from an average of 10 to 15 times more. ^{230}Th is found only on the 3 areas and

Figure 12. The current state of the tailing Kadji-Sai.

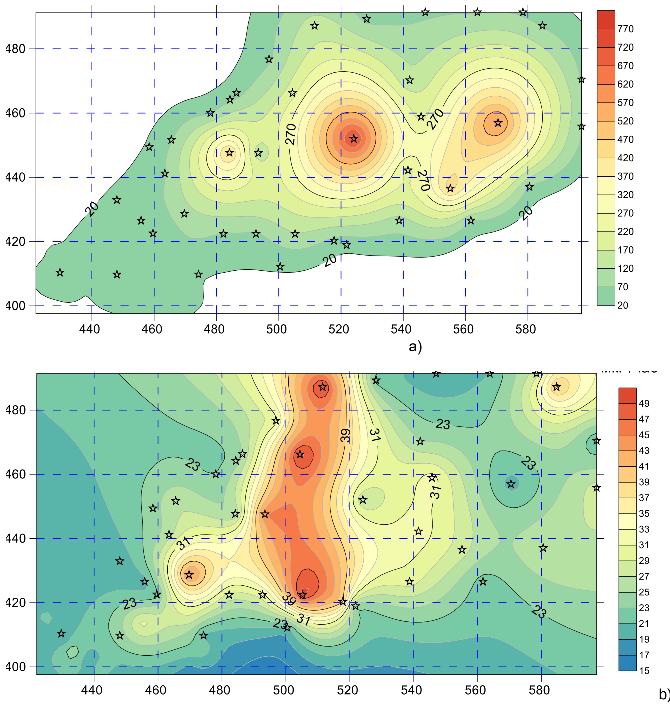

Figure 13. (a) In the field of protective coating violations, (b) After restoring the protective layer (μR/hour).

Table 6. The level of radiation background of the natural-technogenic uranium province of Kaji-Sai.

Location Point	On The Surface of The Soil (μR/h)	From The Soil Surface At A Height 1 m (μR/h)
The river bed in the area of the tailings	20-35	15-28
Sediment № 1	20-35	30
Sediment № 2	20-35	30
Sediment № 3	18-30	25
Processing of coal slag plant	20-45	20 – 35
Tailings	20 - 40	20-37
Above tailings (200 m)	22-28	20
Above tailings (1 km mountain side)	27 - 34	25
Living sector	19 - 25	12 - 20

Table 7. Activities of radionuclide in the soil near the tailing of Kaji-Sai location.

Place of Sampling	^{238}U	^{234}U	^{230}Th	^{226}Ra	^{210}Pb	^{228}Th	^{228}Ra	^{40}K
	Specific Activity, Bq/kg							
The slope in front of the sump 1	105±6	5±3	MDA	134±9	146±10	49±1	51±6	871±24
The bottom stream from the area of the settler	126±7	6±4	MDA	98±3	107±11	73±3	56±7	743±24
Industrial site, ash dumps	157±14	MDA	MDA	117±9	114±14	54±5	44±5	305±23
Industrial site, a spot 140 μR / h	3152±148	154±44	15513±1265	10643±75	12121±204	46±8	MDA	899±187
Ash from Thermal power plant №1	2483±160	120±39	MDA	2551±182	2674±157	82±9	105±50	514±213
Ash in the territory of shop №2	3736±74	184±44	3183±228	3383±228	3462±172	42±4	53±27	443±78
Sediment №1, the cut 70 cm	2338±353	113±21	5403±960	294±29	251±14	63±5	69±10	333±34

their concentration is at a high level, especially it is in the soil on the surface ground of industrial area (spot 140 μR / h) - 15513 ± 1265. Concentrations of ^{210}Pb and ^{226}Ra 1 – in 3 and 7 sites on average at the same level, and it differs to 2 to 3 times, and the maximum accumulation observed at 4 to 6 portions. On the surface of the soil was determined the ash from the plant in the territory of industrial area and the tailings (spot 140 μR/h) ^{210}Pb and ^{226}Ra activity is quite high (^{210}Pb - 12121 ± 204 and ^{226}Ra - 10643±75). A protective dam was built to contain radioactive contamination in 2006 and the cascade dampers were built, also the channels and a protective coating were restored. However, under the influence of a number of natural factors (floods, landslides and mudflows) their partial destruction occurs, moreover, this territory is poorly protected; it has access for the local population (Djenbaev at al., 2016).

CONCLUSION

One of the important environmental problems of Kyrgyzstan is the uranium tailings, it was a legacy left after the defense industry of the Soviet Union, presenting a danger to the environment and human health at the present time. In the past, serious mistakes were made on choosing sites for the storage of radioactive waste and designing the methods of operation and control. A number of uranium tailings damaged the territory of the republic through natural disasters (earthquakes, landslides, mudflows, etc.) the risk of destruction and increasing the danger of radioactive contamination. Currently, most tailings, mines, dumps are in a state of disrepair. The proximity of tailings with radioactive waste to the borders of adjacent states of Central Asia, as well as their location on the catchments of rivers of transboundary nature, water flow, which in the case of emergency situations can contribute to the expansion of pollution boundaries. Particularly relevant is the need for regular monitoring of tailings and dumps of a transboundary nature (Mailu-Suu, Ak-Tyuz and Min-Kush). Based on the above, one of the priority tasks of Kyrgyzstan is to solve the tasks of reducing the risks from radioactive contamination and land degradation in adjacent areas, rehabilitating the tailings of the former uranium mining production, and carrying out active work on attracting international assistance. Within the framework of the National Development Strategy of the Kyrgyz Republic for 2018 to 2040, reclamation of territories (33 tailings and 25 mining dumps, primarily the Min-Kush and Kadzhi-Say tailings) affected by mining and processing of natural uranium will be carried out. A national radiation safety system will be created. The presented results of radioecological research have a practical application in order to monitor the environment and radiation safety of mountain ecosystems and to develop measures and activities of reducing radiation risks.

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