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The Radioecological Peculiarities of Soil Cover in Mountainous Areas (Kyrgyzstan)

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ABSTRACT

The article presents the results of a radiological study of mountain soils depending on the height above sea level (740 - 760; 1600-1700 and 2000-2500 m above sea level) on the territory of the Kyrgyz Republic. Mountainous areas are characterized by denudation-erosion processes and humus; total nitrogen, gross phosphorus and potassium in the soil cover in mountainous zones are not uniform; in general, the studied zones are at the level of a natural area with small deviations, this is due to both natural and man-made processes. The content of natural radionuclides in the studied soil samples of mountain dark chestnut soils (tailing ponds and the adjacent territory) is several times higher than the average Clarke values, where a sharp decrease in the content of radionuclides is observed in the lower 20-60 cm layers, compared to mountain meadow-steppe subalpine soils. Radioecological analyzes in the city of Bishkek showed that, in general, the exposure dose is at background levels and below established standards. In the Issyk-Kul Biosphere Territory, the calculated annual doses to the population from all routes of exposure to radionuclides in the conditions of the Issyk-Kul region do not exceed the established norm (1 mSv per year). Mothballed storage facilities and dumps are a dangerous potential source of environmental pollution and therefore require constant monitoring.

Keywords: radionuclides, activity, alpha-activity, natural-technogenic, the soil, the water, dumps, tailings dams.

RELEVANCE

The danger of radioactive contamination of the soil cover was realized in the 1950s when radioactive fallout from nuclear weapons tests was observed everywhere. At the present stage, the number of potential sources of radioactive contamination has significantly increased, primarily with the expansion of the use of nuclear energy not only for the military but also for peaceful purposes. These include nuclear power plants and other enterprises providing a complete nuclear energy cycle, uranium mines and enrichment plants, mines, isotope separation plants and irradiated nuclear fuel reprocessing plants, and radioactive waste storage facilities. Thermal power plants working with coal and oil shale can also play an important role in increasing the radiation background of the soil cover. Their ash emissions contain such radioactive elements as Po, Ra, Th, and U in concentrations, sometimes many times higher than their natural background level [1, 4, 13].

It should be noted that, despite the great variety of anthropogenic sources of soil contamination, their contribution to the total dose load is small compared to the natural radiation background according to the data of different scientists of soil scientists and radio-ecologists. However, there is a clearly expressed tendency for the local increase of the role of anthropogenic radiation factor over time, which should be taken into account when developing measures to protect soils from radioactive contamination. It is known that V.I. Vernadsky started the study of the behavior of radioactive elements of natural origin at the end of the 20s, created in the Biogeochemical Laboratory of the USSR Academy of Sciences. The main attention in those years was paid to the role of living matter in the concentration of natural radioactive elements (U, Ra, and Th isotopes) in environmental objects [4, 11, 13].

In the recent past, Kyrgyzstan produced uranium oxide (UO_2) rare earth metals, semi-finished products for non-ferrous metallurgy (Pb, Zn, Mo, etc.). From the mid-50s of the last century to the present, 20 mining and processing enterprises have been closed or mothballed in Kyrgyzstan, including 4 enterprises for the extraction and processing of uranium raw materials [7, 11, 17].

Prolonged and intensive technogenic impacts on the subsoil associated with exploration, mining, and processing of mineral resources have led in some mining and industrial areas to significant changes in the soil cover and geological environment of these areas, and in some cases - to the emergence of a wide range of potentially dangerous natural-technogenic geological processes, which have caused and continue to cause significant economic and environmental damage. The soil cover of Kyrgyzstan is formed under the influence of the life of mountain soil formation process. Consequently, all soils of Kyrgyzstan are essentially mountain soils. Mountain ecosystems in general have a complex of characteristic features that distinguish them from other natural regions - plains. The main distinctive natural properties of plains, lowlands, and mountain systems are complexity and fragility. The dynamism of relief, volcanism, soil erosion, high seismicity, landslides, avalanches, rapid water flows, falling rocks, etc. cause natural phenomena and naturally change the conditions of human life. They cause natural processes (e.g., soil erosion, biogeochemical processes) that are tens to thousands of times more intensive than in other natural landscapes [1, 3, 11].

Tailings ponds - special hydraulic structures created from technogenic soils - so-called 'tailings', obtained as a result of complex and diverse processes of ore processing - are in a particularly unfavorable situation. Tailings dumps are concentrated massifs of finely dispersed industrial waste, which, depending on the ores processed, contain radionuclides (Mailuu-Suu, Kara-Balta, Min-Kush, Kadzhi-Sai, Ak-Tuz, Shekaftar). At present, there are 55 tailing dumps with a volume of more than 132 million m^3 on an area of 770 ha, 85 mining dumps with a volume of 700 m^3 occupying more than 1500 ha on the territory of Kyrgyzstan, including 31 tailing dumps, and 25 dumps - uranium production wastes with the volume of 51.8 million m^3 (as of 2014 their total radioactivity exceeds 90 thousand curies), in case of development of new deposits it will increase even more [6, 14, 17].

Occupying significant areas, tailing ponds hurt the environment both at the stage of operation and for long periods after the storage facilities are mothballed. It should also be noted that the close location of facilities with radioactive waste to the borders of the neighboring Central Asian states, as well as their location on the watersheds of rivers with transboundary character, water flow, which in case of emergencies can contribute to the expansion of the boundaries of radioactive contamination. Of particular relevance is the need for regular monitoring of tailing ponds and dumps with transboundary character (Mailu-Suu, Ak-Tuz, Min-Kush). According to experts, there is currently a high risk of radiation-hazardous ecological disasters, with the territories of Kyrgyzstan, Kazakhstan, Tajikistan, and Uzbekistan, where about 5 million people live, falling within the zone of possible contamination [7, 10, 14].

MATERIAL AND METHODS OF RESEARCH

Soil samples were taken for research according to the established observation points. Soil research and soil sampling were carried out according to GOST 17.4.3.01- 83 'General requirements for soil sampling'. General analysis of soil cover was carried out in the Republican Soil and Agrochemical Station under the Ministry of Agriculture of the Kyrgyz Republic. Soil samples were taken from the upper horizons (up to 20-25 cm), where nutrient elements and chemical pollutants are mainly concentrated. When taking soil samples, we used the classification of soils adopted in the soil map of the Kyrgyz Republic [5, 8, 16].

A dosimeter-radiometer DKS-96 was used for the gamma survey of the area. Radiation background measurements were carried out following the IAEA instructions and ground radiation survey. A gamma-spectrometer 'Canberra' (model GX4019 with software Genie-2000 S 502, S501 RUS) was used to determine the isotopic composition of radionuclides in soil samples. The satellite device (GPS), regularly automatically recorded the longitude and latitude of the location.

To conduct a gamma-terrain survey, dosimeter-radiometer DKS-96 and others of the Laboratory of Biogeochemistry of the Biological and Soil Institute of the National Academy of Sciences of the Kyrgyz Republic were used. Measurements were carried out following IAEA instructions for an on-ground survey of the radiation situation at a height of 0.1 and 1 meter from the ground surface. According to the technical instructions of the dosimeters, measurements at one point were carried out at least three times, and then the arithmetic mean was determined. To conduct a gamma survey of the terrain using dosimeter-radiometer DKS-96 and others of the Laboratory of Biogeochemistry of the Biological and Soil Institute of the National Academy of Sciences of the Kyrgyz Republic. Measurements were carried out following IAEA instructions for an on-ground survey of the radiation situation at a height of 0.1 and 1 meter from the ground surface. According to the technical instructions of dosimeters, measurements at one point were performed at least three times, and then the arithmetic mean value was determined (Fig. 1) [1, 15].

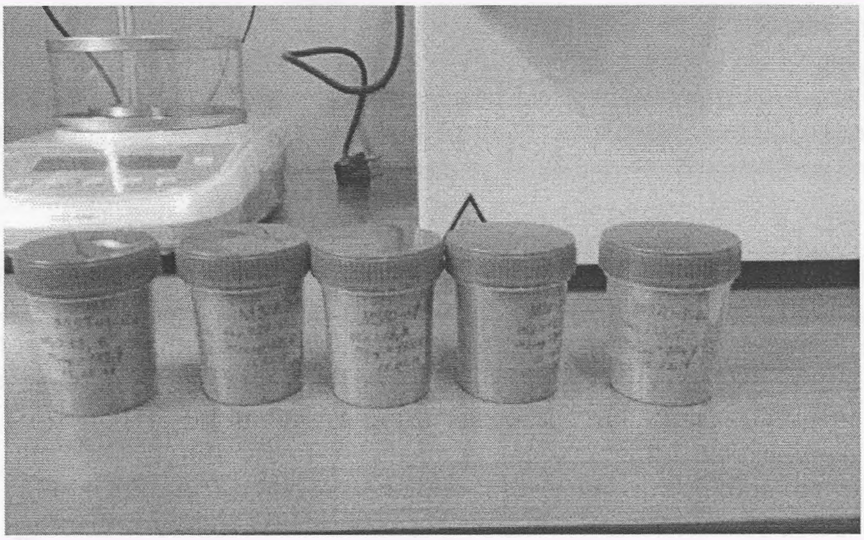

Fig. 1: Packed soil samples for Gamma spectrometry measurements

BISHKEK CITY (740 - 760 M)

Bishkek is located at the foot of the Tien Shan. The relief of the area is hilly, and the average height above sea level is 700-900 meters. The border between the temperate and subtropical climatic belt runs through the city. Here the average temperatures in January are -2° C... -4° C, and in July +23° C... +25° C. In summer, humidity increases up to 75%. The average annual precipitation is 400-500 mm. The capital of the Kyrgyz Republic is the largest industrial center. The city of Bishkek has a uniform gradient of 2.5-300 from south to north, its altitude is from 700 to 950 m above sea level, it is located in the center of the Chui Valley at the foot of the Kyrgyz Ala-Too ranges and 25 km from the border with the Republic of Kazakhstan. The Alamedin and Ala-Archa rivers flow within Bishkek, and the city covers an area of more than 200,000 hectares. Its territory is officially 160 km^2 according to the latest data, but every year it is expanding due to the construction of new residential areas around the city. More than 20% of the country's population (over 1.0 million people) live here, the number of residents, high-rise buildings and motor transport exceeds all existing norms for a small capital city. One of the main factors polluting the city is the expansion of residential areas around the city, where the population uses low-quality coal and industrial waste for heating [2, 7, 9].

Exposure dose rates of the soil cover of Bishkek. The main zonal soil type for the territory of Bishkek is northern ordinary grey soils (low-carbonate). They occupy the southern part of the city, and in the northern-lower part - meadow-chernozem, chernozem-meadow, meadow, and meadow-marsh soils are spread. Northern ordinary grey soils are formed on pale-brown cartilaginous and coarse sandy loams. Groundwaters do not influence soil formation. Pale grey and brown tones prevail in the soil profile, and dark grey tones prevail in cultivated soils. Soils are often skeletonized and stony, low- and medium-powerful. They contain 1.5-2.5% of humus, 0.10-0.18% of total nitrogen. Calcium prevails in the composition of absorbed bases (from 60 to 90% of exchange capacity). In the northern part of the city, there is an approach and inclination of groundwater to the surface, where along with drying (drained) there are strongly overwatered areas, where the processes of secondary salinization and waterlogging are manifested. Meadow-chernozem soils have the light grey color of humus horizon, illuvial horizon with a bluish tint, in the lower horizon bordering with soil-forming rocks - rusty-ochre speckles. It contains 1.3-3.5% humus, 0.2-0.4% total nitrogen, 0.2-0.3% phosphorus, and 2-2.5% potassium. Grey loam-meadow soils are darker in color, with a bluish tinge, with ochre spots. Humus is about 3.6%. Meadow soils (light and dark) with a blackish-brown or dark grey tint. Signs of gleaming and waterlogging in the form of rusty ochre and blue spots - at a depth of 60-80 cm. They contain 3.5- 8.5% humus, 0.20-0.40% total nitrogen, 0.20-0.30% phosphorus, and up to 4% potassium.

Carbonate content is 0.5-2.0% in the upper horizons, 8-10% in the lower horizons, and up to 15-20% CO2 in the meadow lime horizon. Table 1 shows the results of our measurements showing that the radiation background in the area of TPP in Bishkek and other sites radiation background is not high and at the background level (Table 1).

Table 1: Exposure background of soil cover of Bishkek city

The western part of CHP	The northern part of CHP	South-Eastern part	Academy of the Ministry of Internal Affairs	Turguch m/district	V. Kara-Zhygach
0,150-0,238	0,150-0,245	0,180-0,300	0,190-0,212	0,149-0,237	0,188-0,263
4252.403 7438.925	4252.121 7438.971	4252.360 7441.135	4252.316 7440.572	4251.624 7440.180	4251.345 7439.155

From Table 1 it can be seen that, in general, the exposure background of the soil cover is below the permissible norm. However, however, it should be noted that compared to the eastern.

It is on average up to 2 times lower in the western and northern parts of the south-eastern zone, which should be taken into account in further studies. Such difference in values is related to the fuel used at CHPPs and wind direction, which mainly blows from the western side of the city to the east. Measurements of soil exposure doses were also carried out in other parts of Bishkek city (Fig. 2).

We have determined natural and anthropogenic radioactive elements common in technogenesis and toxic in the soil cover in Bishkek city. Previous studies have shown that the content of natural radionuclides in soils varies depending on soil type and geomorphological features. One of the main polluters of the city is the central CHPP, where hard coal is used. At the same time, it is known that hard coal combustion at thermal power plants is accompanied by emission into the atmosphere of a large amount of aerosol particles containing natural radionuclides. The concentration of radionuclides in the coal itself is 0.7÷ 70 Bq/kg 40K, 3÷500 Bq/kg 238U, and 3÷300 Bq/kg 232Th (data are given for samples).

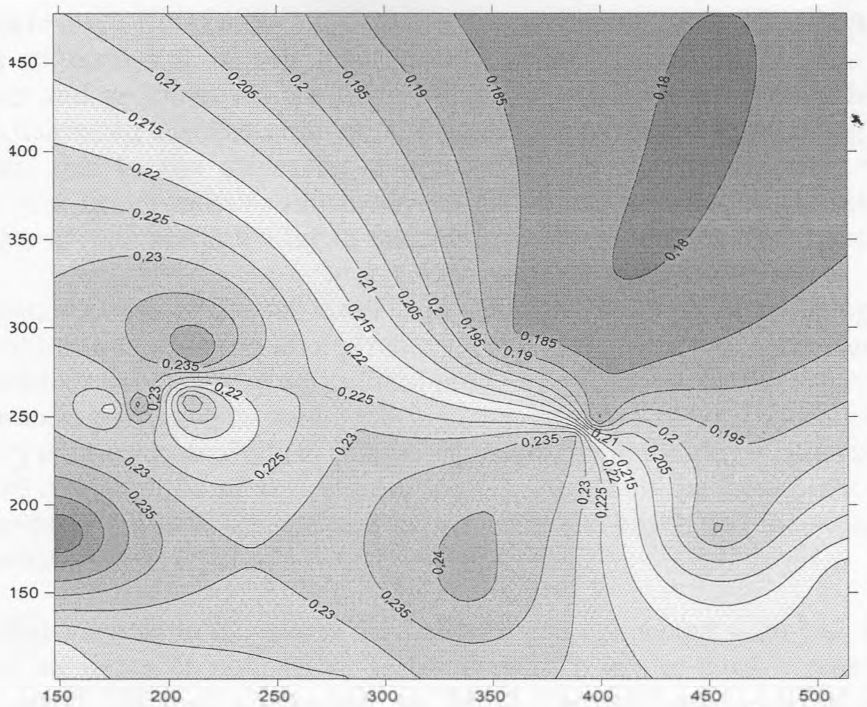

Fig. 2: Contour map of gamma radiation exposure dose rate on the territory of Bishkek, using Surfer 11 program (µSv/h).

Thorium and uranium-radioactive elements, widespread in technogenesis, are highly radiation hazardous and toxic, we have determined them in the soil cover in the CHPP area. Earlier studies have shown that the content of natural radionuclides in soils varies depending on soil type and geomorphological features. The specific activity of uranium-238 in soils in the CHPP area varies between 35-89 Bq/kg, thorium-232 - 48-72 Bq/kg, and potassium-40 - 690-900 Bq/kg, which is lower than the accepted norms (Table 2).

Table 2: Isotopic composition of Bishkek soil cover

Место отбора проб	U/Th-234	Th-232/Ac-228	K-40	Cs-137
	Бк/кг	Бк/кг	Бк/кг	Бк/кг
БТЭЦ-01-03	70±10	48±3	698±38	
БТЭЦ-03-03	49±9	69±3	870±32	4,2±0,7
БТЭЦ-05-03	60±10	72±5	760±38	2±0,4
БТЭЦ-07-03	35±5	61±3	900±43	4±0,5
БВА-08-03	89±11	50±8	817±42	8±0,6
БВА-09-03	48±3	51±8	870±42	7±0,6

Thus, the conducted radioecological studies in Bishkek city showed that, in general, the exposure dose is at the background level and below the established norms (MPD - 0.6 µSv), however, in some areas there is a slight increase in dose, but below the MPD. It should be noted that in perspective it is necessary to periodically monitor radionuclides and other heavy metals in some points of the city, as well as fuel used at CHPPs and small boiler-houses. It is also necessary to carry out measurements in suburban areas to avoid contamination of soil, respectively water, and air.

Biosphere area of Issyk-Kul (1600 - 1700 m). The biogeochemistry of radioactive elements and heavy metals in Issyk-Kul is still insufficiently studied. According to the estimates of biogeochemists and geochemists, the Issyk-Kul Basin is a natural uranium biogeochemical province with increased uranium content in the natural environment and living organisms. At the same time, due to the increasing contamination of the environment with artificial radionuclides and heavy metals, which have a global character of distribution, there is a potential danger of their accumulation in the objects of the natural environment [7, 10, 11].

Radioactive contamination of the soil cover is of great danger, as a human being is exposed to radionuclide radiation in the process of production and consumption of agricultural products. It should be noted that the quality of agricultural products can have a significant impact on public health and the socio-psychological well-being of entire regions. Radioactive contamination of the soil cover is very dangerous, as a human being is exposed to radionuclide radiation in the process of production and consumption of agricultural products. It should be noted that the quality of agricultural products can have a significant impact on public health and the socio-psychological well-being of entire regions [1, 2].

It is known that variations of natural background are connected with the heterogeneous distribution of elements of radioactive series U and Th in the Earth's crust. Insignificant variations of natural radiation background for different types of soils of Priissykkulia are also observed, probably, it is connected with the heterogeneous distribution of natural radionuclides dispersed in soils, earth rocks, surface and underground waters and other objects of the natural environment. For grey-brown soils, its values vary in the range of 20-28 μR/h, for light-brown soils - 16-26 μR/h, for mountain-valley chestnut soils - 21-24 μR/h, for mountain-valley chestnut soils - 18-21 μR/h, for mountain-valley dark chestnut soils - 17-21 μR/h. According to biogeochemical classification, natural radionuclides (^{236}U,^{226}Ra,^{232}Th,^{40}K) are characterized by low accumulation in soil (from 2 to 10 Clarks). The content of artificial radionuclide (137Cs) in soil does not exceed the permissible intervention levels (NRB-99).

On the upper layer of soil cover the radon level of coastal areas is below the permissible concentrations and at the background level, but in some areas, there is a slight increase in the area of hot springs - in the village of Oruktu - 24.24 mBq/(m2×s). Oruktu - 24.24 mBq/(m2×s), Bar-Bulak - 28.48 mBq/(m2×s) and Biological Station - 30.61 mBq/(m2×s). In the area of Kadzhy-Sai, Jenish and Ak-Terek villages on average at the same level. The situation in developed countries is well-studied. For example, in the USA, where typical soil radon content per liter is 7.4-74 mBq/(m2×s), (Fig. 3).

It is known that recently computer programming and mathematical modeling have been used more and more often for ecological, including radioecological monitoring of natural and anthropogenic environments. For the radioecological assessment of the environment, we used the ERICA program (Erica tool 1.2.), as Issyk-Kul territory is a biosphere territory and resort zone of international importance. The Erica tool 1.2. program is a software used to assess the radiation hazard for terrestrial, marine, and freshwater ecosystems. Knowing the radionuclide content in soil or water, the software calculates and models the radionuclide content for plants, animals, and other organisms, and provides an estimate of radiation doses. The assessment element consists of three sections, for a more detailed assessment of radiation factors on living organisms we applied section 3. The sum of risk factors of Issyk-Kul region ecosystems was 0.70-0.90. Fig. 4 shows the increased risk factor for ^{226}Ra and the total dose rate.

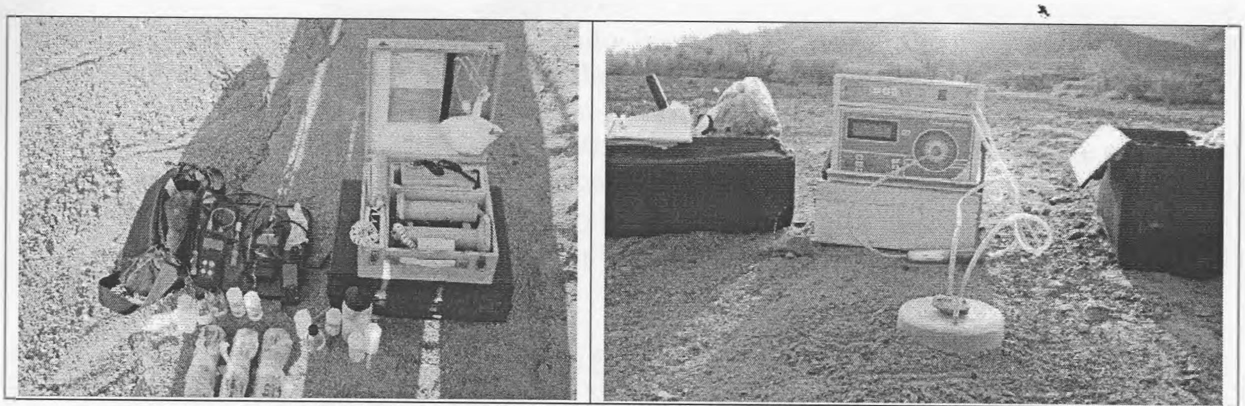

Fig. 3: Process of radon Rn^{222}measurement in the soil cover of the coastal zone of Lake Issyk-Kul

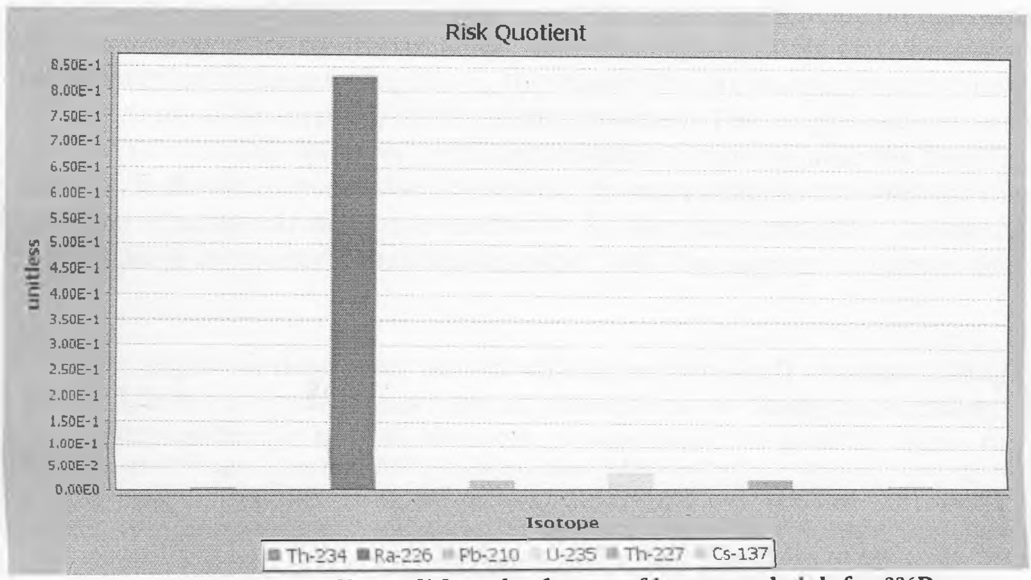

Figure 4: Among radionuclides, the factor of increased risk for ^{226}Ra.

Thus, the total risk factor was 0.90. For radionuclides, the high-risk factor is observed for 226Ra - 0.83. NORMALYSA is a software used to provide scientific bases for radiation safety, and the development of rehabilitation strategies for territories exposed to radioactive contamination. It includes models for calculating radionuclide releases to air, surface, and groundwater from contaminated biosphere sites such as tailings ponds, contaminated land, rock wastes, mines and mines with gaseous or liquid wastes, contaminated surface, and groundwater, it also includes models for calculating individual doses to different groups of people (infants, children, adults) and different species of wildlife. Our estimated annual doses to the public from all pathways of radionuclide exposure in Issyk-Kul region conditions do not exceed the established norm (1 mSv per year).

MIN-KUSH URANIUM-TECHNOGENIC PROVINCE (2000-2500 M)

The object of research was the ecological state of the mountain soil cover in the area of the former uranium mine 'Min-Kush'. Geographically, the territory of the former uranium mine 'Min-Kush' is located in the spurs of the Moldo-Too ridge at an altitude of about 2000-2500 m above sea level, which closes the Jumgal valley from the south of the republic in a latitudinal direction. The Moldo-Too ridge and its numerous spurs of different exposures are part of the Tien Shan Mountain system. The climate of the area is continental, with an average annual air temperature of + 3.8°C. In the summer period (June-August) the air temperature is +20 +25°C and in the winter period (November-January) 20°C. The average annual precipitation is about 214 mm. Their greatest amount falls in the spring-summer period and in the winter period not more than 15% [3, 9, 12].

In this province, there are four tailing ponds (Tuyuk-Suu, Taldy-Bulak, Kak, and Dalneye) with radioactive materials with a volume of 1.15 thousand m3, as well as mountain dumps [5]. Currently, the most dangerous in this area is the Tuyuk-Suu tailings dump, located at the mouth of the Tuyuk-Suu River, where geomorphological processes occur. In general, the tailings dams are flat areas of land located on 20-40° steep slopes between mountains. The ore complex was exploited from 1963 to 1969. After the closure of uranium production, all tailings ponds were mothballed. In addition to these tailing ponds, there are adits, ore dumps, and a former uranium ore enrichment plant on the territory of Min-Kush settlement. The purpose of our research was to study the current state of soil cover in the technogenic territories near the former uranium mine 'Min-Kush'. It should be noted that at present, the most dangerous in this province tailing dump Tuyuk-Suu is being transferred to another to a safer place, and other tailing dumps and industrial areas have completed rehabilitation work with the support of international grants and projects.

Gamma radiation exposure dose rates at various sites of Min-Kush uranium tailings showed from 27 to 60 μR/h, but at some points high, for example, at the Taldy-Bulak tailings 554-662 μR/h. The uranium content in the soil here, on average along the profile, ranges from 3.3 to 17.5-10 -6 g/g is quite high. The territory located above the enrichment plant is in great danger, where the uranium content in the soil reaches 30-35-10-10-6 g/g near the surface, which indicates local contamination of this zone. In general, soils of the Min-Kush geochemical province are significantly enriched with uranium, as the concentration of uranium in them is 5-6 times higher than in the soils of Kyrgyzstan [7, 13, 18].

Mountain dark-chestnut and mountain meadow-steppe subalpine soil types are widespread in the technogenic territories and near the former uranium mine 'Min-Kush'. Mountain dark-chestnut soils are formed under the sagebrush-typical steppe with significant participation of grasses on pluvial-diluvial loams at an altitude of 1900-2100 m above sea level. They are used as hayfields and spring-autumn pastures. These soils have a rather wide area of distribution on the slopes of mountain structures of Tien-Shan.

Mountain dark chestnut soils are also characterized as low to medium fertility, medium stony, and medium thickness, with different mechanical compositions. Humus content is as follows: in 0-25 cm layer it varies within 2,23-6,17%; total nitrogen 0,100-0,290%; phosphorus 0,080-0,145% and potassium 1,14-1,50%; reaction of soil solution from neutral to slightly alkaline - pH within 7,30-8,45. Mountain subalpine meadow-steppe soils in the study area are stony, lowmoisture, with different mechanical compositions, and according to laboratory analyses are characterized as low to medium fertility (humus in 0-10-25cm layer 2.08-6.17%). The content of humus is as follows: in the 0-25cm layer it ranges from 2.08-6.17%; total nitrogen 0.045-0.295%; phosphorus 0.080-0.190% and potassium 0.84-1.23%; soil solution reaction is from neutral to slightly alkaline - pH ranges from 7.30-8.55.

During gamma dose measurements, the highest levels were noted in excavations with open access to tailing material (up to 1.6 mSv/h). Some metal fragments that had been partially recovered earlier from the tailings body showed EDR levels of 10 mSv/h and above.

The average level of gamma-radiation at rock dumps is relatively low - about 230-235 nSv/h. There are centers where the radiation level reaches 2400 nSv/h. The natural gamma background in Min-Kush settlement is in the range of 100-200 nSv/h. Values above 200 nSv/h indicate the zones of coal formations wedging out associated with uranium mineralization. The results of the performed gamma-ray survey have shown that the currently existing cover on tailings dumps allows to effectively reduce the gamma exposure dose rate to the natural background level. However, for this purpose, it is necessary to monitor the condition of the coating and prevent damage to its surface.

Soil studies carried out by us at anthropogenic sites showed a significant amount of natural radionuclides ^{238}**U** and ^{226}Ra. Average values of radionuclide content in soils and Clark values were taken as a control level, as there are no MAC values and average values for the republic. The Clark content of uranium-238 in the Earth's crust is 28.9 Bq/kg and in soil 25 Bq/kg [1, 4, 13].

In the studied soil samples, the specific activity of ^{238}**U** varies from 37.6 to 390.0 Bq/kg. The highest value of ^{238}**U** was observed at point MT2S2 (body of the tailing dump 'Taldy-Bulak'), which showed - 176.4 Bq/kg, at point MT4S2 (body of the tailing dump 'Dalny') - 390.0 Bq/kg, at point M21S4 (adit on the territory of 21-site) - 280.5 Bq/kg and MPS2 (territory of the old enrichment plant) - 251.4 Bq/kg, according to the estimates of Acad. V.I. Vernadsky (1935) the thorium content in soils was estimated, on average, at 32.8 Bq/kg, it is accepted as a geochemical background. In soil samples, the index of ^{232}Th in the tailing dump 'Taldy-Bulak' was 27.6 ±1.7 Bq/kg, ^{226}Ra - 106.2 ± 7.4 Bq/kg, however, the highest index of all points of ^{40}K, which showed - 590 ± 36 Bq/kg. The lowest radionuclide values were found in soil samples of point MSA-05-04 (control point) in which the specific activity of ^{238}**U** was 37.5 ± 4 Bq/kg, ^{232}Th was 32 ± 1.8 Bq/kg, ^{226}Ra was 47.6 ± 10 Bq/kg and ^{40}K showed - 46 ± 25 Bq/kg. Fig.5 shows the indices of uranium series elements in soil samples at the tailings.

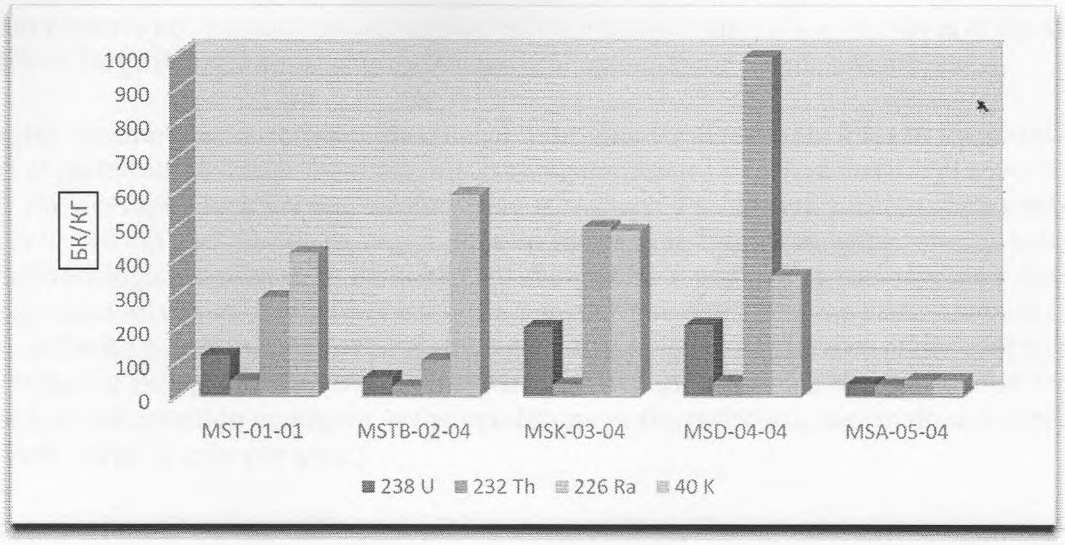

Fig. 5: Comparative specific activity of natural radionuclides at the tailing pits of Min-Kush settlement

Soil radioactivity due to natural radionuclides mainly depends on its potassium (K-40) content, which accounts for 84%. The Clark content of potassium (K-40) in the Earth's crust is 655 Bq/kg, and in soil - 370 Bq/kg, the average value for Russia is 520. The average specific activity of potassium (K-40) in the studied soils varies from 351 Bq/kg to 590 Bq/kg.

As a result, analyses of the obtained results showed that the content of natural radionuclides in the investigated soil samples of tailing dumps exceeds the average Clark values several times: for uranium 5-8 times, for radium 15-20 times, for potassium 1-1.5 times. In all selected mountain dark chestnut soils (the area of tailing dumps 'Tuyuk-Suu' and 'Taldy-Bulak'), where there is a sharp decrease in radionuclide content in the lower 20-40 cm and 40-60 cm layers, compared to mountain meadow-steppe subalpine soils.

It is known that with the increase of organic matter content in the soil the radionuclide content increases and their migration ability decreases, as radioactive elements can bind with organic matter, for example, to form complexes with humic acids. Exploration, extraction, processing, and utilization of mineral resources are accompanied by certain, inevitable, direct and indirect changes in the composition of the soil cover, which leads to the formation of disturbed lands of different types, scales, and genesis. Disturbed areas are a source of pollution and depletion of natural waters, atmospheric dusting, and significant deterioration of sanitary-hygienic and aesthetic conditions of human life.

CONCLUSION

In mountainous zones, soils (mid-mountainous and high-mountainous) are dominated by low-thickness soils with stony-pebble deposits from a depth of 20-50 cm. It is known that denudation-erosion processes are typical for mountainous areas. On steep slopes traces of water erosion are visible in some places, which occurs under the influence of temporary water flows - precipitation, and meltwater, which do not have time to be absorbed by the soil. The content of humus, total nitrogen, gross phosphorus, and potassium in the soil cover in the mountain zones is not homogeneous, in general, the studied zones are at the level of the natural area with no large deviations, this is due to natural and anthropogenic processes.

The results obtained by us showed that the content of natural radionuclides in the studied soil samples of mountainous dark chestnut soils (tailing ponds and attached territory) several times exceeds the average Clark values, where there is a sharp decrease in radionuclide content in the lower 20-40 cm and 40-60 cm layers, compared to mountainous meadow-steppe subalpine soils. Radioecological analyses in Bishkek City showed that, in general, the exposure dose is at the background level and below the established norms, however, in some areas, there is a slight increase in background, mainly in the plain zone of Bishkek City in the area of the central CHPP. In the Issyk-Kul Biosphere Territory, the estimated annual doses for the population from all pathways of radionuclide exposure in the conditions of the Issyk-Kul region do not exceed the established norm (1 mSv per year).

Thus, the results of the expedition and laboratory studies allowed us to identify a variety of negative processes in soils, both primary (natural) and secondary (anthropogenic). We should not forget that mothballed storage sites are a dangerous potential source of environmental pollution, and if they are left unattended and no measures are taken to maintain their integrity, they will turn into a permanent source of dirty soil, water, and atmosphere, which is very difficult to eliminate.

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