Radiation assessment of the loparite ore enrichment tailings from the Umbozero mine

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Abstract. The development of the mining industry inevitably has a negative impact on the environment. Sources of pollution of soils, air and water bodies can come from both operating enterprises and abandoned mines and tailings ponds. Samples of the surface layer (0-8 cm) of the loparite ore enrichment tailings, stored in the tailings of an abandoned processing plant in the Murmansk region, were collected and studied. The effective specific activity of natural radionuclides of less than 1500 Bq/kg allows the tailings to be classified as waste category I. Most of the samples belong to class II building materials. At the same time, almost all samples - 0.071 mm are characterized by an A_{eff} value above 740 Bq/kg, which means they belong to mineral raw materials and materials with a high content of natural radionuclides (II class of mineral raw materials and materials, III class of building materials). The established features should be taken into account when developing environmental protection measures in the zone of influence of the tailings dump and technologies for processing technogenic raw materials.

1 Introduction

The development of the mining industry inevitably leads to a deterioration of the environmental situation in the area of ore mining and processing [1-3]. As a rule, adjacent ecosystems are polluted with heavy metals, petroleum products and other pollutants. At the same time, some mineral deposits, in particular rare metal ores, are characterized by an increased content of natural radionuclides, which makes it particularly relevant to study stored enrichment waste [4, 5].

The Lovozerskoye deposit, located in the Murmansk region, is the only developed rare metal ore deposit in the country [6]. In the mid-late 20th century, mining and enrichment of loparite ores was carried out at two mines and processing plants - Karnasurt and Umbozero.

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In 1999, due to a rock burst, the Umbozero mine was flooded and the factory was mothballed. Currently, no work is being carried out at the enterprise [7].

As a result of the studies, the mineral concentrators of uranium and thorium present in the ores and host rocks of the Khibiny massif were previously established: loparite, perovskite, lomonosovite-murmanite and others with a predominant concentration of radioactive elements in loparite [8]. At the same time, the need to study the radioecological consequences of the mining and enrichment of loparite ores, environmental components and public health was noted.

A previously conducted geoecological assessment of rare metal tailings and the state of nearby environmental components revealed the radium-thorium nature of the radioactivity of the enrichment tailings of the decommissioned Karnasurt tailing dump [9, 10].

The purpose of the study is to evaluate the radiation assessment of the loparite ore enrichment wastes from the Umbozero processing plant.

2 Objects and methods

The object of the study was tailings from the enrichment of loparite ores, selected from the surface layer of the Umbozero tailings dump (Figure 1). Samples were taken using the cutting ring method from a depth of 0-8 cm on a grid with a step of 50 m. For subsequent analysis, the samples were divided into four parts and averaged by quartering. Averaged samples of enrichment tailings and sieved on a sieve with a mesh size of 0.071 mm were submitted for radionuclide analysis.

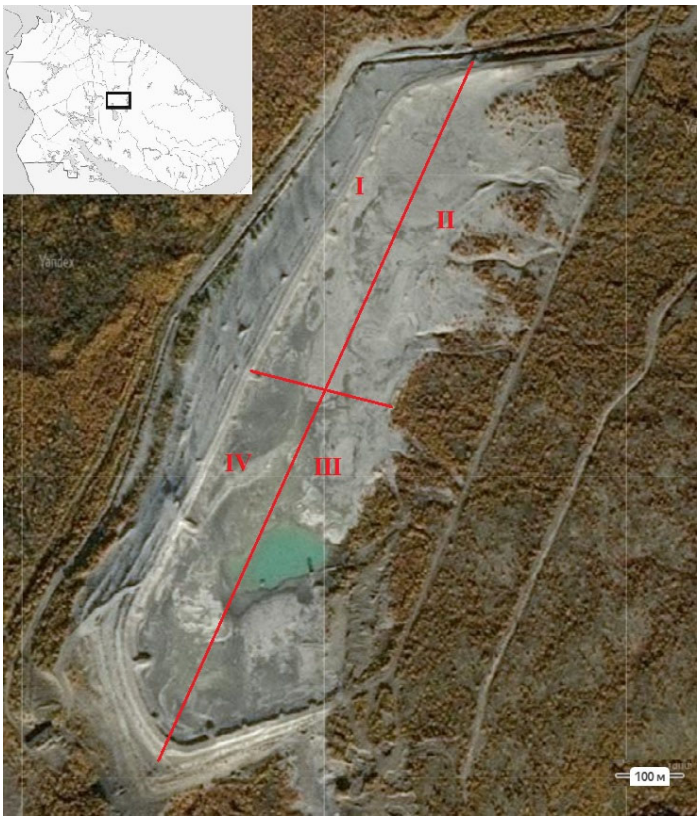

Fig. 1. Sampling scheme for enrichment tailings.

Sample preparation consisted of drying the samples to constant weight using a SNOL 58/350 drying oven and an HL-2000 electronic balance. The following auxiliary equipment was used: a set of KSI sieves for laboratory analyzes (6 sieves), Russia, LLC RNPO Rospribor, thermohygrometer IVA-6.

The analysis methodology is described in detail in clause 4.2 of GOST 30108-94 “Construction materials and products. Determination of the specific effective activity of natural radionuclides (with Amendments No. 1, 2)”. The analysis was carried out using the MKS-01A "Multirad" spectrometric installation (gamma radiation detection unit BDKS-63-01A).

3 Results and discussion

The results of radionuclide analysis of samples are presented in Table 1.

Table 1. Radiation-hygienic characteristics of samples.

Tailings sector	Sample	Specific activity, Bq/kg			A_{eff}, Bq/kg
		Ra-226	Th-232	K-40	
I	Average	49±34	162±26	1703±222	413±51
	-0.071 mm	166±81	368±40	1659±211	**793±98**
	+0.071 mm	59±19	94±22	1928±332	354±44
II	Average	76±24	131±16	1796±231	407±38
	-0.071 mm	104±13	415±38	1219±170	**754±53**
	+0.071 mm	59±16	100±36	1755±236	346±54
III	Average	70±13	143±12	1704±241	409±29
	-0.071 mm	143±49	382±15	1326±252	**759±57**
	+0.071 mm	59±22	67±32	1707±172	299±50
IV	Average	86±18	171±36	1635±467	455±64
	-0.071 mm	102±16	346±18	1691±270	703±36
	+0.071 mm	42±32	73±31	1690±205	289±54

Note. A_{eff} values > 750 Bq/kg are highlighted in bold.

The effective specific activity of natural radionuclides taking into account measurement uncertainty (A_{eff}) in the studied samples is less than 1500 Bq/kg. In accordance with SanPiN 2.6.1.2800-10 “Hygienic requirements for limiting exposure of the population due to sources of ionizing radiation”, these samples belong to waste category I. The management of industrial waste of category I in industrial conditions, including its collection, temporary storage, processing and transportation, is carried out without restrictions on the radiation factor. Industrial waste of this category can be sent for disposal to industrial waste disposal sites without restrictions on the radiation factor.

For a number of samples, certain values of A_{eff} are more than 370 Bq/kg. According to SanPiN 2.6.1.2523-09 “Radiation Safety Standards (NRB-99/2009)”, they belong to class II construction materials. These products can be used in road construction within the territory of populated areas and areas of prospective development, as well as in the construction of

industrial structures. During the construction (reconstruction, major repairs) of residential and public buildings, these materials may only be used for external and internal cladding of buildings (ceramic and porcelain tiles, facing products made of natural and artificial stone, etc.). Materials corresponding to samples with large A_{eff} values. may be used in road construction outside populated areas and areas of prospective development (Class III).

Almost all samples with a particle size of -0.071 mm are characterized by an A_{eff} higher than 740 Bq/kg and belong to mineral raw materials and materials with a high content of natural radionuclides. These materials belong to mineral raw materials and materials of class II. Work with these materials must be accompanied by radiation monitoring: annual effective doses of radiation to workers due to natural radiation sources, A_{eff} in materials and products, in finished products, in industrial waste. In rooms where these materials are stored, access by unauthorized persons must be excluded; permanent workplaces must be located at a distance at which the dose rate does not exceed 1 μSv/h.

Transportation of materials of all samples is allowed by all types of transport as safe cargo in terms of radiation.

The heterogeneity of the radionuclide characteristics of the selected samples of tailings from the enrichment of loparite ores, deposited for a long time in the tailings of the Umbozero enrichment plant, is obvious.

In comparison with the stale enrichment tailings of the Karnasurt tailings dump [10] and the tailings of current production [9], the wastes considered in the article are characterized by lower values of specific effective radioactivity. This fact may be due to more advanced technologies for the enrichment of loparite ore mined at the Umbozero mine.

It is known that elevated levels of naturally occurring radionuclides can lead to adverse health effects [11, 12]. The established features should be taken into account when developing environmental protection measures in the zone of influence of the tailings dump and technologies for processing technogenic raw materials.

4 Conclusion

The extraction and processing of loparite ores at mining enterprises in the Murmansk region led to the formation of a significant amount of waste with a high content of natural radionuclides. The study examined the tailings of the Umbozero processing plant, which were deposited for a long time in the tailings dump after the mine was closed.

As previously for the enrichment tailings of the Karnasurt factory, increased A_{eff} values were revealed for finely dispersed tailing samples (-0.071 mm) in comparison with averaged and screened (+0.071 mm) samples.

Most of the studied samples, in terms of effective specific activity, belong to waste category I (A_{eff} <1500 Bk/kg), class I materials containing natural radionuclides and class II building materials. At the same time, almost all samples -0.071 mm are characterized by an A_{eff} value above 740 Bq/kg, which means they belong to mineral raw materials and materials with a high content of natural radionuclides (II class of mineral raw materials and materials, III class of building materials). The heterogeneity of the radionuclide characteristics of the selected samples of tailings from the enrichment of loparite ores was noted.

Further research is aimed at determining the mineral composition of enrichment waste, establishing the gross content and concentrations of bioavailable forms of heavy metals and rare earth elements in the tailings.

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