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Radiation Factors of Uranium Productions and their Impact on the Environment

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Abstract

This article presents the results of a study of the radiation factors of uranium production and their impact on the environment, namely, by definition, the value - the exposure dose rate of gamma radiation at different distances from the source, the density of radon molasses from different depths of uranium-containing ores, equivalent to the equilibrium volumetric activity of radon in rooms storage of uranium products, the specific activity of gamma radiation - ^{226}Ra and content - ^{238}U.

Keywords: radiation factors, specific activity of radionuclide, exposure dose of gamma radiation, γ-spectrometric method, X-ray fluorescence method.

Introduction

Uranium milling production has a radiation effect around its location. Due to this radiation effect, the background radiation value of the local areas of the given region increases. The magnitude of radiation factors is estimated by determining the amount of various radionuclide in soil, air, water and plants

The value of radiation quantities - exposure dose of gamma radiation, specific activity of radionuclide, specific activity - A_{eff}, total specific alpha activity, equivalent activity of radon, density of radon molasses from soil, etc. show the degree of pollution of a given local area. Radiation indicators in ecosystem objects (soil, air, water and in plants) are regulated by international regulatory documents (ICRP, IAEA, UN, WHO, etc.) and regulatory documents established in the Republic of Uzbekistan (SRR, GS UzSSt, etc.).

The operating uranium processing plant is making an additional impact on the radiation environment of the area, including the distribution and behavior of various radionuclide. Given this fact, the determination of the distribution and behavior of various radionuclide in the area of influence of uranium production is of scientific and practical interest.

Assessment of the distribution and behavior of various radionuclide in a given area and the magnitudes of radiation factors is an urgent problem in nuclear physics and radioecology.

The purpose of this study was to determine the distribution and behavior of various radionuclide and the values of radiation factors in the area affected by uranium production.

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To achieve the goal, the values were determined - the exposure dose rate of gamma radiation at different distances from the source, the density value of radon molasses from different depths of uranium-containing ores, the value of the equivalent equilibrium volumetric activity of radon in the storage rooms of the uranium product and their changes depending on the distance, on the genetic relationship with the parent radionuclide and the storage conditions of the uranium product [1-35].

Technique and experimental methods

Determination of the value - the exposure dose rate (EDR) of gamma radiation at different distances from the source was carried out by direct measurement on the device - DKS-96, the density value of radon molasses from different depths of uranium-containing ores was carried out by measurement on the device - Alfarad, the value of the equivalent equilibrium volumetric activity of radon in storage rooms of uranium products carried out on the device - Search. Specific activity of gamma radiation - ^{226}Ra was determined by gamma-spectrometric method on the device - Progress-Gamma.

The crushed solid sample is packed into a Marinelli vessel and placed on a gamma detector. A spectrum set is started in the mode of measuring the activity of radionuclide ^{40}K, ^{226}Ra and ^{232}Th in the "Marinelli" geometry. At the end of the activity measurement (30 min), the program displays the values of the activity and the absolute statistical error of the activity of these radionuclide. Determination of the content of -^{238}U in the samples was carried out by X-ray spectrometry on an ARF-7 device, which allows the quantitative determination of chemical elements in the range from Mn to U in solid and powder samples at concentrations from 0.00015% (1.5 g/t) [2-4].

For the analysis of samples, they were dried in drying ovens at a temperature of 80 ° C for 1 hour and ground on a laboratory grinder IDA-250. Soil samples are taken in three parallelisms by a weighed portion of 15 grams, packed into a cuvette, installed in the measuring cell of an ARF-7 X-ray fluorescence analyzer, the amount of uranium is determined in them [5].

Results and discussion

The value of the exposure dose rate of gamma radiation is the primary factor showing the magnitude of the effect on the radiation situation in the area in the area of uranium production. To assess the obvious effect of uranium production on the radiation environment, at more than 20 points, we measured the value of the exposure dose rate - EDR located at different distances from the radiation source. Determination of the value - EDR of gamma-radiation at different distances from the source showed in Figure. 1 that with increasing distance from the radiation source it decreases to the background value.

EDR, μSv/h

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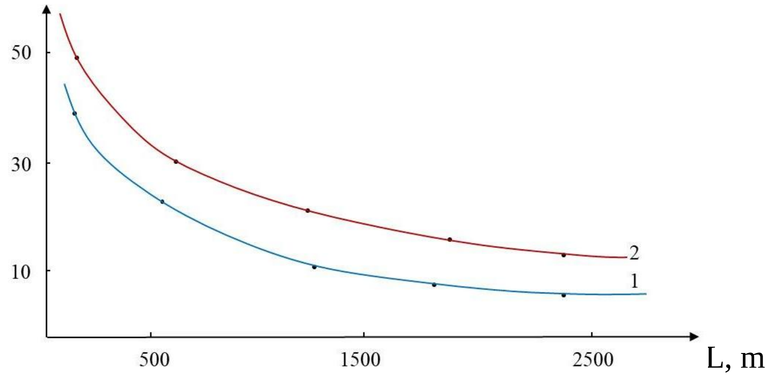

Fig. 1. Dependences of EDR value over distance.
1-line of dependence of the EDR value at the distance from the uranium processing plant; 2-line of dependence of the EDR value at the distance from the tailing dump.

From the plotted graph it can be seen that, at a distance of 2500 m from the uranium processing plant, the EDR value decreases to the background value of the area (0.12 μSv/h) 1-line Figure. 1. And at a distance of 2500 m from the radioactive waste tailing dump, the EDR value decreases to a certain value (0.16 μSv/h), but does not reach the background value of the area 2-line Figure. 1.

This fact confirms that the uranium object clearly affects the radiation background, that is, the higher the EDR values in the object, the greater the effect on the distance. underground leaching - UL of uranium. For these objects in Figure.2, the radiation pattern looks even more complicated, that is, the background radiation is not only related to the EDR value in the object, but it is also related to the height of the dumps and the geographic location of uranium dumps of off-balance ores and UL sites.

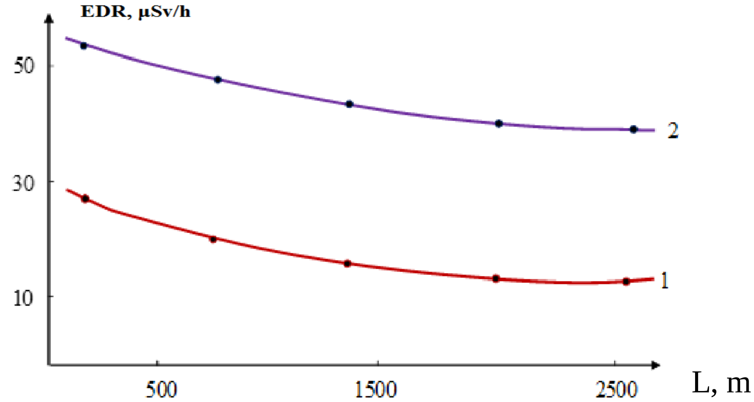

Fig. 2. Dependences of EDR value over distance.
1-line of dependence of EDR value at a distance from uranium dumps;
2-line of dependence of the EDR value at a distance from the sections of the UW uranium

From Fig. 2. it can be seen that the dependence of the EDR value at the distance from the uranium dumps and from the sections of the UL of uranium differs from the graphical dependence of the previous objects. That is, the higher the height of the 1-line dump, the greater the distance of its influence, and the lower the geographic location of the 2-line UL sites from the observation point, the smaller the distance of its influence.

These established facts will help to calculate the annual effective dose for categories of personnel and the population, as well as predetermine the tasks of developing measures to protect against the harmful effects of gamma radiation.

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In addition to the EDR in the area of uranium production, the value of the density of radon molasses was determined in various technogenic objects in the tailing dump and in the area of underground leaching of uranium UL.

According to the method of measuring the density of radon molasses, it is required to clean the surface of the earth from foreign objects with a depth of 5-10 cm, and after 20-30 minutes' measurements are taken. A schematic view of the prepared pit according to the technique for measuring the density of radon molasses is shown in Fig. 3.

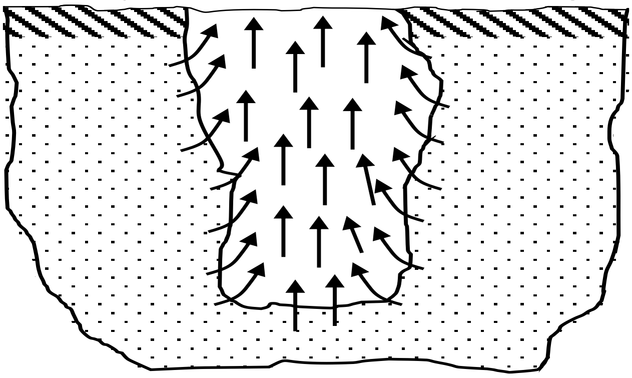

Fig. 3. Schematic view of the prepared pit according to the method for measuring the density of radon molasses.

It can be seen from Figure. 3 that the deeper the pit, the greater the amount of pores and capillaries of rocks in them. In connection with this, with an increase in the depth of the pit, the density of radon molasses increases linearly. On the basis of the obtained values, a graphical dependence of the density of radon molasses on the depth of the pit was plotted. Figure 4. Drilled in various natural and uranium objects.

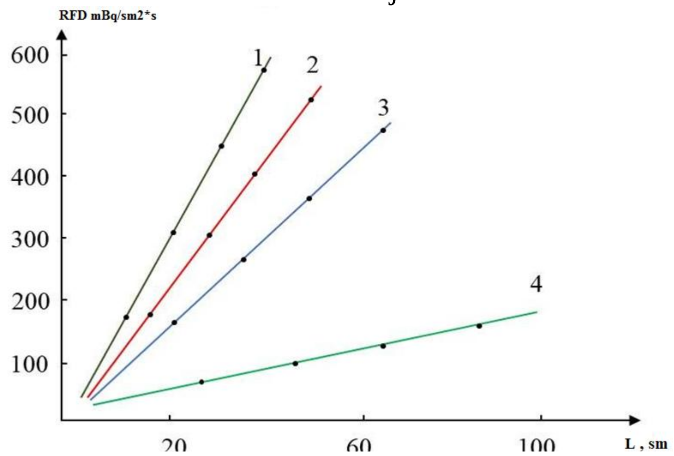

Fig. 4. Graphical dependence of the density of radon molasses on the depth of the pit

1 - line, graphical dependence of the density of radon molasses on the depth of the pit in the uranium dump.

2 - line, graphical dependence of the density of radon molasses on the depth of the pit in the tailing dump of uranium waste. 3 - line, graphical dependence of the density of radon molasses on the depth of the pit in the section of the UL uranium. 4 - line, graphical dependence of the density of radon molasses on the depth of the pit in natural soil.

In these samples the content of uranium was determined by the X-ray fluorescence method and the content of radium was determined by the gamma-spectrometric method. Samples were taken from 1-uranium dump, 2-tailing dump, 3-sites of UL uranium and 4-natural soil. As can be seen from the obtained dependences of the density of radon molasses,

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it directly depends on the depth of the pit. But the intensity of the change depends on the amount of uranium and radium in these samples.

A less intense dependence of the density of radon molasses on the depth of the pit 4 - line has natural soil, because the amount of uranium and radium in it is less than in other samples. More intense dependence of the density of radon molasses on the depth of the pit 1 - the line has samples of uranium dump, because the amount of uranium and radium in it is greater than in other samples.

Based on the results obtained on measuring the density of radon molasses, we faced the task of conducting a study of the dependence of the density of radon molasses on the amount of uranium and radium in these samples. Figure 5 shows the dependence of the value of radon flux density on the amount of uranium and radium in the samples.

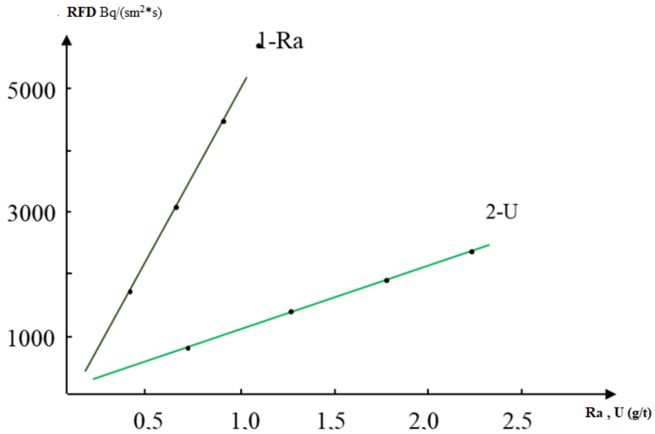

Fig. 5. Graphical dependence of the value of the radon flux density on the depth of the pit.

As can be seen from Figure. 5, the density value of radon molasses depends on the amount of uranium and radium containing in these samples. As you know, the formation of ^{222}Rn occurs by the following nuclear-physical reaction

$$U^{238} \xrightarrow[4.5*10^9\ year]{\alpha} \ldots Ra^{226} \xrightarrow[1600\ year]{\alpha} Rn^{222} \ldots \quad (1)$$

It can be seen from reaction (1) that the parent nucleus for ^{222}Rn is ^{226}Ra, and ^{238}U is the parent nucleus for ^{226}Ra. Therefore, the amount of ^{222}Rn in various objects depends to a greater extent on ^{226}Ra [6, 7].

For a full assessment of the values of radiation factors in the region, the influence of uranium production, the value of the EDR, EEVA (equivalent equilibrium volumetric activity), VAL (volumetric activity of long-lived α- nuclides) was investigated at observation points where there is no technogenic influence of uranium production. The obtained values of EDR, EEVA, VAL are given in Table 1.

Table 1.
Obtained results of EDR, EEVA, VAL at observation points where there is no technogenic impact of uranium production.

No	EDR, μSv/h	EEVA, mBq/m^3	VAL, mBq/m^3
1	28	15	12
2	34	17	10
3	41	23	15
4	23	11	9
5	28	16	11
6	31	18	13

7	25	12	10
8	29	14	12
9	43	24	16
10	20	10	8

On the basis of the obtained values of the EDR, EEVA, VAL given in Table 1, the calculations of the annual effective dose were carried out. Table 2 shows the obtained results of the EDR, EEVA, VAL and the results of the calculation of the annual effective dose for the observation point [7, 9].

Table 2.
Results of EDR, EEVA, VAL and results of calculating the annual effective dose for the observation point.

No	**EDR µSv/h**	**EEVA mBq/m^3**	**VAL mBq/m^3**	**Annual effective dose, mSv/year**
1	28	15	12	2.91
2	34	17	10	3.01
3	41	23	15	3.2
4	23	11	9	3.6
5	28	16	11	2.9
6	31	18	13	2.4
7	25	12	10	2.6
8	29	14	12	3.09
9	43	24	16	2.98
10	20	10	8	2.75

In the atmospheric air, the room where uranium products are stored - uranium chemical concentrate, uranium nitrous oxide, etc. Radon is present in a certain amount - a member of the uranium decay chain, which negatively affects the health of personnel and the environment. Determining the value of the equivalent equilibrium volumetric activity of radon in the storage rooms of uranium products showed that the longer the radioactive product is stored in closed rooms, the more radon accumulates. Figure 6 shows a closed storage room for uranium products.

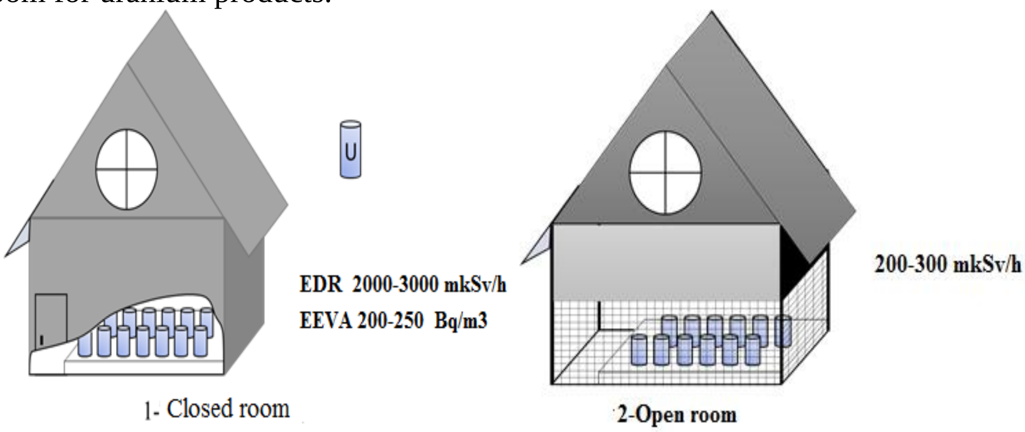

Fig. 6. Shows 1-closed and 2-open storage rooms for uranium products.

Measurements carried out in closed and open rooms show that the longer the time range from closing to open, the greater the volumetric value of radon in this room. Considering this fact, we have developed a measure for storing uranium products in semi-open rooms. Shown in Figure 5. 2- open cavity space satisfies the storage requirement for uranium products [7, 8].

Conclusions

Thus, on the basis of the performed analyzes, the value - the power of the exposure dose of gamma radiation at different distances from the source, the value of the density of radon molasses from different depths of natural and uranium objects, the value of the equivalent equilibrium volumetric activity of radon in the storage rooms of uranium products. Specific activity of gamma radiation ^{226}Ra was determined by gamma-spectrometric method, determination of the content of ^{238}U in samples was carried out by X-ray fluorescence analysis. Dependences of the power value of the exposure dose of gamma radiation on the distance measured at more than 20 points have been established.

Found with increasing distance from the source of exposure dose rate decreases to the background value. It was found that the density of radon molasses is directly proportional to the depth of the pit and the amount of uranium and radium in these samples. Graphical dependence of the genetic relationship of ^{222}Rn with the parent nucleus ^{226}Ra and the nucleus ^{238}U in samples of a uranium technogenic object. Measures have been developed and recommended in production for storing uranium products in semi-open rooms.

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Abbreviations:

EDR – the Exposure Dose Rate;
EEVA – the Equivalent Equilibrium Volumetric Activity;
VAL – the Volumetric Activity of Long-lived α- nuclides;
ICRP – the International Commission on Radiological Protection;
WHO – the World Health Organization;
IAEA – the International Atomic Energy Agency;
UN – the United Nations;
UL – the Underground Leaching;
UW – the Uranium Waste;
SRR – the Sanitary Rules and Regulations;
GS UzSSt – the Government Standard, Uzbekistan State Standard.

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