RADIOMETRIC DETERMINATION OF RADON-222 IN THE ATMOSPHERIC AIR OF THE CITY OF TERMEZA, REPUBLIC OF UZBEKISTAN

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***Abstract:** The article presents the results of determining the activity of beta radiation of radionuclide radon-222 using the MKGB-01 radiometer in the atmospheric air of the city of Termez, Surkhandarya region of the Republic of Uzbekistan. Six samples were taken from different places and the activity of beta radiation was determined in the MKGB-01 radiometer. A small amount of radon-222 was revealed in the atmosphere of the industrial region of the city of Termez.*

***Keywords:** radionuclide, beta and gamma radiation, radiometer, detection unit, HC interference level.*

INTRODUCTION

Radioactivity is one of the factors in the occurrence of cancer in humans. According to the reports of the Ministry of Health of the Republic of Uzbekistan, over the past 30 years, the number of cancer patients in the Republic has grown five times, and in the Surkhandarya region, seven times. In 2018 alone, 378 patients were recorded in the Surkhandarya Regional Oncology Dispensary, and of the 109 were deaths. According to the literature, it is known that the main sources of cancer in humans are drinking water, food products, soil and atmospheric air, which are more contaminated with radioactive particles [2, 5].

In developed countries, radiometric methods for determining radionuclides are widely used: radon, radium, thorium, uranium, plutonium, caesium, strontium, etc. But radiometric methods for determining radionuclides in our country have been little studied. Today, in the Republic, the Ministry of Emergency Situations and its departments provide radiometric monitoring of the environment using portable UMF-2000 UMF-1 radiometers, which have low sensitivity and selectivity. To control beta radiation of radionuclides in environmental objects, the need for highly sensitive and highly effective methods is increasing, which is one of the urgent problems. In this regard, it is of particular importance to developing effective, rapid and economically cheap methods for the determination of radionuclides in natural environments [4, 6].

Radiometers are a class of devices that have the largest number of types in terms of their functions. According to MU 2.6.1.14-2001 “Monitoring of the radiation situation. General requirements "important areas of radiometry are:

- control of the volumetric activity (VA) of radioactive aerosols (vapours);
- control of the volumetric activity of alpha-active gases;
- control of the volumetric activity of beta-active gases, including 3H and 14C;
- control of specific or volumetric activity of radionuclides in liquids and environmental samples;
- control of surface contamination with radionuclides.

The radiometric instruments are divided into portable, portable and stationary radiometers. The first two types are mainly used for environmental inspection. Stationary radiometers are used to monitor individual points (including emergency monitoring) Fig. 1 [5].

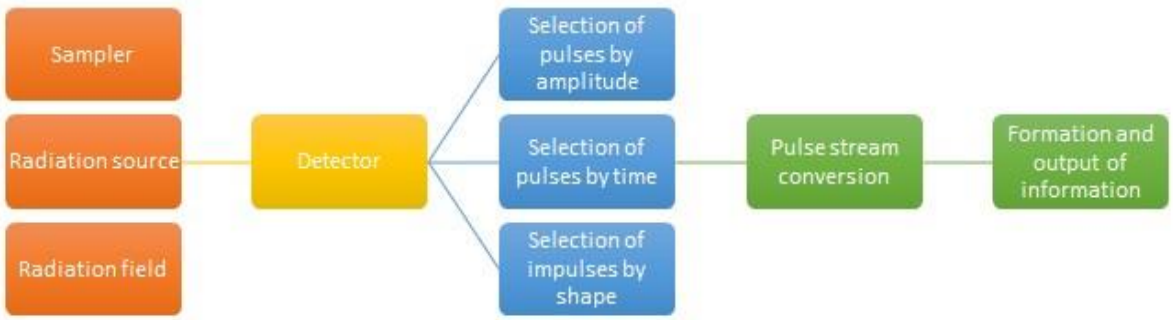

Figure 1 The general block diagram of most types of radiometers is shown

The main tasks of radiometric measurements are to determine the parameters of the radiation field and the characteristics of the radiation source.

A specially selected sample can be the source of radiation for radiometric measurements. Instead of a sample, so-called non-sampling measurements can be carried out by installing the radiometer detector opposite the pipelines through which the process medium passes. The measured values here are practically the same as for sampling measurements, except for aerosols [11].

The second task is to determine the characteristics of the radiation field. Here the measured value is the flux or flux density of ionizing particles or photons at the point of the detector location, as well as the temporal or spatial distribution of the activity of the emitters or the radiation flux density. The registered radiation in determining the characteristics of the radiation field can be alpha, beta, and gamma radiation, as well as neutron radiation. Radiometers can measure only one type of radiation, but they can be adapted to combined radiation, i.e. determine separately in one measurement the flux density of neutrons and gamma radiation and simultaneously measure the volumetric activity of alpha and beta radioactive isotopes [4].

In this work, the specific activity of beta radiation of the ^{222}Rn radionuclide in atmospheric air samples from the city of Termez was determined. Radon is a dangerous radioactive gas, transparent, tasteless and odourless. Radon-222 (like iodine-131, tritium (^{3}H) and carbon-14) is not noticed by standard methods. In the presence of radionuclides, in particular radon, it is necessary to use special methods and equipment for the determination. Radon enters the human body through the respiratory organs and can cause - lung cancer. According to the US Public Health Service, radon is the leading cause of lung cancer in humans after smoking [5, 12].

This radionuclide is formed in the bowels of the Earth as a result of the half-life of uranium, which is part of the rock-forming element of granite and gradually seeps out from the bowels to the surface, where it immediately spreads in the air, as a result of which its concentration remains scanty and does not pose a serious danger. Problems appear when there is no air exchange, for example, in rooms. At the same time, the amount of radon in an enclosed space can reach serious concentrations. Since radon enters buildings from the ground, in developed countries, when building foundations in "radon hazardous" areas, special protective membranes are widely used to prevent radon from infiltrating. However, even using these membranes does not provide adequate protection. If wells are used to supply the house with water, radon enters the house with water and can accumulate in large quantities in kitchens and bathrooms. The fact is that radon dissolves well in water and when groundwater comes into contact with radon, the water is very quickly saturated with radon. In foreign countries, the level of radon interference in natural waters ranges from 10 to 100 Becquerels per litre, in industrial areas reaching hundreds and even thousands of Bq / l [13, 8].

Radon dissolved in water acts two-way. On the one hand, it enters the digestive system together with water, and on the other hand, organisms inhale the radon released by water when it is used. The fact is that at the moment when water flows out of the tap, radon is released from it, as a result of which the concentration of radon in the kitchen or bathroom can be 30-40 times higher than its level in other rooms. The second method of radon exposure is considered to be more hazardous to health. The United States Environmental Protection Agency (USEPA) recommends a recommended limit for radon in the water of 11.1 Bq / L. In the Russian Radiation Safety Standards (NRB-99), the maximum level of radon content in water, at which intervention is already required, is set at 60 Bq / kg. In our republic, the level of radon-222 interference is also set at 60 Bq / kg. One of the most effective methods of combating radon is water aeration ("bubbling" of water with air bubbles, in which almost all radon literally "flies off into the wind"). Therefore, those who use urban drinking water have practically nothing to worry about, since aeration is part of the standard procedure for water treatment at city water treatment plants. As for individual users of well water, the studies carried out by USEPA have shown fairly high efficiency of activated carbon. A filter based on quality activated carbon can remove up to 99.7% of radon. However, over time, this figure drops to 79%. The use of a water softener based on ion-exchange resins in front of the carbon filter makes it possible to increase the latter indicator to 85% [10, 14].

Determination with the spectrometer-radiometer MKGB-01 "RADEK" provides the indicated values of the measurement error under the following conditions:

- The confidence error in determining the sensitivity coefficients of the spectrometer does not exceed ± 7% (P = 0.95) (expanded uncertainty I_s = 7% (k = 2));
- The density value of the sample is in the range from 0.2 to 2 g / cm3;
- Measurement time for geometry "Marinelli vessel" - 2400 s, for geometry "cylindrical vessel with a volume of 250 ml" -1 h;

MATERIALS AND METHODS

Experimental part

The measurement of the specific activity of radionuclides in samples of a fixed mass was carried out by the method of direct assessment using a spectrometer, which was pre-calibrated using standard measuring instruments - exemplary measures of specific activity following Table 1 [1].

Radionuclide	Density range, g / cm^{-3}	Vessel geometry
^{226}Ra, ^{232}Th, ^{40}K, ^{137}Cs	From 0,2 to 2	Marinelli 1L Jar 250 ml
^{222}Rn	1 (water)	Marinelli 1l
^{222}Rn	1 (Activated carbon)	A column with activated carbon 12 ml
^{90}Sr+^{90}Y	From 0.2 to 2	Cuvette 38 ml

Table 1. Measurement of the specific activity of radionuclides

The values of the specific activity of radionuclides and the absolute error of the measurement result were calculated automatically according to the ASW program algorithm based on the measured spectra of the sample and the sensitivity coefficients obtained during the calibration of the spectrometer.

The specific activity of the radionuclide in the sample and the values of the relative measurement error were determined directly from the reading device, which is used as a PC display. The measurement of the control dose rate was carried out in the protective chamber of the beta channels with the protective covers open; three measurements were made at each point and the average value was calculated. The values obtained did not exceed 0.20 μeV / h.

Air samples were dissolved in distilled water with volumes of 200 ml and poured into a container. The containers were weighed and the weight (1-5) of the container with the sample was determined in grams. The mass of the counting sample was determined by the formula:

$$m_{so} = m_{knr} - mx \text{ g.} \quad (1)$$

Calibration of the radiometer

The energy calibration of the NaI (Tl) detector was performed using the certified RGK-1 standard. The following gamma lines were used: Pb-214 (352 keV), Bi-214 (1125 keV), K-40 (1460 keV) and Tl-208 (2615 keV). For this, in the "ASW" program of the MKGB-01 radiometer, the measurement parameters are selected, that is, the measurement geometry and the type of sample as in Figures 1 and 2:

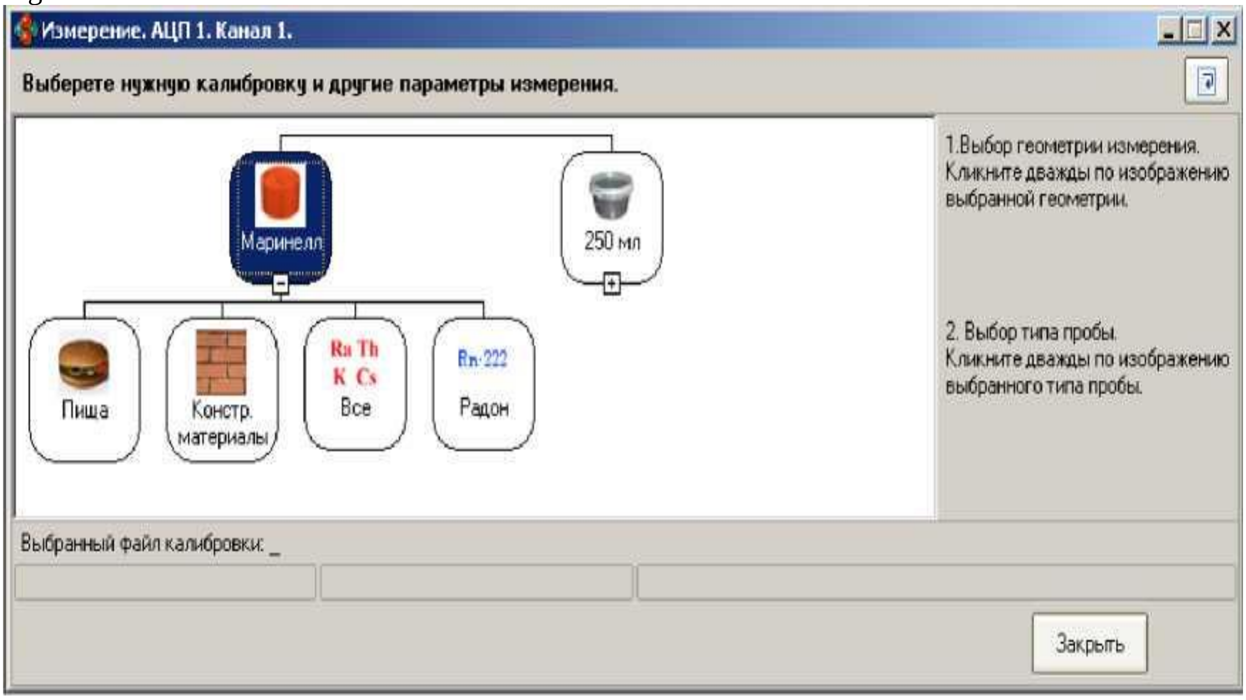

Figure 1. Selection of measurement parameters when calibrating the radiometer MKGB-01 with the "ASW" program.

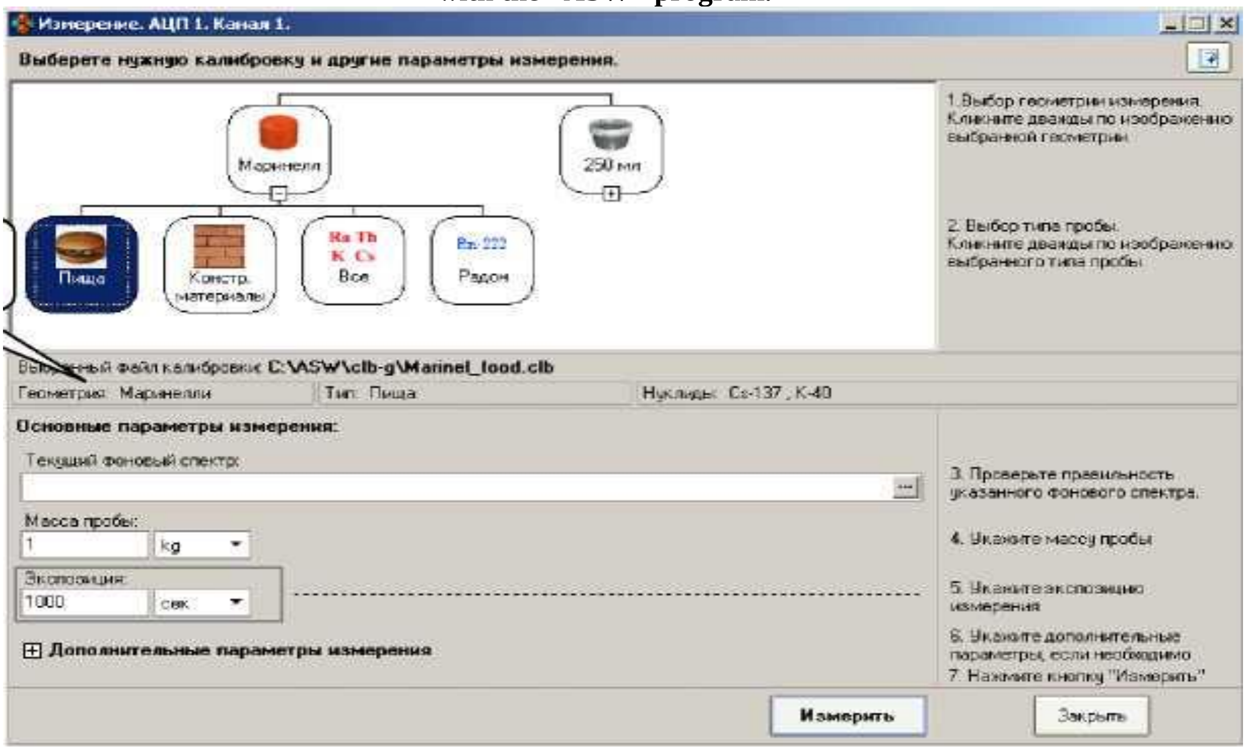

Figure 2. Selecting other measurement parameters: sample mass, spectrum channel, measurement time.

The radiometer measures the activation energy of the selected radionuclides for 1000 s and displays the measurement data (Fig. 3).

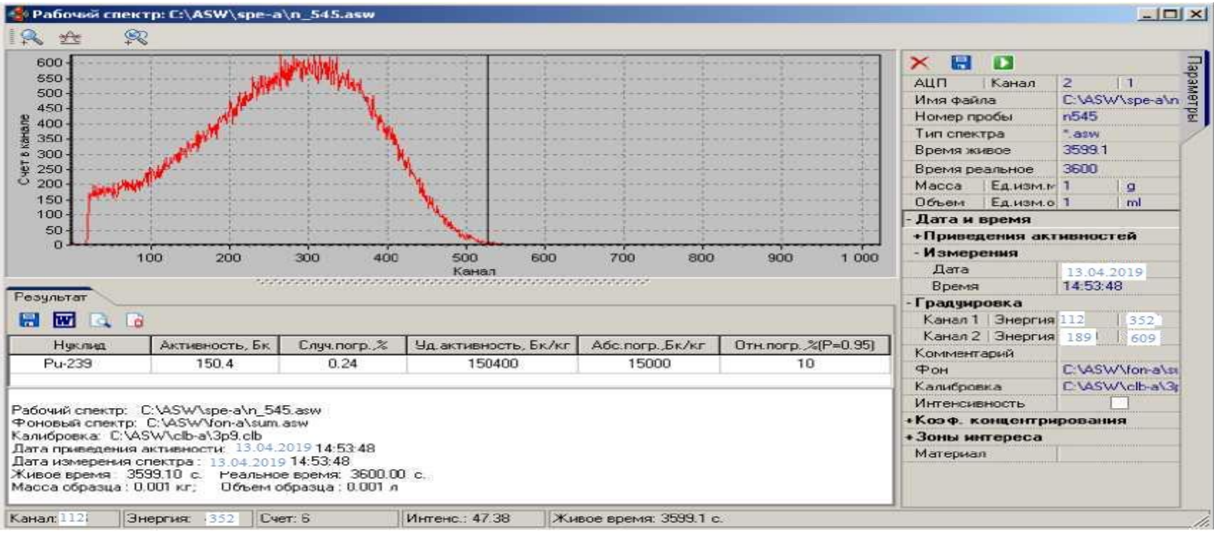

Figure 3. Calibration data of the MKGB-01 radiometer using the “ASW” program.

The ASW program automatically executes mathematical data according to equation (3) to represent the photon energy as a function of the C channel number;

$$E = E_0 + BC + AC^2 \tag{3}$$

where E_0, B and A are constants.

BACKGROUND MEASUREMENT

Provided that the distilled water is not radioactive, background activity was determined by running an inert sample consisting of a polyethene bag filled with distilled water. The background was measured for 30,000 seconds and subtracted from each recorded spectrum.

Thus, we prepared the MKGB-01 radiometer for analysis, chose the optimal measurement conditions, and now it will be possible to determine the activity of radon-222 radionuclide in air samples.

Standard and control samples were analyzed for the content of radionuclide radon-222 by the radiometric-spectrometric method. The MKGB-01 radiometer is connected to a laptop and works with the ASW program. The "ASW" program developed by the RADEK company (Russia) will simplify the work with the radiometer. That is, with the "ASW" program there is no need to monitor the background every 2 hours, calculate the results, analyze the accuracy of the results and analyze the determination error. And also "ASW" program provides calculations of the volumetric and specific activity of radionuclides (α_{ak}) both separately and by several radionuclides. Measurement duration is 30 minutes. The research results are presented in Table 2.

No	* Barcode probes	Sampling location	The value of the specific activity of β-radiation Rn-222, Bq / kg (HC = 0.2)
1	T-1-20	A. Navoi street, house-2 of the city of Termez	0,02
2	T-2-20	A. Temur street house-122 of the city of Termez	0,08
3	T-3-20	M. Kahkhara street house-45 of the city of Termez	0,15
4	T-4-20	S. Zununova street house-93 of the city of Termez	0,06
5	T-5-20	I. Karimov street house-212 of the city of Termez	0,08
6	T-6-20	At-Tirmizi street, house-5 of the city of Termez	0,05

Table 2. Results of determination of β-radiation of Radon-222 in the atmospheric air of the city of Termeza, Surkhandarya region.

(t_{meas} = 40 min, E_{max} = 624 keV, CW = 0.64 imp / s * bcl)

It can be seen from the table that a high value of β-radiation Rn-222 was obtained at point 3. But even these values are not high above the intervention level (HC Rn-222 = 0.2). The 3-point is the northern part of the city and is an industrial zone with several construction factories.

DISCUSSION

Radioactivity is one of the factors in the occurrence of cancer in humans. According to reports from the Ministry of Health of the Republic of Uzbekistan, over the past 30 years, the number of cancer patients in the Republic has grown fivefold, and in the Surkhandarya region, sevenfold. In 2018 alone, 378 patients were recorded in the Surkhandarya Regional Oncology Dispensary, and of the 109 were deaths. It is known from the literature that the main sources of oncological diseases in humans are drinking water, food products, soil and atmospheric air, which are more contaminated with radioactive particles. In developed countries, radiometric methods for determining radionuclides are widely used: radon, radium, thorium, uranium, plutonium, caesium, strontium, etc.

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CONCLUSION

The article presents the results of determining the activity of beta radiation of radionuclide radon-222 using the MKGB-01 radiometer in the atmospheric air of the city of Termez, Surkhandarya region of the Republic of Uzbekistan. Six samples were taken from different places and the activity of beta radiation was determined in the MKGB-01 radiometer.

A high value of β-radiation of Rn-222 was found at point 3 of the city of Termez. But even this value is not high above the intervention level (IL Rn-222 = 60). 3-point is the northern part of the city and is an industrial area with several construction factories.

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