

# DETERMINATION OF THE AMOUNT OF RADON-222 BY RADIOMETRIC METHOD IN THE ATMOSPHERIC AIR OF THE CITY OF TERMEZ, SURKHONDARYA REGION OF THE REPUBLIC OF UZBEKISTAN

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## Abstract

The article presents the results of determining the activity of beta radiation of radon-222 radionuclide using the MKGB-01 radiometer in the atmospheric air of the city of Termez, Surkhondarya region of the Republic of Uzbekistan. 6 samples were taken from different locations and the activity of beta radiation in the MKGB-01 radiometer was determined. A small amount of radon-222 was detected in the atmosphere of the industrial district of the city of Termez.

**Keywords:** radioactivity, radionuclide, beta and gamma radiation, radiometer, activity, detection unit, UV level of intervention, marinelli vessel.

## Introduction

Radioactivity is one of the factors that cause cancer in humans. According to the reports of the Ministry of Health of the Republic of Uzbekistan, the number of cancer patients has increased five times in the Republic over the past 30 years, and 7 times in Surkhondarya region. Only in 2018, 378 patients were registered at the Surkhondarya Regional Oncology Dispensary, and 109 of them were fatal. According to the literature, it is known that the main sources of cancer in humans are drinking water, food, soil and atmospheric air - polluted with radioactive particles [1].

In this paper, an improved theoretical model has been developed that allows us to estimate the concentration of radium in building materials solely by measuring the concentration of radon-222 in indoor air. This model has been applied to two different materials: cement mortar and concrete. This non-destructive method is not limited by the size of the samples, and it inherently involves reverse diffusion. The resulting equation gives an exact solution for the concentration of radon-222 as a function of time and distance in one dimension. The effective concentration of radium-226 is a suitable parameter of this equation. To reduce its complexity, this equation has been simplified to take into account two cases: low diffusion into the building material compared to air, and a building material initially saturated with radon-222. Radium was studied with direct measurements in the same materials (the same sources) using gamma-ray spectrometry performed at the Centro de Desenvolvimento da

Technologic Nuclear (CDTN), the results of which were respectively  $(13.81 \pm 0.23)$  B/kg and  $(12.61 \pm 0.22)$  B/kg [2, 3].

Building materials such as concrete, cement, brick and gypsum usually contain small amounts of radioactive elements. These natural radioactive materials (NORMS) contribute to individual exposure to ionizing radiation. The impact can occur in two ways: external and internal. External radiation is associated with sources in the environment, outside the human body. This is a case of radium-226 present in a building material that decays as a result of alpha radiation into radon-222, and then emits gamma rays. Radon is a noble gas, so it is chemically inert. This means that radon-222 has no color, smell and taste, so it can be inhaled unconsciously. Inhalation of radon-222 is an example of internal irradiation. Radon-222 is an alpha emitter with a half-life of 3.8 days, the decay products of which are post-transition alpha and gamma radioactive metals. Consequently, these products can be absorbed by the lung tissue, easily causing DNA damage, which can lead to lung cancer [4]. The World Health Organization estimates that between 3% and 14% of lung cancer deaths are associated with radon.

Emanation occurs when a mineral grain releases a gas molecule. So, the emanation is the rate of radon flow in the material, and it is proportional to the activity of radium-226. The emanation coefficient is the fraction of radon reaching the pore space and depends on the crystal structure, grain size and humidity [5,6]. Its registered values range from 1% to 50% in a wide range of materials, conditions, definitions and measurement methods [7,8].

The exhalation rate is the density of the flow on the surface of the material. If it is possible to accumulate gas inside residential premises, it is necessary to determine the activity of radon-222 indoors [9-10], its release from soil [11-15], building materials [21-27] and objects rich in radium-226. There are several different methods for determining the emanation factor and the effective activity of radium-226 in the exhaled air of radon-222 [29-30].

In the same year, M. Campos et al. used the Yang equation to study the release of radon in recycled phosphogypsum [16]. In this paper, an improved equation is proposed to describe the average concentration of radon-222 in a closed atmosphere as a function of time [17].

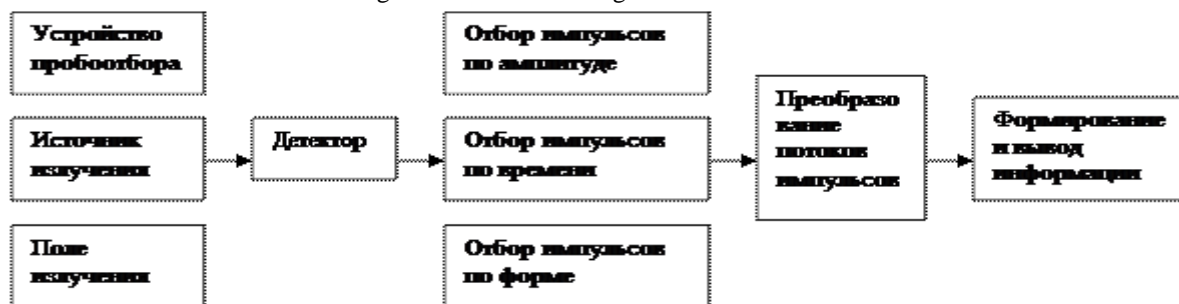
Radiometric methods for the determination of radionuclides are widely used in developed countries: radon, radium, thorium, uranium, plutonium, cesium, strontium, etc. But radiometric methods for determining radionuclides in our country are little studied. Today, in the Republic, the Ministry of Emergency Situations and its departments provide radiometric monitoring of the environment using portable radiometers of the UMF-2000 and UMF-1 brands, 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, the development of effective, rapid and cost-effective methods for the determination of radionuclides in natural environments is of particular importance [18].

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

- monitoring of the volumetric activity (OA) of radioactive aerosols (vapors);
- Control of the volumetric activity of alpha-active gases;
- Control of the volumetric activity of beta-active gases, including  $^3\text{H}$  and  $^{14}\text{C}$ ;
- monitoring of specific or volumetric activity of radionuclides in liquids and environmental samples;
- Control of surface contamination with radionuclides.

Radiometric devices are divided into wearable, portable and stationary radiometers. The first two types are mainly used for environmental inspection control. Stationary radiometers are used to monitor individual points (including emergency monitoring). The general block diagram of most types of radiometers is shown in Fig. 1 [19].

Fig 1. General block diagram of the radiometer



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

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

- 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 detector location, as well as the temporal or spatial distribution of the activity of emitters or the density of the radiation flux. The recorded 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, and can be adapted to combined radiation, i.e. determine the neutron and gamma radiation flux density separately in one dimension and simultaneously measure the volumetric activity of alpha and beta radioactive isotopes [20].

- In this work, the specific activity of beta radiation of radionuclide  $^{222}\text{Rn}$  in atmospheric air samples of the city of Termez was determined. Radon is a dangerous radioactive gas, transparent, tasteless and odorless. Radon-222 (like iodine-131, tritium ( $^3\text{H}$ ) 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 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 most serious cause of lung cancer in people after smoking [21].

- This radionuclide will form 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 seep from the bowels to the surface, where it is immediately dispersed in the air, as a result of which its concentration remains scanty and does not pose a serious danger. Problems appear if there is no air exchange, for example, in the premises. 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 seepage. However, even the use of these membranes does not provide full 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 liter, reaching hundreds and even thousands of Bq/l in industrial areas [22].

- Radon dissolved in water acts bilaterally. On the one hand, it enters the digestive system together with water, and on the other hand, the body inhales radon released by water when using it. The fact is that at the moment when the 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 exposure to radon is considered more dangerous to health. The US Environmental Protection Agency (USEPA) recommends as a recommended limit value of radon content in water at the level of 11.1 Bq/l. In the Russian Radiation Safety Standards (NRB-99), the limit 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 into the air"). Therefore, those who use urban drinking water have practically nothing to worry about, since aeration is included in the standard procedure of water treatment at urban water treatment plants. As for individual users of borehole water, studies conducted by USEPA have shown a fairly high efficiency of activated carbon. A filter based on high-quality activated carbon is able to remove up to 99.7% of radon. However, over time, this figure drops to 79%. The use of a water softener on ion-exchange resins in front of a carbon filter makes it possible to increase the latter indicator to 85% [23-26].

- Determination with a spectrometer-radiometer MKGB-01 "RADEK" provides the specified values of measurement error when the following conditions are met:
  - The confidence error in determining the sensitivity coefficients of the spectrometer does not exceed  $\pm 7\%$  ( $P = 0.95$ ) (extended uncertainty  $I_s = 7\%$  ( $k = 2$ ));
  - The density value of the sample is in the range from 0.2 to 2 g/cm<sup>3</sup>;
  - The measurement time for the geometry "Marinelli vessel" is 2400 s, for the geometry "cylindrical vessel with a volume of 250 ml" - 1h [27,28].

## The experimental part

The measurement of the specific activity of radionuclides in fixed-mass samples was carried out by direct evaluation using a spectrometer, which was pre-calibrated using reference measuring instruments - model measures of specific activity in accordance with the table 1 [29].

Table 1

Radionuclide	Density range, g/sm <sup>3</sup>	Vessel geometry
<sup>226</sup> Ra, <sup>232</sup> Th, <sup>40</sup> K, <sup>137</sup> Cs	from 0.2 to 2	Marinelli 1L Vessel 250 ml
<sup>222</sup> Rn	1 (water)	Marinelli 1L
<sup>222</sup> Rn	1 (activated carbon)	Column c
<sup>90</sup> Sr+ <sup>90</sup> Y	from 0.2 to 2	Activated carbon 12 ml

The values of the specific activity of radionuclides and the absolute error of the measurement result were calculated automatically according to the algorithm of the "ASW" program based on the measured spectra of the sample and the sensitivity coefficients obtained during 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 power of the control dose was measured in the protective chamber of beta channels with the protection covers open, three measurements were carried out at each point and the average value was calculated. The obtained values did not exceed 0.20 msv/h. Air samples were dissolved in distilled water with volumes of 200 ml and drained into a container. The containers were weighed and the mass (1-5) of the container with a sample in grams was determined. The mass of the counting sample was determined by the formula:

$$m_{so} = m_{knr} - m_x \quad (1)$$

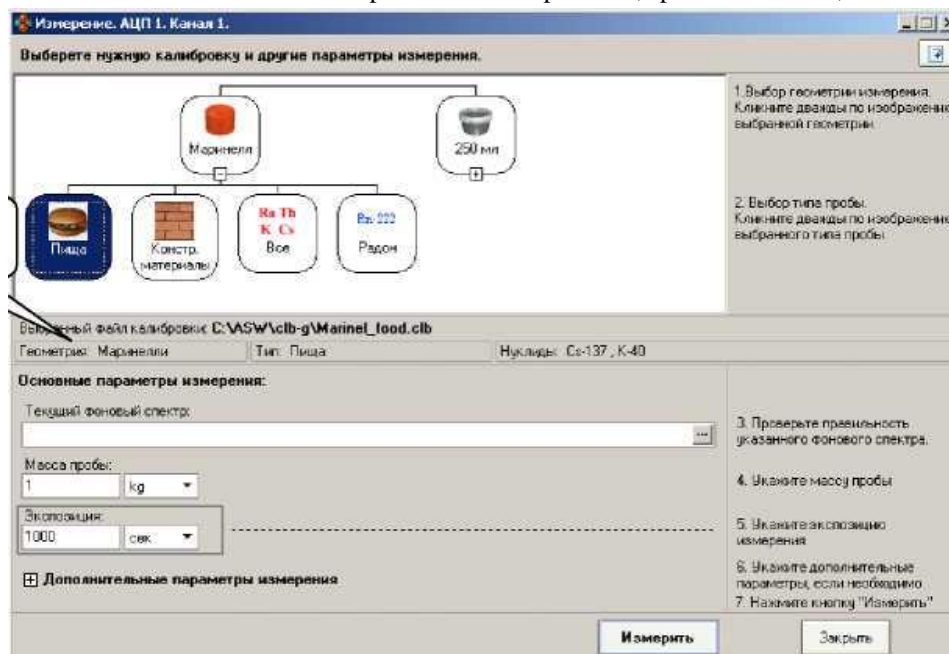
**Calibration of the radiometer.** The energy calibration of the NaI (TI) detector was carried out using the certified RGK-1 standard. The following gamma lines were used: Pb-214 (352 keV), Bi-214 (1125 kv), K40 (1460 keV) and Tl-208 (2615 keV). To do this, in the program "ASW" of the radiometer MKGB-01, measurement parameters are selected, that is, the geometry of the measurement and the type of sample as in Figures 2 and 3:

Figure 2. Selection of measurement parameters during calibration of the radiometer



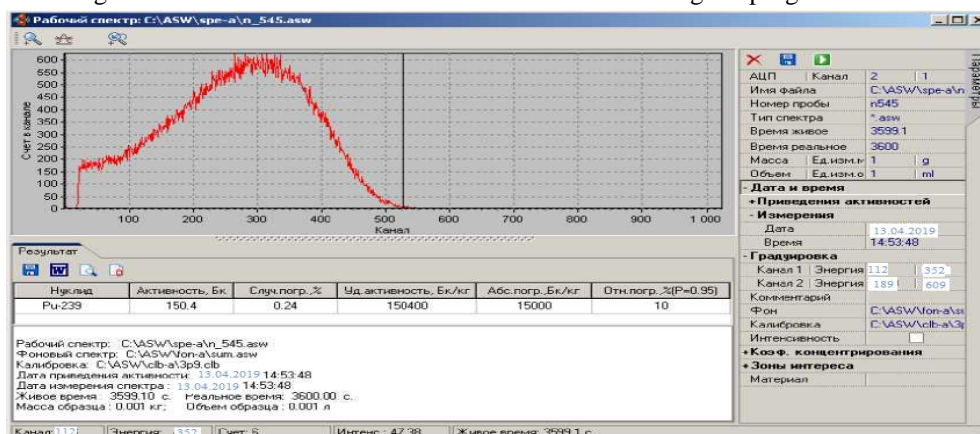
MKGB-01 with the program "ASW"

Figure 3. Selection of other measurement parameters: sample mass, spectrum channel, measurement time



The radiometer measures the activity energy of selected radionuclides for 1000 s and displays the measurement data on the screen (Fig. 4).

Figure 4. Calibration data of the MCG-01 radiometer using the program "ASW"



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

$$E = E_0 + BC + AC^2 \quad (3)$$

$E_0$ , B and A are constant.

Figure 4 shows the energy calibration curve.

Background measurement. Provided that the distilled water is not radioactive, the background activity was determined by running an inert sample consisting of a plastic 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, selected 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 radon-222 radionuclide in them by radiometric spectrometric method. The MKGB-01 radiometer is connected to a laptop computer and works with the "ASW" program. The "ASW" program developed by RADEK (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 error of determination. As well as the "ASW" program provides calculations of the volume and specific activity of radionuclides (ac) both separately and with several radionuclides. The measurement duration is 40 minutes. The results of the studies are presented in Table 3.

Table 3 RESULTS OF DETERMINATION OF beta-RADIATION OF RADON-222 IN ATMOSPHERIC AIR OF THE CITY OF TERMEZ, SURKHANDARYA REGION (t=40 min, E=624 keV, PM=0.64 imp/s\*bk)

№	* The barcode is punching	The Sampling location	The value of the specific activity of $\beta$ -radiation Rn-222, Bq/kg (UV=60)
1	T-1-20	A.Navoi Street house-2 of the city of Termez	0,02
2	T-2-20	A.Temura Street house-122 of the city of Termez	0,08
3	T-3-20	M.Kakhkhara Street house-45 of Termez	0,15

4	T-4-20	S.Zunnunova Street house-93 of Termez	0,06
5	T-5-20	I.Karimov Street house-212 of Termez	0,08
6	T-6-20	At-Termizi Street house-5 of Termez	0,05

The table shows that a high value of  $\beta$ -radiation Rn-222 was obtained at point 3. But this value is not high above the level of intervention (HC Rn-222 = 60). 3-point is the northern part of the city and is an industrial area where several construction plants are located.

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