Method of Determining and Assessment of Radon Exhalation Characteristics in Technogenic Objects

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Abstract: *This article presents the methods of determining radon exhalation and the results of assessment the characteristics of radon in technogenic objects. Studies conducted in recent years show that radon in terms of contribution to the total annual dose of radiation creates 20 times more contribution than the rest of the radionuclides of the uranium decay chain. Radon simultaneously belongs to the highest group A toxicity. For workers of category A (personnel), the values RAP and DKa of 222Rn (without decay products) are equal to 146 MBq / year and 55.5 Bq / l, respectively. Radon accounts for more than 75% of the total annual dose of radiation, which on average receives the human body from technogenic factors of the environment, especially those working in the uranium technogenic objects.*

Keywords: *Radon exhalation, characteristics of radon behavior, total annual dose, individual annual dose, radioactive decay, radioactive series, uranium technogenic object.*

1. INTRODUCTION

Among the radioactive radionuclides is one of the most dangerous. By entering the human body, radon contributes to the processes leading to cancer of various organs of a living being, especially the lungs. The decay of the nuclei of radon and its daughter radionuclides in the lungs causes a micro scald burn, since all the energy of α-particles are absorbed almost at the decay point. Radon is also able to enter the body through intact skin. During the decay of radon, non-volatile radioactive products (isotopes Po, Bi and Pb) are formed, which are hardly excreted from the body.

In addition to natural sources, one of the main sources of radon is mill tailings of radioactive waste, sites of underground uranium leaching, storage sites of radioactive technological products, uranium oxide piercing workshops, sites of uranium productive solution processing, etc [1-6]. In the Republic of Uzbekistan, in 2000, the Law of the Republic of Uzbekistan "On Radiation Safety" was adopted and in 2006 the Norms of Radiation Safety (NRB-2006) and the Basic Sanitary Rules for Ensuring Radiation Safety (OSPORB-2006) which is populated on reduction of levels of irradiation of the population and production personnel from natural and technogenic sources of ionizing radiation [7]. On the basis of the abovementioned, the development of methods for determination and assessment the characteristics of radon exhalation in various technogenic objects is an urgent task of analytical chemistry, applied nuclear physics and radioecology [8-10].

2. EXPERIMENTAL METHODS AND TECHNIQUES

The measurements of radon exhalation were carried out by the measuring complex "Alpha plus» designed to determine the radon flux density from the soil surface, Rapid measurements and continuous monitoring of the volumetric activity - (VA) of radon-222 (222Rn) and the number of decays of Po (218ThA). The limit of permissible relative error at the measurements of VA 222Rn in soil, ±30 %.

Measurement of the specific activity of the selected solid samples were carried out on a gamma radiometer "PROGRESS-GAMMA", which the margin of permissible basic relative error is ± 10%.

3. RESULTS AND DISCUSSION

The amount of radon is determined by the "Alpha rad plus" complex based on the following reaction:

$$^{222}Rn\,\frac{\alpha}{3,8\,day}\,...\,^{214}Pb\,\frac{\beta}{26.8\,min}\,^{214}Bi\,\frac{\gamma}{19,8\,min}$$

(1)
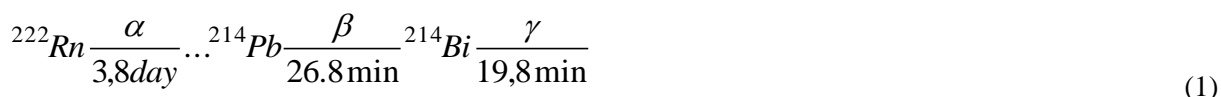
The basics of radiation monitoring and studying the behavior of radon is based on experimental studies of the physicochemical properties of controlled radionuclides. On the basis of the obtained results it is possible to draw a conclusion allowing to predict their migratory activity in objects of ecosystems.
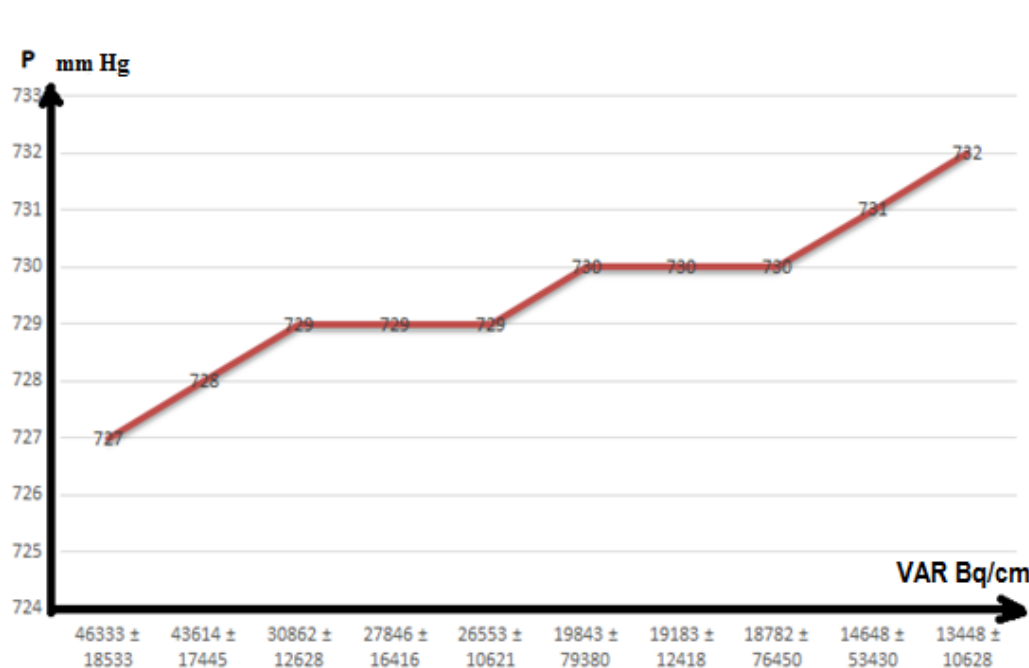
The volumetric activity of radon in the atmospheric air of the mill tailing that comes out of the soil has been determined. The value concentration of radon in these soils is determined by the content of radionuclides in the uranium chain. Table 1 shows the results of measurement on the determination of VAR, specific activity of radionuclides, effective specific activity, and physical parameters of environment.

Table1.*The results of measurements on determination of VAR, specific activity of radionuclides, effective specific activity and physical parameters of environment*

№ s/n	VA of radon mBq/sm^2	Air temperature ^0C	Humidity%	Pressure mm.Hg	The specific activity in the soil			
					K^{40} Bq/kg	K^{40} Bq/kg	K^{40} Bq/kg	K^{40} Bq/kg
1	46333 ± 18533	30	26	727	3896	18560	226	19188
2	43614 ± 17445	30	37	728	3685	16985	216	17619
3	30862 ± 12628	24	31	729	3149	16009	249	17180
4	27846 ± 16416	28	33	729	2785	15500	185	15993
5	26553 ± 10621	33	38	729	4158	13190	258	13902
6	19843 ± 79380	31	23	730	3311	12680	207	13249
7	19183 ± 12418	25	22	730	3256	12185	192	12689
8	18782 ± 76450	23	29	730	1933	12091	142	12517
9	14648 ± 53430	24	31	731	1704	11570	103	11958
10	13448 ± 10628	28	30	732	2925	11249	185	11746

From the results obtained in table 1 it can be seen that the VAR values vary from 13448 mBq / cm2 to 46333 mBq / cm2, the specific activity of radionuclides – K40 varies from 1704 Bq / kg to 4158 Bq / kg, - Th232 varies from 103 Bq / kg to 258 Bq / kg and - Ra226 varies from 12680 Bq / kg to 18670 Bq/kg. from 13902 Bq / kg to 19280 Bq / kg. Effective specific activity – (Aeffec) varies from 13902 Bq / kg to 19280 Bq/kg.

In addition, the VAR value is directly proportional depends on the specific activity of Ra226 and the effective specific activity - Aeffec.

Figure1. *shows the dependences of the VAR with the atmospheric pressure of the environment.*

As can be seen from figure 1 with increasing atmospheric pressure of the environment, the volumetric activity and in parallel radon exhalation decreases.
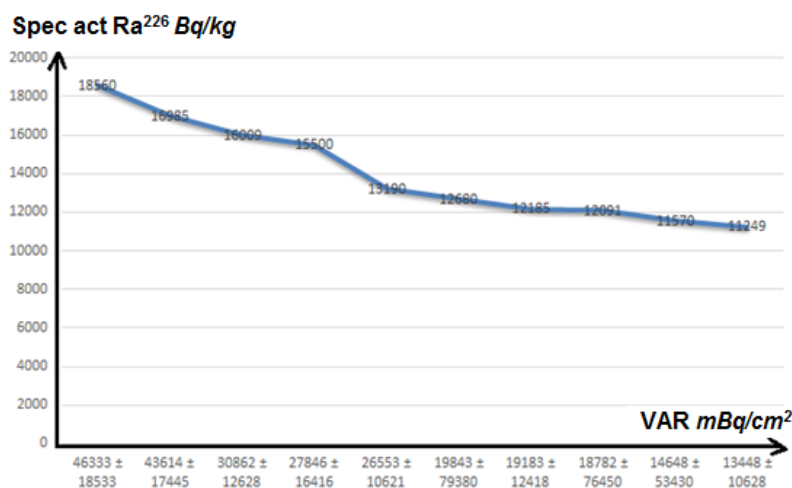

Figure2. *Shows the dependences of the VAR depending on the specific activity of Ra^{226}.*

As can be seen from figure 2 with increasing specific activity of Ra226 in the soil and increases radon exhalation.
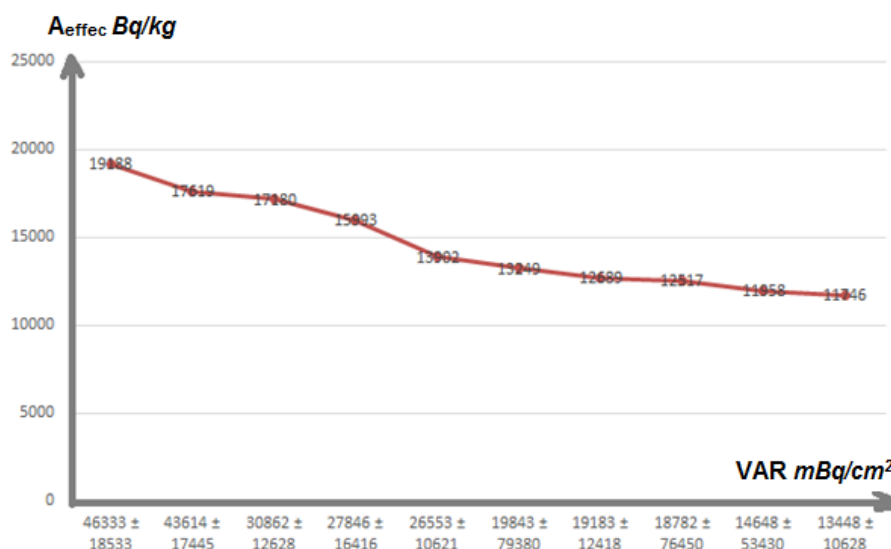

Figure3. *Shows the dependence of the VAR on the specific effective activity-A$_{effec.}$*

As can be seen from figure 3 with increasing specific effective activity - soil Aeffec and increases radon exhalation.

In addition to the above, it was found that radon emission from the soil has a seasonal character - the temperature increase causes the expansion of pores in the soil, and therefore increases the release of radon. In addition, the increase in temperature increases the evaporation of water, with which radon is carried into the surrounding space.

It has been determined that the VAR in the atmospheric air of production facilities is on average-from 4 to 212 Bq / m^3 and in the territories of the sanitary protection zone of production is-from 3 to 14 Bq / m^3.

Thus, as a result of the studies, changes in the OAR value were established, the specific activity values of radionuclides - K^{40}, Th^{232}, Ra^{226} were determined, the effective specific activity — (Aeff) was determined, and the dependences of the VAR on the values of the abovementioned quantities were constructed.

On the basis of the conducted researches in the long term planned actions for systematic control of radon behavior and carrying out calculation of total annual effective dose for the population living in

the territory of influences of the industrial enterprise, the personnel working in them and improvement of a radio ecological condition in a zone of action of this enterprise can be developed.

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