
Comparative Analysis of Radon Accumulation in Public Buildings of Different Class on the Example of Several Sogd Region Cities of Tajikistan

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Abstract: The article presents data and a comparative analysis of the accumulation of radon in public buildings (preschool, school and medical institutions) located near radioactive tailings, deployed in certain regions of Northern Tajikistan (Istiklol, Buston). Most of the preschool and school educational institutions buildings in Istiklol are two-storey and according to the type of building materials – brick, concrete and stone. It has been revealed that the average value of radon volumetric activity in indoor air in public buildings located in Istiklol city (formerly Taboshar) reaches up to 175 Bq/m³ and in Buston city (formerly Chkalovsk) to 26 Bq/m³. The values of radon equivalent equilibrium volumetric activity in indoor air at investigated objects are in the range of 10-330 Bq/m³ in Istiklol and 8-19 Bq/m³ in Buston cities. The range of the annual effective dose is from 0.3 mSv to 7.1 mSv. Toron has been measured in selected public buildings (schools, kindergartens and hospitals) in Istiklol city and its levels have been established between 20 and 160 Bq/m³. Indoor gamma dose values measured in schools and kindergartens fixed in the range of 0.1–1.3 mGy/h and the lowest reading determined less than 0.2 mGy/h. It has been discovered that building materials are the main source for radon intake. But the geology of the region also plays an important role. The data obtained from radon monitoring will be used in preventive measures to protect children from the effects of a radioactive factor. It is noted that the issue of protecting future generation from the harmful effects of ionizing radiation requires a comprehensive study and assessment. For preventive purposes, it is necessary to recommend mandatory periodic ventilation of preschool and school institutions.

Keywords: Radonmeter, Radon, Monitoring, Detectors, Dose, Activity, Irradiation, School, Kindergarten

1. Introduction

1.1. Issue Relevance

The radioactive gas radon gives about half of the radiation dose that each person receives from natural radionuclides annually. Preschool and school institutions are the second most important place after housing, where exposure to radon

is possible [1].

Radon situation assessment on the territory of northern Tajikistan [2-7] indicates that the uranium legacy sites are the main sources for radon intake into the air. Especially radioactive tailing dumps, located in Istiklol city (factories of poor ores) and B. Gafurov region (Digmay tailing dump), which do not have the necessary protection arrangements to restrict their impact to the environment [8-13]. The places of

deployment, in many cases, are located near settlements.

1.2. Research Objective

The objective of current research is to carry out a comparative analysis of radon accumulation in public buildings of various classes on the example of several cities of the Sogd region of Tajikistan.

1.3. Research Objects

The objects of research are schools, kindergartens and medical buildings in Istiklol and Buston cities, Goziyon settlement and B. Gafurov district, which are located close to radioactive tailing dumps, and these dumps are the legacy sites from the former Soviet uranium industry.

1.4. Study Subject

The subject of the study is the experimental determination of radon concentration in premises of medical and preschool institutions and schools of the above-mentioned settlements.

2. Material and Research Methods

An integral method for radon VA measurement using track

detectors and a radon radiometer PPA-01M-03 [14] has been used as a measurement tool.

Indoor radon VA measurements have been carried out during the summer season. Instant radon measurements have been used as a preliminary screening for radon, while accurate measurements should be based on long-term measurements over a long period of time (298 days) using solid state nuclear trackers such as SSNTD.

The radioactive equilibrium coefficient F_{Rn} equal to 0.4 is used to convert the radon VA into the equivalent equilibrium volumetric activity (EEVA) of radon [15, 16].

3. Research Results and Discourse

In total, 8 educational institutions located in different areas of Istiklol city have been investigated. Most of preschool and school educational institutions buildings in Istiklol city are two-storey and the type of building materials are mostly brick, concrete and stone. The measurements have been conducted on the first floors; the duration of one measurement was 25 minutes. The measurements were carried out in the premises of the permanent residence of children - gyms, playrooms and bedrooms. The measurement results are summarized in Table 1.

Table 1. Radon VA values in air of preschool, school and other educational institutions buildings at Istiklol and Buston cities.

No.	Institution, address	Construction materials	Radon VA, Bq/m ³	Radon EEVA, Bq/m ³
Istiklol city				
1	School No. 1	concrete	43	17
2	School No. 2	concrete	37	15
3	School No. 3	brick	25	10
4	School No. 4	brick	144	58
5	School No. 5	stone	150	60
6	School No. 6	brick	52	21
7	Kindergarten No. 3	brick	37	15
8	Vocational technical school	stone	259	104
9	Medical center	brick	826	330
Buston city				
10	Tajikistan Mining and Metallurgical Institute	brick	47	19
11	Buston Presidential School	brick	20	8
12	Gymnasium No. 1	brick	20	8
13	School No. 4	brick	37	15
14	School No. 11	brick	20	8
15	Kindergarten No. 4	brick	20	8
16	Kindergarten No. 13	brick	20	8
17	Kindergarten «Mehrona»	brick	21	8

Radon concentration during instantaneous measurements in schools and kindergartens ranges from 20 Bq/m³ to 259 Bq/m³. The average radon concentration value is 75 Bq/m³ and the annual effective dose ranges from 0.3 mSv to 7.1 mSv.

Based on obtained data, it is shown that building materials have a significant effect to indoor radon concentration. Regardless of building materials type (natural, artificial or by-products), they contain variable amounts of naturally occurring radionuclides such as the ²³⁸U and ²³²Th decay chain, ⁴⁰K, etc. Concrete made of granite, pumice and shale aggregates, has higher radon emission rates. For instance, the radon VA value in the vocational school building, built using stone as a building material is equal to 259 Bq/m³ and in the

school No. 5 building this indicator is equal to 150 Bq/m³.

Furthermore, in addition to building materials, the site geology plays an important role for gamma radiation activity in the room. For example, high radon concentration (826 Bq/m³) in medical center building (old Taboshar) is explained by the fact that the building was built on a land plot with geological anomaly (increased radon emanation), as well as the lack of ventilation in building basement. These parameters exceed the standard of 200 Bq/m³ (for old buildings) established in the Radiation Safety Standards of the Republic of Tajikistan (NRB-06 SP 2.6.1.001-06) [17].

The obtained data by the instantaneous method have been compared with the indicators obtained by long-term radon

concentration measurement using SSNTD type solid-state nuclear track detectors for 298 days in a separate public building at Istiklol city. The comparison showed that the data obtained by the radon instantaneous measurement method, as

a rule, is higher than the data obtained by the integral method, which were in the range of 30-830 Bq/m³. Detailed results presented in Table 2.

Table 2. Radon and thoron concentration in some public buildings premises at Istiklol city.

Sampling site	²²² Rn, Bq/m ³	²²⁰ Rn, Bq/m ³	Dose of gamma radiation, mGy/hour	Annual effective dose of radon, mSv/year*
City library	516±23	154±72	-	3,7
Palace of Culture (dance hall)	275±17	119±54	0,19	2,0
School No. 4 (Entrance)	53±7	21±23	0,32	0,4
Hospital (2nd floor)	31±6	17±18	-	0,2
Medical centre (gynecological office)	574±24	-	0,24	4,1
Palace of Culture (concert hall)	59±8	32±25	0,17	0,4
Maternity hospital (1st floor)	67±8	19±26	0,49	0,5
School No. 4 (chemistry room)	93±10	-	0,15	0,7
School No. 5 (1st floor)	88±9	63±31	1,26	0,6
School No. 5 (teachers room)	217±15	88±48	0,18	1,6
School No. 5 (history room)	42±6	-	0,18	0,3

*For calculating the annual effective dose from radon, 2000 hours per year as an exposure time has been taken into account (for a patient's stay in a hospital, the time of an actual stay has been taken into account).

Thoron has been measured in selected public buildings (schools, kindergartens, hospitals) at Istiklol city and its levels have been established from 20 to 160 Bq/m³ (Table 2).

High radon and thoron concentration have been noted in the city library (²²²Rn=516±23 Bq/m³ and ²²⁰Rn=154±72 Bq/m³), in Palace of Culture dance hall (²²²Rn=275±17 Bq/m³ and ²²⁰Rn=119±54 Bq/m³), which are located on the first floors of these buildings, erected in 40-50s of the last century using building materials with increased NORM content.

Excess radon (²²²Rn=217±23 Bq/m³) and thoron (²²⁰Rn=88±48 Bq/m³) concentrations have been also observed in school No. 5 teacher's office (the former mining administration building). This room area is about 20 m² and it is ventilated poorly in cold weather, unlike other school classrooms. It should be noted that the school No. 5 building, located on a hill near open dumps of "Poor ores factory" and open pit No. 1, is well blown by winds from different directions.

Indoor gamma dose values measured in schools and kindergartens presented in the range 0.1–1.3 mGy/hour, with most readings being less than 0.2 mGy/hour.

Radon concentration range in hospitals, medical centers in Istiklol city has been established from 20 to 2900 Bq/m³, in three medical centers radon concentration exceeded 1500 Bq/m³. Gamma radiation dose range presented from 0.12 mGy/h to 21 mGy/h, measurements have been carried out in the same rooms. The highest radon concentration values have been observed in basements and on the first floors of buildings.

Indoor air radon ERAA is an important factor for radon hazard to territories and it is considered during buildings design and operation for various purposes. The radon intake into indoor air is regulated by radon presence in underlying surface and in building materials that make up the building structure.

4. Conclusions

Based on the experimental data of radon VA measurements

in the air in public buildings of Istiklol and Buston cities, it can be argued that the main source for radon intake is building materials. As, the building of the Vocational School built using stone as a building material, the value of radon VA is equal to 259 Bq/m³, and in the building of school No. 5 with the same building material this figure is equal to 150 Bq/m³.

A comparative analysis of radon accumulation in public buildings showed that the contribution of radon and its decay daughter products to the average annual effective dose for children exposure in the premises of schools and kindergartens is 0.2–4.1 mSv/year.

In addition to building materials, the geology of the region plays an important role in the indications of radon volume activity in the room. For example, the high concentration of radon (826 Bq/m³) in the medical center (old Taboshar) is explained by the fact that the building was built on a plot of land with a geological anomaly (increased radon emanation), as well as the lack of ventilation in the basement of the building.

The obtained data from radon monitoring results indicate that the problem protecting future generation from ionizing radiation harmful effects requires a comprehensive study and assessment.

For preventive purposes, it is necessary to recommend mandatory periodic ventilation of preschool and school institutions.

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