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Radon flux density on the soil surface in the southern regions of Uzbekistan

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Abstract

A method measuring the radon flux density (RFD) from the soil surface before the construction allows to assess the volumetric activity of radon (VAR) inside a dwelling after the construction. Data on RFD and VAR values is scarce in case of Uzbekistan. The current work presents the results of research on RFD on the soil surface at six sites in the southern regions of Uzbekistan. Measurements were carried out at 150 control points, with RFD ranging from 16.0 ± 2.7 mBq×m^{-2}×s^{-1} to 151.7 ± 15.0 mBq×m^{-2}×s^{-1}. A passive adsorption method of radon on activated charcoal followed by measurement of the activity of the sorption columns on a NaI(Tl) gamma spectrometer was used in the study.

Keywords: Radon flux density, soil surface, volumetric activity of radon

Introduction

The proportion of radiation exposure to the population from all sources of ionizing radiation that comes from radon is 43% [1]. Exposure to radon and its decay products in homes and workplaces is a significant risk factor for lung cancer, resulting in thousands of cases annually [2]. The inert radioactive gas radon-222 is formed by the alpha decay of the Ra-226 isotope present in soil and rocks, and as a result of diffusion processes occurring in the soil, it can accumulate in indoor air. Preliminary measurement of the radon concentration on the soil surface at construction sites allows for an estimation of the volumetric activity of radon in the air of buildings after construction [3]. Generating radon flux maps can be useful for regulatory national organisations in order to classify radon prone areas [4].

According to the Sanitary Rules and Norms SanPiN 0193-06 in effect in Uzbekistan, when selecting sites for the construction of residential buildings and social facilities, the radon concentration on the soil surface (RFD) should not exceed 80 mBq×m^{-2}×s^{-1}. If a site for a building has a radon flux density of more than 80 mBq×m^{-2}×s^{-1}, a radon protection system should be provided in the building design. For the construction of industrial buildings, sites should be chosen where the radon flux density on the soil surface does not exceed 250 mBq×m^{-2}×s^{-1} [5].

There are very few studies available in the literature on the determination of radon concentration on the soil surface (RFD) in Uzbekistan. In this work, we investigated the levels of PPR on the soil surface in some areas of the southern regions of Uzbekistan.

Passive adsorption of radon on activated charcoal was used in the research, followed by measurement with a gamma spectrometer. This method is relatively simple and provides satisfactory results compared to other methods for measuring RFD [6].

Study area

We selected three sites each measuring 400 by 400 meters in the Karshi and Surkhandarya regions of Uzbekistan near populated areas (Fig. 1). Radon concentration on the soil surface (RFD) was measured at 25 control points on each site, which were located on a grid with a spacing of 100 meters. The coordinates of the sites are given in Table 1.

Fig 1: Karshi and Surkhandarya regions of Uzbekistan near populated areas

Table 1: Sampling areas

Site ID	Region	Settlement	Coordinates		Altitude (m)	Number of sampling points
			Latitude	Longitude		
S1	Karshi	Yangi Nishon	38.646293°	65.672848°	346	25
S2	Karshi	Guzor	38.622066°	66.228941°	512	25
S3	Karshi	Kamashi	38.792089°	66.469268°	511	25
S4	Surkhandarya	Sherabad	37.672791°	67.034748°	408	25
S5	Surkhandarya	Termez	37.280186°	67.383913°	315	25
S6	Surkhandarya	Shurchi	37.987695°	67.758013°	446	25

Materials and methods

Sampling

To measure radon concentration on the soil surface, stands with sorption columns were installed on a prepared surface (40×40 cm area with removed vegetation to a depth of 5-10 cm) and covered with a sampling chamber with a volume of 3.3 liters. In sunny weather, to prevent heating of the chamber, they were covered with white woven fabric (Fig. 2). The exposure time of the sorption columns was 3 hours. Then, they were placed in airtight transport containers, marked, and transported to the laboratory for measurements on a gamma spectrometer.

Fig 2: Sorption chamber setup.

Equipment, calibration, measurement, and data processing

The activity of the sorption chambers was measured using a NaI (Tl) scintillation gamma spectrometer with a crystal size of Ø80×80 mm and an energy resolution of 8.5% at the 662 keV line. Energy calibration of the spectrometer was performed using certified point sources of radionuclides ^{137}Cs and ^{232}Th.

Efficiency calibration was performed using a volume source of ^{226}Ra deposited on activated charcoal of the SKT-3 brand with dimensions of Ø60×25 mm (corresponding to the geometry of the sorption chambers), with an activity of 680 Bq and an accuracy of activity determination of 7%.

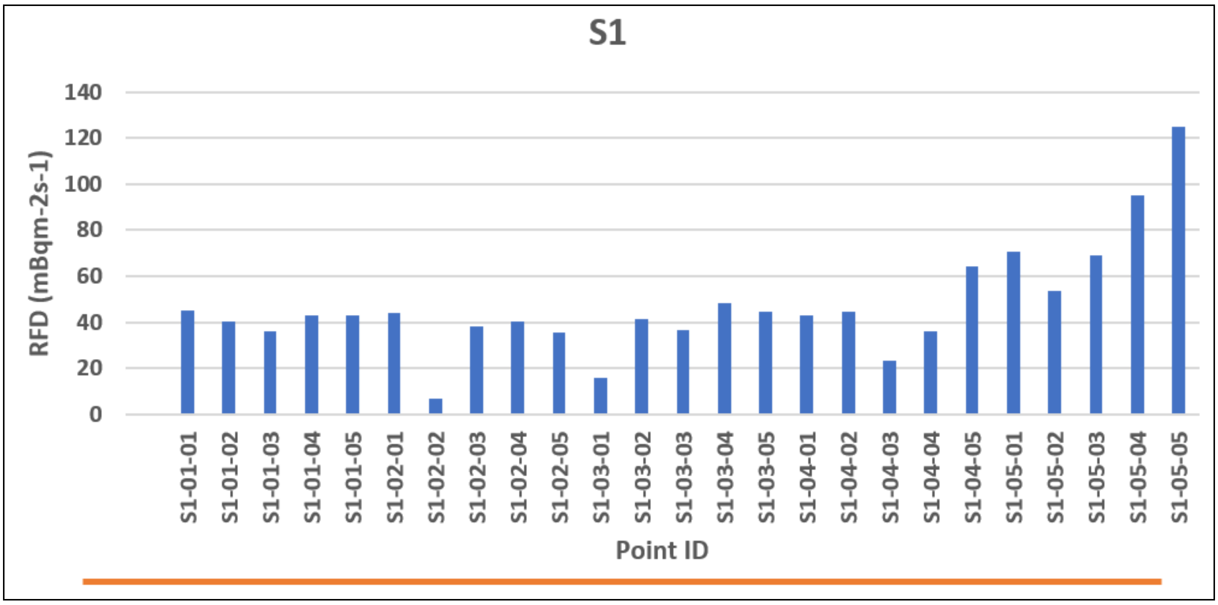
Spectra were collected for 30 minutes, and spectrum processing was performed using ASW software from the RADEK Scientific and Technical Center.

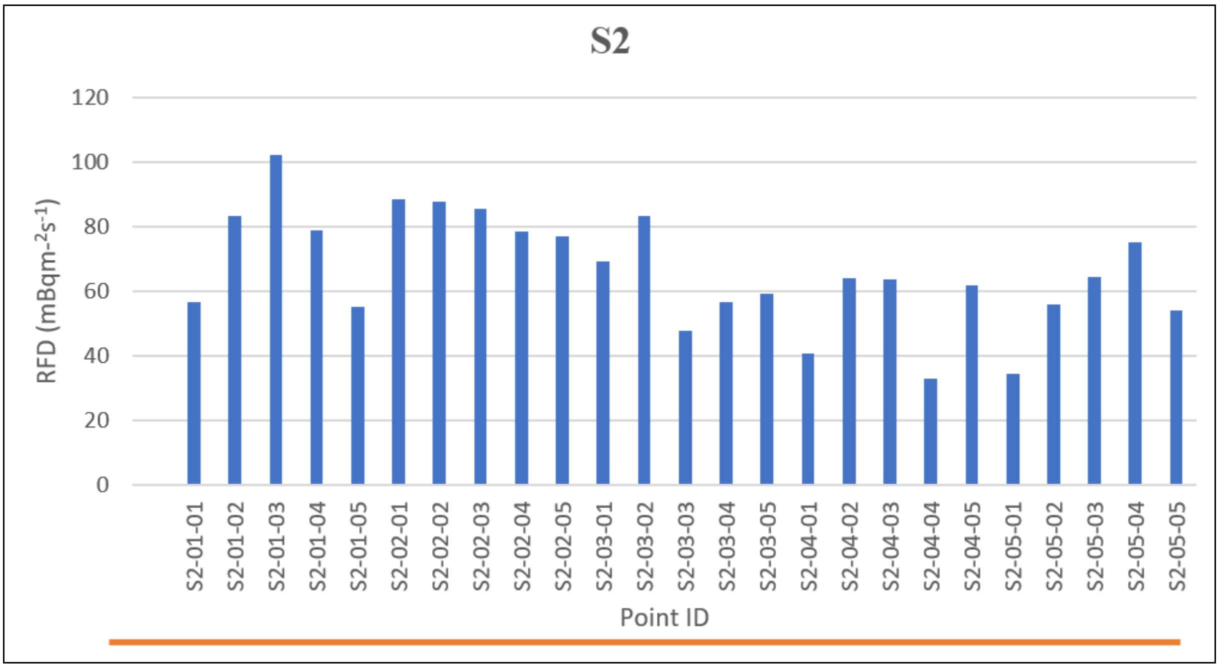
Research results

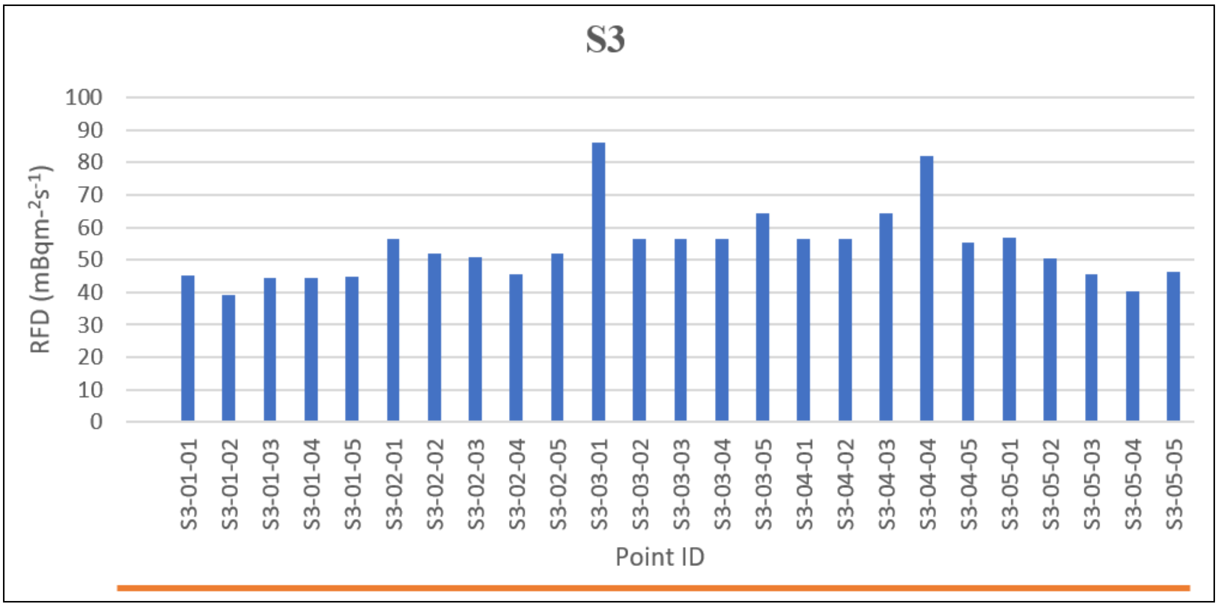
Table 2 shows the minimum, maximum, and mean arithmetic values of RFD on the soil surface in the control points for all investigated sites.

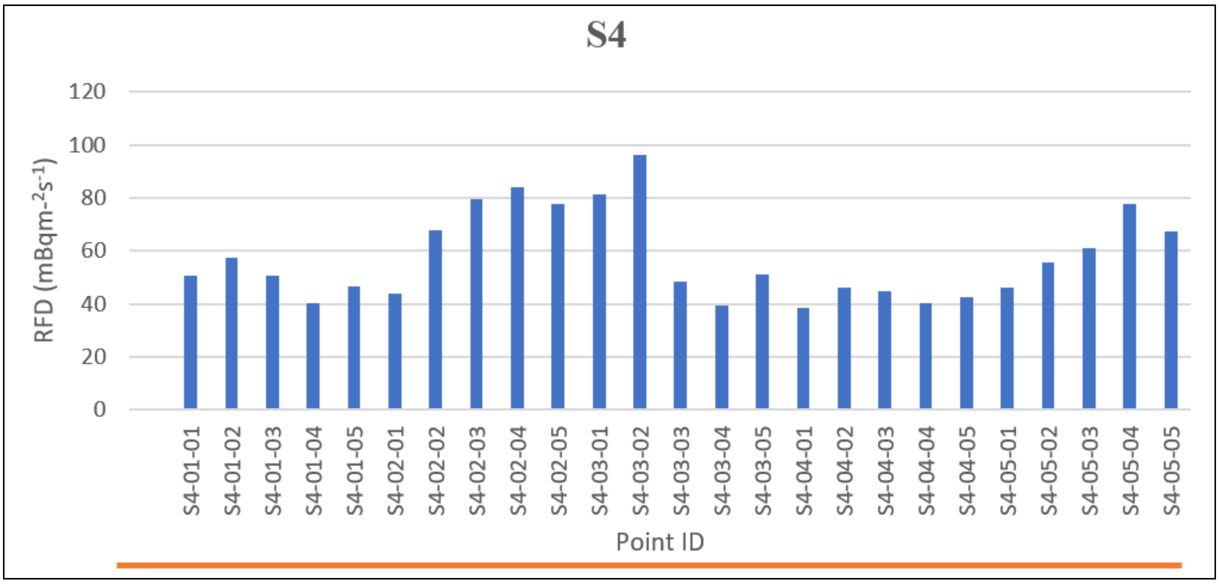
Table 2: Maximum, minimum, and mean values of RFD on the sites.

Site ID	Min $\Phi_{Rn} \pm \Delta\Phi_{Rn}$, $mBq \times m^{-2} \times s^{-1}$	Max $\Phi_{Rn} \pm \Delta\Phi_{Rn}$, $mBq \times m^{-2} \times s^{-1}$	Mean $\Phi_{Rn} \pm \Delta\Phi_{Rn}$, $mBq \times m^{-2} \times s^{-1}$
S1	16.0 ± 2.7	124.9 ± 12.0	70.45 ± 7.35
S2	33.1 ± 5.2	102.2 ± 13.0	67.65 ± 9.1
S3	39.2 ± 7.5	86.0 ± 9.0	62.6 ± 8.25
S4	38.6 ± 4.8	96.0 ± 9.9	67.3 ± 7.35
S5	34.0 ± 6.0	99.4 ± 11.0	66.7 ± 8.5
S6	27.7 ± 2.8	151.7 ± 15.0	89.7 ± 8.9






S3
RFD (mBqm-2s-1)
0
10
20
30
40
50
60
70
80
90
100
S3-01-01
S3-01-02
S3-01-03
S3-01-04
S3-01-05
S3-02-01
S3-02-02
S3-02-03
S3-02-04
S3-02-05
S3-03-01
S3-03-02
S3-03-03
S3-03-04
S3-03-05
S3-04-01
S3-04-02
S3-04-03
S3-04-04
S3-04-05
S3-05-01
S3-05-02
S3-05-03
S3-05-04
S3-05-05
Point ID


S4
RFD (mBqm-2s-1)
0
20
40
60
80
100
120
S4-01-01
S4-01-02
S4-01-03
S4-01-04
S4-01-05
S4-02-01
S4-02-02
S4-02-03
S4-02-04
S4-02-05
S4-03-01
S4-03-02
S4-03-03
S4-03-04
S4-03-05
S4-04-01
S4-04-02
S4-04-03
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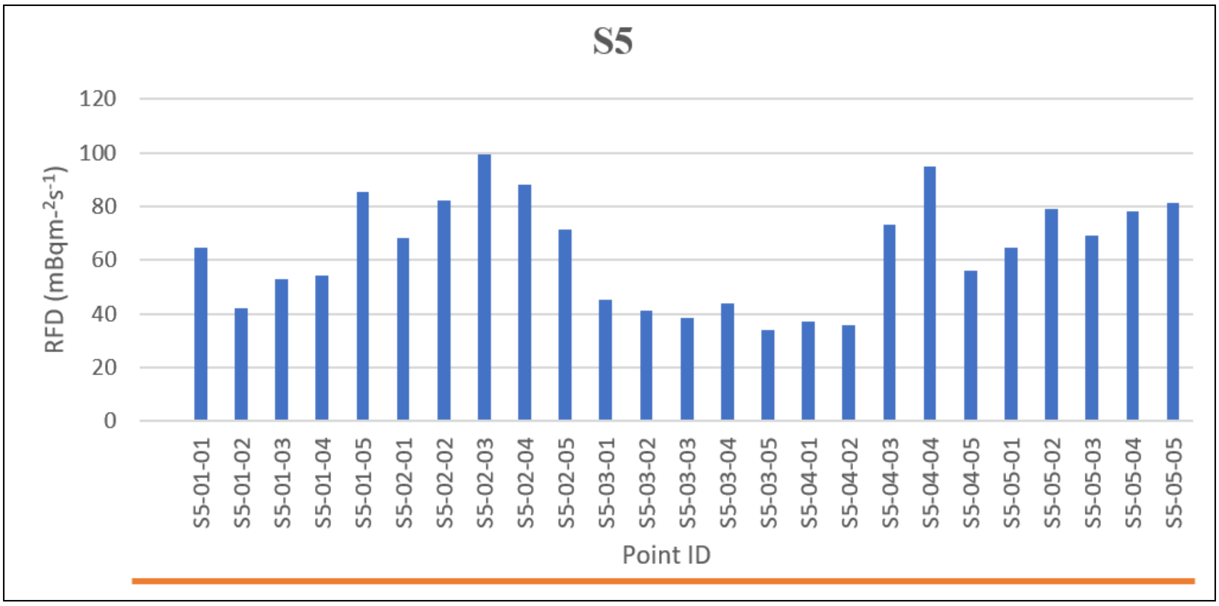
S4-05-04
S4-05-05
Point ID


S5
RFD (mBqm-2s-1)
0
20
40
60
80
100
120
S5-01-01
S5-01-02
S5-01-03
S5-01-04
S5-01-05
S5-02-01
S5-02-02
S5-02-03
S5-02-04
S5-02-05
S5-03-01
S5-03-02
S5-03-03
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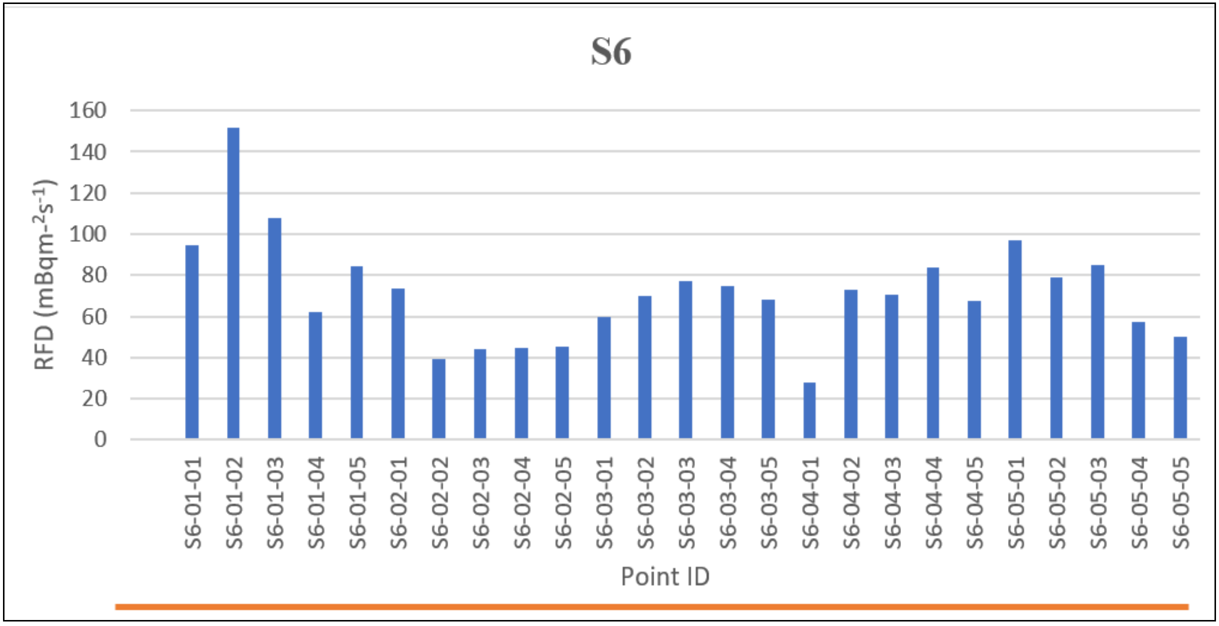

Fig 3: Shows the RFD values on the soil surface for all control points in the form of a histogram.

Conclusion

According to the results of the study of 150 control points on 6 sites, the minimum value of RFD on the soil surface was 16.0 ± 2.7 mBq×m^{-2}×s^{-1}, while the maximum value was 151.7 ± 15.0 mBq×m^{-2}×s^{-1}. At the same time, in 23 control points, the value of RFD on the soil surface exceeded the limit of 80 mBq×m^{-2}×s^{-1} established in [5] when selecting sites for the construction of residential buildings and social facilities. The limit of 250 mBq×m^{-2}×s^{-1} established in [5] when selecting sites for the construction of industrial buildings was not exceeded in any of the measurement control points.

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