MEASUREMENT OF GAMMA DOSE RATE IN HOSPITALAS FOR REHABILITATION IN BULGARIA

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Summary: The gamma dose rate in the air was measured in 355 rooms in 17 inspected hospitals for rehabilitation on the Bulgarian territory. The maximum value of the parameter was 0.390 µSv/h and the minimum value was 0.06 µSv/h with the arithmetic mean 0.157 µSv/h (standard deviation - 0.160). The gamma dose rate is within the natural variations of the parameter in buildings. Direct measurements of radon were conducted and range of the results was from 12 Bq/m^3 to 3920 Bq/m^3. The relationship between the two parameters was examined. A weak correlation between gamma dose rate and indoor radon concentration was found. The measurement of gamma dose rate could be useful parameter for carrying out the radon workplace control.

Keywords gamma dose rate, hospitals, radon, direct measurement.

INTRODUCTION

Natural radioactivity is an integral part of our environment. Humans are exposed to it at different levels depending on natural radioactive elements present in rocks, soil and water on the region. The levels of radioactivity formed the various public dose rates. Accumulated indoor radon and its products is the largest natural source of public exposure, accounting for approximately half the total effective dose from all sources [1]. Some human activities, such as manufacturing, mineral extraction, or water processing could technologically enhance the natural background by concentrating the radionuclides as ^{222}Rn, ^{226}Ra and ^{228}Ra [2, 3]. Water supplies are contributed a small part to the indoor radon exposure but can be the dominant source in areas where the radon content of groundwater is unusually high [4]. The hot spring and its surrounding area is an example of an elevated source of natural radiation. The water from the hot spring is used extensively for balneotherapy and in thermal baths. In thermal spas, the exposure to natural radiation occurs mainly from radon dissolved in water depending mostly on the concentration of uranium in the surrounding rock and on the circulation of water [3]. Radon could release to the indoors air, and together with its solid decay products could exposure the people. Although the radon exposure will be of much higher magnitude, the workers and users of the water for therapeutic purposes would exposure also from external gamma radiation [5]. In the field of radiation protection, there are adopted basic safety standards for protection against the dangers arising from exposure to ionizing radiation public, including in operation and use sources of natural radiation, such as thermal spas.

Bulgaria has many places, where the mineral water is used for rehabilitation and for thermal baths and spas. These places are planned in National Radon Action Plan for investigation. The observation was started in the Specialized Hospitals for Rehabilitation – National Complex EAD (SBR – NK EAD) during the 2019.

The objective of this study was to evaluate the indoor gamma dose rate in 17 inspected hospitals for rehabilitation where the radon measurements were made and to give a more comprehensive evaluation of total exposure dose.

MATERIALS AND METHOD

The survey was carried out in 17 buildings at 12 the Specialized Hospitals, which use mineral water for treatment located on the territory of the whole country from March 2019 to February 2020. The measured buildings were given a certain code: Narechenski Bani - building 1; Momin Prohod - buildings 2 and 3; Banya - building 4; Hisarya - building 5; Pavel Banya - buildings 6 and 7; Varshec - buildings 8 and 9; Bankya - building 10; Kyustendil - buildings 11 and 12; Sandanski - building 13; Velingrad - buildings 14 and 15 and Ovcha Mogila - building 16. The surveyed sites by settlements are shown on the map (Figure 1). In the hospitals, natural and remedial factors such as the climate, mineral water, curative mud in combination with instrumental physiotherapy and kinesitherapy are being applied. Most of the objects (11 units) of the department are located in mountainous areas, except for one in the Danube plain (the village of Ovcha Mogila).

The gamma dose rates were measured using the Geiger Muller counter type RADOS RDS-110 dosimeter. The dosimeter measuring range is from 0.05 µSv/h to 100 mSv/h in the energy range of 50 keV to 1.25 MeV. A professional AlphaGUARD PQ 2000 monitoring system and TERA system were used to perform direct radon measurements (Genitron, Germany).

The device is not affected by high humidity and vibration. Its range has a linear dependence from 2 to 2,000,000 Bq/m^3. DataEXPERT is used for graphical processing and presentation, evaluation and storage of the measured spectra. The values are registered for 10-min intervals over approximately a 12-24 hours period. The instrument is calibrated to reference in accredited.

AlphaE is based on a silicon diode diffusion chamber, has been developed by a cooperation of the Munich Helmholtz Centre and Saphymo GmbH, Germany. The detector provides a wide measurement range up to 10 MBq/m^3 and is sufficiently sensitive for reliable measurements below 100 Bq/m^3.

TERA System consist Central Unit and probes. The probe measures in autonomous and time continuous way. It processes results at given intervals (default 4-minute intervals) and it counts moving average of radon concentration value at an interval of 1 hour. It also counts moving average of radon concentration value at an interval of 24 hours. The probe saves time records of these radon concentration values within internal memory (typically at an interval of 1 hour).

The instruments are also equipped with sensors for temperature, relative humidity and atmospheric pressure. Measurement of indoor radon concentration was performed continuously at 41 selected locations in the hospitals. In 16 rooms the measurements were performed with AlphaGUARD, in 23 places with system TERA and in 2 premises with Alpha E.

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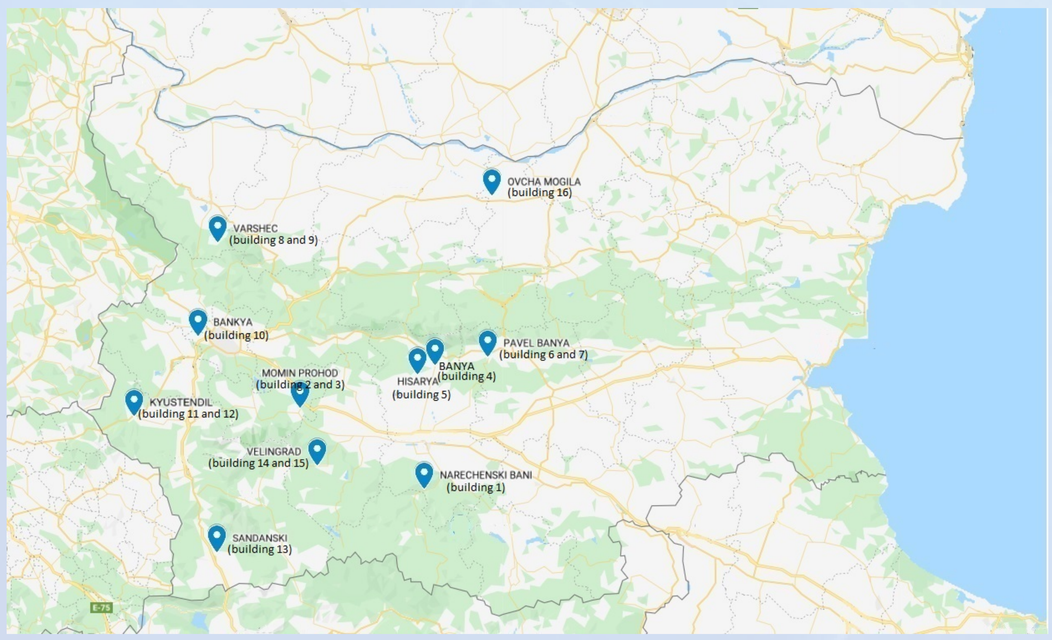

Figure 1. Measuring sites on the territory in Bulgaria

RESULTS AND DISCUSSION

Descriptive statistics (arithmetic mean - AM, standard deviation STD, geometric mean - GM) of the results for gamma dose rate in the premises of hospitals present in the Table 1. Gamma dose rate was measured in two types of premises in hospitals, where the water is used for procedure and others. Descriptive statistics of the results according types of premises is given in the Table 1.

Table 1. Descriptive statistics of gamma radiation dose rate in the premises of SBR-NK

Descriptive parameters	***Total premises***	***Other premises***	***Premises with water procedure***
Number of measured rooms	355	180	175
Arithmetic mean, µSv/h	0.158	0.144	0.150
Standard deviation	0.058	0.037	0.160
Median, µSv/h	0.160	0.150	0.040
Geometric mean	0.141	0.139	0.145
Minimum value, µSv/h	0.070	0.070	0.070
Maximum value, µSv/h	0.390	0.250	0.390
CV, %	37	26	27

The dose rate of gamma radiation is within the natural variations of the parameter in buildings. Usually the gamma dose rate in buildings is higher than the dimensions outside. The maximum value of the parameter was measured in the building of the Narechenski Bani - building 1 (0.390 µSv/h), followed by that in buildings 3 and 4 in village Banya, Karlovo municipality, Plovdiv district (0.29µSv/h). Such kind of values and higher were report in a study conducted in Portuguese thermal spas (0.645µSv/h) [11, 12, 13]. The variations of the gamma dose rate by buildings are presented in Figure 2. Regarding the variation of the gamma radiation dose rate data, it was found in the buildings with code 3, 4, 9 and 10 that the values obtained has no variation compare on the buildings 1 in Narechenski Bani and 2 in Momin Prohod. In those buildings, the high radon concentration was measured. The Krushkal Wallis Test, which was applied, shows a statistically significant difference between measurements in different buildings, $p<0.001$.

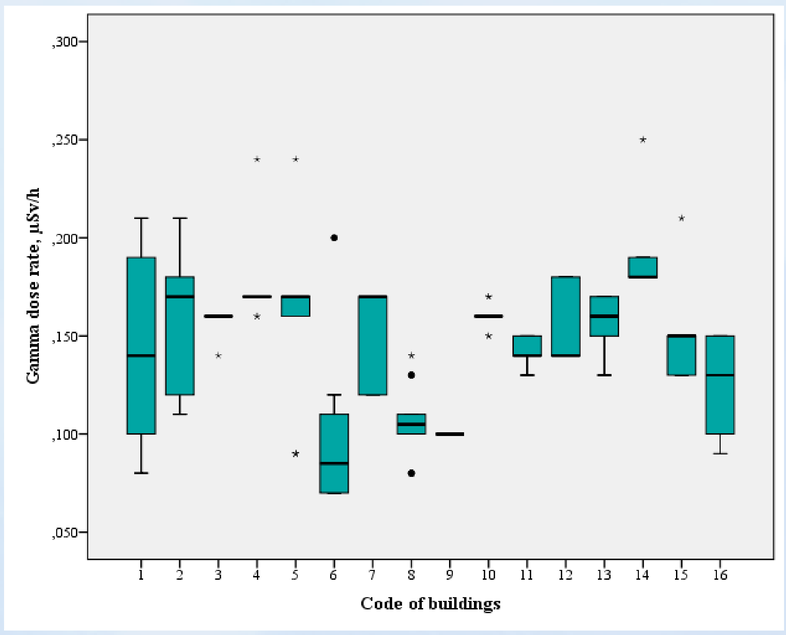

Figure 2. Variations of gamma dose rate by buildings

CONCLUSION

Gamma dose rate was measured in 17 buildings during the investigation of radon concentration in 12 hospitals for rehabilitation. There are not detected too high values of gamma dose rates in observed premises. Therefore, the contribution of the external dose to the exposure of people is negligible. The variation of the parameter is considered and the results are grouped by type of the procedure premises (therapy with water and without water). No statistically significant difference was found, indicating that dose rate is not affected by water use in therapy. The analysis of the relation between radon measured with passive detectors and gamma dose rate show the linear regression with low correlation coefficient only 2.5%. The investigation of gamma dose rate and radon with integral, direct measurement would be useful in observation of the building with public access for assessment of people exposure.

ACKNOWLEDGEMENTS

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