Radon in Montenegrin schools and kindergartens – preliminary results

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INTRODUCTION

After a national radon survey in dwellings, carried out in the period 2014-2016 [1, 2], radon research in Montenegro continued, in the period 2016-2018, with a national project of radon measurements in schools and kindergartens. The both projects were funded by the International Atomic Energy Agency and the Government of Montenegro.

In Montenegro there are 247 pre-university education institutions, which perform educational activities with children and students in 519 buildings − 376 primary school buildings, 51 high school buildings, 81 kindergarten buildings, 4 buildings of resource centers and 7 of student dormitories.

EXPERIMENTAL

Radon was measured during the academic year 2016/17 (September − June) in all 519 buildings of the pre-university education in Montenegro. Radosys detectors (RSFV type, with two CR-39 detector chips and sensitivity up to 80 MBqh/m^3), purchased from AGES - Austria, were placed in all classrooms, offices and playrooms on the ground floor, and in some rooms on the first floor. The total number of detectors was 4078 (3793 main and 285 control detectors). After 9-month exposure period, 11.4% of them were lost or damaged. The exposed detectors were returned to the AGES laboratory for etching and reading. Maximum detectable radon activity was 3600 Bq/m^3.

RESULTS

Average 9-month radon (^{222}Rn) activity concentrations were obtained for 3345 rooms in 507 educational buildings, whose characteristics are given in Table 1 and histogram in Fig. 1.

Table 1. Characteristics of radon activity concentrations in the rooms of educational buildings (9-month average).

Number of rooms	AM (Bq/m^3)	SD (Bq/m^3)	MAX (Bq/m^3)	MED (Bq/m^3)	GM (Bq/m^3)	GSD	C_{Rn} > 300 Bq/m^3	C_{Rn} > 1000 Bq/m^3
3345	243	345	>3600	129	142	1.09	23.3%	3.4%

AM – arithmetic mean; SD – standard deviation; MAX – the highest radon activity concentration; MED – median; GM – geometric mean; GSD – geometric standard deviation

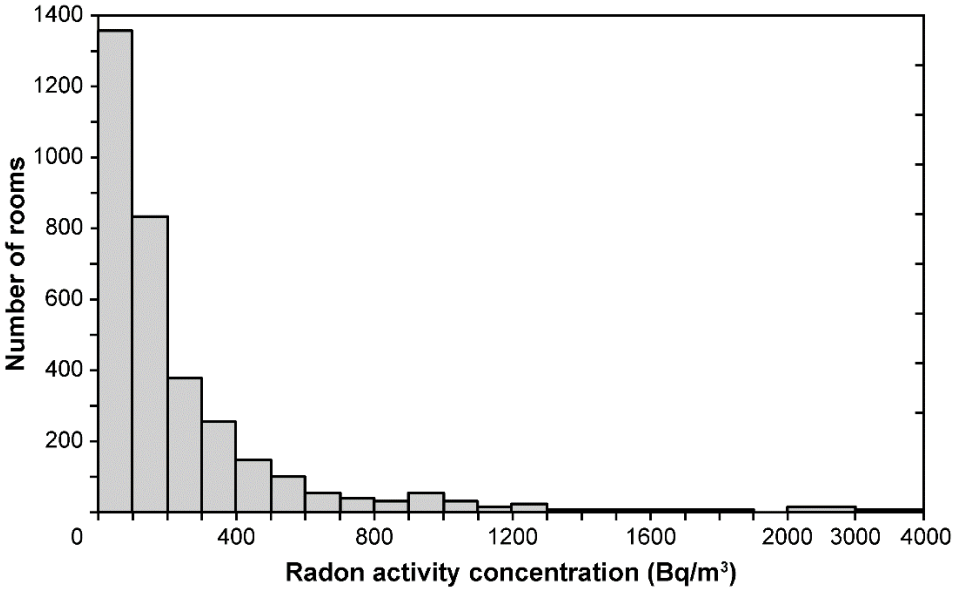

Fig. 1. Frequency distribution of radon concentrations in 3345 rooms in educational buildings.

Mean values of radon activity concentrations in 3345 rooms in educational buildings (AM, MED and GM) are more than twice higher than the corresponding values for 953 dwellings from national radon survey in Montenegro (Table 2) [1]. Average 9-month radon concentrations above 300 Bq/m^3 were found in 23.3% of all sampled rooms in educational institutions, while in 3.4% of all rooms they were above 1000 Bq/m^3 (Table 1). The corresponding percentages for Montenegrin homes (12-month average) are 7.9% and 0.6% (Table 2), respectively, which means 3 and 5 times lower.

Table 2. Characteristics of radon activity concentrations in Montenegrin dwellings (annual average).

Number of dwellings	AM (Bq/m^3)	SD (Bq/m^3)	MAX (Bq/m^3)	MED (Bq/m^3)	GM (Bq/m^3)	GSD	C_{Rn} > 300 Bq/m^3	C_{Rn} > 1000 Bq/m^3
953	110	182	2320	52	58.3	2.91	7.9%	0.6%

Even comparing to the „winter“ 6-month (October−April) averages in Montenegrin homes (Table 3) [2], all above mentioned values for radon concentrations in educational buildings are about twice higher.

Table 3. Characteristics of radon activity concentrations in Montenegrin dwellings during the „winter“ period (October−April).

Number of dwellings	AM (Bq/m^3)	SD (Bq/m^3)	MAX (Bq/m^3)	MED (Bq/m^3)	GM (Bq/m^3)	GSD	C_{Rn} > 300 Bq/m^3	C_{Rn} > 1000 Bq/m^3
953	140	265	3798	58	65.1	3.24	10.5%	1.5%

Radon activity concentrations above 300 Bq/m^3 were found in some rooms of 223 educational buildings, while in 48 of these buildings there were rooms with radon concentrations above 1000 Bq/m^3 (Fig. 2).

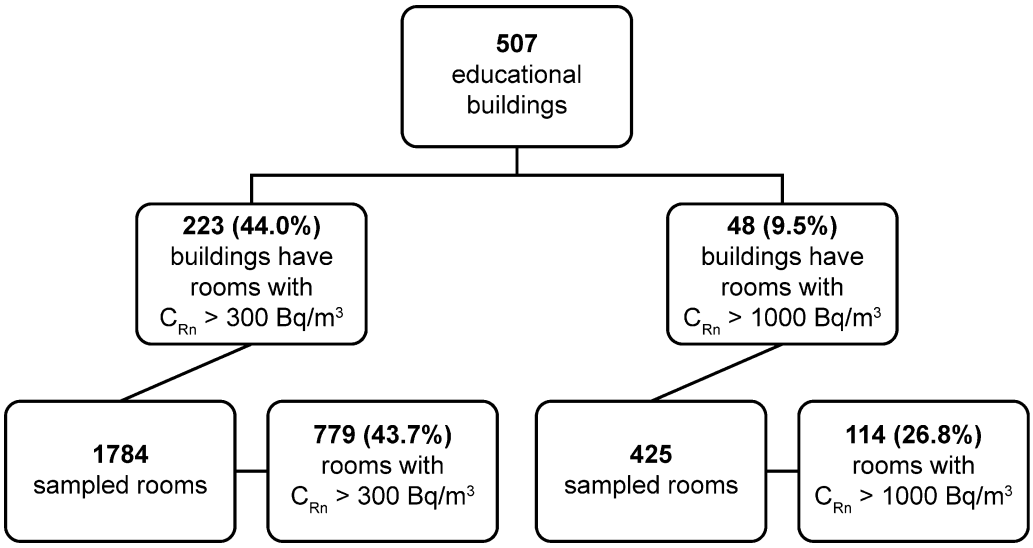

Fig. 2. Educational buildings with some rooms having radon concentrations above 300 Bq/m^3 and 1000 Bq/m^3.

CONCLUSION

Radon concentrations in educational institutions are, on average, significantly higher than in Montenegrin homes. This is probably due to the type of construction and age of educational buildings, which are mostly spacious low-rise structures and relatively old.

REFERENCES

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