RADON MEASUREMENTS IN BUILDINGS WITH HIGH RADON CONCENTRATIONS

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INTRODUCTION

Regarding radiation protection regulations in Slovenia [1] measurements of natural radiation in public institutions have to be done by accredited laboratory [2] to determine those with elevated radon concentrations. Ministry of Health started measurements of radon concentrations in schools and kindergartens twenty years ago. Almost all kindergartens and schools were included in monitoring [3]. In kindergartens and schools with very high radon concentrations measurements were repeated and remediate if needed.

Monitoring is continuing and in last five years 330 measurements of radon concentrations in public buildings by track each detectors were done. Radon concentrations in thirty five kindergartens and schools and twelve other public institutions were higher than proposed by regulations, 400 Bq/m^3 for schools and kindergartens and 1000 Bq/m^3 for other institutions. For those institutions special monitoring was carried out. We did thirty five measurements by electronic devices in the period of one week to determine radon and radon progeny concentrations. In case of high radon concentration in rooms also radon concentrations in cracks and water or electricity installations in the basement were measured. In special cases radon concentration in soil near building was measured. After measurements dose assessment was done and remediation actions proposed.

MATERIAL AND METHODS

Regarding the program determined by the Ministry of Health, measurements of radon and/or daughter concentrations on different locations were taking into account. First measurements were always performed by track each detectors. After the inspection of the building one or more detectors were placed in rooms for the period of at least one month. After the exposure period detectors were sending back for analysis. If radon concentration in room exceeded 400 Bq/m^3, the measurement in the same room was repeated next year. Radon and radon progeny concentrations were measured by electronic devices for the period of one week in the same room. Devices were put on place away from windows and doors.

If radon concentration measured by track each detector and radon and daughter concentrations measured by electronic devices were higher than regulated by law, measurements of radon concentrations in cracks, holes, installations, shafts etc. were performed. Tube was put in the crack or hole and isolated (Figure 1). Measuring period was from 5 to 30 minutes, depending from the device and strength of the source.

Figure 1. Radon in crack

Figure 2. Radon in soil

In last two years also measurements of radon concentration in soil nearby the building were implemented (Figure 2). The idea was to find possible connection between radon concentration in soil and in buildings. The stick was beat in the soil up to the depth of 80 cm and connected through tube with the device. Measuring period was from 5 to 30 minutes, depending from the device and strength of the source.

After the set of three year measurements possible remediation actions were suggested. Period of three years was used because more data are available and it is easily define rooms for remediation, while some buildings are very small and have only one room in the basement, some buildings have more rooms in the basement and there is no need to remediate complete basement.

Long-term radon concentrations in buildings were measured by passive track each detectors made by Gammadata, Sweden, using a detection film made of CR39/PADC plastic mounted inside a closed container. Container is manufactured from an electrically conducting material to avoid effects of static buildup. The closed container permits only radon gas to enter. Thoron gas can not enter due to its short half-life.

For continuous measurements of radon concentrations electronic devices RAD7 (Durridge, USA), System 30 (Scintrex, Canada) and Alphaguard (Germany) were used. For continuous measurements of radon progeny concentrations electronic devices System 30 (Scintrex, Canada), WLM 30 (Scintrex, Canada) and Doseman Pro (Sarad, Germany) were used. Measuring period for radon progeny concentration measurement was 30 minutes and for radon concentration measurement was one hour.

RESULTS

In the period from 2006 to 2010 three hundred thirty (330) measurements of radon concentrations in 101 schools and kindergartens and 26 other public institutions by track each detectors were done [4-7]. In schools and kindergartens 233 radon concentration measurements were done, in 81 cases radon concentrations were higher than 400 Bq/m^3. In other public institutions 97 radon concentration measurements were done and in 31 cases radon concentrations were higher than 1000 Bq/m^3. Regulated values were increased in thirty five kindergartens and schools and twelve other public institutions.

Measuring locations with elevated radon concentrations are presented in Figure 3, based on the map of the radon potential in soil measurements in Slovenia [8]. Locations of radon concentrations for kindergartens and schools are presented in black circles and locations for other public institutions are presented in pink circles. Equilibrium factor F determined by electronic devices ranged from 0.20 up to 0.82, mean value was 0.54, which is higher than 0.4, usually used for living conditions. The reason for higher equilibrium factor is that we did the major part of measurements in autumn and winter period.

In ten kindergartens or schools and four other institutions radon concentrations in cracks or holes were measured. In five of them also radon concentration in soil near the building was measured (Table 1, Figure 3). Radon concentrations in rooms are presented in black rectangles, radon concentrations in cracks are presented in blue rectangles and radon concentrations in soil are presented in pink rectangles.

Regarding the geology measuring locations are located in typical karst area (locations 1 and 2) with limestone and marl and in central and southern part of Slovenia (locations 3, 4, 6, 7 - 10) where the major geological basement forms marl and conglomerate.

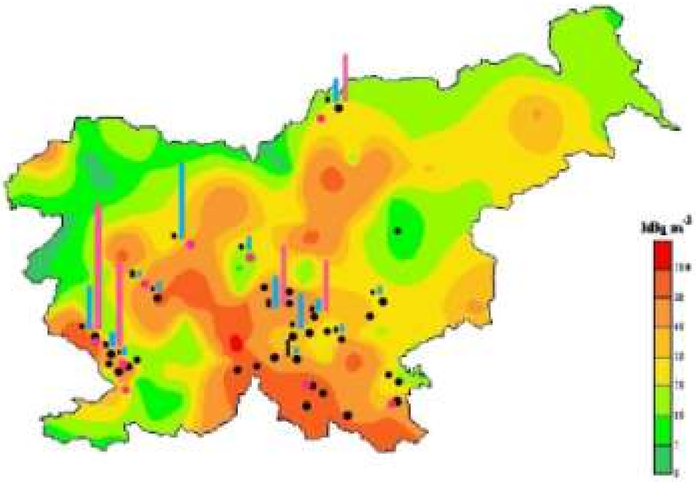

Figure 3. Measuring locations with elevated radon concentrations

There are another two interesting locations, OŠ Prevalje and MORS Todraž. OŠ Prevalje is located on the slag from steel industry in the vicinity, which is the main reason for high radon concentrations. MORS Todraž is located on the uranium mine tailings and increased radon concentrations were expected. We can see good correlation between radon concentrations in soil, cracks and rooms for the first five locations (Table 1).

Table 1. Radon concentrations in rooms, cracks or holes and in soil

		Radon concentration (Bq/m^3)		
No	Location	Room	Crack or hole	In soil
1	OŠ Komen	2030 ± 150	88000 ± 5000	226000 ± 15000
2	VVO Sežana	1300 ± 100	13000 ± 1000	150000 ± 8000
3	VVO Muljava	7430 ± 400	59000 ± 3000	101000 ± 7000
4	OŠ Prevole	2410 ± 160	11000 ± 1000	82000 ± 5000
5	OŠ Prevalje	2900 ± 180	40000 ± 2500	75000 ± 5000
6	OŠ Bučka	950 ± 90	3600 ± 300	
7	OŠ Dvor	530 ± 100	76600 ± 5000	
8	VVO Vavta vas	1800 ± 150	3600 ± 350	
9	OŠ Godovič	475 ± 50	6500 ± 600	
10	GŠ Ribnica	2350 ± 150	550 ± 100	
11	Hosp. Ljubljana	5520 ± 70	16000 ± 1500	
12	Hosp. Idrija	1190 ± 100	1000 ± 200	
14	Train st. Divača	1290 ± 120	5000 ± 500	
14	MORS Todraž	950 ± 90	168000 ± 10000	

From other locations we can eliminate OŠ Dvor and GŠ Ribnica. OŠ Dvor is the only new building from presented, all other building on the Table 1 are older. There is a strong source of radon under the basement, but the floor is good isolated and radon can not enter the building. GŠ Ribnica has a classroom in the cellar about two meters below the surface. The floor was remediated three years ago and we could not find any cracks in the floor or on the contacts floor-walls. Probably there are cracks in the walls.

CONCLUSION

Concerning results of radon concentration measurements we can conclude, (i) karst area and central southern part of Slovenia with limestone, marl and conglomerate as a main geological structure represent a strong radon source, (ii) old buildings with cracks in the floor make a great possibility to radon entering the rooms, and finally (iii) remediation actions are urgent in almost all old schools and kindergartens on the area presented.

REFERENCES

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