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RADON SURVEY IN HOSPITALS IN SLOVENIA

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INTRODUCTION

In Slovenia, several radon studies at workplaces have been carried out in last years, supported by the Ministry of Education, Science and Sport, and the Ministry of Health. After radon surveys in kindergartens [1], schools [2] and homes [3], within which about 2600 buildings were checked for radon and which provided the level of radon problem in the country, next investigations were focused on the workplaces with potentially higher radon risk. Hence, in the Postojna Cave permanent radon monitoring was introduced in 1995 [4] and comprehensive radon studies were performed: in 5 bigger spas during 1996-1998 [5], in major waterworks [6] and wine cellars in 2001, and in major Slovene hospitals in 2002.

This paper reports the results of radon study in 26 major Slovene hospitals, comprising radon concentrations in 201 rooms and dose estimates for 1025 persons working in these rooms.

MATERIAL AND METHODS

The list of hospitals, to be surveyed, was proposed by the Health Inspectorate of the Ministry of Health. Measurements were performed between September 15 and October 25, 2002, according to the following protocol:

- brief general information about radon, and description of measurements were sent to the hospital management
- number of measurements was defined according to the building characteristics and number of workers
- each hospital was visited; first, rooms for measurements were selected (of main concern were offices, laboratories and pharmacy rooms located in basements), then grab samples were collected using scintillation cells (JSI, Slovenia), and etched track detectors (KfK, Germany) placed in the same rooms

- after 1-month exposure, etched track detectors were collected by hospital management and sent to us, together with data on occupancy time of the examined rooms needed for dose calculations
- in hospitals located on radon risk areas, continuous 7-10 day radon and radon decay products concentration measurements were performed using EQF-3020 monitors (Sarad, Germany)
- data evaluation and dose calculations.

Short summary of the work:

- altogether 201 workplaces were surveyed; 116 located in basement, 84 in ground floor and 1 in a cave (speleotherapy)
- 207 measurements were done by scintillation cells in 186 rooms (results are reported as instantaneous radon concentrations)
- 215 etched track detectors were exposed in 198 rooms (17 duplicates) (results are reported as monthly radon concentrations)
- 2 rooms were surveyed by continuous monitors for 7 to 10 days
- annual effective doses were calculated for 1025 persons.

RESULTS

In 26 hospitals, 198 rooms were surveyed by etched track detectors exposed for 1 month (2 detectors were lost). The distribution of radon concentrations is presented in Table 1. In general, radon concentrations are satisfactory low, with only 7 rooms (3.6%) exceeding 400 Bqm^{-3}. The situation is similar to that in UK, where the percentage of hospitals exceeding 400 Bqm^{-3} ranged from 2 to 13% for different regions [7], and thus, elevated radon levels have seldom been found [8].

Table 1. Frequency distribution of monthly radon concentrations (C_{Rn})

Number of rooms	**Percentage of rooms** *(%)*	C_{Rn} *(Bqm^{-3})*
46	23.5	< 50
94	47.9	50 - 100
39	19.9	100 - 200
8	4.1	200 - 300
2	1.0	300 - 400
7	3.6	> 400

Figure 1 shows average values of instantaneous and monthly radon concentrations for each hospital; the hospitals of more than 400 Bqm^{-3} are

not included. The ratio of instantaneous versus monthly concentration is 0.62 Bqm^{-3}. Although instantaneous and monthly concentrations were obtained under different conditions and therefore represent different approach, instantaneous concentration may give a good orientation for the next step. Thus, on the basis of the instantaneous radon concentrations, further work plan and selection of places for continuous monitoring have been made. Higher radon levels have mainly been found in the same regions (01 Ljubljana, 04 Kranj and 07 Novo Mesto) as in our previous studies in kindergartens and schools [1,2,9].

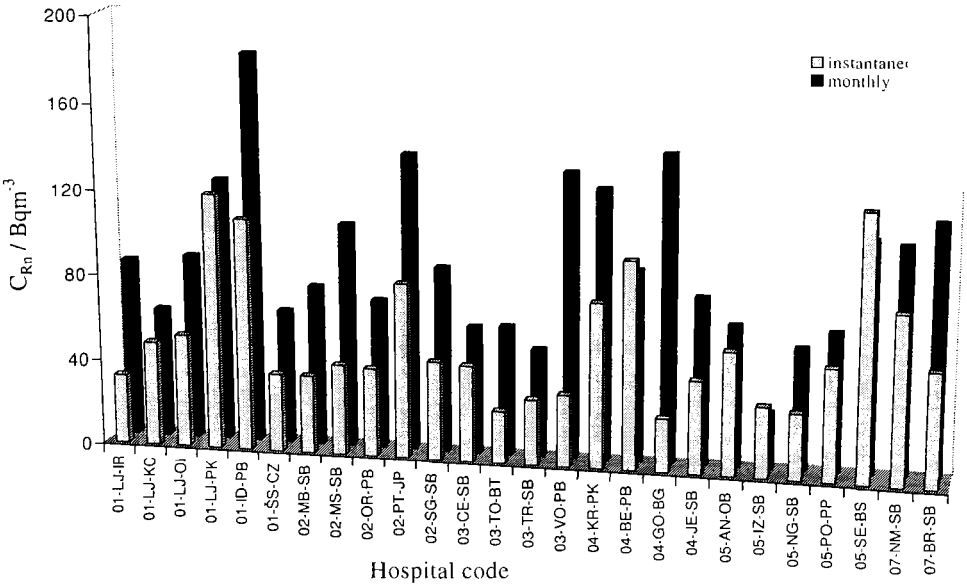

Figure 1. Average values of instantaneous and monthly radon concentrations

Annual effective doses of the personnel working in the rooms surveyed were calculated on the basis of the monthly radon concentrations, assumed as being the annual average, according to the Basic Safety Standards 115 [10]. In total, 1025 persons were taken into account. Because of low radon concentrations, annual effective doses were low, with only a few exceptions, and no concern is necessary. In Figure 2, for each hospital are shown average annual effective doses received by workers working in the rooms surveyed for radon. They range from 0.1 to 1.5 $mSva^{-1}$. The doses received by workers in rooms with radon concentration exceeding 400 Bqm^{-3} are not included in the figure.

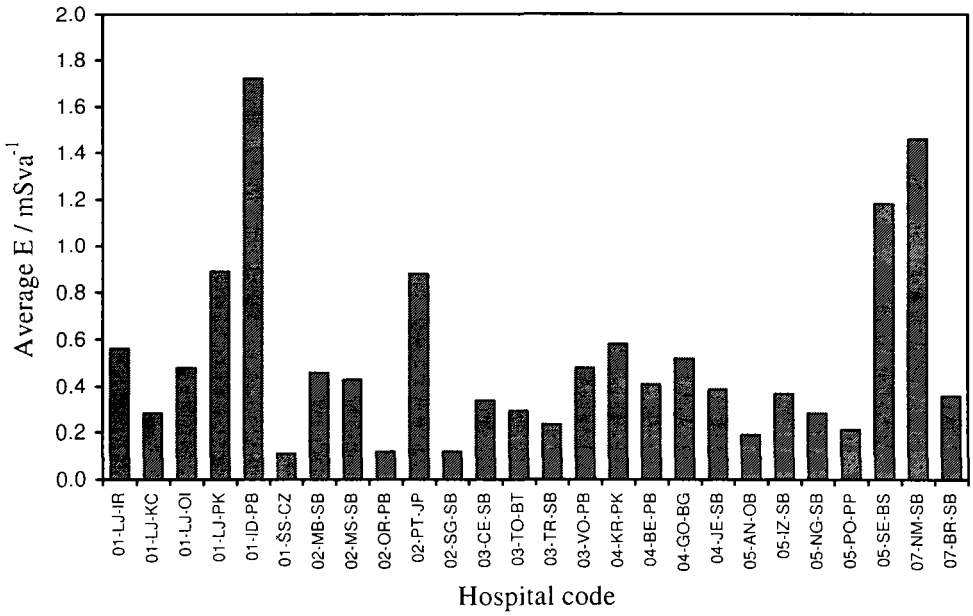

Figure 2. Average annual effective dose (E) of workers of each hospital

All 7 workplaces with average monthly radon concentration above 400 Bqm^{-3} are listed in Table 2, together with the number of persons, their annual exposure times, radon concentrations and annual effective doses. Five places with high radon levels have been found in ground floor and two in basements. Annual effective doses ranged from 2.1 to 7.3 mSv.

Table 2. Workplaces in hospitals exceeding 400 Bqm^{-3}: number of persons and their annual working time, monthly radon concentration (C_{Rn}) and annual effective doses (E) of workers (* number of hours of each person)

Hospital code	**Workplace**	**No. person / no. hours**	**C_{Rn}** *(Bqm^{-3})*	**E** *($mSva^{-1}$)*
01-LJ-PK	nursery	1 / 1098	600 ± 35	2.1
	maintenance shop	1 / 816	2800 ± 140	7.3
01-ID-PB	pharmacy – room 1	1 / 1590	1700 ± 85	7.1
	pharmacy – room 2	1 / 1590	1000 ± 50	5.1
02-MB-SB	office	1 / 1984	565 ± 35	3.6
05-SE-BS	speleotherapy	4 / 348*	3000 ± 150	3.3
07-NM-SB	pharmacy	7 / 1984*	1100 ± 55	6.8

To plan our further measures, special attention was paid to the workers, spending the majority of their working time in rooms with high radon concentrations. To start with, the maintenance room of the hospital coded 01-LJ-PK was additionally inspected for radon and its decay products in December 2002, using EQF-3020 monitor (Sarad, Germany). The results are shown in Figure 3. During the morning hours, the worker was commonly exposed to radon concentration of about 15 kBqm^{-3} and to radon decay products concentration of about 5 kBqm^{-3}. The Health Inspector has required urgent mitigation of the room. Meantime, the room is allowed to be attended only a limited time, preceded by intensive ventilation. In February 2003, in addition to the maintenance room, all workplaces in the building were surveyed for radon.

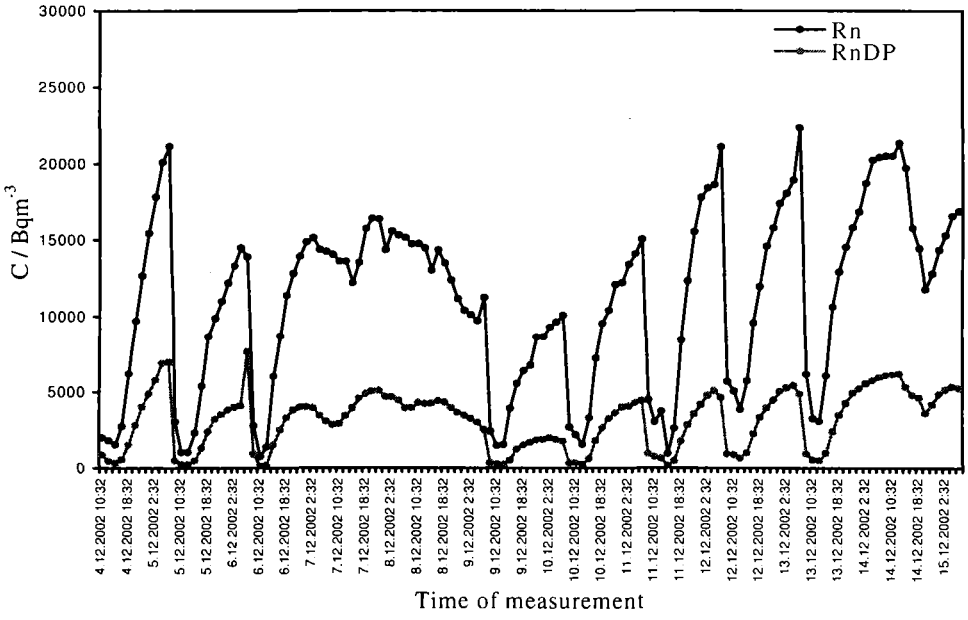

Figure 3. Continuous monitoring in the maintenance room at 01-LJ-PB

CONCLUSIONS

Radon survey in 201 rooms of 26 major hospitals in Slovenia revealed only 7 rooms in which monthly average radon concentration in the indoor air exceeded 400 Bqm^{-3}. Generally, concentrations in basement were on average for about 30% higher than in ground floor, although exceptionally

high values have also been found in the ground floor. For 966 persons (94.2%) of the total of 1025 persons working in the rooms surveyed, the annual effective dose, estimated according to the Basic Safety Standards was below 1 mSv, while for 59 it exceeded 1 mSv. In 7 rooms with more than 400 Bqm^{-3} in which 16 persons receive between 2.1 and 7.3 mSv per year radon monitoring is continued.

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