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## MEASUREMENTS OF <sup>222</sup>Rn ACTIVITY IN THE BUILDINGS OF THE OPOLE UNIVERSITY\*

### POMIARY AKTYWNOŚCI <sup>222</sup>Rn W BUDYNKACH UNIwersytetu OPolskiego

**Abstract:** The aims of this study were the analysis of the risk arising from the activity of <sup>222</sup>Rn in the buildings of the Opole University. The <sup>222</sup>Rn activity measurements were made using a portable spectrometer Alphaguard in five buildings of Opole University. The study was conducted at different levels/floors of the buildings (building on the Kominka street, the Main Building lobby, the Department of Physics (Wing of Main Building) the *Collegium Biotechnologicum* and *Collegium Chemicum*), and in classrooms in *Collegium Biotechnologicum*. The obtained results showed no potential health risk from radon contamination. However it was observed that humans staying on the lower floors are more vulnerable to radiation associated with <sup>222</sup>Rn decays, due to the physical properties of this element.

**Keywords:** <sup>222</sup>Rn, activity concentration, spectrometer, Alphaguard

Natural radionuclides gets into the human body mainly by ingestion, like uranium, thorium and its decays products as well as potassium <sup>40</sup>K. Radon and thoron is transported into body through the respiratory system [1].

Radon (<sup>222</sup>Rn) is a colorless, odorless, alpha radioactive noble gas produced during decays of <sup>226</sup>Ra [2]. It is the first gaseous element in <sup>238</sup>U decay series and because radium occurs ubiquitously in rocks, soils and sediments with broad range of concentrations it can be found almost everywhere [3, 4].

<sup>222</sup>Rn easily diffuse into air and gets into water solution during water-rock interactions with bedrock that contains <sup>226</sup>Ra [5].

The decay of radon is the largest source of ionizing radiation on Earth [6, 7]. According to the Polish Central Statistical Office radon accounted 36.4% of the annual effective dose of ionizing radiation per inhabitant in Poland in 2012 [8]. The activity concentration of radon and their progeny in buildings are largely influenced by factors such as topography, type of house construction, building materials. It penetrates into building from the soil through the cracks in the walls and floors and also with water (when the water is aerated) and natural gas [9, 10]. Even small pressure differences between the soil under the foundation and the interior space causes that the building draws radon from the ground [11].

The <sup>222</sup>Rn and its decay products are one of the major causes of lung cancer [12]. In the U.S. it is the second cause of this disease, after smoking cigarettes [13]. Radon itself is not a serious threat, however decay products such as polonium, bismuth and lead easily create a radioactive aerosol depositing on the mucous membranes of the respiratory system creating significant threat to the health [14]. The WHO recommends that the <sup>222</sup>Rn activity

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in closed rooms should not exceed  $200 \text{ Bq/m}^3$  [15] while The International Commission on Radiological Protection gives two reference values (for dwellings),  $400 \text{ Bq/m}^3$  for houses already built and  $200 \text{ Bq/m}^3$  for newly built homes [16].

The aims of this study were the analysis of the risk arising from the activity of  $^{222}\text{Rn}$  in the buildings of the Opole University.

### Material and methods

Measurements were performed at five buildings at the Opole University. These objects were on the Kominka street (K), the Main Building lobby (M), the Department of Physics (Wing of Main Building) (F) and, newer than the former, buildings of the *Collegium Biotechnologicum* (CB) and *Collegium Chemicum* (CH). The study was conducted at different floors and levels of the building and in an enclosed rooms in the *Collegium Biotechnologicum* that were located on the floor -1 (I), 1 (II), 3 (III). The analysis was carried out in the morning before lectures and in the afternoon, after didactical activities.

Determination of radon activity concentrations in air were performed using the portable spectrometer Alphaguard, located at about 1.5 m above the ground level.

### Results and discussion

The averaged results of measurements in each building are shown in Figure 1. The highest values were recorded in the building at Kominka street, which is a small building equipped with limited air exchange system. Buildings CB, M and CH were characterized by radon concentration at similar low levels. The comparable measurements results in these facilities were due to the efficient ventilation system in buildings.

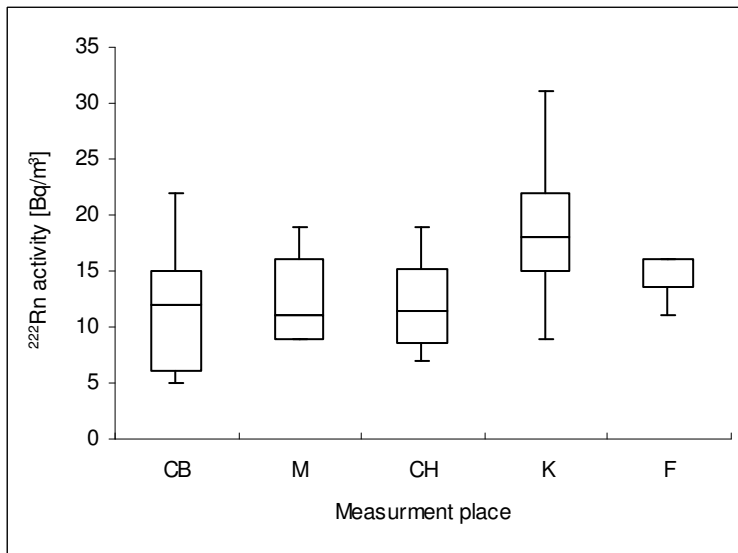


Fig. 1. The concentration of  $^{222}\text{Rn}$  in the particular measurement places

The results of measurements carried out in enclosed rooms are shown in Figure 2. The relatively high activity concentrations of  $^{222}\text{Rn}$  in the air were recorded on the lower floors, as a result of radon specific density bigger than that of air. At -1st floor these values ranged between 18 and 35  $\text{Bq}/\text{m}^3$  with the mean of 27  $\text{Bq}/\text{m}^3$ , while at 3rd floor the mean activity concentration of  $^{222}\text{Rn}$  in the air was 21  $\text{Bq}/\text{m}^3$ .

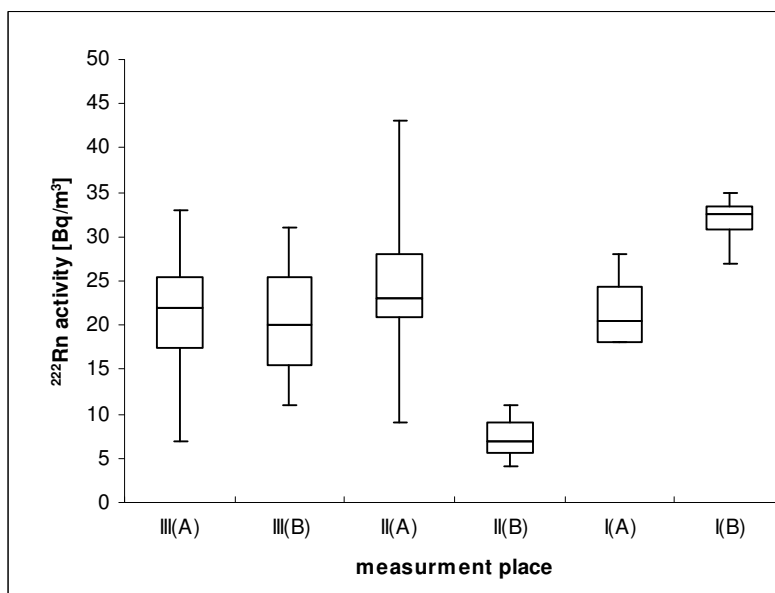


Fig. 2. The concentration of  $^{222}\text{Rn}$  in a confined spaces on selected floors CB. The results marked by A were obtained in the morning and the ones obtained in the afternoon by B

Measurements carried out in the afternoon in the hall III showed no differences between the measurements results which were performed in the morning. In the case of the room II there was a significant decrease in the concentration of radon in the air - from 24  $\text{Bq}/\text{m}^3$  recorded in the morning to 7  $\text{Bq}/\text{m}^3$  in the afternoon. The cause of such strong decrease was the mechanical ventilation of the room, which took place between measurements. In the I room there was a reverse process - the values of activity concentration increased from 22 to 32  $\text{Bq}/\text{m}^3$ .

Results obtained in the room I are linked with the daily changes of the  $^{222}\text{Rn}$  concentration and specific density, which causes accumulation of  $^{222}\text{Rn}$  in the lower places in the buildings.

Further analysis was carried out under three assumptions proposed by Moskal in 2012 [17]: (1) the hypothetical person stays in the room all day, (2) the person inhales 1 liter of air in one breath, (3) the lungs of this person weight 1 kg.

In order to determine the  $^{222}\text{Rn}$  radiation dose inhaled with the air Formula (1) and (2) were used:

$$R = \frac{2433 \cdot Er \cdot a \cdot c}{m} \quad (1)$$

$$E = R \cdot w_t \cdot w_r \quad (2)$$

where:  $R$  - the energy of the  $^{222}\text{Rn}$  decay in the ambient air over the year [J/kg];  $Er$  - the energy released during a single decay of  $^{222}\text{Rn}$  (5.5 MeV);  $a$  - the amount of  $^{222}\text{Rn}$  decays per second [ $\text{Bq}/\text{m}^3$ ];  $c$  - the conversion factor [eV/J];  $m$  - the mass of the lung [kg];  $E$  - radon radiation dose inhaled with the air [Sv];  $w_t$  - tissue weighting factor; for lung = 0.12;  $w_r$  - radiation weighting factor; for radiation  $\alpha = 20$ .

The calculated radiation doses are shown in Figure 3.

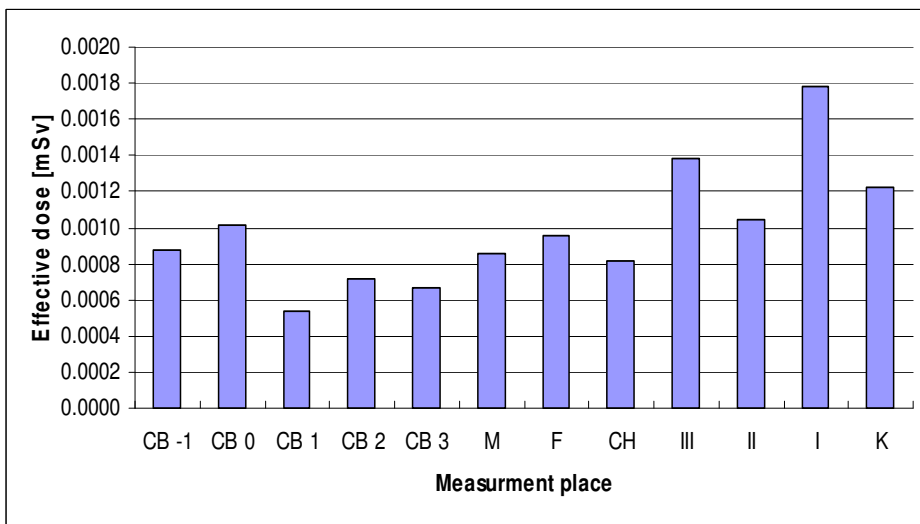


Fig. 3. The radiation dose from  $^{222}\text{Rn}$  inhaled with air

The lowest dose of radiation will be received by the person located on the first floor of the *Collegium Biotechnologicum*, while the highest one will be received by people staying in a room on floor -1. Contributions of calculated radiation doses from radon in annual effective dose of ionizing radiation are shown in Table 1.

Table 1

The radiation dose from inhaled radon and its percentage of the total annual dose of radiation

	<b>CB -1</b>	<b>CB 0</b>	<b>CB 1</b>	<b>CB 2</b>	<b>CB 3</b>
Dose [mSv]	0.0009	0.0010	0.0005	0.0007	0.0007
Percent of annual dose	0.03	0.03	0.02	0.02	0.02
	<b>M</b>		<b>F</b>	<b>CH</b>	<b>K</b>
Dose [mSv]	0.0009		0.0010	0.0008	0.0012
Percent of annual dose	0.03		0.03	0.02	0.04
	<b>III</b>		<b>II</b>	<b>I</b>	
Dose [mSv]	0.0014		0.0010	0.0018	
Percent of annual dose	0.04		0.03	0.05	

The doses received by people in closed rooms are much higher than those obtained in the residence halls and corridors of buildings. Radiation doses absorbed from inhaled  $^{222}\text{Rn}$  did not exceed 1% of the total annual effective dose of ionizing radiation for an inhabitant of Poland (3.3 mSv/year).

## Conclusions

Radon activity in the buildings changes with the intensity of air movements, similar conclusions gives Dołhańczuk-Śródka et al [18] and Obed et al [19]. The activity concentration of  $^{222}\text{Rn}$  in *Collegium Biotechnologicum* is much higher in an enclosed area and there was a small effect of the construction method on the concentration of radon in buildings. On the base of the research conducted in CB it can be concluded that people staying on the lower floors of the building are more susceptible to radiation associated with radon decay. The measurements have also shown a lack of potential risks to health from radon inhalation in buildings at the Opole University.

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## POMIARY AKTYWNOŚCI $^{222}\text{Rn}$ W BUDYNKACH UNIwersYTETU OPOLSKIEGO

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**Abstrakt:** Celem przeprowadzonych badań była analiza ryzyka związanego z aktywnością  $^{222}\text{Rn}$  w budynkach Uniwersytetu Opolskiego. Pomiarów aktywności  $^{222}\text{Rn}$  dokonano za pomocą przenośnego spektrometru Alphaguard w pięciu budynkach Uniwersytetu Opolskiego. Badania przeprowadzone na różnych poziomach budynków (*Collegium Biotechnologicum*, *Collegium Chemicum*, budynek przy ulicy Kominka, budynek Wydziału Fizyki oraz budynek główny), a także w klasach na terenie *Collegium Biotechnologicum*. Uzyskane wyniki wykazały brak potencjalnego zagrożenia zdrowia wynikającego z zanieczyszczeniem radonem. Jednocześnie zaobserwowano, że pracownicy przebywający na niższych piętrach są bardziej narażeni na promieniowanie związane z jego rozpadami, co wynika z właściwości fizycznych tego pierwiastka.

**Słowa kluczowe:**  $^{222}\text{Rn}$ , aktywność, spektrometr, Alphaguard