Proceedings of ECOpole

Vol. 4, No. 2 2010

Agnieszka DOŁHAŃCZUK-ŚRÓDKA[1], Zbigniew ZIEMBIK[1]
Tadeusz MAJCHERCZYK[1] and Maria WACŁAWEK[1]

INFLUENCE OF YEAR SEASON AND ROOM TYPE ON INDOOR ^{222}Rn ACTIVITY

WPŁYW PORY ROKU I RODZAJU POMIESZCZENIA NA AKTYWNOŚĆ ^{222}Rn

Abstract: In this work the monitoring of ^{222}Rn was carried out in selected houses, located in the district of Krapkowice (it lies to the south of Opole, PL). The passive detectors LR-115 type II films (Kodak, Pathe) have been used in this survey. The measurements were carried out in single-storied residential houses in two time periods: from the end of June to the end of September and from the beginning of November to the beginning of February. The detectors were placed in kitchens, bathrooms and cellars. Our results showed that in all of the rooms examined the Rn activity did not exceed 149 kBq/m^3. This value is lower than the European Commission recommendations for existing buildings (Commission recommendation 2001/928/Euratom). Considering all of room types investigated, no statistically significant differences between ^{222}Rn activities in summer and in winter were asserted. But in cellars higher than in other rooms ^{222}Rn activities were confirmed, independently on the season of year. In most of the houses activities of ^{222}Rn were similar, though in two of them they were significantly higher than in the others.

Keywords: indoor radioactivity, ^{222}Rn, seasonal changes

Radon radioisotopes and their decay products are one of the most important contributors to human radioactive exposure from natural sources. Gaseous Rn can penetrate into living organism, especially while respiration. Remaining in close contact with tissues the radioisotopes of Rn may cause dangerous damages in human cells structure, leading to appearance of serious diseases. Because of its intermediate period of half-life (3.8 days) the main attention is usually paid to ^{222}Rn. In 2009 an average Polish citizen received a dose of 3.19 mSv, in which the contribution of radon was 37.6% [1].

The concentrations activity of radon and their progeny are largely influenced by factors such as topography, type of house construction, building materials, temperature, pressure, humidity, ventilation, wind speed, and even the life style of the house residents [1-9].

In this work the monitoring of ^{222}Rn was carried out in selected houses, located in the district of Krapkowice (it lies to the south of Opole, PL). The passive detectors LR-115 type II films (Kodak, Pathe) have been used in this survey. The measurements were carried out in single-storied residential houses in two time periods: from the end of June to the end of September and from the beginning of November to the beginning of February. The detectors were placed in kitchens, bathrooms and cellars.

Materials and methods

In the present investigations the indoor ^{222}Rn concentration was studied in nine houses. All of them were located in the district of Krapkowice. They were similar to each other and were more than 50 years old. Each of them was built of clay-bricks and has a cellar. They

[1] Independent Chair of Biotechnology and Molecular Biology, Opole University, ul. kard. B. Kominka 4, 45-032 Opole, tel. 77 401 60 46, email: agna@uni.opole.pl

were single-family houses with kitchens, living-rooms and bathrooms. The largest distance between buildings does not exceed 1 km.

In the present investigations, a passive technique was employed using Solid State Nuclear Track Detectors (SSNTDs) which are sensitive to alpha particles in the energy range of the particle emitted by radon. SSNTDs also have the advantage of being mostly unaffected by humidity, low temperatures, moderate heating and light.

LR-115 Type 2 (12 m cellulose nitrate on 100 m polyester base) plastic track detectors each with a size of about (1.5 cm × 2 cm) were used.

The measurements were carried out in one-storey residential houses in two time periods: from the end of June to the end of September and from the beginning of November to the beginning of February. The detectors were placed in kitchens, bathrooms and cellars.

After 3 months of exposure, the detectors were subjected to chemical processing in a 10 M analytical grade sodium hydroxide solution at (60 ±1)°C, for 90 min, in a constant temperature water bath to enlarge the latent tracks produced by alpha particles from the radon decay. After the etching, the detectors were washed for 30 min with running cold water, then with distilled water and finally with a 50% water/alcohol solution. After a few minutes of drying in air, the detectors were ready for track counting. The etched tracks were counted using an optical microscope at 40 × magnification, observing 0.059 cm^2 of detector surface. The number of tracks was counted for each plate in 30 microscope fields of view. The ^{222}Rn concentration a [Bq/m^3] is calculated by the following formula:

$$a = (Q/t) \times 13.8 \qquad (1)$$

where: Q - number of tracks per cm^2 plate, t - exposure time in days, 13.8 - empirical coefficient in $Bq \cdot d \cdot cm^2/m^3$, calculated from data published by Srivastava [10].

Errors σ in the track densities were calculated by multiplying the track density by $(1/N)^{1/2}$, where N is the total number of tracks counted in a sample [11]. In our measurements the background radiation from other than ^{222}Rn was not taken into account. However, the considerable similarity between the buildings investigated and the relatively low surface area on which they were located may indicate that the variability in track densities is a result of differences in the utilization of the rooms.

Results and discussion

For statistical computations the R language [12] was used. R is a free software environment for statistical computing and graphics. The capabilities of R can be extended through packages, which allow specialized statistical techniques, graphical devices, programming interfaces and import/export capabilities to many external data formats.

Table 1

Statistical parameters computed from the ^{222}Rn activities

Min.	q_l	ME	q_u	max	a_m	SD
[Bq/m^3]						
8	27	49	57	78	148	36

It was expected that, in the winter season, the ^{222}Rn activity would be highest in the rooms, due to limited ventilation. In Table 1 the values of minimum min., lower quartile q_l, median ME, upper quartile q_u, maximum max, arithmetic mean a_m and standard deviation

SD of ^{222}Rn activity computed from the data are shown. The calculated σ error was high for low activities, reaching 100% for single tracks observed on a detector surface area. For the highest activities σ was 14%.

The differences between ^{222}Rn activities in different room types can be assessed by comparing the boxplots shown in Figure 1. In these plots the lower base of the rectangle is a lower quartile, the upper base is an upper quartile and a horizontal line dividing the rectangle represents a median. Whiskers are formed by connecting the formed box with short horizontal lines drawn for quantile q = 0.95 (upper whisker) and quantile 0.05 (lower whisker). The points marked by a circle are located more than 1.5 times of interquartile range from the median. The values of ^{222}Rn activities were similar in all of the rooms investigated. Median values are comparable and no significant differences in their values were observed. The ^{222}Rn activities considerably exceeded the common range only in one kitchen and two living-rooms.

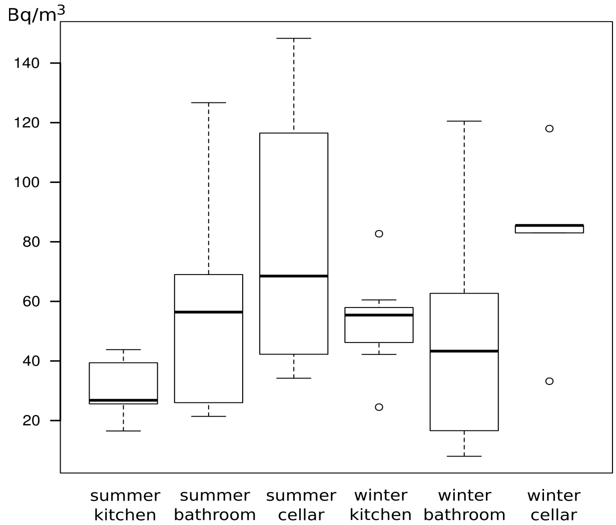

Fig. 1. The differences between ^{222}Rn activities in different room types

All of the measurement results were lower than the limits of ^{222}Rn activity given in the recommendations. The International Commission on Radiological Protection gives two reference values (for dwellings), above which action must be taken to reduce radon concentrations: 400 Bq/m^3 - for houses already built and 200 Bq/m^3 for newly built homes [13]. A recent recommendation of International Commission on Radiological Protection for the reference level for radon gas in dwellings is 300 Bq/m^3 [14].

Conclusions

The highest ^{222}Rn activity did not exceed the recommended value. Distribution of traces numbers was not normal (gaussian). After logarithmic data transformation they became normally distributed, what was confirmed by results of Anderson-Darling, Lilliefors and Cramer-von Mises tests. One-way ANOVA showed not statistically significant differences in means of ^{222}Rn activities measured in summer and in winter. The same statistical method indicated significantly higher ^{222}Rn concentration in cellars, regardless of season of year.

The rooms investigated do not need actions reducing ^{222}Rn concentration in air.

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WPŁYW PORY ROKU I RODZAJU POMIESZCZENIA NA AKTYWNOŚĆ ^{222}Rn

Samodzielna Katedra Biotechnologii i Biologii Molekularnej, Uniwersytet Opolski

Abstrakt: Przedstawiono wyniki badań aktywności ^{222}Rn przeprowadzonych w wybranych budynkach znajdujących się na terenie powiatu krapkowickiego (na południe od Opola, PL). W badaniach wykorzystano pasywne detektory typu LR-115 (Kodak, Pathe). Pomiary przeprowadzono w jednorodzinnych domach mieszkalnych w dwóch okresach: od końca czerwca do końca września i od początku listopada do początku lutego. Detektory zostały umieszczone w kuchniach, łazienkach i piwnicach. Otrzymane wyniki wskazują, że w żadnym z pomieszczeń aktywność ^{222}Rn nie przekroczyła 149 kBq/m^3. Wartość ta jest niższa od zalecanej przez Komisję Europejską dla budynków istniejących (zalecenie Komisji 2001/928/Euratom). Biorąc pod uwagę wszystkie rodzaje badanych pomieszczeń, nie stwierdzono statystycznie istotnych różnic między aktywnością ^{222}Rn w okresie letnim i zimowym. W piwnicach stwierdzono wyższą niż w innych pomieszczeniach aktywność ^{222}Rn, niezależnie od pory roku. W większości domów aktywności ^{222}Rn były podobne, choć w dwóch z nich były one znacząco większe niż w pozostałych.

Słowa kluczowe: radioaktywność w pomieszczeniach zamkniętych, ^{222}Rn, zmiany sezonowe