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HOURLY MEASUREMENT METHOD FOR RADON PROGENY VOLUMETRIC ACTIVITY IN AIR

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Abstract. A method of radon progeny volumetric activity hourly measurement in air was created. A radiometer, which measures the activity of a filter band through which air is sucked, was installed in a hermetic metal frame. Radiometer data was recorded and sent to the computer. The time of suction and the time for the filter band to turn were programmed by electronic stopwatches. This created an opportunity to estimate the hours for self-contained measurement and to leave the device in a room for any time. This hourly measurement method measured radon and radon progeny volumetric activity and evaluated its change and dependency on meteorological parameters. The radon progeny volumetric activity value varies from 62 Bq/m^3 (in the cellar) to 27 Bq/m^3 (on the second floor) in the ventilated air, and from 273 Bq/m^3 (in the cellar) to 149 Bq/m^3 (on the second floor) in the unaired room. The values in the ventilated air and in the unaired rooms differ approximately 4–5 times. It is also determined that volumetric activity depends on wind intensity, temperature and humidity.

Keywords: radon, radon progeny, volumetric activity, alpha particles, measurement method.

1. Introduction

Radon gathers in the room and decays into metal ions, i e decay products. Radon itself (i e inert gas) is not as detrimental to health as its progenies (i e alpha emitters): ^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Po [1, 2]. Their ionizing power is 20 times larger than the ionizing power of beta rays and gamma rays [3]. These non-gaseous radon progenies, which settle on airways, are the main reason for exposure. Radioactive alpha particles are characterized by low permeability but high ionizing power. Human derma epithelium protects humans from external alpha particle effect. Derma epithelium stops non-penetrating alpha particles; however, these particles become health hazards when they pass into human organism and can damage bronchia epithelium and lung tissue [4, 5].

The problem of radon progenies in air is very serious as after inhaling air with radon progenies they settle on the airway. These alpha particles then damage tissues. The risk then appears that organism can create a malformed cell which can be the beginning of cancerous disease [6, 7]. This substance does not have a threshold dose, i e even small amount of radon progenies can be detrimental to health [8]. There is always a possibility that even small amount of radon progenies in the air can cause alpha decay and damage cells. Larger amount of radon progenies in the air definitely causes more risk to human health.

Radon is inert gas; therefore, it easily passes into the rooms through the gaps in the ground where the house stands. Radon can also pass into the house through building material and even water [9, 10]. As a result, large amounts of radon settle in the air and after its decay dangerous radon progeny volumetric activity appears, especially in the unaired room. The larger the amount of aerosol particles in the air, the larger part of radon progeny settles on these particles [11, 12]. Thus, when comparing rooms with the same amount of radon in the air, there will be more radon progenies in the rooms with a larger aerosol concentration [13].

The value of radon progeny volumetric activity depends on ventilation intensity, radon exhalation from the ground, building materials, room tightness and other objects in a particular location [14, 15].

Radon and radon progenies are one of the most important sources of ionizing radiation. Other sources (either natural or created by humans) for ionizing radiation are many times smaller [16, 17]. Thus, there is a worldwide interest in radon and radon progenies; however, the problem of radon and its progenies has not yet been solved. This is a motivation for a more thorough and larger-scale research. In order to measure the factors related to radon progeny volumetric activity in the air, special measurement methods and equipment to analyse volumetric activity, its variation and dependence on environmental parameters have to be created and improved.

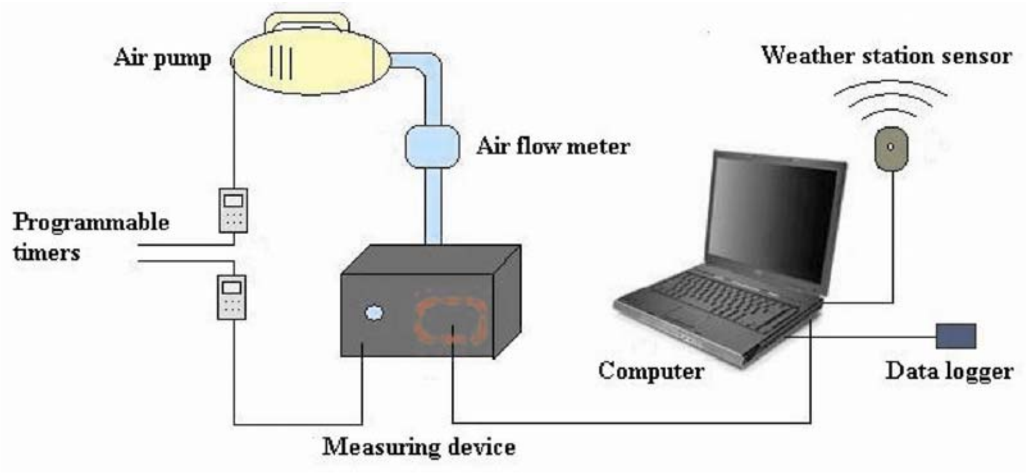

Fig 1. Scheme of radon progeny volumetric activity hourly measurement in air

2. Methodology of investigation

In order to examine radon progeny volumetric activity a special hourly measurement method and equipment was created. A radiometer, put in a hermetic metal frame with a filter through which air is sucked, was attached to the computer (Fig 1).

The radiometer is fixed in the metal frame (340×230×220 mm) so that the filter band through which air is sucked moves beside radiometer measurement window (Fig 2).

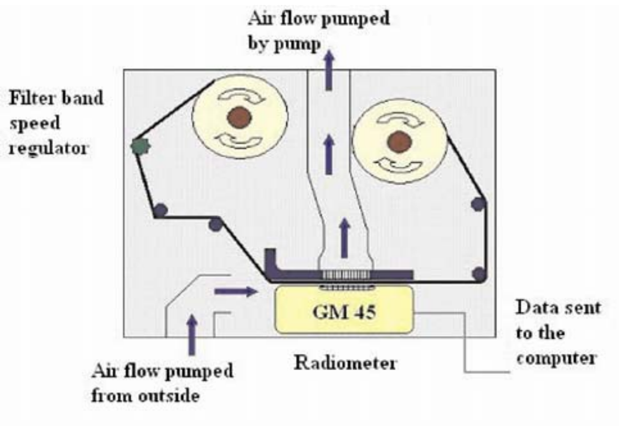

Fig 2. Measurement control equipment

The metal frame has two holes. One of them is used for air suction. A pump is attached to the other hole. The width of the air suction hole is 20 mm. The speed of filter band translation is controlled by a special regulator. During the experiment the speed is usually 5mm/min. Air is sucked through the part of filter band which is between a suction channel and a radiometer. The band is stopped at the time of measurement. When the measurement is finished, the band is overwound so that the "clean" (i e without radon progenies) part of the filter appears above the radiometer and the air suction channel of the pump. The data of the radiometer are constantly being sent to the computer where they are then kept. The time of suction and the time when the filter band is turned is programmed with the help of electronic stopwatches which are switched on/off according to the necessary programme.

Equipment operation can be programmed in various ways: the suction or measurement time can be changed or the measurement can be made after a certain period of time after the suction (e g when there is a need for ^{218}Po to be fully decayed).

Normally air suctions were carried out for a 5-minute period each hour. After the suction the displayed part of the filter was being measured for 40 minutes. Then during 15 minutes period the device overwinded the band. The band usually overwinds at 5mm/s speed rate. After 15 minutes the band is already overwound and the new part of the filter is ready to be displayed. Air is then being sucked for 5 minutes, ionizing radiation is being measured, etc.

The image of measurement equipment is shown in Fig 3.

Fig 3. Scheme of measuring equipment

The electronic stopwatches TS-ED1 have 24 programming functions. These stopwatches can be programmed to work any day of the week. They can also be programmed to switch on/off at any hour. These stopwatches programme the appropriate time when the pump should work and when the band should be overwound. This creates an opportunity for the continuous and uninterrupted work of the equipment.

The air pump (power – 800 W) sucks air through the filter. Air suction rate is 40 L/min and it is controlled with the air flow meter. Air in the device can change in about 25 seconds. The radiation of the particles, settled on the filter, is measured by the radiometer GM-45.

The nemaline filter band "Fiberglaz" was used in the experiment. The band is 50 mm in width. The efficiency of band filter, measured using the method of in series connected filters, is 96 %.

The mechanism which overwinds the band is put in the metal frame. The band is turned by the engine programmed with the electronic stopwatch.

GM-45 is a small, light and very sensitive ionizing radiation detector. This detector is used by attaching it to the stationary computer or laptop with MS Windows operating system. GM-45 has Geiger counter radiation detector sensitive to alpha, beta and gamma radiations. The diameter of isinglass is 42 mm. This device needs very little energy. The energy comes through the cable of the computer; therefore, no additional current source is needed. The radiometer GM-45 has RAD (Radiation Acquisition and Display) program which helps to transfer data to MS Excel where they are then processed. The measurement data are automatically recorded and saved.

GM-45 can be used for various purposes: to observe the level of ionizing radiation, to detect the increase of ionizing radiation because of radon, to detect the increase of ionizing radiation because of human factors (incidents in nuclear power-stations, atomic bomb tests), to detect radioactive substances.

Indoor amounts of radon and radon progenies depend on many environmental parameters. Thus, other environmental parameter measurement devices were added to the set of devices for the method of radon progeny volumetric activity hourly measurement.

Indoor and outdoor environmental parameters are measured with the help of the Professional Remote Weather Station WS7001. This station measures environmental parameters which are then sent to the computer on radio waves. The information is automatically recorded to the computer (with date and time of the record). The equipment of the weather station includes an indoor sensor (it measures indoor temperature, pressure and humidity), outdoor sensor (it measures outdoor temperature, pressure and humidity), wind direction and speed meter, rainfall meter, and a special monitor which shows all the data of the weather station (Fig 4). The sensors have to be no more than a hundred meters far from the computer to which the information is sent. The information is sent on radio waves, at the 433 MHz frequency.

The Remote Weather Station always shows exact date and time as the signal comes on radio waves from Frankfurt antenna (DCF-77). With the help of sensors the Weather Station has an opportunity to measure indoor and outdoor parameters at the same time:

- Indoor temperature. Range from 0 °C to +70 °C, resolution 0,1 °C, accuracy ± 1 °C;
- Indoor humidity. Range from 20 % to 95 %, resolution 1 %, accuracy ± 8 %;
- Outdoor temperature. Range from –30 °C to +70 °C, resolution 0,1 °C, accuracy ±1 °C;
- Outdoor humidity. Range from 20 % to 95 %, resolution 1 %;
- Atmospheric pressure. Range for absolute pressure: from 800 hPa to 1100 hPa, resolution 1 hPa, accuracy ± 1 hPa;
- Wind speed and wind direction. Range from 0 to 200 km/h;
- Rain. Range from 0 to 3999 mm, resolution 0,5 mm, accuracy 0,5 mm.

The Weather Station also measures dew point, presents weather forecasts and has alarm function.

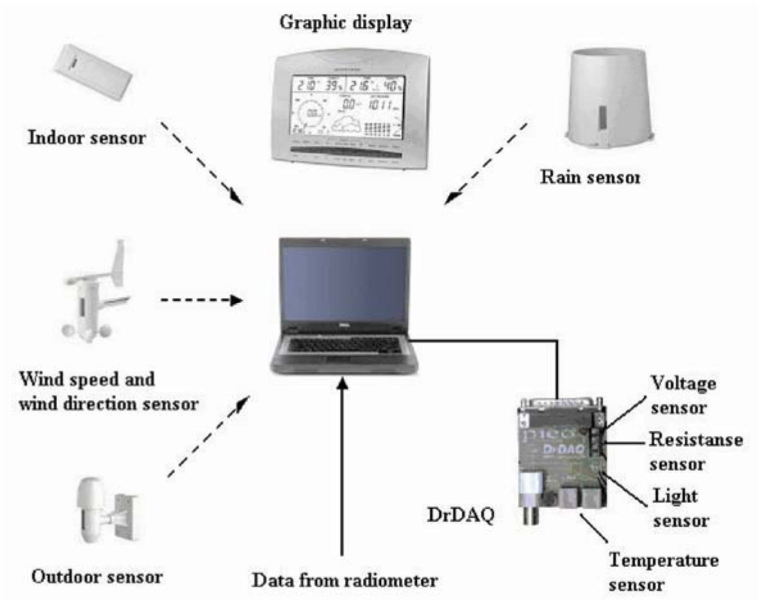

Fig 4. System of the Professional Remote Weather Station and Multifunctional Data logger DrDAQ

The multifunctional data accumulator DrDAQ is used to measure indoor parameter changes and to perform laboratory experiments (Fig 4). This accumulator has sensors for light, sound, temperature and humidity. Moreover, it measures voltage and resistance and has a receptacle for a standard pH electrode. DrDAQ is attached to the computer with MS Windows operating system. This device needs very little energy which comes through the cable of the computer. Sensitive DrDAQ temperature sensors can measure the value of ventilation. The temperature is measured with 2 sensitive temperature sensors, one of which is fixed outdoors, while the other is left indoors. During the experiment these sensors help to measure temperature differences. The change and differences of temperature help to evaluate ventilation rate and the impact of ventilation on radon progeny concentration

All the information from the radiometer and the Weather Station are automatically sent and recorded to the computer. The computer must have MS Windows operating system and USB and RS outputs to attach the radiometer and the Weather Station.

The possible error of radon progeny measurement method was evaluated. This error depends on the changes of filter band efficiency, windblast speed, display time and progeny concentration in air. The estimated error was no more than 6 %.

The change of the amount of indoor radon progenies was measured with a special measurement model by in-system units (Bq/m^3). This measurement model used an algorithm created from the equations of radioactive decay law and equilibrium conditions [18].

The method of radon progeny hourly measurement using a twin-chamber device is described in [19]. A two-filter detector is used for alpha spectroscopy two pomps and a computer are installed in this device. The data processor registers the activity of the alpha filter incessantly. Though this device lets to register the volumetric activity of the radon progeny incessantly, its complex sample change system makes the work difficult. A better measurement method is described in [20]. The filter band is overwinded automatically in it, and an alpha spectrometer is used for measurements. In [21] a two-filter method is described in which the measurement principle of radon progeny is similar to the above mentioned method. Alpha particles are registered by a semiconductor silicon detector. This method is easy to use for research because it is not enough computerized and automatic. However, work with this device requires more time.

3. Measurement results

This measurement method was approved by experimental indoor investigation of radon progenies. The amount of progenies was measured in 1–2 floor individual stone houses which are the most popular houses in Lithuania.

Table 1 shows the average values of volumetric activitys in 1–2 floor stone houses. The volumetric activitys was measured in ventilated houses and when houses were kept closed for a few days.

The results show the impact of the ground as a source for radon. This shows the dependency of radon progeny volumetric activity on the floor where the measurement is made.

The results show that the amount of radon progenies in closed houses is 4–5 times larger than the amount of radon progenies in ventilated houses. The amount of radon progenies enlarges when there are no people in the house, when the house is closed and the ventilation intensity is rather low. Ventilation rate is usually lower at night when people sleep, and the doors and windows are closed. Ventilation rate is higher in the morning, daytime and evening when the doors and windows are opened frequently.

If the doors of the rooms to which radon passes through the ground are hermetic, radon and radon progeny concentration in the other rooms is lower when these doors are closed. Furthermore, if the house is hermetic enough, the amount of radon changes due to wind destination and speed.

Fig 5 shows the differences of separate isotope volumetric activity.

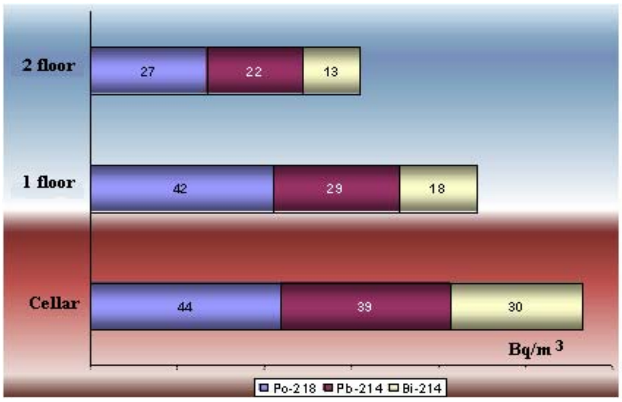

Fig 5. Amount of radon and radon progenies on separate floors

Table 1. Radon progeny volumetric activity in individual houses

Accommodation	Average volumetric activity, Bq·m^{-3}		Volumetric activity ratio of ventilated and non-ventilated accommodations
	Ventilated accommodations	Non-ventilated accommodations	
Cellar	62 ± 6	273 ± 28	4,4
1 floor	39 ± 4	196 ± 20	5,0
2 floor	27 ± 4	149 ± 14	5,5
Volumetric activity ratio between the building floors			
Cellar – 1 floor	1,6	1,4	
1 floor – 2 floor	1,4	1,3	
Cellar – 2 floor	2,3	1,9	

Fig 6 presents the change of radon progenies during 24 hours in a stone house cellar. This change is shown in the computer monitor with the use of RAD program.

The results are presented in conditional measures, i e impulses per minute (CPM). In this case the measurement method with air suctions every hour was chosen. The diagram clearly shows that the highest values were measured early in the morning (6–7 am). The lowest values of volumetric activity were measured at about 1 pm.

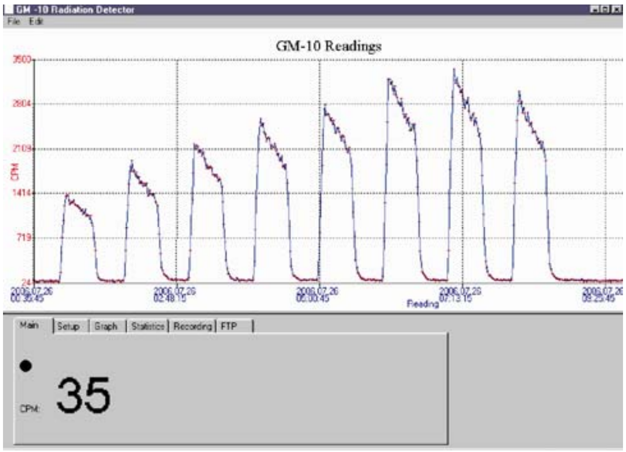

Fig 6. Indoor radon progeny volumetric activity in air during 24 hours

The main factor for such changes is the 24-hour shift of radon volumetric activity in the lower layer of the atmosphere, when due to the cloudless anticyclone weather a great difference between day and night concentrations appears (Fig 7).

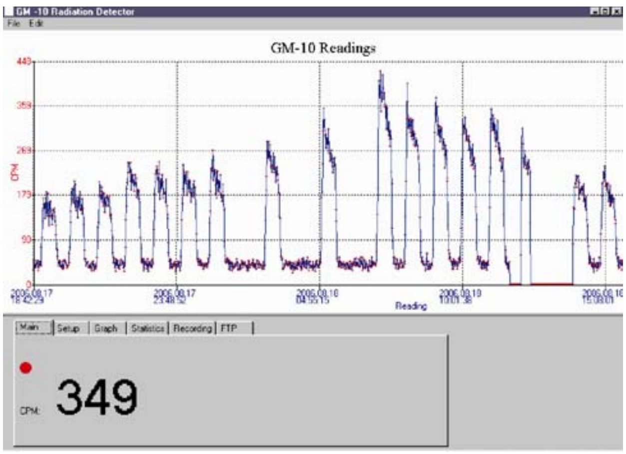

Fig 7. Outdoor radon progeny volumetric activity in air during 24 hours

The shift of radon progeny volumetric activity depends on the day and night air turbulence intensity and radon concentration at night during temperature inversion.

Fig 8 shows the frequency of radon progeny volumetric activity in the rooms where a person spends most of his/her time.

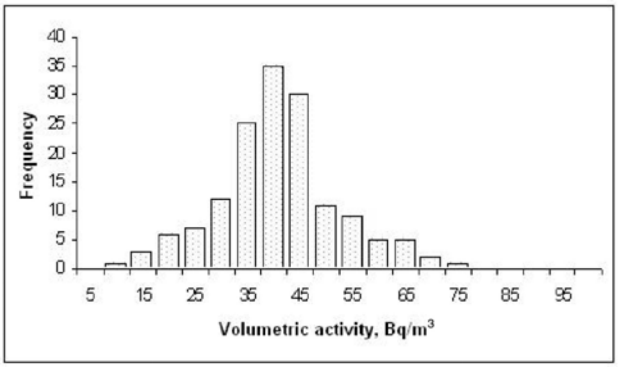

Fig 8. Frequency of indoor radon progeny volumetric activity in air

Measurement results in cellars are not included in this analysis of radon progeny volumetric activity shifts (Fig 8). This was done for the reason that cellars are usually uninhabitable, and people spend rather a small amount of their time in cellars.

The values of radon progeny volumetric activity are divided according to the normal distribution law. The figure shows that the most frequent values are 40–45 $Bq{\cdot}m^{-3}$.

The above discussed method of radon progeny volumetric activity hourly measurement and the data from The Professional Remote Weather Station and DrDAQ helped to evaluate the importance of meteorological parameters for the radon progeny volumetric activity.

Measurements were performed during all the seasons of the year, on purpose to evaluate the influence of seasonality on the volumetric activity of radon progeny. Air-conditioning existed through the doors and cracks of the windows.

Fig 9 shows hourly measurement data of radon progeny volumetric activity, temperature and relative humidity. The statistical averages are shown. Hourly measurements of radon progeny volumetric activity, temperature and relative humidity are indicated in the figure.

In this case radon progenies, temperature and relative humidity have similar paths, except for cases when temperature gradient changes. Then the increase of temperature causes a sudden fall in the amount of radon progenies and humidity. The rise of radon progeny volumetric activity in early mornings is described by the correlation of rising exhalation at night and falling temperature. A sudden fall of radon progeny volumetric activity was noticed between 8 and 9 a m (then the doors are opened more often). A lower radon concentration was measured between 9 a m and 6 p m when there is a more intense movement in the house (doors and windows are opened).

The daily behaviour during the whole week of radon progeny volumetric activity, temperature and relative humidity the evidence of working days and weekend days having the same pattern indicate also that the radon fluctuations are related mainly to the temperature variations in an accommodation. Humidity has less correlation with radon fluctuations than temperature.

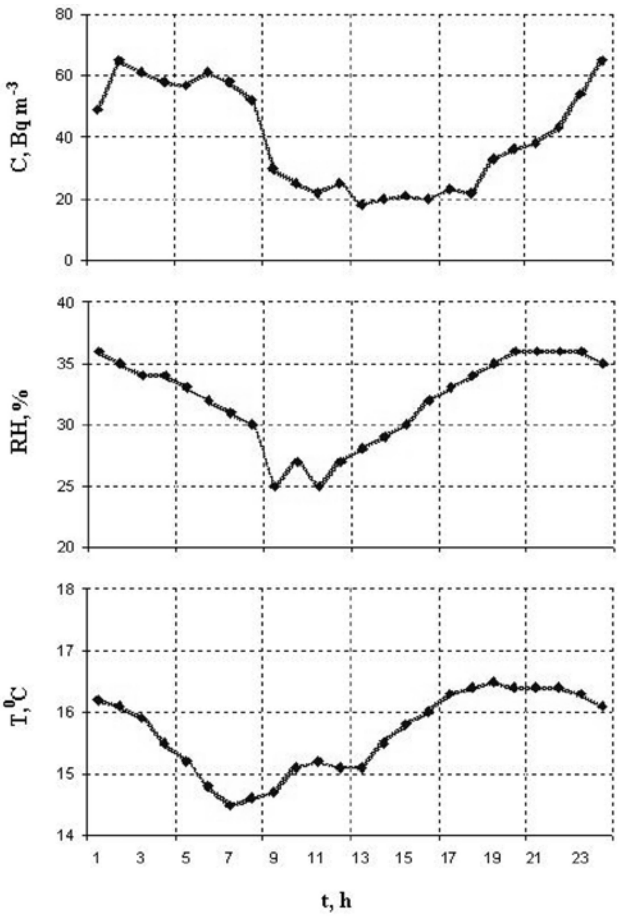

Fig 9. Dependency of ^{222}Rn progeny volumetric activity on temperature and relative humidity

Estimating the seasonal effect, a clear correlation occurs between temperature and radon progeny and an anticorrelation between radon and the relative humidity, particularly during rainy months. During a dry season between radon progeny volumetric activity and relative humidity a better correlation is observed. When all the data were analysed, the radon, humidity and temperature data had a correlation coefficient lower than 0,3. However, when the data of a dry and rainy seasons were separated, a 0,9 correlation factor was obtained between temperature and radon progeny volumetric activity when humidity was lower than 30 %.

Variation of indoor and outdoor radon decay product volumetric activity due to wind speed were evaluated. It was estimated that due to a higher wind speed the values of indoor and outdoor radon decay products were lower.

During the period of measurement the wind speed started to increase at about 6–7 a m and reached its peak – 1,5–2 $m \cdot s^{-1}$ at about 12 a m. Wind speed was rather low at night – about 0,2–0,4 $m \cdot s^{-1}$.

Fig 10 shows the dependency of indoor and outdoor radon progeny volumetric activity on wind speed. This figure introduces the measurement period of 7 days.

The values of radon progeny volumetric activity change during the 24-hour period. Radon concentration increases during the whole night, and the highest values are reached in the early morning – between 5 and 8 a m. The lowest radon values were measured at the midday.

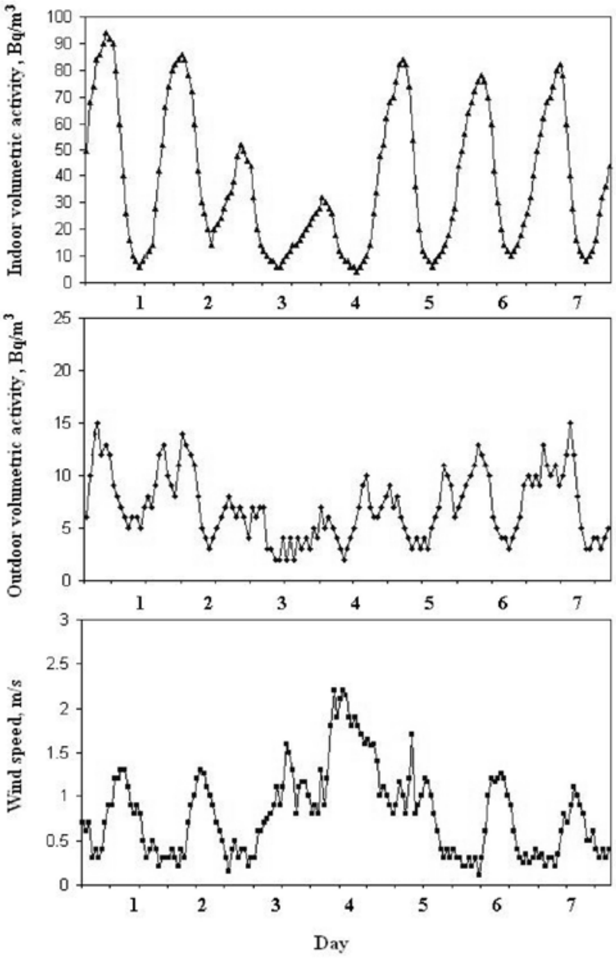

Fig 10. Shifts of ^{222}Rn progeny volumetric activity due to wind intensity

These shifts were measured regularly during the whole week.

Fig 10 clearly shows the shifts of indoor and outdoor radon progeny volumetric activity due to wind speed. It is seen that the values of indoor and outdoor radon progenies are lower at a higher wind speed. Indoor-outdoor air change rate is rather low at night but starts to increase in the morning and reaches its highest values around the midday. Wind speed is the main factor for the indoor-outdoor weather change.

4. Conclusions

1. Hourly measurement method and equipment for radon progeny volumetric activity in air was created. This computerized method allowed to measure radon progeny volumetric activity and environmental meteorological parameters.

2. This created an opportunity to change the work of the device by choosing suction speed and time, measurement time, and the time to overwind the band. Thus, various experiments could be organized and separate amounts of radon progenies could be evaluated.

3. Other environmental parameter measuring devices were added to the set of devices for the method of radon progeny volumetric activity hourly measurement. These included the Professional Remote Weather Station

and Multifunctional Data Accumulator. Parallel measurements with these devices helped to analyse radon progeny dependency on many environmental parameters.

4. The average values of radon progeny volumetric activity in individual houses varies from 62 Bq/m^3 (in a cellar) to 149 Bq/m^3 (on the second floor) in ventilated rooms, and from 273 Bq/m^3 (in a cellar) to 149 Bq/m^3 (on the second floor) in unaired rooms. The main radon source is the ground under the house. The values of radon progeny volumetric activity in ventilated and unaired rooms differ about 4–5 times.

5. A 24-hour shift of radon progeny in a lower layer of the atmosphere was analysed, and the diversity of daytime and night volumetric activity was noticed. Radioactivity starts increasing at about 7–8 p m. The night maximum is reached at about 5–8 a m.

6. Radon progeny volumetric activity depends on meteorological parameters. Radon progenies, temperature and relative humidity have similar paths, except for cases when the temperature gradient changes. Then the increase of temperature causes a sudden fall in the amount of radon progenies and humidity.

7. Indoor and outdoor shifts of radon progeny volumetric activity due to wind intensity were measured. The indoor and outdoor values of radon progenies are lower at a higher wind speed. The indoor and outdoor air change rate is low at night but starts increasing in the morning and reaches its highest values around the midday.

References

1. GIRGŽDYS, A.; ULEVIČIUS, V. *The concentration of radon and its short-term decay products in the air Atmospheric Enviroment*. Vilnius, 1985, p. 28–33 (in Lithuanian). ISSN 0135-1419
2. EL-HUSSEIN, A.; MOHHAMED, A.; AHMED, A. Radon exhalation and ultrafine fraktion of radon progeny in closed room air. *Atmospheric Enviroment*, 1999, 33(2), p. 183–190.
3. MASTAUSKAS, A.; MORKŪNAS, G. Problem of indoor radon in Lithuania. *Health Physic*, 1996, Vol 70 (6), p. 581.
4. LUBIN, J. H. Studies of radon and lung canser in north America and China. National cancer institute, USA. *Radiation Protection Dosimetry*, 2003, Vol 104, No 4, p. 315–319.
5. PETER, J. E. Analysis of radon and thoron daughter concentrations in air by continuous alpha spectroscopy. *Radiation Protection Dosimetry*, 1994, Vol 56, No 4, p. 267–270.
6. LUBIN, J. H. Studies of radon and lung canser in north America and China. National cancer institute, USA. *Radiation Protection Dosimetry*, 2003, Vol 104, No 4, p. 315–319.
7. ISHIKAWA, T.; YAMADA, Y.; FUKUTSU, K.; TOKONAMI, S. Deposition and clearance for radon progeny in the human respiratory tract. *Radiation Protection Dosimetry*, 2003, Vol 105, No 1–4, p. 143–148.
8. MOHAMED, A. Study on radon and radon progeny in some living rooms. *Radiation Protection Dosimetry*, 2005, Vol 105, No 1–4, p. 143–148.
9. KELLER G., HOFFMANN B., FEIGENSPAN T. Radon permeability and radon exhalation of building materials. *The Science of Total Enviroment*, 2001, 272, 85–89.
10. KOJIMA, H. The exhalation rate of radon in the atmosphere and the influencing factors. In *Proceedings of 7th Tohwa University International Symposium*, Fukuoka, Japan, 23–25 October, 1997, p. E-240 (1998).
11. REINEKING, A.; KNUTSON, E. A.; GEOGE, A. C.; SOLOMON, S. B.; KESTEN, J.; BUTTERWECK, G.; PORSTENDORFER, J. Size distribution of unattached and aerosol-attached short-lived radon decay products: some rezults of intercomparison measurements. *Radiation protection dosimetry*, 1994, Vol 56, No 1–4, p. 113–118.
12. MOHAMMED, A. Activity size distributions of short-lived radon progeny in indoor air. *Radiation Protection Dosimetry*, 1999, Vol 86, No 2, p. 139–145.
13. CLAVENSJO, B.; AKERBLOM, G.; MORKŪNAS, G. *Indoor radon*. Vilnius, 1999, p. 126 (in Lithuanian).
14. KELLER, G.; HOFFMANN, B.; FEIGENSPAN, T. Radon permeability and radon exhalation of building materials. *The Science of Total Environment*, 2001, 272, p. 85–89.
15. SWEDJEMARK, G. A. Recent Swedish experiences in radon control. *Health Physics,* 1990, 58, p. 453–456.
16. NEDVECKAITĖ, T. *Radiation protection in Lithuania*. Vilnius, 2004, p. 239 (in Lithuanian).
17. LEUNG, J. K. C.; TSO, M. Y. W.; HO, C. V. Behavior of ^{222}Rn and its progeny in high-rise building. *Health Physics*, 1990, Vol 75, No 3, p. 303–312.
18. JASAITIS, D.; PEČIULIENĖ, M.; GIRGŽDYS, A. The variations of radon and its short – term decay products in living rooms. In *The 6th International Conference Environmental Engineering, selected papers*, 2005, Vol 1, p. 114–117.
19. HAIDER, B. A twin channel device for the continuous spectrometry of radon daughters. *Radiation Protection Dosimetry*, 1992, Vol 7, No 1–4, p. 211–213.
20. FURUTA, S.; ITO, K.; ISHIMORI, Y. A continuous radon progeny monitor with a vacuum vessel by alpha spectrometry. *Radiation Protection Dosimetry*, 2000, Vol 90, No 4, p. 429–435.
21. TOKONAMI, S.; EMOLO, T.; ICHIJI, T.; FUJITAKA, K.; KUROSAWA, R. Continuous radon monitor using a two-filter method. *Radiation Protection Dosimetry*, 1996, Vol 63, No 2, p. 123–126.

RADONO SKILIMO PRODUKTŲ TŪRINIŲ AKTYVUMŲ ORE NUOLATINIŲ MATAVIMŲ METODAS

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S a n t r a u k a

Sukurtas trumpaamžių radono skilimo produktų tūrinių aktyvumų nenutrūkstamo matavimo metodas. Hermetiniame metaliniame korpuse įtaisytas radiometras, matuojantis slenkančios filtrinės juostos, pro kurią siurbiamas oras, aktyvumą. Radiometro duomenys visą laiką siunčiami ir įrašomi į kompiuterį. Siurbimo ir juostos persukimo laikai užprogramuoti elektroniniais laikmačiais. Taip sudaryta galimybė palikti dirbti prietaisą patalpoje bet kuriam laikui, nustačius, kad matavimai vyktų nustatytomis valandomis. Taikant šį nenutrūkstamo matavimo metodą, išmatuoti radono ir jo trumpaamžių skilimo produktų tūriniai aktyvumai patalpose ir įvertinta jų priklausomybė bei pokyčiai nuo aplinkos meteorologinių parametrų. Išmatuotos trumpaamžių skilimo produktų tūrinių aktyvumų vertės patalpose kinta nuo 62 Bq/m^3 (rūsyje) iki 27 Bq/m^3 (antrame aukšte) – išvėdintose patalpose, ir nuo 273 Bq/m^3 (rūsyje) iki 149 Bq/m^3 (antrame aukšte) – neišvėdintose patalpose. Vertės išvėdintose ir neišvėdintose patalpose skiriasi maždaug 4-5 kartus. Nustatyta tiesioginė tūrinio aktyvumo priklausomybė nuo vėjo intensyvumo, temperatūros ir santykinės drėgmės.

Reikšminiai žodžiai: radonas, trumpaamžiai radono skilimo produktai, tūrinis aktyvumas, alfa dalelės, matavimo metodas.

МЕТОД НЕПРЕРЫВНОГО ИЗМЕРЕНИЯ ОБЪЕМНОЙ АКТИВНОСТИ ПРОДУКТОВ РАСПАДА РАДОНА В ВОЗДУХЕ

Д. Ясайтис, А. Гиргждис

Р е з ю м е

Создан метод непрерывного измерения объемной активности короткоживущих продуктов распада радона. В герметичном металлическом корпусе поставлен радиометр, измеряющий активность с помощью скользящего ленточного фильтра, через который засасывается воздух. Данные радиометра все время фиксируются компьютером. Время засасывания воздуха и скольжения ленты запрограммированы электронными счетчиками. Таким образом, создана возможность самостоятельной работы прибора в помещении в течение любого времени, предварительно установив необходимые часы работы. Используя этот метод, в помещении была измерена объемная активность радона и его короткоживущих продуктов распада, определена их зависимость от метеорологических параметров. Измеренные в помещении значения объемной активности короткоживущих продуктов распада колеблются от 62 Бк/м^3 (в подвале) до 27 Бк/м^3 (на втором этаже) – в проветриваемых помещениях и от 273 Бк/м^3 (в подвале) до 149 Бк/м^3 (на втором этаже) в непроветриваемых помещениях. Значения в проветриваемых и непроветриваемых помещениях различаются примерно в 4-5 раз. Установлена прямая зависимость объемной активности от интенсивности ветра, температуры и относительной влажности.

Ключевые слова: радон, короткоживущие продукты распада радона, объемная активность, альфа-частицы, метод измерения.

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