*Jr. of Industrial Pollution Control 32(2)(2016) pp 397-400*
*www.icontrolpollution.com*
*Research*

# DEPENDENCES IN GROUND ATMOSPHERE RADON, THORON AND THEIR DECAY PRODUCTS DYNAMICS

**KONDRATYEVA AG[1], YAKOVLEVA VS[1]*, NAGORSKY PM[2] AND STEPANENKO AA[1]**

[1]National Research Tomsk Polytechnic University, 634050, Tomsk, Russian Federation
[2]Institute of Monitoring of Climatic and Ecological System SB RAS, 634055, Tomsk, Russian Federation

(Received 16 July, 2016; accepted 8 August, 2016)

**Keywords:** Atmosphere, Atmosphere radon, Radon isotopes, Thoron, Ionizing radiation.

## ABSTRACT

The results of continuous automated radon monitoring, which started in 2011 with using radiometer of radon isotopes and their decay products (SARAD GmbH), are reported here. The analysis of seasonal variations of radon activity concentration in the ground atmosphere revealed maximum in spring-summer period and minimum in winter. In diurnal variations minimum appears afternoon and maximum–before noon. These results are in a good agreement with results of other radon investigations. The analysis of changes of equilibrium coefficients between radon and its decay products showed that the annual average value was 0.2 (0.25 in March-April, 0.12 in May, and 0.27 at the end of September). Significant correlations were revealed between activity concentrations of radon, thoron and some of their short lived decay products at synoptic scale. A synchronism in diurnal variations of atmospheric radon field characteristics was found only in certain time periods. Other interesting results of analysis of correlations between field characteristics of radon and produced ionizing radiation in dependence on weather conditions are also reported.

## INTRODUCTION

Ground atmosphere is characterized by low activity of radioactive gases and aerosols, which leads to some difficulties in the choice of control methods. Modeling techniques in these cases have undeniable advantages for determining the volumetric activity (VA) of radioactive gases and aerosols in the ground atmosphere. It is known that the activity of radon isotopes and aerosols decay products in the atmosphere in the same area is have variations depending on weather conditions, time of day and season of the year, the height above the ground. In the seasonal variation of radon activity in the air maximum shown in summer-autumn and a minimum in winter-spring. Throughout the day minimum is observed in the afternoon time (12-15 hours), and the maximum-after midnight (0-6 hours).

Processes of transport and removal of radionuclides in the ground atmosphere is varied (Yakovleva and Karataev 2005; Borisov and Yakovleva 2005).

On the transfer of radionuclides affect humidity, wind, precipitation passage, cyclones, and severe weather conditions change.

## MATERIALS AND METHODS

Continuous monitoring of radon fields characteristics is carried out since March 2011 with the use of instruments of German company SARAD, based on semiconductor α-spectrometry. To determine VA of radon and thoron decay products used method of pumping air through a membrane filter with a parallel α-spectrometry semiconductor detector (Nazaroff and Nero, 1988).

The monitoring process is completely automated, pumping air continuously produced. One measurement time is 30 min. Installation height devices 1m above the ground. Installed equipment can measure the following characteristics of radon fields: VA of radon and thoron; equivalent equilibrium volumetric activity of radon (EEVA); latent energy radon and thoron decay products in the air; as well as the number of pulses from polonium

***Corresponding author's email:** karengin@tpu.ru

isotopes. Isotopes $^{218}$Po and $^{216}$Po are decay products of radon, $^{214}$Po and $^{212}$Po-thoron.

The long-term experiment was performed at Tomsk Observatory of Radioactivity and Ionizing Radiation (TORIR). Instrumental equipment included: scintillation detectors of α- and β-radiation (ATOMTEX, Republic of Belarus) installed at series of heights (0.1; 1; 5; 10; 25 and 35 m); radon isotopes and DPs radiometers (EQF 3200, SARAD, Germany; RRA-01-03, Russia; Ramon-01, Kazakhstan) and automated devices for radon and thoron flux densities measurements. In order to determine the degree of external factors influence the monitoring of meteorological, actinometrical and atmospheric-electrical values was performed via automated information measuring system.

## RESULTS AND DISCUSSION

Analyze the diurnal variation of radon VA in different seasons. In late summer, an increase in the daily average value of radon VA, as well as increases the amplitude of variations. Minimum values are typical for evening time of day (around 18:00), and the maximum observed in the wee hours (around 5:00). The results obtained are in good agreement with the results obtained in earlier experiments (Serdyukov et al., 1979). Daily average value of radon VA in the second half of September increased, compared with the observed value in August, and almost 3 times more than the average daily value characteristic of the spring season.

If we take into account the physical processes affecting on the transport of atmospheric radionuclides, and the results of modeling the influence of the turbulent diffusion coefficient $DT$ and the vertical component of the wind velocity $vW$ on radioactive equilibrium radon and decay products, the monitoring results allow us to conclude that the average value lies in the $vW$ 0.01-0.03 m/s, and the vector directed upwards from the earth's surface.

Fig. 1 shows the regression dependence between the characteristics of the radon field.

Represented from top to bottom: 1st line VA of radon (axis X)-VA of thoron (axis Y); 2nd line VA of radon (axis X)-VA of radon decay products (axis Y); 3rd line VA of thoron (axis X)-VA of thoron decay products (axis Y); 4th line VA of radon decay products (axis X)-VA of thoron decay products (axis Y). The data smoothed by the low-frequency filter: left column upper cut-off frequency was 1/(4 hours), right column-1/(1 day).

Significant correlations were detected between the characteristics of the radon field on the synoptic scale. When considering the diurnal scale synchronicity in changing characteristics of the radon field appears only in certain time intervals.

We analyze the dependence between variations in the radon fields and fields of ionizing radiation (IR) in the ground atmosphere. In order to reliably establish the influence of radon, its isotopes and their decay products contribute render to the atmospheric fields

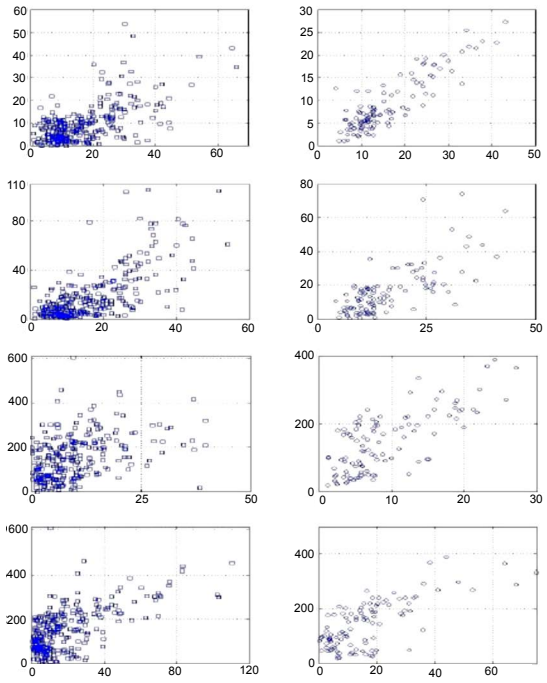

**Fig. 1** shows the regression dependence between the characteristics of the radon field.

of IR, requires an integrated approach to solving the problem. This approach involves the simultaneous with high frequency of sampling monitoring of different types of IR at one point, and at different heights (the study of spatial temporal distributions).

Example of synchronous measurements of the IR fields and radon fields characteristics in the ground atmosphere is shown in Fig. 2. As shown earlier, the statement of radioactive equilibrium between radon and decay products, determined by the combined influence of several factors, namely, the height above the earth's surface; the speed of wind vertical component; turbulent diffusion coefficient; rainfall.

Equilibrium coefficient, in turn, defines the dependence between the characteristics of radon fields and fields of IR, because sources of β-and γ-radiation are precisely aerosol decay products of radon isotopes (Durrani and Ilić, 1997).

The results fit well with the general idea of the atmosphere circulation. At night, there is a decrease of the atmospheric turbulence that leads to the recovery of radioactive equilibrium between radon and decay products.

Analysis of the dependences between the characteristics of the IR fields and the radon field showed that in the warm season in the precipitation absence is observed of a significant connection between the activity of radon, EEVA and the

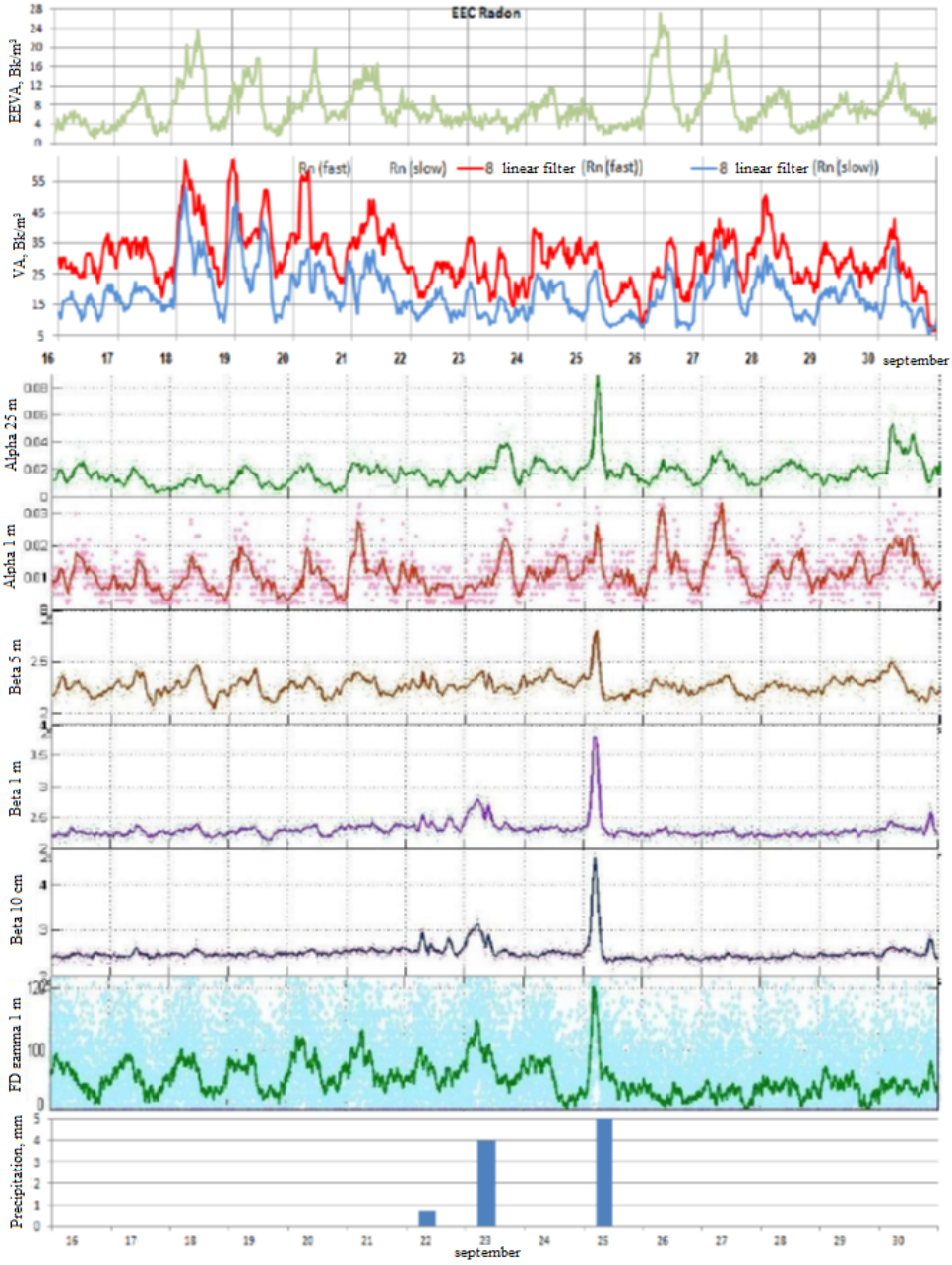


**Fig. 2** Dynamics VA of radon and decay products, the flux densities of IR in the second half of September 2011.

density of alpha-, beta-and gamma-radiation. It is worth mentioning that data from detectors based on a fundamentally different registration methods (gas-discharge, scintillation, semiconductor), which increases the accuracy of the data.

Dynamics VA of radon decay products at 1 m behaves consistently with the dynamics of the flux density of alpha radiation at 1 m, less significant association observed with a flux density of alpha radiation at 25 m, beta radiation at 5 m and gamma radiation at 1 m. Weak connection is observed between VA of radon decay products and flux density of beta radiation at 1 m and 10 cm is due to the influence of beta-emitting soil radionuclides, which radiation "lubricates" the diurnal variation. Effect of soil radionuclides ceases to affect on the heights of 3 m and up due to the low penetrating power of beta radiation. As for the standard diurnal variation of radon VA with one maximum, he expressed worse, compared with the decay products. In some periods the two peaks observed at one day. Disruption of the normal diurnal variation and reduction VA of aerosol decay products of radon occurs in the period from September 22 to 25. This period is characterized by rainfall.

## CONCLUSIONS

Analysis of the results of the control structure and dynamics of radon fields and IR in the "lithosphere-atmosphere" system revealed. 1) High-intensity rainfall more than 20 mm does cause abnormal splashe not only in atmospheric β-and γ-background, but also in the soil α- and β-background to 1 m depth. Length of splashe in the atmospheric background is a few hours, does not depend on the height and rainfalls, and in the ground may last several days, strongly depend on the depth and the rainfalls. 2) Low-intensity rainfall cause splashes in atmospheric β-and γ-background is almost the same duration of a few hours, but of lesser value, which is weakly dependent from the rainfall intensity, as well as violate the standard "diurnal variation" VA of aerosol decay products of radon and thoron in the atmosphere reducing their activity, but within the observed period to rainfall variations. 3) Low-intensity rainfalls significantly violate the standard "diurnal variation" soil fluxes α-and β-radiation at a depth of 0.5 m, and lead to their increase, but within the observed period to rainfall variations.

## ACKNOWLEDGMENTS

This work is funded by Russian Federal Target Program № 14.575.21.0105 (RFMEFI57514X0105) of Ministry of Education and Science of Russian Federation.

## REFERENCES

Borisov VP and Yakovleva VS. 2005. Comparative analysis of radon sources contribution into total radon indoor levels for Altai and Tomsk regions of Russian Federation. *Radiat. Meas*. 40: 682-685.

Durrani SA and Ilic R. 1997. Radon measurements by etched track detectors: applications in radiation protection. Earth sciences and the environment. *World Sci*. Singapore.

Nazaroff WW and Nero AV. 1988. Soil as a source of indoor radon: generation, migration and entry. *A Wiley-Intersci. Publ*. New York.

Serdyukov AS and Capitanov Yu T. 1979. Radon isotopes and their decay products are short-lived in nature. *Clarendon. Press*. Oxford.

Yakovleva VS and Karataev VD. 2005. Factors determining the formation of radon levels inside buildings. *Radiat. Biol. Radioekologiya*. 45: 333-337.