RADON AND ITS DECAY PRODUCTS DYNAMICS INSIDE THE ACCUMULATIVE CHAMBER

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The basic requirement for this work was the need for a simple, reliable, and cheap method of using an accumulative chamber to measure radon flux density. A high sampling frequency is needed because the final goal is to acquire radon field data in a continuous, informative time series. At the monitoring stations, the accumulative chamber as well as radon pore activity measurement devices used in the soil and air will enable us to improve the accuracy of the predictive estimate. In addition, it will help in the specification and determination of the radon transport model parameters in the ground atmosphere and geological medium. The simulation of radon and its decay products' dynamics inside the accumulative chamber was the main goal of this research work.

The radon and its decay products' dynamics inside an accumulative chamber with a constant radon flux of 10 $mBqm^{-2}s^{-1}$ from the soil surface at a volume of 3,14 liters, a height of 0,1 m, and an accumulative time of 1 hour selected based on optimal conditions were determined. The volumetric activity dynamics of ^{222}Rn and ^{218}Po at different radon flux densities (5-20 $mBqm^{-2}s^{-1}$) were also determined. Furthermore, the changes in the ratio of the decay product activity to the radon activity over time were calculated, as well as the ionizing radiation yield dynamics per radionuclide nuclear decay. The change in ionizing particles and gamma rays produced in 5 minutes was calculated, and the dynamics of the ion production rate were studied using different types of radon radiation as well as gamma radiation from soil radionuclides. The accounting of thorium and its decay products was also calculated.

Figure 1 shows the radon and its daughter nuclides' dynamics with a constant radon flux of 10 $mBqm^{-2}s^{-1}$ in an accumulative chamber. The result showed that at a constant radon flux of 10 $mBqm^{-2}s^{-1}$, the radon activity in the accumulative chamber reached 350 Bqm^{-3}, and the volumetric activities of ^{222}Rn and ^{218}Po increased linearly over time and can be written as: $A_{1,2}(t) = at + b$. The coefficients "a" and "b" for ^{222}Rn and ^{218}Po were similar to integers as the radon flux was changed for the function of linear approximation, as shown in figure 2. This shows that they are determined by intensity value *K*.

Figure 3 represents the changing ratio of the decay product activity to radon activity over time. From the graph, it can be seen that in an hour, the activity of ^{218}Po reached 90 %, ^{214}Pb reached 40% and, ^{214}Bi and ^{214}Po both reached 20 %. Furthermore, the beta and gamma radiation yields were approximately two times less than the alpha particle, so the alpha particle of radon and its daughter nuclides are primarily used for radon flux density measurements, as shown in figure 4. Figure 5 shows that when the gamma rays and ionizing particles produced in 5 minutes were changed, the flux of the alpha particles registered by a detector was twice that of the gamma radiation and beta particles under the same conditions. The curves of the combined radiation of the beta and gamma and the alpha particles, on the other hand, overlapped in the accumulative period of 90 minutes.

Figure 6 represents the rate at which various radon radiation types and the amount of gamma radiation emitted by soil radiation. The beta and gamma radiation contributed no more than 10– 12 ion-pairs cm^{-3} to the total ions produced in the accumulative chamber. After 15 min the alpha radiation-induced ion production was higher than the background value produced by the soil radionuclides.

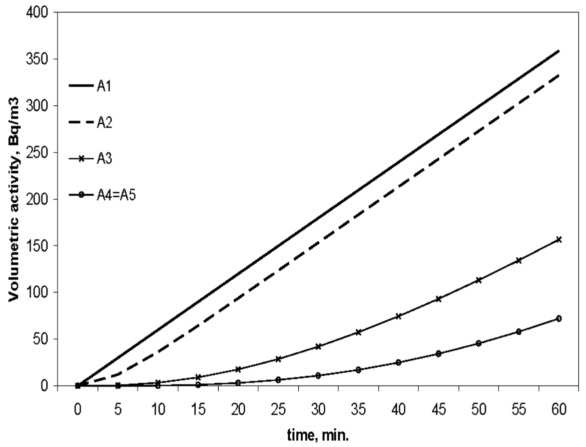

Fig. 1. Radon and its daughter nuclides dynamics in an accumulative chamber at the surface of the soil with a constant flux density of radon

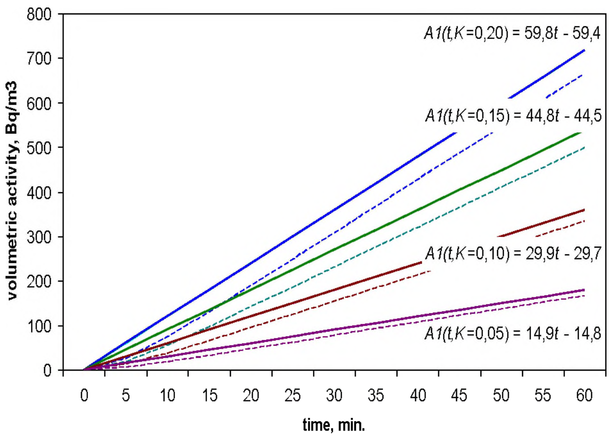

Fig. 2. The dynamics of volumetric activity for ^{218}Po are represented with dotted line and that for ^{222}Rn are represented in solid line at different intensities (K values)

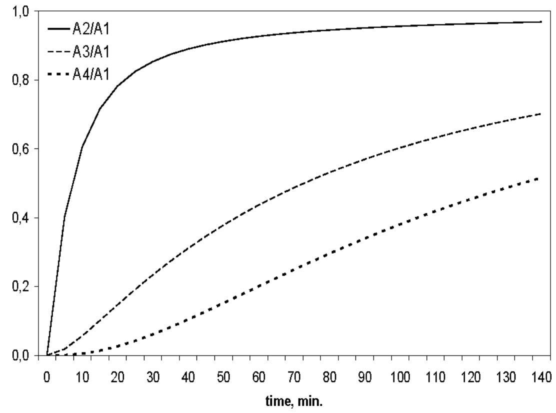

Fig. 3. The ratio of decay product activity to radon activity changes over time

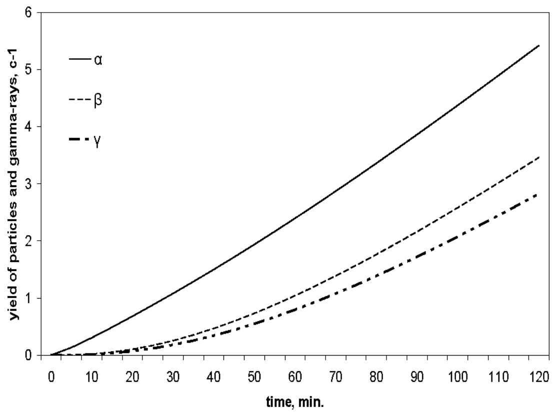

Fig. 4. Ionizing radiation yield dynamics inside the accumulative chamber

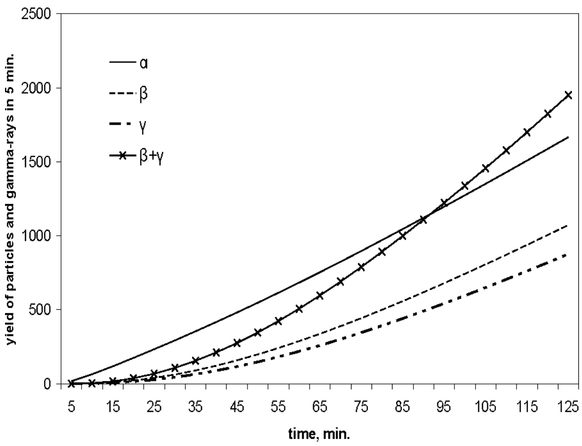

Fig. 5. The formation of the gamma-rays quantity and ionizing particles dynamics in 5 minutes

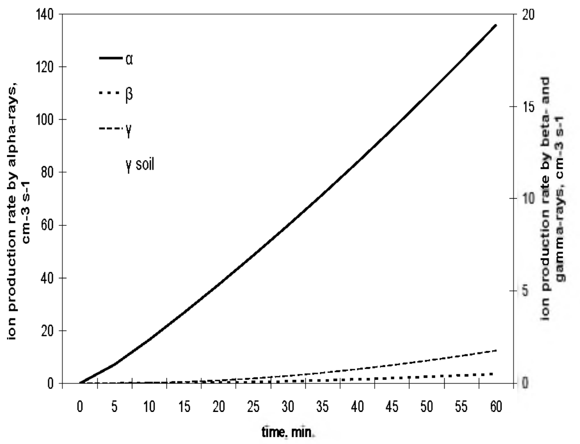

Fig. 6. The rate at which various types of radon radiation, DPR, and gamma-radiation of radionuclides of the soil produces ion

The dynamics of the volumetric activity of thoron and its daughter nuclides in the accumulative chamber are shown in figure 7. Figure 8, depicts the regularities in the dynamics of the yield of the ionizing radiation at the decay of radionuclides accumulating inside the chamber as well as the dynamics of the rate by which this radiation produces ions. From fig. 7, it is evident that the accumulative curves for ^{222}Rn and ^{220}Rn showed a significant difference due to the difference between the halflives of the parent and their daughter radionuclides. Both ^{216}Po and thoron have similar accumulative curves. After the chamber is shut, they reach saturation in 6–7 min, and remain nearly constant for the duration of the accumulation period. The activity of thorium decay products and ^{212}Pb accumulates insignificantly, about 6 % of thorium activity because of their long half-life. These specific differences in the regularities of thorium and radon accumulation inside the chamber can be accurately used for flux density measurements. The alpha-particles yield dynamics in figyre 8 are caused by ^{220}Rn, ^{216}Po, ^{212}Bi and ^{212}Po nuclei accumulating inside the accumulative chamber. Gamma-rays and beta radiation yields are caused by ^{212}Pb, ^{212}Bi and ^{208}Tl nuclei accumulating.

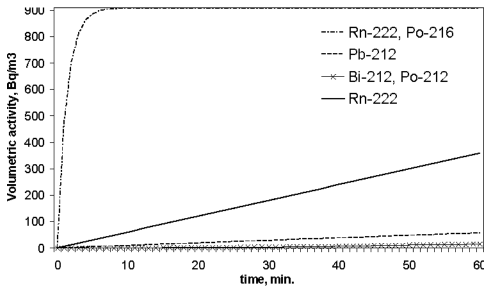

Fig. 7. Radionuclides volumetric activity dynamics inside the accumulative chamber

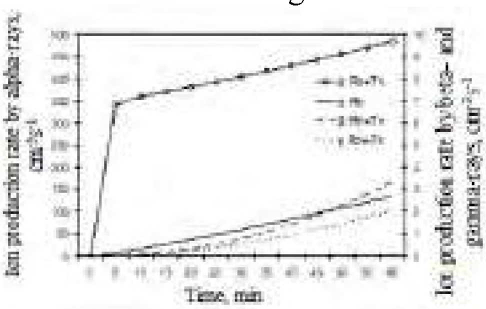

Fig. 8. Dynamics of the rate by which various types of radon, thoron, and their decay products produces ion

The presented works were performed to determine the use of the obtained regularities in the selection and design of a method and device to measure, from the surface of the ground, the flux density of radon. The results showed that because there is only one variable quantity, the soil radon entry K-intensity into the chamber, they have a qualitative character but are effective for quantitative estimation. Furthermore, they are generally beneficial to the measurement-counting regime and can serve as a useful guide for the development of new methods. In addition, the following conclusions can be made for the calculation of the dynamics for radon and its daughter product; for the registration of alpha-radiation: Tn and its daughters' contribution to a detector signal is approximately 80 % if 30 minutes counting and in 60 % if 60 minutes counting. For registration of β-particles and/or γ-rays the contribution, of Tn and its daughters in a detector signal is approximately 25 % if 30 minutes counting and in 15 % if 60 minutes counting. For registration of the number of ions, the contribution of Tn and its daughters in a detector signal is approximately 95 % in the first 10 minutes counting.

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ИССЛЕДОВАНИЕ ПРОЦЕССОВ ТЕРМИЧЕСКОЙ КОНВЕРСИИ СМЕСЕВЫХ ТВЕРДЫХ ТОПЛИВ С ПОЛУЧЕНИЕМ ПОЛЕЗНЫХ ПРОДУКТОВ

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Аннотация

Приведены результаты экспериментальных исследований процессов термической конверсии смесевых твердых топлив с учетом изменения их влагосодержания с получением трех полезных продуктов: углерод, жидкие углеводороды, синтез-газ. Применена методика приготовления топливных смесей, торфа с древесными отходами путем их смешения для термического разложения с последующим получением полезных продуктов. Эксперименты проводились при температуре 560±2 °С на экспериментальном стенде. Получены синтез-газ, твердый