RADON EMANATION COEFFICIENTS IN SANDY SOILS

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Introduction

Many authors referred that the moisture content has a significant influence on the emanation coefficient for the soils [1-3]. However, it was also found out that the effect of the water content on the radon emanation coefficient is depended on the complex of other characteristics of the soil, for example on the porosity and grain sizes [4]. Their influence on the emanation coefficient can be described only qualitatively. Therefore, in practice, the best way to obtain the information about the emanation coefficient is its measurement.

In this contribution we report the results of the study of an influence of the water content on the emanation coefficient for two sandy soil samples. These samples were chosen because of the long-term continual monitoring of the ^{222}Rn concentration just in such types of soils and this radon concentration showed the significant variations during a year [5]. These variations are chiefly given in connection with the soil moisture. Therefore, the determination of the dependence of the emanation coefficient of radon on the water content can help to evaluate the influence of the soil moisture variations on the variations of radon concentrations in the soil air.

Materials and Methods

The samples for the study of an influence of the soil moisture on the emanation coefficient were collected 2 meters from the place where the radon concentration in the soil air was continually monitored. The first sample - sandy clay - was taken from the depth of 0.1 m and the second one - sandy loam - from the depth of 1.2 m under the surface. In the first step the roughest fraction of the samples were removed. Then the samples were dried at the temperature of 105°C during several hours and subsequently their grain size analysis was done [6].

The characteristics of the samples used in the experiment are listed in the Table 1.

Table 1.

Sample	^{226}Ra (Bq.kg^{-1})	Grain content (% dry weight)				
		< 0.06 (mm)	0.06 - 0.2 (mm)	0.2 - 0.6 (mm)	0.6 - 2.0 (mm)	> 2 (mm)
Sandy loam	33.0 ± 0.4	46	4	16	27	7
Sandy clay	46.3 ± 0.6	50	27	11	9	3

For the determination of the activity concentrations of the ^{226}Ra the dried samples were inserted into the plastic cans of Martinelli type with the volume of 460 *ml* and hermetically closed. After the achievement of the radioactive equilibrium between ^{226}Ra and ^{222}Rn the activity concentration of ^{226}Ra in the samples was measured by a HPGe detector placed in the low background shield [7]. The γ - transitions of 351.9 keV (^{214}Pb) and 609.3 keV (^{214}Bi) were used for the activity determination.

For the determination of the radon exhalation rates at different water contents the amount of 0.5 kg of the dried samples was steamed by the distilled water. The moisture content of the samples was determined as the difference between the weight and dry weight of the sample, divided by the dry weight.

The ^{222}Rn exhalation rates were measured by the closed chamber method. For these aims the soil sample with the volume about 0.47 *l* was placed into the emanation chamber of 10 *l*. After the radon accumulation in the tightly sealed chamber (15 - 20 hours) all radon was absorbed in the column filled with the activated charcoal and then it was transported into the Lucas cell for the ^{222}Rn activity concentration measurement. In detail, the method is described in a previous paper [8].

Because the thickness of the soil samples was small in comparison to the diffusion length so the radon emanation coefficient could be calculated according to the relation:

$$K_e = \frac{E}{\lambda \, . \, M \, . \, A_{Ra}}$$

where E is the radon exhalation rate from the sample (Bq.s^{-1}), λ is the decay constant of ^{222}Rn (s^{-1}), A_{Ra} is the ^{226}Ra activity concentration of the sample (Bq.kg^{-1}) and M is the dry mass of the sample (kg).

Results and discussion

In Fig. 1 there are shown the ^{222}Rn emanation coefficients as a function of the moisture content. We can see that the courses are similar for both types of samples. The emanation coefficient increases with an increase of the soil moisture and after the achievement of the certain value it remains constant. It is between 5 % and 20 % of the weight moisture content for the sandy clay sample and between 8 % and 30 % of the weight moisture content for the sandy loam sample. The next increase of the moisture causes the sharp decrease of the emanation coefficient until it obtains the lower values than the measured values for the dry soil. Such courses used to be explained by the following effects in soils [9]. In the dry soil the considerable part of the radon atoms is adsorbed under the influence of the Van der Waal's forces on the internal surfaces of the soil and the emanation is relatively low. By the increase of the moisture the water hinders from the adsorption of the radon atoms on the internal surfaces of the material. Simultaneously the water presence in the internal pores of the material causes the increase of the direct recoil fraction of the emanation. On the other hand, the water presence in the internal pores reduces the diffusion of the radon atoms out of the material. However, the first two processes can be dominant up to a certain level of the moisture in the material and the increase of the emanation is occurred. After an optimum moisture content the radon diffusion is significantly reduced and the emanation is constant or it is slowly decreased. When the pores are completely filled with the water the reduced diffusion reduces the emanation dramatically.

In the Fig. 1 there can be also seen that the values of the emanation coefficient are lower for the sample of the sandy loam than for the sample of the sandy clay. It is obviously connected with the fact that the 38 % of weight of the sandy loam is created by the grains larger than 0.5 mm and in the sandy clay it is only 13 %. Just these grains could be responsible for the lower emanation coefficient [4]. On the contrary, almost 80 % of the weight of the sandy clay is created by the grains less than 0.25 mm for which the high values of emanation coefficient are characteristic.

The ratio of the maximal emanation coefficient to that of a dry sample also gives an information about the sample composition. In case of the increase of grain size this ratio should decreases [4]. However, for both measured samples this ratio was close upon 1.3. This confirms the insignificant influence of the middle- and rough- grain's sandy fraction in sandy loam sample on this ratio.

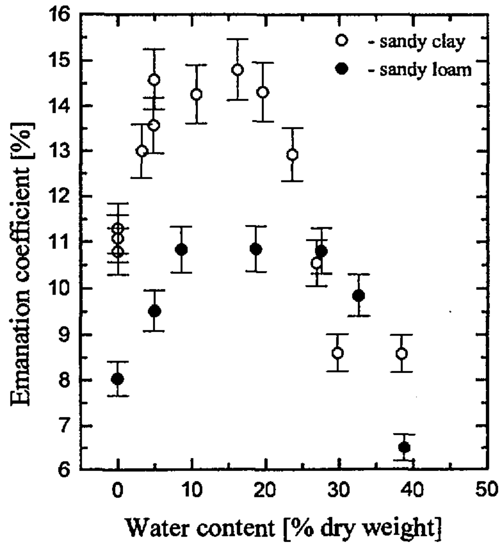

Fig. 1. The influence of the water content on the radon emanation coefficient.

The presented results show that the emanation coefficient reaches the constant value in the wide interval of the water content for both sandy soil samples. Therefore, in the common range of the soil moisture (5 % - 20 %) it is impossible to expect the variations of the radon concentration in the soil air due to the change of the emanation coefficient. The expressive changes of the radon concentration in the soil air can be observed in case of the significant decrease of the emanation coefficient during the soil drying when the water content decreases under 5 % or during the complete filling of the soil pores by the water.

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