**THESIS INFORMATION**

Thesis title: Determination of some factors affecting radon concentration in soil.

Speciality: Atomic Physics

Code: 62440106

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1. SUMMARY:

238U, 226Ra and their daughter isotopes are present in soil and rock in different concentrations. In which, radon is a gaseous radioactive element and has high immigration. There are 3 physical parameters affecting radon concentration and flux of a region including the content of 226Ra, radon emanation and diffusion coefficients. The parameters are meaningful in assessing and predicting radon concentrations in houses and buildings. In addition, measurement of emanation and diffusion coefficients in various covers for burying the waste containing radon isotopes is often necessary for radiation safety (Ishimori, 2013). For the environmental sciences, these parameters contribute to predicting some soil dynamics. They are also applicable to identify radioactive ore deposits, to detect hydrocarbon mines, … (Baskaran, 2016).

The thesis has built processes for determining the parameters by experimental methods in nuclear physics. The process of analyzing the radioactive content of 226Ra in soil samples by gamma and alpha spectrometry was built. In particular, the analytical process by alpha spectrometry can help save a lot of time and effort spent on experiment while ensuring accuracy. Experimental systems were designed to determine the radon emanation coefficients. The systems had suitable sample chamber volume and tightness, ability to analyze for large weight of samples and compatibility with RAD7. Radon emanation coefficient was also measured by gamma spectroscopy. The thesis also has designed the experimental system and built a process for determining the radon diffusion coefficient in the soils. From diffusion theory, the author found solutions for diffusion equations which are suitable for determining this coefficient by experiment. In addition, the processes of determining the radon emanation and diffusion coefficients in the field were also built based on the radon diffusion theory.

The radon emanation and diffusion coefficients depend on the radium distribution, the size and the shape of soil particles, as well as the moisture content, mineralogy, and other soil characteristics and weathering conditions, … (Ishimori, 2013). The thesis examined the effects of the soil characteristics on radon emanation and diffusion coefficients. The criterion for accurately evaluating the dependence of the radon emanation and diffusion on the particle size and the moisture content is to use samples with the same composition but different particle sizes. Therefore, to avoid the effect of the soil composition on the radon emanation coefficients among the different grain size fraction divided from an original soil sample, coarser particles (diameter greater than 2 mm) of five soil samples were washed to remove the fine particles from the surface of the crude particles. These five samples were collected in Ninh Son, Vietnam. Subsequently, the samples were dried, dispersed the particles prior to size separation by sieving into five grain size fractions: <0.1, 0.1–0.2, 0.2–0.3, 0.3–0.5 and > 0.5 mm. Simultaneous effects of radon emanation and diffusion coefficients were assessed. We investigated the function of the contents of major elements (Al, Si, Fe, Mn, K, Na, Mg, Ca and Ti), 226Ra content and their effect on the radon emanation and diffusion coefficient values by PIXE technique (Particle-induced X-ray emission) combined with principal component analysis method (PCA). A chemical process for removal of 226Ra from the soil particle surface was built and the radon emanation was assessed after the process. Regarding the influence of temperature, the emanation and diffusion coefficients were evaluated in the temperature range from 20 to 100oC.

Besides, the parameters were also surveyed for 80 soil samples with different characteristics in Ninh Son region.

2. NOVELTY OF THESIS:

* Vietnam has almost no research on development of an analytical method for radioactive content using alpha spectroscopy, determining emanation and radon diffusion coefficient in soil. The thesis has selectively inherited, built and developed a process to determine the parameters suitable for the characteristics of the soil samples and the conditions of the research team based on the studies in the world. Therefore, the designed experimental systems and the procedure for defining these three parameters can be considered novelty.
* The radon emanation coefficients in the five ranges of grain size increase with increasing moisture content exponentially and achieves a saturation value at different humidity depending on the particle size (porosity) of the soil. This coefficient decreases as the sample porosity increases exponentially. Regarding the effect of temperature, this coefficient increases slowly as the temperature increases linearly. Based on the content of major elements in the soils, the multiple regression indicates that the radon emanation coefficient appears to be significantly dependent on iron content. After being removed of 226Ra from the particle surface, the soil samples have almost similar radon emanation coefficient. The amount of 226Ra extracted and the reduction rate of the radon emanation coefficient correlate well with the iron content in the soils.
* The measured radon diffusion coefficient in the soil has a tendency to decrease with increasing moisture content and decreasing grain size. At low humidity (below 26%) and saturation moisture (over 70%), the diffusion coefficient decreases with the water content in the sample in accordance with the linear function rule. Especially, in the low humidity, the diffusion coefficient in the soils is close to the value of the diffusion coefficient of radon in the air. In contrast, in the saturated moisture, the diffusion coefficient is close to the radon diffusion coefficient value in water. At the intermediate moisture (26-70%), this coefficient decreases exponentially with increasing of moisture in the soils. When the porosity in the soil sample decreases, the radon diffusion coefficient decreases exponentially with all different moisture levels. Experimental values show that the temperature dependence of the radon diffusion coefficient follows Arrhenius behavior. The average activation energy for radon diffusion reaches 21.8 ± 0.9 kJ.mol-1.
* Radioactive content of 226Ra, the emanation and diffusion coefficient and radon flux were estimated for 80 soil samples collected in Ninh Son region. When analyzing for many soil samples, the results still show that the particle size, porosity, organic content, iron content in the soils are the main factors affecting the emanation and radon diffusion.

3. APPLICATIONS/ APPLICABILITY/ PERSPECTINE

* The designed experimental systems and analytical procedures can be applied to determine the 226Ra content, the radon emanation and diffusion coefficient in various materials.
* The parameters are meaningful in assessing radiation safety for nuclear waste, soils or materials. The parameters are also indicators that detect radioactive ore deposits, hydrocarbon mines, ...
* The process of removing and analyzing the radioactive content of 226Ra in the soils can be applied to treat radioactive radium contamination in various radioactive wastes.
* The process of grinding and sieving to divide the different grain size fraction requires a lot of time and the thesis only evaluated radon emanation and diffusion coefficients with five soil particle ranges. Assessments are required for more particle grades, especially for particles below 100 µm.
* The dependence of radon emanation and diffusion coefficients on soil characteristics was assessed for quite few of samples. More studies are needed for more general conclusions. In particular, the construction of a simulation program to evaluate the effects of the parameters on the radon emanation and diffusion in accordance with the experiment is a research issue that needs to be developed. At that time, many surveys and assessments related to this research orientation can be done without taking too much time.

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