博士学位論文内容の要旨

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【論文の内容の要旨】

The absorbed dose rate in air from natural and artificial radionuclides is influenced by many different human activities such as construction of artificial structures, mining, atmospheric nuclear weapon tests, nuclear power plant accidents, etc. Recently, a few studies were performed to estimate effective dose from activity concentrations of soil samples collected in Vietnam. However, this method did not consider the effects from artificial structures. At the present time, there is remarkable economic growth in Vietnam. Thus, there is a lot of new construction being carried out, including roads, bridges and high-rise buildings that are expected to have an impact on absorbed dose rate in air from natural radionuclides contained within the materials of these newly constructed artificial structures. Then, the measurement of ambient dose rate in air in the current environs is desired to estimate an accurate effective dose for residents of Vietnam.

The absorbed dose rates in air (nGy h^{-1}) from natural radionuclides such as ^{40}K, ^{238}U series and ^{232}Th series were measured in the south-central and southern Vietnam during March 2015 and March 2017 by the first time using a car-borne survey with an 3-in × 3-in NaI(Tl) scintillation spectrometer and a global positioning system for the purpose of establishing a baseline for the radiation dose rate in air in south-central and southern Vietnam as well as to draw a detailed dose rate distribution map using the obtained data for these areas. South-central and southern Vietnam was divided into four regions: The south-central coast, central highlands, south-east and Mekong River Delta (including Phu Quoc Island). South-central and southern Vietnam consists of Da Nang, Ho Chi Minh and Can Tho Cities and twenty-nine provinces with an area of over 163,158 km^2, accounting for 50% of the whole area of Vietnam, and a population of over 47.95 million people, representing about 53% of the Vietnamese population as of 2014. The survey route encompassed all three cities and twenty-nine provinces. Roads which could be accessed by car were chosen for this survey and the total distance was approximately 17,140 km. The measured absorbed dose rates were compared with previous reports (i.e., estimated dose rates based on the activity concentration in soil samples) to estimate the impact on absorbed dose rate in air from artificial structures and annual effective dose was then calculated.

The average absorbed dose rate in air measured on Phu Quoc Island on asphalt pavement was 61 ± 15 nGy h^{-1} and higher dose rates in air were observed along asphalt roads, whereas the average value measured on unpaved roads was 29 ± 6 nGy h^{-1}, meaning the former average dose rate was 2.0 times higher. This height difference of the dose distribution might be caused by the presence of crushed stones (with relatively high natural radioactivity) under the asphalt cover. On Phu Quoc Island, transportation infrastructure developments such as roads and bridges and the construction of high-rise buildings have been associated with resort development. Thus, it is expected that the absorbed dose rate in air on Phu Quoc Island would be changed depending on those developments. The average dose rate for the entire island was 44 ± 20 nGy h^{-1}. The estimated annual external effective dose was 0.36 mSv, which is 75% of the worldwide average of 0.48 mSv y^{-1}.

The mean absorbed dose rates in air (range) for the south-east and Mekong River delta were found to be 61 ± 17 nGy h^{-1} (12 - 142 nGy h^{-1}), 66 ± 19 nGy h^{-1} (9 - 177 nGy h^{-1}), respectively. Those dose rates were respectively 2.1 and 0.9 times that of the previously estimated values based on the soil samples for each region. Especially, a higher dose rate compared with that previously reported was observed for the south-east region which is an urban area around Ho Chi Minh City and would have a large impact on dose rate from artificial structures.

The mean absorbed dose rates in air (range) for the south-central coast region and central highlands region were found to be 88 ± 27 nGy h^{-1} (8 - 249 nGy h^{-1}) and 69 ± 29 nGy h^{-1} (9 - 234 nGy h^{-1}), respectively. The ratio of the present mean dose rate for south central coast region and central highlands region with the literature mean dose rate (i.e., dose rate estimated from soil samples) were 1.0 and 0.9, respectively. The impacts on absorbed dose rate in air from artificial structures were small compared with that of the south-east region. Thus, the absorbed dose rate in air from natural radionuclides in these areas are not affected by the artificial structures. A heterogeneous distribution of absorbed dose rates in air was observed. Especially, the dose rate in the south-central coast region was higher than the central highlands region and it was highly correlated with the basement geology. The mean absorbed dose rate in air (range) for south-central and southern Vietnam was found to be 71 ± 23 nGy h^{-1} (8 - 249 nGy h^{-1}). The annual effective dose was calculated to be 0.58 mSv. This value was 1.2 times higher than the world-wide average of 0.48 mSv

y^{-1}.

This thesis found impacts on absorbed dose rate in air from natural radionuclides contained within the materials of newly constructed artificial structures. Additionally, the impacts from artificial structures were higher in urban areas and smaller in the countryside. This means that there is limitation to estimating dose rates based on the activity concentration in soil samples.

The results of this thesis will be useful for investigating the environmental impacts on absorbed dose rate in air from artificial structures in Vietnam. Furthermore, the methodology of the car-borne survey will be useful for making similar assessments in other rapidly developing countries worldwide.