§2. Investigation on Atmospheric Transport of Natural Radionuclides in NIFS

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The understanding of environmental radiation in the Toki site of NIFS plays an important role in the assessment of environmental effects associated with sophistication of LHD. The ambient gamma absorbed dose rate (DR) have been continuously measured by environmental radiation monitoring in the Toki site. It has been found that the DR varies with time and space due to the temporal and spatial variation in concentration of natural occurring radionuclides. Therefore, the measurement of radioactive concentration in the atmosphere and soil under present condition is needed to obtain background information for the assessment. In the previous study, the high level concentrations of natural occurring radionuclides in soil have been found in the Tono region of Gifu prefecture where the NIFS is located[1)]. Of the natural occurring radionuclides, radon-222 that is produced by the decay of Ra-226 and Rn-222 decay products are main contributor to the temporal variation in the DR. The purpose of this study is to measure the temporal variation in surface air Rn-222 concentration and to analyze its causes. From this study, we aim to provide fundamental knowledge to predict and estimate the variation in the DR.

Hourly atmospheric Rn-222 concentration was measured by an electrostatic radon monitor (OKEN Co. Ltd.). A silicon semiconductor detector was used as an alpha particle detector. A voltage of -3.0 kV was applied to electrostatically collect the Rn-222 decay products on the surface of the detector. Positive Po-218 and Po-214 ions newly produced from Rn-222 in the detection vessel were collected on the negatively charged electrode. A 16.8 L spherical detection chamber was used. Ambient air was drawn into the chamber through a dehumidifier and a membrane filter at a constant flow rate of 1.0 L min^{-1}. The membrane filter was used to remove the Rn-222 decay products. The detection limit which was calculated for 1 hour as defined by Currie (1968)[2)] was 0.5 Bq m^{-3}. Measurements were made at two heights of air inlet, 2.9 m asl and 10.7 m asl, on the Plasma Diagnostics Laboratory of NIFS at 252 m asl elevation. The difference of the concentration between the two monitors was evaluated to be about 0.1 % by calibration prior to the measurement at NIFS. The surface air Rn-222 concentration at two different heights show a diurnal cycle with a nighttime maximum at 6–8 JST (Japan Standard Time) and a daytime minimum at 17–20 JST in Fig. 1. The Rn-222 concentration at 2.9 m was slightly higher than that at 10.7 m. The concentration at 2.9 m varied from 1.8 to 33.0 Bq m^{-3} and the mean concentration was 9.9 Bq m^{-3}. The concentration at 10.7 m varied from 1.8 to 30.7 Bq m^{-3} and the mean concentration was 9.4 Bq m^{-3}. A phase difference of the concentration in two heights was not observed. The mean amplitude of the cycle was around 13 Bq m^{-3} and maximum amplitude was 27 Bq m^{-3} at 8 JST August 8. The high concentration at night was typically measured on sunny days when the sky was clear both by day and by night. Several small nighttime peaks and no clear peaks can be seen in Fig. 1 when the rainfall was measured at eastern boundary of NIFS (WA point) and at Nagoya local meteorological observatory. The wind velocity had a diurnal cycle with a daytime peak of 2–5 m s^{-1} and a nighttime calm of around 1.0 m s^{-1}. Westerly wind from ENE to SE was predominantly observed in daytime and easterly wind from NE to E in nighttime.

The diurnal variation of the Rn-222 concentration is explained by the variation of meteorological conditions, mixing layer height and atmospheric stability. The decrease in the concentration peak at night is probably caused by reduction of Rn-222 exhalation from ground by rainfall. The mean concentration in August measured in this study is comparable with that from August to September obtained by Yamanishi (1991)[3)]. The hourly peak concentration in nighttime is found to reach a high value of 33 Bq m^{-3} although oceanic air masses prevailed in this month. The high concentration may imply higher Rn-222 exhalation flux density from soil. The fact that the bedrock in the Tono region consists mainly of granite, which is abundant in Ra-226, is consistent with our consideration. It is a future subject to observe Rn-222 exhalation flux density in the Tono region. Furthermore, measurements of atmospheric Rn-222 concentration and flux from soil will allow us to examine the dispersion characteristics in the air over the Toki site and to estimate the variation in the DR.

1) Hosoda, M. et al.: RADIOISOTOPES, 64, (2015), 465–474.
2) Currie, L. A.: Anal. Chem., 40, (1968), 586–593.
3) Yamanishi, H. et al.: J. Nucl. Sci. Technol., 28, (1991), 331–338

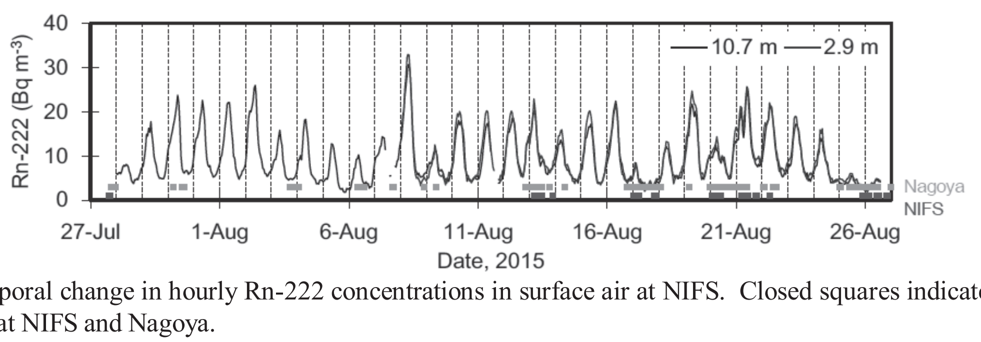

Fig. 1. Temporal change in hourly Rn-222 concentrations in surface air at NIFS. Closed squares indicate the rainfall occurrence at NIFS and Nagoya.