Experience of Airborne Radiation Monitoring After the Fukushima Dai-ichi Nuclear Station Accident

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1. Introduction

In order to evaluate the influence of radionuclides emitted by the accident at the Fukushima Dai-ichi Nuclear Power Station (FDNPS) of the Tokyo Electric Power Company Holdings, Inc. caused by the Great East Japan Earthquake, various types of environmental radiation monitoring data have been obtained by many governmental institutes and universities. An airborne radiation monitoring technique is suitable to grasp the overall distribution of the ambient dose rate (referred to hereinafter as the air dose rate) and the deposition of radionuclides.

After the FDNPS accident, the radiation measurement using a manned helicopter (MRM: Manned helicopter Radiation Monitoring) national project was started [1]. Even though the MRM initially monitored only the area around the FDNPS, the surveyed areas were gradually expanded and eventually airborne radiation monitoring was used in eastern Japan, excluding Hokkaido, after October 2011 and in western Japan and Hokkaido, after May 2012 [3]. The distributions of the air dose rate at a height of 1 m above ground level (agl.) and of the contamination concentration of radioactive cesium (^{134}Cs and ^{137}Cs) on the ground surface were monitored for all areas in Japan via this MRM project. This monitoring project is ongoing with regularly repeating surveys conducted [3]. While conducting the MRM project, we developed and established an analysis method concurrently with the development of the monitoring method [3].

A radiation measurement technique that is more detailed than the method using a manned helicopter is required to form a decontamination plan and to evaluate the effect of decontamination. Radiation measurement using an unmanned helicopter (URM: Unmanned helicopter Radiation Monitoring) is one solution because an unmanned helicopter can make detailed air dose rate maps by flying below 150 m, in accordance with Japanese aviation law. The URM was developed for monitoring high air dose-rate areas [4]. This article presents the methods and results of the MRM and URM missions performed around the FDNPS.

2. Method and Results

2.1 Monitoring system

The dedicated MRM radiation detection system (RSX-3, Radiation solution Inc., Mississauga, Canada), which was installed on a manned helicopter. This system consists of six large NaI detectors (dimensions: 2” × 4” × 16”, total NaI crystal volume: 12.6 L), a data processing unit (RS501 and RS701), and a Global Positioning System (GPS) receiver.

Unmanned helicopters, R-MAX G1 (manufactured by YAMAHA Co., Ltd., Iwata, Japan), originally developed for spraying pesticides, were used for radiation measurements. An unmanned helicopter can conduct a programmed flight with the help of detailed self-localization using a Real-time Kinematic Global Positioning System (RTK-GPS), and we can set its flight waypoints and altitude. Three LaBr3:Ce scintillation detectors (dimensions, 1.5”φ × 1.5”H; total LaBr3:Ce crystal volume, 0.13 L) are used in the URM radiation monitoring system.

2.2 Analytical methods

This section describes the method used to analyze the measurement data. The detailed analysis methods of MRM and URM are described in our previous articles [4, 5]. In order to convert MRM and URM data at the flight altitude to the air dose rate at a height of 1 m agl., a straight topographically flat road with a relatively flat distribution of the air dose rate was set as the test line. A conversion factor (CD:μSv h−1 cps-1) is used to convert the count rate at the flight altitude in the air to the air dose rate at a height of 1 m agl. Furthermore, flights at various altitudes from 150 m to 1,000 m (URM: from 10 m to 150 m) were performed over the test line and the effective attenuation factor in the air (AF) was obtained from the relationship between the count rate and the flight altitude.

Mapping was performed by supplementing unmeasured areas via an interpolation of the measured results. The inverse distance weighted (IDW) method was applied to the MRM. The URM data were interpolated using Kriging because this dataset is smaller than that of MRM.

3. Result and discussion

Fig. 1 shows maps of the air dose rate at 1 m agl. that were constructed from the MRM measured data. Area of high air dose rate exceeding 10 μSv h-1 was oriented toward the northwest from the FDNPS to an area approximately 30 km of the FDNPS. The area of high air dose rate (more than 1 μSv h−1) is gradually decreasing. In a recent result (2016), the air dose rates of more than half the areas within a range from 3 km to 80 km from the FDNPS were less than 0.5 μSv h−1. Conversely, the air dose rate northwest of the FDNPS remains relatively high.

Fig. 1 shows maps of the air dose rate at 1 m agl. that were constructed from the URM measured data. Four deposition patterns in which the air dose rate is particularly high extend from the FDNPS. This indicates that there were four separate releases of adioactive material to the ground side during the FDNPS accident. As in the result of the MRM, the area of high air dose rate is gradually decreasing.

4. Conclusion

In order to investigate the influence of radioactive cesium, the distributions of the air dose rate were measured via MRM and URM. In Japan, no technical experience or example measurements were available for evaluating the air dose rate distribution via wide-spread MRM and URM prior to the FDNPS accident. Therefore, we developed and established an analysis method concurrently while carrying out actual monitoring.

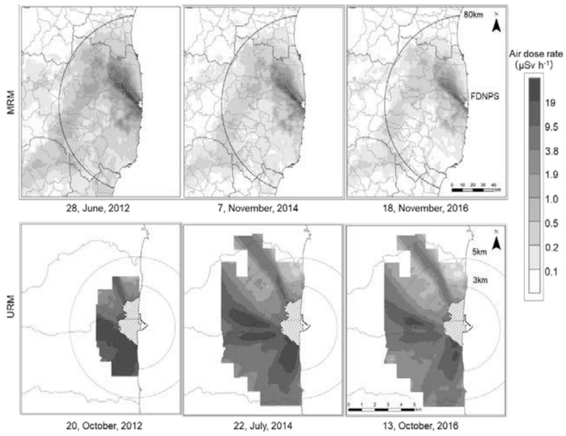

Fig. 1. Counter maps of dose rate around Fukushima Dai-ichi Nuclear Power Plant by airborne radiation monitoring.

This report summarized results that JAEA carried out as commissioned business by "the projects of the radiation monitoring using manned helicopter around the Fukushima Daiichi Nuclear Power Station" of the Nuclear Regulation Authority.

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