Results of Airborne Monitoring Survey by MEXT in the Kyushu Region and Okinawa Prefecture

The results of the airborne monitoring survey by MEXT in the Kyushu region and Okinawa prefecture ("Airborne Monitoring by MEXT in the Western Part of Japan, etc": announced on January 27, 2012) were summarized today, so they are provided here.

1. Objective of airborne monitoring in the Kyushu region and Okinawa Prefecture

MEXT conducted airborne monitoring* over the eastern part of Japan (Tokyo and 21 other prefectures) and has confirmed air dose rates and the distribution of the deposition of radioactive cesium in respective areas. Furthermore, through this monitoring, we were able to confirm the influence of natural radionuclides in East Japan, for which detailed measurement results had not been available.

In the meantime, the results of the monthly measurements of fallout conducted so far by MEXT have revealed that radioactive cesium has also been deposited in the western part of Japan and Hokkaido, although in small amounts.

Therefore, in order to confirm that deposition amounts of radioactive cesium are surely small, MEXT conducted airborne monitoring in the Kyushu region and Okinawa prefecture, as monitoring in the western part of Japan, where airborne monitoring had never been conducted.

This monitoring was conducted in respective target areas under the following systems.

- The airborne monitoring survey in the Kyushu region was conducted by the staff of the Japan Atomic Energy Agency using a private helicopter equipped with an airborne monitoring system borrowed from the U.S. Department of Energy or such a system owned by MEXT.
- The airborne monitoring survey in Okinawa was conducted by the staff of the Japan Atomic Energy Agency using a private helicopter with an airborne monitoring system borrowed from the U.S. Department of Energy.

These measurement results were analyzed by the Japan Atomic Energy Agency.

* Airborne monitoring: A technique in which highly sensitive, large radiation detectors are installed in an aircraft, and gamma rays from radioactive substances accumulated in the ground are quickly measured over a large area, in order to check the surface deposition.
2. Details of this monitoring

- Monitoring dates:
  (i) Kyushu region: January 30 to March 22 (50 flights in total)
  (ii) Okinawa: March 24 to March 29 (6 flights in total)
- Aircraft:
  (i) Kyushu region: private helicopter (BELL412SP, Sikorsky S-76)
  (ii) Okinawa: private helicopter (Sikorsky S-76)
- Items covered: Air dose rate at 1 m height above the ground surface, and deposition of radioactive cesium on the ground surface

3. Results of this monitoring

Attachments 1 to 8 are maps showing the distribution of air dose rates at 1m height above the ground surface and maps showing the deposition of radioactive cesium on the soil surface in the Kyushu region and Okinawa prefecture. Maps were prepared under the following conditions.

- The flight altitudes were from around 300m above the ground and the values for this monitoring survey are the averages of the measured values in circles with a diameter of around 600m (varies by flight altitude) below the aircraft.
- The width of the track is around 5km in this monitoring survey.
- In order to prepare distribution maps of air dose rates, we first obtained the relation between counting rates (cps) measured in the air above the test line established at each of the monitoring areas and air dose rates (μSv/h) at the height of 1m above the ground measured around the test line using NaI scintillators, and then calculated air dose rates at the height of 1m above the ground using counting rates measured in the air above respective measuring points.
- Maps showing deposition amounts of radioactive cesium were prepared by first assessing the characteristics of energy spectra of gamma rays measured in the air by type of helicopter and measuring equipment used, and then sorting out areas where the energy spectra of radioactive cesium (Cs-134 and Cs-137) were detected significantly and those were they were not. The details are as follows.
  (i) Areas where the energy spectra of radioactive cesium were detected significantly
    • Compared with the eastern part of Japan, the western part is further from Fukushima Dai-ichi NPP, and therefore deposition amounts of radioactive cesium are considered to be smaller. In addition, monitoring results prior to the occurrence of the accident at Fukushima Dai-ichi NPP have revealed that air dose rates due to natural radionuclides are higher in the western part of Japan.
    • Therefore, in order to calculate detailed deposition amounts of radioactive cesium in the western part of Japan, a new method was developed and used to assess influences of natural radionuclides in detail based on information on the energy spectra of gamma rays measured in the air (see Attachment 9 for details).
Based on this method, deposition amounts of radioactive cesium were calculated by deducting the contribution by natural radionuclides from measurement results of air dose rates at respective measuring points, and also based on the correlation between air dose rates and the results of the in-situ measurement* using germanium semiconductor detectors, which was conducted by the Japan Chemical Analysis Center in the course of the project, the 2011 Strategic Funds for the Promotion of Science and Technology, entitled “Establishment of the Base for Taking Measures for Environmental Impact of Radioactive Substances — Study on Distribution of Radioactive Substances.”

* In-situ measurement using germanium semiconductor detectors: Means to analyze the concentration of radionuclides accumulated in soil by setting up transportable germanium semiconductor detectors in the environment and detecting gamma rays that are emitted from radiation sources distributed in soil.

(ii) Areas where the energy spectra of radioactive cesium were not detected significantly
• In the same manner as before, they were indicated on maps as areas showing the minimum range of radioactive cesium (≤10kBq/m²) for the sake of simplicity.

The energy spectra of radioactive cesium were not detected significantly at any measuring points within the areas targeted in this monitoring.
○ Decay compensation of air dose rates and radioactive cesium were calculated as follows:
• After deducting air dose rates due to natural radionuclides from measurement results of air dose rates at respective measuring points, air dose rates were calculated by taking into account the physical attenuation of Cs-134 and Cs-137 from the measurement date to the final measurement date.
• Regarding deposition amounts of Cs-134 and Cs-137, physical attenuation from the measurement date up to the final measurement date was taken into account.
Readings of the Airborne Monitoring Survey by MEXT in the Kyushu Region and Okinawa Prefecture
(Air dose rates at 1 m above the ground surface in the Kyushu region)

Legend
Air dose rate over 1 meter above ground level (μSv/h)
[Compensated value as of March 22, 2012]

This map contains air dose rates by natural radionuclides.
Readings of the Airborne Monitoring Survey by MEXT in the Kyushu Region and Okinawa Prefecture
(Total deposition of Cs-134 and Cs-137 on the ground surface in the Kyushu region)
Readings of the Airborne Monitoring Survey by MEXT in the Kyushu Region and Okinawa Prefecture

(Deposition of Cs-134 on the ground surface in the Kyushu region)
Readings of the Airborne Monitoring Survey by MEXT in the Kyushu Region and Okinawa Prefecture
(Deposition of Cs-137 on the ground surface in the Kyushu region)
Readings of the Airborne Monitoring Survey by MEXT in the Kyushu Region and Okinawa Prefecture
(Air dose rates at 1 m above the ground surface in Okinawa prefecture)

This map contains air dose rates by natural radionuclides.
Readings of the Airborne Monitoring Survey by MEXT in the Kyushu Region and Okinawa Prefecture
(Total deposition of Cs-134 and Cs-137 on the ground surface in Okinawa prefecture)
文部科学省による九州地方、沖縄県の航空機モニタリングの測定結果について
(Deposition of Cs-134 on the ground surface in Okinawa prefecture)
Readings of the Airborne Monitoring Survey by MEXT in the Kyushu Region and Okinawa Prefecture

(Deposition of Cs-137 on the ground surface in Okinawa prefecture)
Method to Assess Influences of Natural Radionuclides in Airborne Monitoring over the Western Part of Japan

1. Background/Objective

- In airborne monitoring surveys, deposition amounts of radioactive cesium are calculated based on values obtained by deducting air dose rates due to natural radionuclides from estimated air dose rates at the height of 1m above the ground surface at respective measuring points.
- In the case of the airborne monitoring surveys conducted all over the eastern part of Japan last year, air dose rates due to radioactive cesium were first calculated by deducting the average air dose rate for all over the eastern part of Japan before the accident at Fukushima Dai-ichi NPP (air dose rates due to natural radionuclides) from estimated values of air dose rates at the measuring points, and then deposition amounts of radioactive cesium were calculated based on the correlation between air dose rates and the results of the in-situ measurement using germanium semiconductor detectors, which was conducted by the Japan Chemical Analysis Center in the course of the project, the 2011 Strategic Funds for the Promotion of Science and Technology, entitled “Establishment of the Base for Taking Measures for Environmental Impact of Radioactive Substances — Study on Distribution of Radioactive Substances” (June to August 2011).
- Meanwhile in the western part of Japan,
  (i) the average air dose rate due to natural radionuclides for all over the western part of Japan is higher, compared to that for East Japan overall (see Fig. 1),
  (ii) air dose rates in the western part of Japan vary in a wider range than those in East Japan (see Fig. 1), and
  (iii) based on past airborne monitoring results, it is expected that air dose rates due to radioactive cesium are lower all over the western part of Japan.

Accordingly, if the average air dose rate due to natural radionuclides for all over the western part of Japan is deducted from estimated results of air dose rates at respective measuring points using the same method as that employed in the airborne monitoring in East Japan, it is highly likely that the obtained values of air dose rates due to radioactive cesium will become negative at many measuring points in the western part of Japan, which makes it difficult to make accurate assessments of deposition amounts of radioactive cesium.

- Therefore, in airborne monitoring in the western part of Japan, a new method was studied, under which detailed surveys would be conducted with regard to the energy spectra of gamma rays measured in the air (data per second) by type of helicopter and measuring equipment used, thereby assessing the influences of natural radionuclides in each area. In this study, the method developed by the US DOE was referred to.
Fig. 1 Air Dose Rates in East Japan and West Japan before the Accident at Fukushima Dai-ichi NPP
(Results of the measurement of air dose rates using survey meters)

2. Results of the study

○ In order to calculate air dose rates at the height of 1m above the ground surface, counting rates of gamma rays from the ground surface measured in the air above respective points are used in airborne monitoring surveys.

○ In order to ascertain the contribution of counting rates due to natural radionuclides based on information on the energy spectra of gamma rays measured in the air, a comparison was made with regard to the following counting rates for areas where the energy spectra of radioactive cesium were not detected significantly (see Fig. 2):

(i) Counting rates in the overall energy range (the total counting rates due to natural radionuclides)

(ii) Counting rates in part of the energy range that does not include the energy spectra of radioactive cesium but does include the energy spectra of natural radionuclides (the range where the gamma-ray energy is 1400keV or over)

○ As a result, it was confirmed that the ratios of counting rates in the energy range (hereinafter referred to as the “counting rate ratios”) are almost constant irrespective of measuring points (see Fig. 3). Then, it was examined whether it would be possible to estimate air dose rates due to natural radionuclides at the respective measuring points by using these ratios.
Fig. 3 Correlation between Counting Rates in the Range over 1400 keV and Counting Rates in the Overall Energy Range

2.1 Factors that decide the counting rate ratios

○ In order to confirm factors that decide the counting rate ratios, a comparison was also made by type of helicopter and measuring equipment used, with regard to the correlation between (i) counting rates in the overall energy range (the total counting rates due to natural radionuclides) and (ii) counting rates in the range where the gamma-ray energy is 1400 keV or over.

○ As a result, it was confirmed that counter rates (i) and (ii) are correlated with each other in any combination of helicopter and measuring equipment, showing a specific counting rate ratio for each combination (see Fig. 4).
2.2 Method to separate only counting rates of radioactive cesium

- According to the results of 2.1 above, it was confirmed that when the same measuring equipment and helicopter were used, the counting rate ratios were almost constant at any measuring points in areas where the energy spectra of radioactive cesium were not detected significantly. Therefore, a method is examined to use these counting rate ratios for assessing counting rates due to natural radionuclides at points where the energy spectra of radioactive cesium were detected significantly, under the condition where the combination of measuring equipment and helicopter used is the same.

- The total counting rates (cps) measured in the air at these points (black line) are considered to be the sum of the counting rates (cps) due to radioactive cesium (red line) and the counting rates (cps) due to natural radionuclides (green line) (=the counting rates in the region where the gamma-ray energy is 1400 keV or over × the counting rate ratios) (see Fig. 5).

- Therefore, it was judged possible to calculate the counting rates solely due to radioactive cesium (red line part in Fig. 5) by formula as follows, through deducting the counting rates due to natural radionuclides from the total counting rates in the overall energy range by using a specific counting rate ratio for each combination of measurement equipment and helicopter used.
2.3 Method to calculate air dose rates due to radioactive cesium

- As explained above, in order to calculate deposition amounts of radioactive cesium in airborne monitoring surveys, it is necessary to calculate air dose rates (μSv/h) based on counting rates (cps) obtained at respective measuring points.
- Therefore, a method was examined to convert counting rates (cps) obtained in 2.2 into air dose rates (μSv/h) due to radioactive cesium.
- In airborne monitoring surveys, test lines are established for each of the monitoring areas and the ratios of air dose rates measured at the height of 1m above the ground against the counting rates in the overall energy range (μSv/h(cps; hereinafter referred to as the “dose-rate conversion factors”) are obtained. These dose-rate conversion factors vary by the combination of measuring equipment and helicopter used, but are confirmed to be almost constant for any of the combinations, irrespective of deposition amounts of radioactive cesium (see Fig. 6).
- As the dose-rate conversion factors are almost constant both in areas where deposition amounts of radioactive cesium are large and the influences of natural radionuclides can be ignored, and areas where the energy spectra of radioactive cesium are not detected significantly, it was judged possible to calculate air dose rates due to radioactive cesium, by formula as follows, through making an assessment based on the counting rates of radioactive cesium by using specific dose-rate conversion factors for each type of measuring equipment and helicopter used.

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\text{Air dose rates due to radioactive cesium (μSv/h)}
= \text{Dose-rate conversion factors (μSv/h(cps))} \times \text{Counting rates solely due to radioactive cesium (cps)}
\]
Given these, in the case of the airborne monitoring survey for the western part of Japan, in order to obtain accurate calculation results of radioactive cesium in areas where the energy spectra of radioactive cesium were detected significantly, it was decided to adopt a method different from that employed in the airborne monitoring in East Japan, i.e., first assessing air dose rates of radioactive cesium by deducting the air dose rates due to natural radionuclides from the air dose rates at respective points, based on the information on gamma rays measured at respective points, and then converting the obtained air dose rates into deposition amounts of radioactive cesium (see Fig. 7).

The conventional method contains the possibility, due to a statistical reason, that in some areas, deposition amounts of radioactive cesium are indicated as being 10kBq/m² or over, although the energy spectra of radioactive cesium are not detected significantly, just because air dose rates become higher due to the influences of natural radionuclides. The new method can also be used for such areas in order to properly assess deposition amounts of radioactive cesium.
Fig. 7 Outline of the Method Newly Adopted for Calculating Deposition Amounts of Radioactive Cesium