Analysis Results Concerning (i) Gamma-emitting Nuclides and (ii) Sr-89 and Sr-90 (Second Distribution Survey)
by MEXT

Since December 6, 2011, MEXT has conducted an analysis of gamma-emitting nuclides, as well as Sr-89 and Sr-90, in its Second Distribution Survey of radioactive materials discharged due to the accident at TEPCO’s Fukushima Dai-ichi NPS. The results of the analysis have been compiled below.

1. Objective of this survey

MEXT carried out a radiation survey in June 2011 (hereinafter referred to as the “First Distribution Survey”), collecting soil samples at about 2,200 locations (Note 1) within an area approximately 100km from TEPCO’s Fukushima Dai-ichi NPS (hereinafter referred to as “Fukushima Dai-ichi NPS”) and in the western part of Fukushima prefecture beyond this range. MEXT analyzed the amounts of gamma-emitting nuclides (radioactive cesium, I-131, Te-129m, and Ag-110m) in all soil samples, and of Sr-89 and Sr-90 in some soil samples, collected at 100 locations within 80km from Fukushima Dai-ichi NPS.

The results were compiled into distribution maps of radioactivity concentration in the soil that plot out deposition amounts of gamma-emitting nuclides (radioactive cesium, I-131, Te-129m, and Ag-110m) within an area approximately 100km from Fukushima Dai-ichi NPS and in the western part of Fukushima prefecture beyond this range (for details, see “Preparation of Distribution Map of Radiation Doses, etc. (Map of Radioactive Cesium Concentration in Soil) by MEXT” dated August 30, 2011, and other publications (Note 2)). Regarding Sr-89 and Sr-90, maps showing the concentrations of Sr-89 and Sr-90 in soil within 80km of Fukushima Dai-ichi NPS were prepared (for details, see “Results of the Nuclide Analysis of Plutonium and Strontium by MEXT” dated September 30, 2011).

In the meantime, airborne monitoring of all areas in eastern Japan (Note 3) revealed spots more than 100km from Fukushima Dai-ichi NPS in which relatively large amounts of radioactive cesium were detected. Furthermore, the First Distribution Survey revealed that Te-129m and A-110m were detected at some survey points within 100km of Fukushima Dai-ichi NPS, which suggests that these radioactive nuclides may have also been deposited more than 100km from Fukushima Dai-ichi NPS. Through the First Distribution Survey, it was further confirmed that deposition of Sr-89 and Sr-90 was not limited to 80km from Fukushima Dai-ichi NPS and that deposition amounts of Sr-89 and Sr-90 are rather large compared with Cs-137 at some of the survey points.
This suggested the possibility that similar trends could be found in the surrounding areas.

Therefore, in order to more widely ascertain the deposition of gamma-emitting nuclides, this survey (hereinafter referred to as the “Second Distribution Survey”) targeted wider areas than the First Distribution Survey and measured deposition amounts of gamma-emitting nuclides mainly in areas of eastern Japan in which high air dose rates were detected. Furthermore, in order to ascertain a wider range of deposition amounts of Sr-89 and Sr-90 discharged due to the accident at Fukushima Dai-ichi NPS, MEXT collected new soil samples mainly in areas of eastern Japan in which high air dose rates were detected, and analyzed the amount of Sr-89 and Sr-90 in the soil samples. At the same time, MEXT measured deposition amounts of Sr-89 and Sr-90 in soil samples collected in areas surrounding survey points measured in the First Distribution Survey which had shown large deposition amounts of Sr-89 and Sr-90 compared with Cs-137 in order to ascertain whether similar trends applied in such surrounding areas.

The results of the Second Distribution Survey were compiled after verification of their validity by experts in the relevant fields, as was the case with the First Distribution Survey.

Note 1: In the First Distribution Survey, one survey point was selected in each 2km × 2km area in a grid placed on habitable areas within 80km of Fukushima Dai-ichi NPS, and one in each 10km × 10km area in a grid placed on the area from 80 to 100km of Fukushima Dai-ichi NPS and in the western part of Fukushima prefecture beyond this range. At each survey point, soil samples were collected in U-8 containers to a depth of 5cm from the surface at five different spots in a three meters square.

Note 2: “Preparation of Distribution Map of Radiation Doses, etc. (Map of Radioactive Cesium Concentration in Soil) by MEXT” (August 30, 2011), “Preparation of Distribution Map of Radiation Doses, etc. (Map of Iodine 131 Concentration in Soil) by MEXT” (September 21, 2011), and “Preparation of Distribution Map of Radiation Doses, etc. (Maps of Concentration of Tellurium 129m and Silver 110m in Soil) by MEXT (October 31, 2011)

Note 3: “Results of the Fourth Airborne Monitoring Survey by MEXT” (dated December 16, 2011), Reference 1 “Air dose rates at 1m above the ground surface throughout all of East Japan, reflecting the results of the fourth airborne monitoring (Converted into the value as of November 5, 2011)”

2. Details of this survey
(i) Measurement of deposition amounts of gamma-emitting nuclides

Survey points (1,016 locations)

Deposition amounts of gamma-emitting nuclides were measured mainly in areas where the results of the airborne monitoring of all of eastern Japan showed relatively high air dose rates (0.2μSv/h or higher), equivalent to an annual dose of 1mSv. (Note 4) One survey point was selected in each 5km × 5km area in a grid placed on areas in which air dose rates of 0.2μSv/h or higher had been measured, and one in each 10km × 10km area in a grid placed on areas in which air dose rates of 0.2μSv/h or lower had been measured.

Note 4: Measurements were made in some areas of Tokyo and ten other prefectures (Fukushima, Ibaraki, Iwate, Kanagawa, Gunma, Saitama, Chiba, Tochigi, Miyagi, and Yamanashi). Areas in which air dose rates are high due to the influence of natural radionuclides were excluded.

Measuring organizations: Japan Atomic Energy Agency, RIKEN, L'Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Tsukuba University, Japan Chemical Analysis Center, Institute of Radiation Measurements, and Nuclear Safety Technology Center
○ Items covered: Deposition amounts of gamma-emitting nuclides on the ground surface per unit area [Bq/m²]
○ Survey method:

  Through the First Distribution Survey, it was confirmed that deposition amounts of radioactive nuclides on the ground surface vary even within small areas (3 meters square). Therefore, in the Second Distribution Survey, we carried out in-situ measurements using germanium semiconductor detectors.\(^{\text{Note 5}}\) Using this method, which enables the evaluation of average deposition amounts at the measuring points, we measured the deposition amounts of gamma-emitting nuclides at as many points as possible.

  At survey points which had shown very high air dose rates or where it was otherwise found that proper in-situ measurement would be difficult, we carried out the measurements in the manner used in the First Distribution Survey: collecting soil samples to a depth of 5cm from the surface at five different spots surrounding each survey point, stirring the collected soil samples well, and conducting nuclide analysis using fixed germanium semiconductor detectors (measurement time was around one hour).

  \(^{\text{Note 5}}\): These measurements were conducted by analyzing the average concentration of radioactive materials accumulated in soil by installing portable germanium semiconductor detectors in the environment (at flat places without any buildings, etc. nearby), carrying out measurements of the overall soil surface, and measuring the gamma rays emitted by radiation sources distributed in the soil. This survey was conducted based on MEXT's Radiation Measurement Method Series, “In-situ Measurement Using Germanium Semiconductor Detectors” and by referring to ICRU report 53 as a parameter to show the vertical distribution of radionuclides in soil. 0 to 1 year was to have elapsed since deposition and 3mm or more in precipitation was to have fallen. The measurement time was to be one hour in principle, but for some measuring points, the measurement time was shortened after confirming the measurement’s statistical accuracy.

○ Correction of the gamma-emitting nuclide measurement results:

  Considering the physical half-lives of radionuclides (Cs-134: 2.0648 years; Cs-137: 30.1671 years; Ag-110m: 249.95 days), the obtained values were corrected for their decay as of March 1, 2012, the midpoint of the survey period (December 13, 2011 – May 29, 2012).

(ii) Measurement of Sr-89 and Sr-90 deposition amounts

○ Survey points (63 samples from 60 locations)

  This survey targeted the following two areas.

  1) Areas more than 80km from Fukushima Dai-ichi NPS (50 samples from 50 locations)

    Excluding areas 80km from Fukushima Dai-ichi NPS covered by the First Distribution Survey, we collected new soil samples in areas where airborne monitoring of all of eastern Japan had shown relatively high air dose rates (0.2\(\mu\)Sv/h or higher),\(^{\text{Note 6}}\) and measured the deposition amounts of Sr-89 and Sr-90. Survey points were determined by apportioning areas showing air dose rates of 0.2\(\mu\)Sv/h or higher into 5km×5km grids and selecting points evenly from these grid areas (50 locations: 50 samples).
Note 6: Measurements were carried out for some areas in Tokyo and nine other prefectures (Fukushima, Ibaraki, Iwate, Gunma, Saitama, Chiba, Tochigi, Miyagi, and Yamanashi). Areas in which air dose rates are high due to the influence of natural radionuclides were excluded.

2) Soma City and surrounding areas (13 samples from 10 locations)

The First Distribution Survey ascertained that a sample collected at one point in Soma City showed very large ratios of deposition amounts of Sr-89 and Sr-90 against those of Cs-137 (hereinafter referred to as “ratios of Sr-89 and Sr-90 against Cs-137”), compared with samples collected at other points.

This time, we analyzed the other four samples collected at this point (hereinafter referred to as “Soma City Point 1”) during the First Distribution Survey, and also conducted an analysis of Sr-89 and Sr-90 with regard to one sample each selected from those collected from nine points surrounding Soma City Point 1 in the First Distribution Survey that contained the largest amount of Cs-137.

(Reference 1) Results of the First Distribution Survey (deposition amounts of Sr-89 and Sr-90 contained in soil samples collected at Soma City Point 1)

<table>
<thead>
<tr>
<th>Measuring organization: Japan Chemical Analysis Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items covered: Deposition amounts of Sr-89 and Sr-90 on the ground surface per unit area [Bq/m²]</td>
</tr>
<tr>
<td>Sampling period: December 17, 2011 – February 9, 2012 (period for collecting soil samples at survey points in areas more than 80km from Fukushima Dai-ichi NPS showing air dose rates of 0.2μSv/h or higher)</td>
</tr>
<tr>
<td>Survey method:</td>
</tr>
<tr>
<td>We conducted radiochemical analysis of the following soil samples using low background beta-ray counters for around 60 minutes. The amounts sampled and the detection limits were as follows.</td>
</tr>
<tr>
<td>1) Soil samples collected in areas more than 80km from Fukushima Dai-ichi NPS</td>
</tr>
<tr>
<td>We used sample amounts approximately three times larger than those used in the First Distribution Survey (100g compared with 30g in the First Distribution Survey) and also lowered the detection limits for Sr-89 and Sr-90. The detection limits adopted were around 100Bq/m² for Sr-89 and around 15Bq/m² for Sr-90.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measurement results of the First Distribution Survey (deposition amounts of Sr-89 and Sr-90 in soil samples collected at Soma City Point 1)</th>
<th>Measurement results of the First Distribution Survey (ratios of Sr-89 and Sr-90 against Cs-137 in soil samples collected at Soma City Point 1)</th>
<th>(Reference) Measurement Results of the First Distribution Survey (average ratios of Sr-89 and Sr-90 against Cs-137 contained in soil samples, out of the 100 samples for which measurements were carried out in the First Distribution Survey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sr-89 7,800 (Bq/m²) 1.9×10⁻¹ 9.8×10⁻³</td>
<td>Sr-90 2,400 (Bq/m²) 5.8×10⁻² 2.6×10⁻³</td>
<td></td>
</tr>
</tbody>
</table>
2) Soil samples collected at Soma City Point 1 and the surrounding areas

We used 30g samples collected at the relevant points as we did at the time of the First Distribution Survey, and measured the deposition amounts of Sr-89 and Sr-90. The detection limits adopted were around 300Bq/m² for Sr-89 and around 40Bq/m² for Sr-90.

○ Correction of the Sr-89 and Sr-90 measurement results:

Considering the physical half-lives of Sr-89 and Sr-90 (Sr-89: 50.53 days; Sr-90: 28.79 years), the obtained values were corrected for their decay as of January 13, 2012, the midpoint of the survey period (December 17, 2011 – February 9, 2012).

3. Results of this survey

3.1 Results of measurement of deposition amounts of gamma-emitting nuclides

○ See the following URL for the gamma-emitting nuclide (Cs-134, Cs-137, and Ag-110\(^{(Note\,7)}\)) measurement results obtained in this survey.

URL: [http://radioactivity.mext.go.jp/en/list/269/list-1.html](http://radioactivity.mext.go.jp/en/list/269/list-1.html)

In this survey, radioactive cesium was detected at all survey points, but Ag-110m was detected only at some points in Fukushima, Iwate, Ibaraki, Gunma, Tochigi, and Miyagi prefectures (detection limits were around 20 to 200Bq/m²). The First Distribution Survey showed that Te-129m\(^{(Note\,7)}\) had been deposited on the soil surface over a relatively wide area, but it was not detected at all in this survey as its physical half-life is 33.6 days.

Note 7: Ag-110m and Te-129m have the same atomic number and mass as Ag-110 and Te-129. However, as there are multiple nuclides with different energy levels, the letter “m,” indicating that the substance is in a metastable state, is added to distinguish radioactive nuclides with higher relative energy levels.

○ The results of the Cs-134, Cs-137, and Ag-110m measurements obtained in this survey were compiled into distribution maps of radioactivity concentration in the soil \(^{(Note\,8)}\) showing their deposition levels in different colors, as shown in Attachments 1, 2, and 3. In preparing these maps, we used the results of the in-situ measurements for survey points where we carried out such measurements using germanium semiconductor detectors, and for other survey points where we newly collected and analyzed samples, we used arithmetic mean values for the measurement results for samples collected at five different spots at each survey point in the same manner as in the First Distribution Survey. With regard to Ag-110m, the measurement results from the samples collected at the five different spots at each survey point sometimes contained values below detection limits. For such survey points, the deposition amounts of Ag-110m were determined as follows, in the same manner as in the First Distribution Survey:

• Where one or more of the five samples collected at the same point showed values above the detection limit, the arithmetic mean value of the measured values above the detection limit and the reference values for those below the detection limit shall be used.

• Where all samples collected at the same point showed values below the detection limit, the measurement results for said point were deemed not detectable.
Note 8: These maps show the distribution of radioactivity remaining near the soil surface per unit area, and the term “distribution maps of radioactivity concentration in the soil” is used for convenience.

- Additionally, in order to capture details of the distribution of Cs-134, Cs-137, and Ag-110m, we prepared distribution maps adding decay-compensated values for the results of the First Distribution Survey (see Attachment 1 (Reference), Attachment 2 (Reference), and Attachment 3 (Reference)). With the assumption that changes in the deposition amounts since the time of the First Distribution Survey (June 14, 2011) would only result from decay, the deposition amounts of Cs-134, Cs-137, and Ag-110m obtained at each survey point from the First Distribution Survey were corrected for their decay as of March 1, 2012, considering their physical half-lives.

3.2 Results of the measurement of deposition amounts of Sr-89 and Sr-90
- The results of the Sr-89 and Sr-90 nuclide analysis in this survey are provided in Attachment 4. In the First Distribution Survey, Sr-89 was detected as far as the border of the targeted 80km radius from Fukushima Dai-ichi NPS, but Sr-89 was not detected at all in this survey as its physical half-life is short (50.53 days).
- The results of the Sr-89 and Sr-90 measurements in this survey were compiled into a distribution map as shown in Attachment 5.
- Although Sr-89 was not detected at all survey points in this survey, in order to capture details of the distribution of Sr-90, we also prepared a distribution map adding decay-compensated values for the results of the First Distribution Survey (see Attachment 5 (Reference)). With the assumption that changes in the deposition amounts since the time of the First Distribution Survey (June 14, 2011) would only result from decay, the Sr-90 deposition amounts obtained at each survey point through the First Distribution Survey were corrected for its decay as of January 13, 2012, considering its physical half-life (28.79 years).
- This time, we collected 13 new samples at 10 locations near Soma City Point 1, where the ratios of Sr-89 and Sr-90 against Cs-137 were the largest in the First Distribution Survey, so as to ascertain the deposition of radioactive strontium around these areas. Sr-89 was not detected in any of these 13 samples. Sr-90 was detected in some of them, but in very small amounts (around 1/50 to 1/25 of the amounts detected in the samples collected at Soma City Point 1 in the First Distribution Survey).

4. Considerations
4.1 Overall considerations
- Through the First and Second Distribution Surveys, the distribution of Cs-134, Cs-137, and Ag-110m over wide areas was ascertained in detail. These results are expected to be utilized for the assessment of exposure doses, examination of the status of the radioactive plume discharged by Fukushima Dai-ichi NPS, and clarification of the route through which these radioactive materials came to be deposited on the ground surface.
- With the assumption that a person would remain for fifty years at the points where the largest deposition amounts of Cs-134, Cs-137, Ag-110m, and radioactive strontium were detected in the
Second Distribution Survey, we calculated the estimated effective dose of inhalation exposure that would be caused by breathing airborne soil and of the external exposure from the soil (hereinafter such effective dose shall be referred to as the “effective dose over 50 years”) based on the procedures for dose evaluation during a radiological emergency proposed by the IAEA. \(^{(Note \ 9)}\) As a result, it was confirmed that the effective doses over 50 years at the points where the largest deposition amounts of Cs-134 and Cs-137 were detected this time were considerably larger than the doses at points where the largest deposition amounts of Ag-110m and radioactive strontium were detected. These results were the same as those obtained through the First Distribution Survey.

\(^{(Note \ 9)}\) Method to assess exposure levels described in IAEA-TECDOC-955, 1162

Presuming that a radioactive nuclide deposited on the ground stays on that spot, this method defines the procedures to evaluate effective doses for a certain period of time after the nuclide is deposited on the ground surface (for the first month, for the second month, and for 50 years). The effective doses thus obtained include external exposure doses and committed doses caused by the inhalation of resuspended radioactive nuclides. In the calculation of effective doses, consideration was given to the effects of radionuclide decay, nuclear transmutation, and weathering. Furthermore, in order to assess inhalation exposure caused by resuspended radioactive nuclides on the safer side, \(10^{-6}/m\) was adopted as the resuspension factor, which is larger than the value actually measured at the time of the nuclear accident.

(Reference 2) Effective doses over 50 years at points where the largest deposition amounts of Cs-134, Cs-137, Ag-110m, and Sr-90 were detected in this survey

(i) Cs-134 \((6.5\times10^6\text{Bq/m}^2)\): 33mSv
(ii) Cs-137 \((9.1\times10^6\text{Bq/m}^2)\): 1.2\times10^3\text{mSv}
(iii) Ag-110m \((1.3\times10^4\text{Bq/m}^2)\): 0.50mSv
(iv) Sr-90 \((130\text{Bq/m}^2)\): 0.0027mSv

○ The effective doses over 50 years of Cs-134 and Cs-137 are very large compared with those of Ag-110m and radioactive strontium. Therefore, when assessing exposure doses or implementing decontamination in the future, we should continue to focus attention on the deposition amounts of Cs-134 and Cs-137.

4.2 Considerations related to the gamma-emitting nuclide measurement results

○ In the First Distribution Survey, it was confirmed that the ratios of deposition amounts of I-131 and Te-129m against those of radioactive cesium showed certain characteristics by region, while the deposition amounts of I-131 and Te-129m were consistent. However, there was no clear regional trend in the ratios of deposition amounts of Ag-110m against those of radioactive cesium.

○ The Second Distribution Survey, which broadened the targeted areas, revealed survey points showing similar ratios of deposition amounts of Ag-110m against those of Cs-137 from Nakadori district in Fukushima prefecture to Gunma prefecture, as indicated in Attachment 6. It was also confirmed that at some points in the coastal areas of Fukushima prefecture, located on the south and north sides of Fukushima Dai-ichi NPS, the ratios of deposition amounts of Ag-110m against those of Cs-137 were higher than in areas from Nakadori district in Fukushima prefecture to Gunma prefecture.
In order to verify the validity of the gamma-emitting nuclide measurement results, we checked for correlations between deposition amounts of Cs-134 and Cs-137 as measured in this survey. As a result, it was confirmed that they showed very clear correlations, irrespective of the measuring point, and that the air dose rates obtained based on in-situ measurement results coincided with air dose rates measured using NaI survey meters at points where in-situ measurement was carried out. Given these facts, it was verified that gamma-emitting nuclides were properly measured in this survey (for details, see Attachment 7).

As shown in Attachment 8, we indicated the Cs-137 deposition amounts obtained through this survey on a map showing the results of nationwide airborne monitoring (Cs-137 deposition amounts), and confirmed that the results of the measurement of Cs-137 in this survey generally indicates trends similar to those indicated by the results of the airborne monitoring, although with some locally observed differences due to differences in the measurement methods.

Note 10: The results shown in “(i) Results of Airborne Monitoring Survey in Hokkaido and (ii) Revision to the Results of Airborne Monitoring Survey over the Eastern Part of Japan with Detailed Consideration of the Influence of Natural Radionuclides” (dated July 27, 2012), Reference 4, “Measurement Results of the Airborne Monitoring Surveys Conducted by MEXT Nationwide (Deposition of Cs-137 on the ground surface nationwide)”

4.3 Considerations related to the Sr-89 and Sr-90 measurement results

(i) Consideration of the range of deposition of radioactive strontium discharged due to the accident at Fukushima Dai-ichi NPS

In this survey, detection limits were lowered to about one-third of those adopted in the First Distribution Survey to measure the deposition amounts of Sr-89 and Sr-90. Even so, Sr-89 was not detected at all in areas outside the 80km-range from Fukushima Dai-ichi NPS as its physical half-life is short.

Sr-90 was detected, but the values obtained were all within the range caused by past nuclear testing in the atmosphere when compared with the results of the nationwide survey conducted from FY1999 to FY2009, prior to the accident at Fukushima Dai-ichi NPS. Given these facts, it can be said that radioactive strontium discharged due to the accident at Fukushima Dai-ichi NPS was not detected in areas more than 80km from the NPS in this survey.

Note 11: Sr-90 – Detection limit to 950Bq/m² (average of detected values: 79Bq/m²)

However, “Sr-90 Analysis Results from the Monitoring of Environmental Radioactivity Levels by Prefecture (Fallout)” (dated July 24, 2012) revealed that Sr-90 radiation levels in fallout samples collected in March or April 2011 in Tokyo and in 9 other prefectures exceeded the maximum Sr-90 radiation levels measured nationwide before the accident during the 11 years from FY1999 to FY2009. In light of this, it is believed Sr-90 may have fallen in Tokyo and in these 9 other prefectures due to the accident at Fukushima Dai-ichi NPS but in amounts not large enough to affect the depositions amounts of Sr-90 in soil measured before the accident.

Note 12: Airborne material, such as dust, which falls from the air due to rain and wind, is collected each month in large basins installed by prefectures, and beta rays from Sr-90 are measured for these collected samples.
(ii) Considerations related to measurement results concerning soil samples collected around Soma City Point 1

○ In this survey, in order to ascertain the deposition of radioactive strontium in areas around Soma City Point 1, where the ratios of Sr-89 and Sr-90 against Cs-137 were the largest in the First Distribution Survey, we performed new measurements of the deposition amounts of Sr-89 and Sr-90 with regard to 13 soil samples collected in June 2011. As a result, Sr-89 was not detected at all, and the amounts of Sr-90 detected were very small at around 1/50 to 1/25 of the amounts detected in samples collected at Soma City Point 1 in the First Distribution Survey. Accordingly, it was confirmed that the ratios of deposition amounts of radioactive strontium against those of radioactive cesium are not especially large characteristically around these areas around Soma City Point 1, but the deposition of radioactive strontium on soil varies more significantly than that of radioactive cesium.

○ Furthermore, we newly measured the deposition amounts of Sr-89 and Sr-90 in the 30g soil samples used to measure the deposition amounts of Sr-89 and Sr-90 at Soma City Point 1 in the First Distribution Survey, but neither Sr-89 nor Sr-90 was detected this time. We also confirmed that the deposition amounts of radioactive strontium vary even among the 100g soil samples collected at the same survey point (Soma City Point 1).

○ In order to ascertain the factors influencing the deposition amounts of Sr-90, we checked for changes in the ratios of deposition amounts of Sr-90 against those of Cs-137 in the results of the First Distribution Survey. As indicated in Attachment 9, the deposition amounts of Sr-90 were around 1/1000 of those of Cs-137 at many survey points. However, as can be seen in the measurement results for Soma City Point 1 (measured in the First Distribution Survey), deposition amounts of Sr-90 only occasionally vary up to around one-tenth of those of Cs-137.
Results of nuclide analysis of Cs-134 (Results of the Second Distribution Survey)

Legend
Deposition amounts of Cs-134 (Bq/m²)
(As of March 1, 2012)

Points where values were below detection limits

Mesh (5km, 10km)

Fukushima Dai-ichi NPS

“×” in the map indicates points where measurement results were below detection limits in the Second Distribution Survey.
Results of nuclide analysis of Cs-137 (Results of the Second Distribution Survey)

Legend
Deposition amounts of Cs-137 (Bq/m²)
(As of March 1, 2012)

Mesh (5km, 10km)
Results of nuclide analysis of Ag-110m (Results of the Second Distribution Survey)

Legend
Deposition amounts of Ag-110m (Bq/m²)
(As of March 1, 2012)
- 100k <
- 50k - 100k
- 20k - 50k
- 10k - 20k
- 5k - 10k
- 1k - 5k
- 0.1k - 0.2k
- ≤ 0.1k

Points where values were below detection limits
Mesh (5km, 10km)
Habitable area
Non-habitable area

“x” in the map indicates points where measurement results were below detection limits in the Second Distribution Survey.
Results of nuclide analysis of Cs-134
(Results of the First Distribution Survey\(^{(1)}\) were added to those of the Second Distribution Survey)

Considering the physical half-life of Cs-134 (2.0648 years), the results of the first distribution survey were corrected for its decay as of March 1, 2012.

\(^{1}\) - Points where values were below detection limits in the Second Distribution Survey.

\(^{1}\) : "×" in the map indicates points where measurement results were below detection limits in the Second Distribution Survey.
Results of nuclide analysis of Cs-137
(Results of the First Distribution Survey(※1) were added to those of the Second Distribution Survey)

Considering the physical half-life of Cs-137 (30.1671 years), the results of the first distribution survey were corrected for its decay as of March 1, 2012.
Results of nuclide analysis of Ag-110m
(Results of the First Distribution Survey were added to those of the Second Distribution Survey)

1: Considering the physical half-life of Ag-110m (249.95 days), the results of the first distribution survey were corrected for its decay as of March 1, 2012.

2: "×" in the map indicates points where measurement results were below detection limits in the Second Distribution Survey.

Legend
Deposition amounts of Ag-110m (Bq/m²)
(As of March 1, 2012)

Points where values were below detection limits
Mesh (5km, 10km)
Habitable area
Non-habitable area
Background image: Denshi Kokudo
### Results of nuclide analysis of Sr-89 and Sr-90 (Second Distribution Survey)(As of January 13, 2012)

<table>
<thead>
<tr>
<th>Subject of survey</th>
<th>№</th>
<th>Prefecture</th>
<th>Address of Sampling Point</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Sr-89(Bq/m²)</th>
<th>Sr-90(Bq/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results of the measurement of four samples out of the five collected at Soma City Point 1, which were left unanalyzed in the first distribution survey.</td>
<td>1</td>
<td></td>
<td></td>
<td>37.79617</td>
<td>140.91464</td>
<td>Not Detectable (Lower detection limit 800)</td>
<td>Not Detectable (Lower detection limit 62)</td>
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<td></td>
<td>2</td>
<td></td>
<td></td>
<td>37.79617</td>
<td>140.91464</td>
<td>Not Detectable (Lower detection limit 800)</td>
<td>Not Detectable (Lower detection limit 75)</td>
</tr>
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<td>3</td>
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<td></td>
<td>37.79617</td>
<td>140.91464</td>
<td>Not Detectable (Lower detection limit 750)</td>
<td>57</td>
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<td>140.91464</td>
<td>Not Detectable (Lower detection limit 800)</td>
<td>53</td>
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<td>37.78872</td>
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<td>Not Detectable (Lower detection limit 260)</td>
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</tr>
<tr>
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<td>37.78739</td>
<td>140.89053</td>
<td>Not Detectable (Lower detection limit 200)</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td>37.7971</td>
<td>140.87977</td>
<td>Not Detectable (Lower detection limit 500)</td>
<td>53</td>
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Results of the measurement of soil samples collected at survey points in areas more than 80km from Fukushima Dai-ichi NPP which showed air dose rates of 0.2μSv/h or higher

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<th>Subject of survey</th>
<th>No.</th>
<th>Prefecture</th>
<th>Address of Sampling Point</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Sr-89(Bq/m²)</th>
<th>Sr-90(Bq/m²)</th>
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<td>(When measurement results were below detection limit (not detectable), “Not detectable” is indicated and relevant detection limits are indicated below.)</td>
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Results of the measurement of Sr-89 and Sr-90 (Results of the Second Distribution Survey)

Deposition amounts of Sr-89 and Sr-90 (Bq/m²)  
(As of January 13, 2012) 
Upper: Measured value of Sr-89  
Lower: Measured value of Sr-90

Monitoring locations
- Detected
- Not Detected

Mesh (5km x 5km)
- Habitable area
- Non-habitable area

Mesh (10km x 10km)
- Habitable area
- Non-habitable area

Fukushima Dai-ichi NPS

*“×” in the map indicates points where the results of the measurement of Sr-89 and Sr-90 were below detection limits in the Second Distribution Survey.*
Results of the measurement of Sr-90
(Results of the First Distribution Survey(※) were added to those of the Second Distribution Survey)

Deposition amounts of Sr-90 (Bq/m²)
(As of January 13, 2012)

Considering the physical half-life of Sr-90 (28.79 days), the results of the first distribution survey were corrected for its decay as of January 13, 2012.
Map showing the ratios of deposition amounts of Ag-110m against those of Cs-137
(Results of the Second Distribution Survey)
Deposition amounts of Cs-134 and Cs-137 show very clear correlations, irrespective of the measuring point, and the air dose rates obtained based on in-situ measurement results coincide with air dose rates measured using NaI survey meters at points where in-situ measurement was carried out. Given these facts, it was verified that gamma-emitting nuclides were properly measured in this survey.

Fig. Relation of deposition amounts of Cs-134 and Cs-137 in this survey

Fig. Relation of air dose rates measured using NaI survey meters at points where in-situ measurement was carried out and air dose rates obtained based on in-situ measurement results
Comparison between the results of airborne monitoring and the distribution map of Cs-137 in soil (the second distribution map)

※The background map is the distribution map of Cs-137 in Soil shown in "(i) Results of Airborne Monitoring Survey in Hokkaido and (ii) Revision to the Results of Airborne Monitoring Survey over the Eastern Part of Japan with Detailed Consideration of the Influence of Natural Radionuclides" (dated on July 24, 2012), Reference 4, “Measurement Results of the Airborne Monitoring Surveys Conducted by MEXT Nationwide (Deposition of Cs-137 on the ground surface nationwide).” ○ on the map indicates the results of the measurement of Cs-137 in this survey.
Ratios of Deposition Amounts of Sr-90 against Those of Cs-137 in the First Disposition Survey

- Points where the ratio of deposition amounts of Sr-90 against those of Cs-137 was much larger than at other points (measurement results at Soma City Point 1)
  - Deposition amounts of Sr-90 were about one-tenth of those of Cs-137, and the ratio of deposition amounts of Sr-90 against those of Cs-137 was vary large.

- Results of the measurement of four samples out of the five collected at Soma City Point 1, which were left unanalyzed in the First Distribution Survey (the results of the Second Distribution Survey)
  - *The results for the two samples showing values above the detection limit are indicated.
  - Deposition amounts of Sr-90 were around 1/1000 of those of Cs-137, showing similar ratios as in many other survey points.

- At many survey points, deposition amounts of Sr-90 were around 1/1000 of those of Cs-137.
Radiation in Daily-life

- **Upper limit of radiation dose permitted for people who engage in emergency work.** [250,000 μSv/year]
- **Upper limit of radiation dose permitted for radiation workers, police, and firefighters who engage in disaster prevention.** [50,000 μSv/year]

**Radiation dose (microsievert: μSv)**
- 250,000
- 50,000
- 10,000
- 1,000
- 100
- 10

**Radiation in Daily-life**

- **Radiation dose in Guarapari (Brazil) per year.** [~10,000 μSv/year]
- **Natural radiation dose per year.** [~2,400 μSv/year]
- **Maximum difference of the average of natural radiation dose in each prefecture.** [~400 μSv/year]
- **An air travel between Tokyo and New York (RT).** (Increased cosmic radiation at high altitude.) [~200 μSv/round trip]
- **Evaluated dose of radiation from radioactive substance emitted from the nuclear fuel reprocessing plant per year.** [22 μSv/year]
- **Standard radiation dose from Clearance level.** [10 μSv/year]

- **Chest CT scan** [6,900 μSv/each time]
- **gastrointestinal X-ray examination.** [1,000 μSv/year]
- **Chest X-ray examination.** [50 μSv/each time]
- **Standard dose of radiation around a nuclear plant (light water reactor).** [50 μSv/year]

- **Upper limit of radiation dose permitted for people who engage in emergency work.** [250,000 μSv/year]

**※ Unit: μSv**

- Sv [Sievert] = Constant of organism effect by kind of radiation (※) × Gy [gray]
- ※ It is 1 in case of X ray and γ ray.

MEXT makes this, based on "Nuclear power 2002" made by Agency of Natural Resources and Energy.