報道発表

文部科学省 MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

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Results of the Nuclide Analysis of Plutonium and Strontium by MEXT

The results of nuclide analysis of plutonium 238 and 239+240, and strontium 89 and 90 were compiled as follows, in the course of the project commenced on June 6, 2011, under 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."

1. Objective of the survey

In order to continuously check the impact of radioactive substances deposited on the ground surface on the health of residents and the environment, MEXT measured air dose rates at around 2,200 locations within approximately 100 km from the Fukushima Dai-ichi NPP, and at the same time collected soil samples from the 5 cm surface layer at around five points at each location to analyze nuclides, prior to the rainy season, before any changes occurred on the soil surface. (The measurement results of air dose rates were already publicized on August 2 and 12, and the map of radioactive cesium concentration in soil and the map of iodine concentration in soil were released on August 30 and on September 21, respectively.)

At the same time, in order to check the deposition of alpha and beta-emitting nuclides, which were released from the Fukushima Dai-ichi NPP together with gamma-emitting nuclides, MEXT conducted a nuclide analysis of plutonium (one of the representative alpha-emitting nuclides) and strontium (one of the representative beta-emitting nuclides) at 100 locations (one point for each location) out of around 2,200 locations where it had carried out the soil monitoring survey.

The Review Meeting for the Preparation of Distribution Map of Radiation Dose, etc. (Attachment 1), which was established within MEXT, verified the validity of the results of the measurement of plutonium 238 and 239+240,* and strontium 89 and 90, and compiled the results thereof.

* Because the alpha particle energy emitted from plutonium 239 and 240 is almost the same, these cannot be distinguished through the usual analysis method adopted for alpha-emitting nuclides measurement. Therefore, the analysis is conducted for the sum of these two nuclides.

2. Details of the survey

○Periods: The first period – June 6 to June 14
The second period – June 27 to July 8

○Entities of collecteting soil samples:
Osaka University, University of Tsukuba, the University of Tokyo, Japan Atomic Energy Agency, "Local Support Team" of the Federation of Electric Power Companies of Japan, etc. (For details, see the "List of Organizations Offering Cooperation in the Preparation of Distribution Map of Radiation Dose, etc." already released on August 2 and 12.)

○Entity of conducting nuclide analysis: Japan Chemical Analysis Center

○Targets: The amounts of deposition on the ground surface per unit area of plutonium 238 and 239+240, and strontium 89 and 90 (Bq/m^2)

3. Results of the survey

Attachments 2-1 and 2-2 are the maps showing the nuclide analysis results of the plutonium 238 and 239+240, and strontium 89 and 90 contained in the collected soil samples.

The aforementioned nuclide analysis results were compiled into maps under the following conditions.

○ Data are based on the nuclide analysis of soil samples that MEXT collected during June 6 to July 8 at places with certain space free from disturbance, in the course of the project under 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."

○ As the airborne monitoring in April revealed that spots showing high radiation doses were concentrated in areas within 80 km from the Fukushima Dai-ichi NPP, MEXT, in principle, conducted measurement at one point per 2×2 km grid for these areas, and selected points to monitor plutonium 238 and 239+240, and strontium 89 and 90 from among these soil samples. Pretreatment of plutonium 238 and 239+240, and strontium 89 and 90 for nuclide analysis takes time compared with that for gamma emitting nuclides, such as radioactive cesium and iodine. Therefore, MEXT selected points for nuclide analysis in the following manner, and chose only one sample each from multiple soil samples collected at each of these selected points to conduct nuclide analysis.

(i) 59 points were selected from each of the municipalities located within 80 km from the Fukushima Dai-ichi NPP (59 municipalities), mainly from where the product of detected air dose rates and the population is high.

(ii)The remaining 41 points were selected from municipalities located in the restricted areas, evenly in all directions from the Fukushima Dai-ichi NPP.

○ Regarding plutonium 238 and 239+240, radiochemical analysis was conducted for 50 g of each of the collected soil samples, using silicon semiconductor detectors. The measurement was carried out for nearly 20 hours. The detection limit was set at around 0.5 Bq/m^2 both for plutonium 238 and plutonium 239+240.

○ Regarding strontium 89 and 90, radiochemical analysis was conducted for 30g of each of the

collected soil samples, using low background beta-ray counters. The measurement was carried out for nearly 60 minutes. The detection limit was set at around 300 Bq/m^2 for strontium 89 and around 40 Bq/m^2 for strontium 90.

○ As there was an interval between the first period and the second period for collecting soil samples, upon preparing maps, we corrected measured values into radiation levels as of June 14, the final day of the first period, taking into consideration the half-life period for each nuclide, in the same manner as we did for preparing the map of radioactive cesium concentration in soil and the map of iodine concentration in soil.

4. Discussion

4.1 General consideration

○ Soil samples for this survey were collected at places with a certain space free from disturbance. Although the monitored points were limited, we were able to ascertain the distribution of plutonium 238 and 239+240, and strontium 89 and 90 in the area within 80 km from the Fukushima Dai-ichi NPP.

○ For some points where the largest deposition amounts of plutonium or radioactive strontium were detected in this survey,[*1] we calculated possible inhalation exposure caused by resuspension from the soil and accumulated external exposure from the soil supposing that a person stays there for 50 years (hereinafter referred to as the "accumulated effective dose for 50 years"), based on the Generic Assessment Procedures for Determining Protective Actions During a Reactor Accident proposed by IAEA.[*2] As a result, it was confirmed that the accumulated effective doses for 50 years at these points were considerably smaller than the doses at the locations where the largest deposition amounts of cesium 134 or 137 were detected.

*1: These points are located in the restricted areas and planned evacuation areas, in which nobody resides at present.

*2: 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 assess accumulated 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 accumulated 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 1)

● Accumulated effective doses for 50 years at points where the largest deposition amounts of plutonium 238 and 239+240, and strontium 89 and 90 were detected in this survey

(i) Plutonium 238 : 0.027 mSv

(ii) Plutonium 239+240 : 0.12 mSv
(iii) Strontium 89 : 0.61 μSv (0.00061 mSv)
(iv) Strontium 90 : 0.12 mSv

(Reference 2)

● Accumulated effective doses for 50 years at points where the largest deposition amounts of cesium 134 and 137 were detected in this survey

(v) Cesium 134 : 71 mSv
(vi) Cesium 137 : 2.0 Sv (2,000 mSv)

○ Compared with the accumulated effective doses for 50 years of cesium 134 and 137, those of plutonium and radioactive strontium were very small. Therefore, when assessing exposure doses or implementing decontamination measures in the future, we should focus attention on deposition amounts of cesium 134 and 137.

4.2 Consideration on the results of plutonium measurements

○ As seen in Attachment 3, the ratio of deposition amounts of plutonium 238 (half-life: 87.7 years) against those of plutonium 239+240 (plutonium 239 half-life: 2.41×10^4 years; plutonium 240 half-life: 6564 years) that were monitored in a nation-wide survey from FY1999 to FY2008 was around 0.026 (national average). However, the ratios were around 0.33 to 2.2 at five points where plutonium 238 and plutonium 239+240 were both detected in this survey. These higher ratios observed after the accident suggest that plutonium 238 and plutonium 239+240 are newly deposited at these five points due to the accident.

At one point where plutonium 239+240 were not detectable but plutonium 238 was detected, the deposition amount of plutonium 238 was larger than the detection limit for plutonium 239+240 (around 0.5 Bq/m^2), which suggests that plutonium 238 was newly deposited due to the accident.

○ Deposition amounts of plutonium 238 and 239+240 confirmed in this survey all fell within the range of measured values of plutonium 238 and 239+240 that were monitored nationwide prior to the occurrence of the accident (range of the influence of past nuclear tests in the atmosphere).

4.3 Consideration on the results of strontium measurements

○ As the half-life of strontium 89 is 50.53 days (the half-life of strontium 90 is 28.8 years), at points where strontium 89 was detected in this survey, it is considered that it was newly deposited due to the accident.

○ At the points where strontium 89 was not detectable but strontium 90 was detected in this survey, measured values of strontium 90 fell within the range of values measured nationwide prior to the occurrence of the accident (2.3 to 950 Bq/m^2).

○ With regard to soil samples in which strontium 89 and 90 were detected, we calculated the ratios of deposition amounts of strontium 89 against those of strontium 90. The calculation results were 1.9 to 6.5 (average : 4.0) and the ratios of these two nuclides stayed almost the same. On the other hand, with regard to soil samples in which strontium 89 was detected, calculated ratios of deposition amounts of strontium 89 against those of cesium 137 varied widely from 5.6×10^{-4} to

1.9×10^{-1} (average: 9.8×10^{-3}).

These results show that the distribution of deposited radioactive strontium and radioactive cesium is not even. In the future, we will conduct additional surveys mainly at locations where the ratios of deposition amounts of radioactive strontium against those of radioactive cesium are high. Furthermore, we will examine the behavior of strontium in detail through a survey on the movement of radioactive substances and the results of the inspection of the inside of the reactor when a radioactive plume is released from the reactor.

(Reference)

Ratios of deposition amounts of strontium 90 against those of cesium 137

Ratios of deposition amounts of strontium 90 against those of cesium 137 in soil samples in which strontium 90 was detected: 1.6×10^{-4} to 5.8×10^{-2} (average :2.6×10^{-3})

5. Future plans

○ Regarding the results of the measurement of radioactive nuclides other than iodine-131, radioactive cesium, radioactive strontium, and plutonium, as well as the results of the survey on the movement of radioactive substances, we have verified their validity and have discussed how to compile them, based on opinions from experts. We will prepare a report compiling the results of this survey and will release it later. We will also publicize anything that we find necessary to release immediately in the process of preparing the report.

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Attachment 1

Concerning the Review Meeting for the Preparation of Distribution Map of Radiation Dose, etc.

1. Objective of the review meeting

Based on the "Plan to Strengthen Environmental Monitoring" (Nuclear Emergency Response Headquarters; April 22, 2011) and the "Policies for Emergency Responses for Those Affected by the Nuclear Incident" (Nuclear Emergency Response Headquarters; May 17, 2011), MEXT decided to prepare a distribution map of radiation doses and other maps for the purpose of utilizing them to ascertain the overall picture of the accident and consider the removal of the designation of evacuation areas.

Prior to the preparation of the maps, "the Review Meeting for the Preparation of Distribution Map of Radiation Dose, etc." will be held to discuss technical matters.

2. Matters to be discussed

- ○ Technical matters related to the preparation of an air dose rate map for the purpose of ascertaining the distribution of radioactive substances
- ○ Technical matters related to the preparation of a soil concentration map for the purpose of ascertaining the accumulation of radioactive substances in the surface layer of soil
- ○ Technical matters related to the preparation of a radiation concentration distribution map for farmland soil for the purpose of ascertaining the accumulation of radioactive substances in farmland soil
- ○ Technical matters related to the confirmation of movements of radioactive substances from the soil surface (movements to rivers and groundwater, etc., splash from the soil surface, and infiltration into soil, etc.)

3. Clerical work

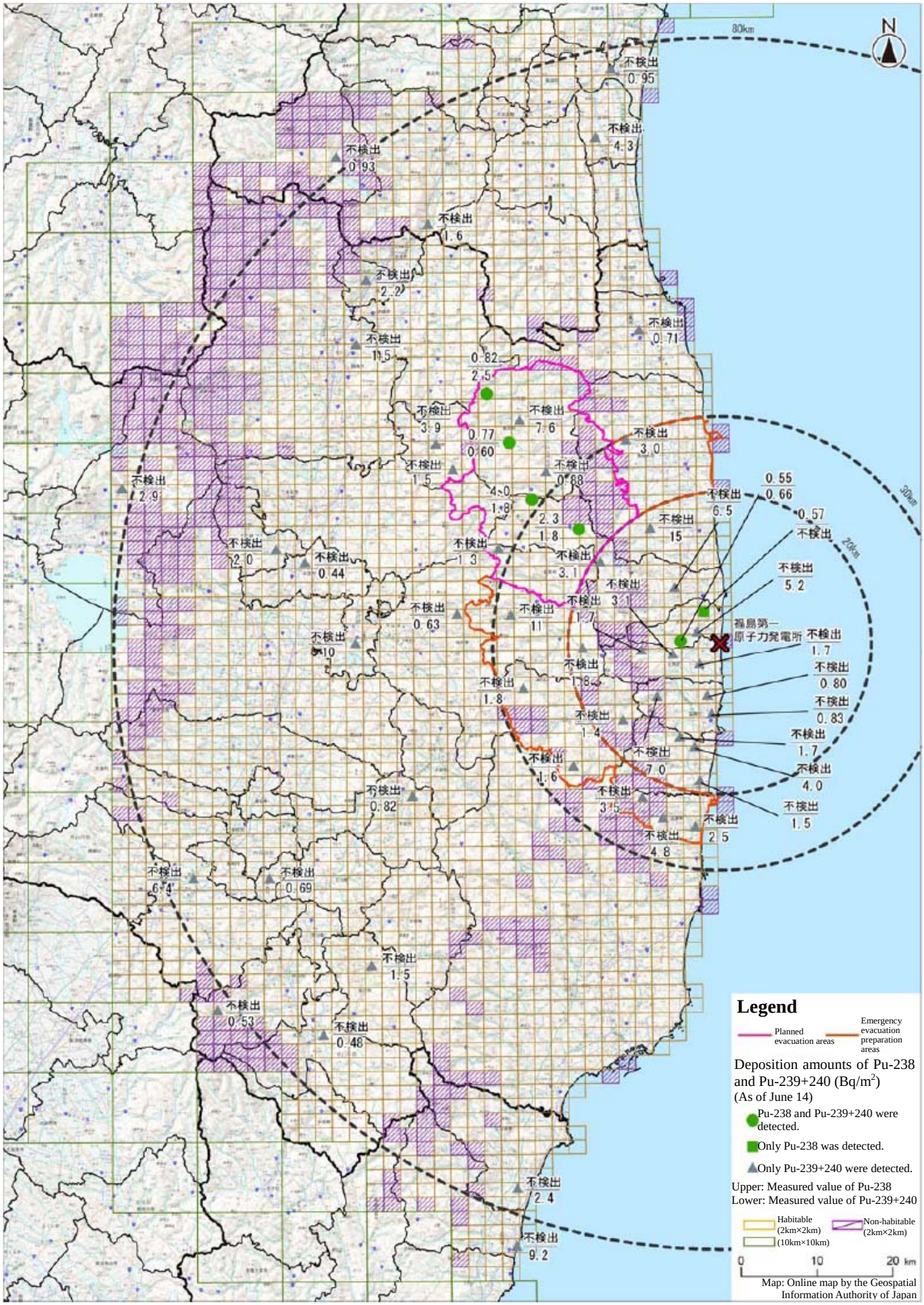
Clerical work of the review meeting will be handled by the Nuclear Safety Division of the Science and Technology Policy Bureau.

4. Members of the review meeting

Name	Professional affiliation
IKEUCHI Yoshihiro	Commissioner, Japan Chemical Analysis Center
KIMURA Hideki	Vice Counselor, Nuclear Safety Division, Department of Environment and Public Affairs, Aomori Prefectural Government
KOYAMA Yoshihiro	Division Chief, Nuclear Safety Division, Department of Living Environment, Fukushima Prefectural Government
SAITO Kimiaki	Chief of Senior Researcher, Headquarters of Fukushima Partnership Operations, Japan Atomic Energy Agency
SHIBATA Tokushi	Visiting Researcher, Japan Proton Accelerator Research Complex, Japan Atomic Energy Agency
SHIMO Michikuni	Visiting Professor, Fujita Health University
SUGIURA Nobuyuki	Director, Research Center for Radiation Emergency Medicine, National Institute of Radiological Sciences
TAKAHASHI Takayuki	Vice President (in charge of research) and Library Director, Fukushima University
TAKAHASHI Hiroyuki	Professor, Department of Nuclear Engineering and Management, The University of Tokyo
TAKAHASHI Tomoyuki	Associate Professor, Division of Nuclear Engineering Science, Kyoto University Research Reactor Institute
CHINO Masamichi	Vice Directorate Head, Nuclear Science and Engineering Directorate, Japan Atomic Energy Agency
NAGAOKA Toshi	Head of the Safety Management Division, Japan Synchrotron Radiation Research Institute
NAKAMURA Hisashi	Professor Emeritus, Tohoku University
HASEBE Akira	Research Supervising Chief, National Institute for Agro-Environmental Sciences
HISAMATSU Shunichi	Department Director, Department of Radioecology, Institute for Environment Sciences
MURAMATSU Yasuyuki	Professor, Department of Chemistry, Faculty of Science, Gakushuin University
YOSHIDA Satoshi	Unit Chief, Operation and Planning Unit, Research Center for Radiation Protection, National Institute of Radiological Sciences

Attachment 2-1

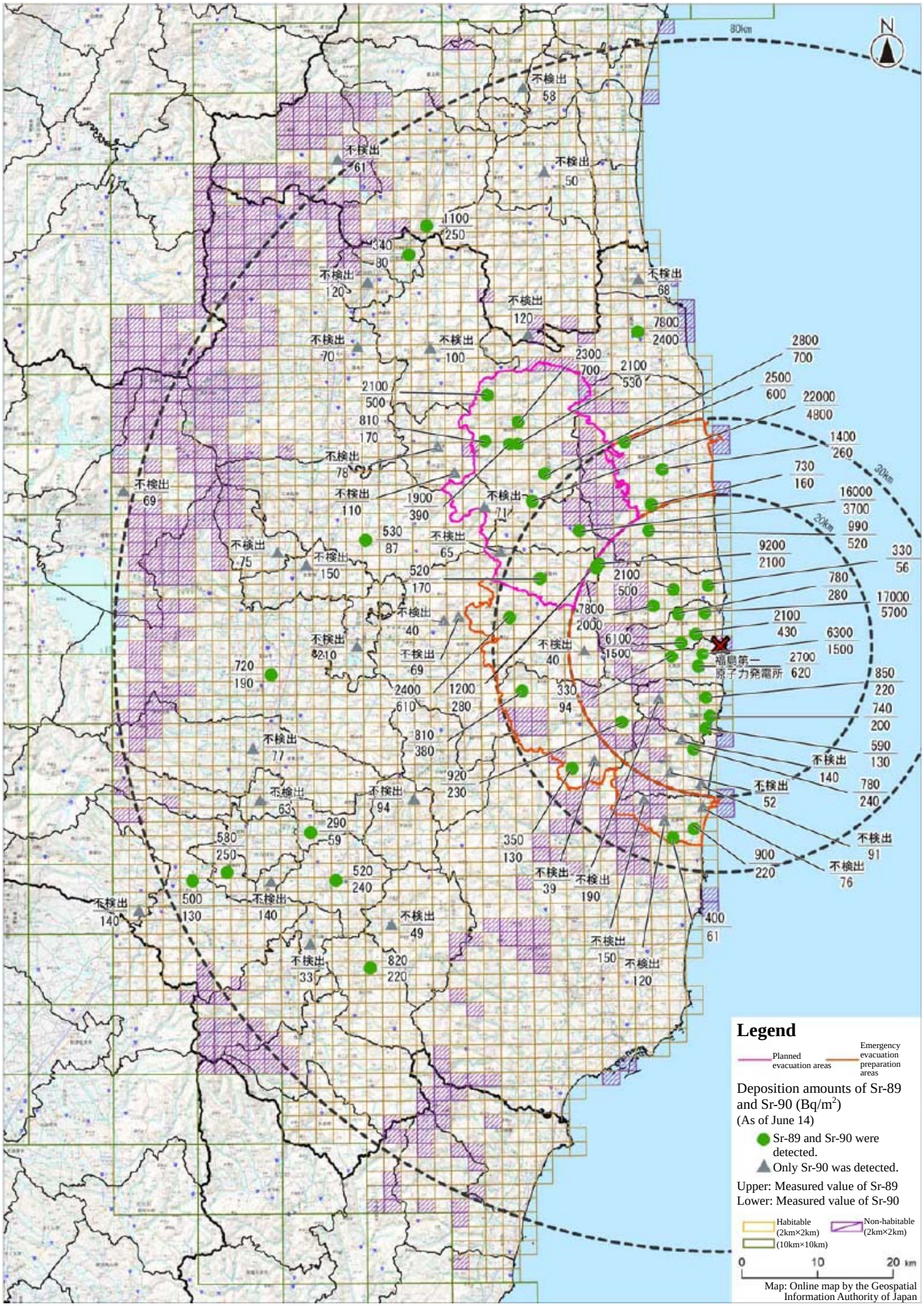
Results of the Measurement of Plutonium 238 and 239+240



* ● ■ : Where Pu-238 and Pu-239+240 are considered to have been newly deposited due to the accident at the Fukushima Dai-ichi NPP

Attachment 2-2

Results of the Measurement of Strontium 89 and 90

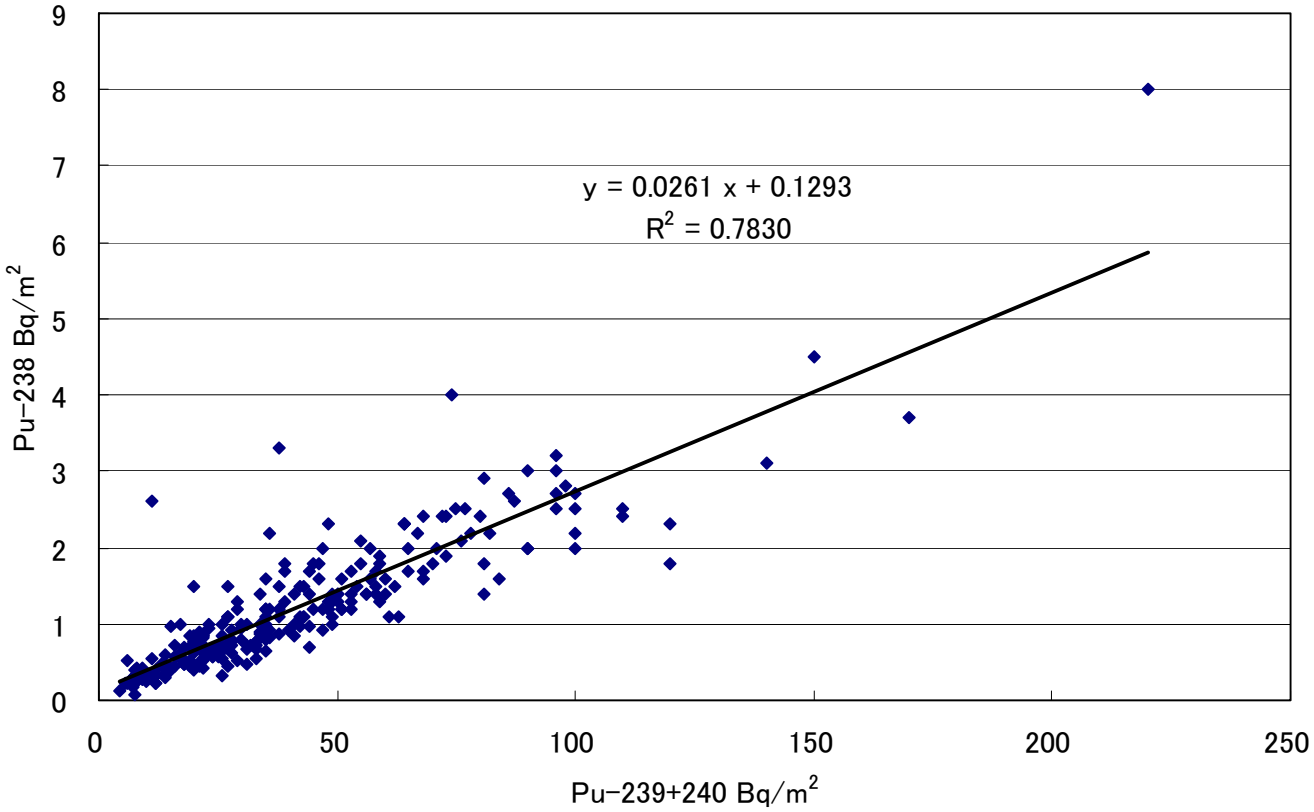


*●: Where Sr-89 and Sr-90 are considered to have been newly deposited due to the accident at the Fukushima Dai-ichi NPP

Attachment 3

Relation between Pu-238 and Pu-239+240 Confirmed in a Nationwide Survey

● Results of the environmental radioactivity monitoring survey from FY1999 to FY2008



→ Out of 1,054 soil samples collected in the environmental radioactivity monitoring survey from FY1999 to FY2008, plutonium 238 and 239+240 were detected in 252 samples. Regarding these 252 samples, we evaluated the ratios of deposition amounts of Pu-238 against those of Pu-239+240 and it was found that the national average of the ratio was 0.0261.

(Reference)
Average concentration and range of measured values for 1,054 soil samples collected in the survey from FY1999 to FY2008:
[Pu-238] Average: 0.498 Bq/m^2; Range: Detection limit to 8.0 Bq/m^2
[Pu-239+240] Average: 17.8 Bq/m^2 ; Range: Detection limit to 220 Bq/m^2