# FY2012 Radioactive Material Monitoring Surveys of the Water Environment

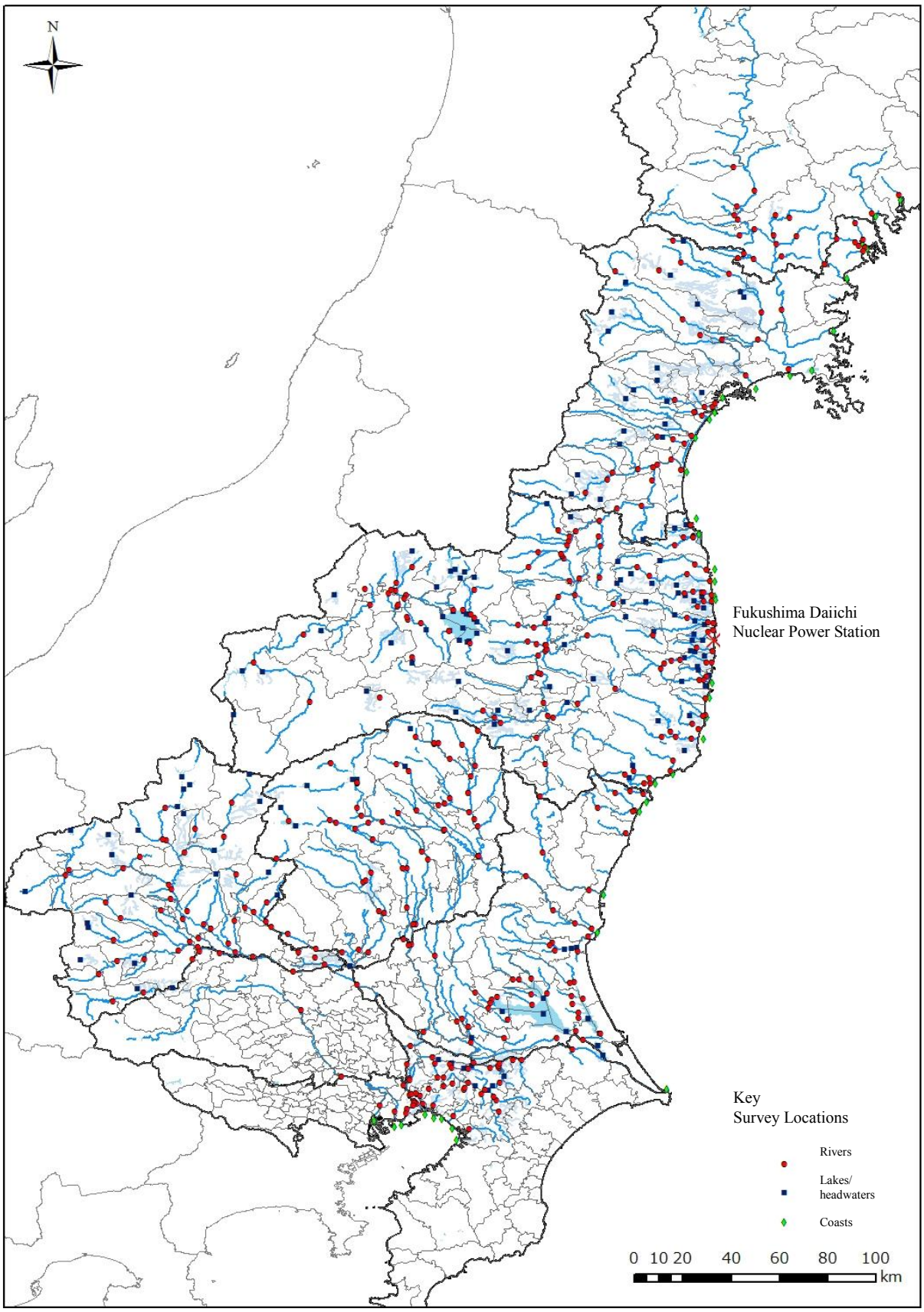
1. Survey Overview

Surveys of the concentration of radioactive material (radioactive iodine, radioactive cesium, and radiostrontium) in water, sediment and the surrounding environment (soil and herbaceous plants on river terraces and the shores of lakes) were carried out in water environments (surface water bodies (rivers, lakes and headwaters, coasts, etc.)) in the prefectures of Iwate, Miyagi, Fukushima, Ibaraki, Tochigi, Gunma, Saitama, Chiba, and Tokyo from April 2012 (surveys of the surrounding environment also included measurement of the air dose).

2. Number of Survey Locations

| Survey | Prefecture | Survey Period | Rivers | Lakes and Headwaters | Sea Areas | Total |
|---|---|---|---|---|---|---|
| 1st Time | Iwate | 2012. 6. 4 - 6. 7 | 18 | – | – | 18 |
| | Miyagi | 2012. 4.28 - 6.29 | 43 | 16 | – | 59 |
| | Fukushima | 2012. 4.29 - 6.20 | 120 | – | – | 120 |
| | Ibaraki | 2012. 5.29 - 7.11 | 53 | 12 | 5 | 70 |
| | Tochigi | 2012. 6. 1 - 7.31 | 49 | 1 | – | 50 |
| | Gunma | 2012. 5.28 - 7.11 | 48 | 8 | – | 56 |
| | Chiba, Saitama, Tokyo | 2012. 5.22 - 6.29 | 51 | 8 | 7 | 66 |
| 2nd Time | Iwate | 2012. 9. 3 - 9. 5 | 14 | – | – | 14 |
| | Miyagi | 2012. 7. 3 -10.12 | 43 | 17 | – | 60 |
| | Fukushima | 2012. 7. 3 - 9. 6 | 123 | 61 | 9 | 193 |
| | Ibaraki | 2012. 7.19 - 9.28 | 47 | 12 | 3 | 62 |
| | Tochigi | H24. 7.30 -10.18 | 56 | 8 | – | 64 |
| | Gunma | 2012. 7.17 -10.12 | 43 | 22 | – | 65 |
| | Chiba, Saitama, Tokyo | 2012. 7.13 - 9.11 | 51 | 8 | 5 | 64 |
| 3rd Time | Iwate | 2012.11.28 -12. 6 | 18 | – | 2 | 20 |
| | Miyagi | 2012.10. 3 -12.20 | 43 | 21 | 12 | 76 |
| | Fukushima | 2012. 9.10 -11.30 | 123 | 82 | 12 | 217 |
| | Ibaraki | 2012.10.22 -12.27 | 53 | 12 | 5 | 70 |
| | Tochigi | 2012.10.12 -12.25 | 56 | 8 | – | 64 |
| | Gunma | 2012.10. 8 -12.19 | 48 | 22 | – | 70 |
| | Chiba, Saitama, Tokyo | 2012. 9.18 -11.16 | 51 | – | 5 | 59 |
| 4th Time | Iwate | 2013. 2. 4 - 3. 5 | 14 | – | 2 | 16 |
| | Miyagi | 2013. 1. 8 - 3.12 | 43 | 16 | 12 | 71 |
| | Fukushima | 2012.12. 3 - 2013. 3.13 | 123 | 81 | 12 | 216 |
| | Ibaraki | 2013. 2. 7 - 3. 8 | 47 | 12 | 5 | 64 |
| | Tochigi | 2013. 2. 4 - 2.22 | 56 | 8 | – | 64 |
| | Gunma | 2013. 1. 9 - 3. 3 | 46 | 22 | – | 68 |
| | Chiba, Saitama, Tokyo | 2012.12. 3 - 2013. 2.20 | 51 | 8 | 8 | 67 |
| Total | | | 1531 | 465 | 104 | 2103 |

Survey Locations (All)



3. Outline of Results

(1) Water

Radioactive materials were not detectable at almost all locations (lower detection limit: 1Bq/L). Such materials were detected at some locations (up to a maximum of 100Bq/L); this is thought to be mainly the effect of turbidity due to increased water levels.

(2) Sediment

[Rivers, Lakes]

In the case of both rivers and lakes, high readings were seen at a limited number of locations, such as those within the 20km zone, but at the majority of locations, the figures were generally around 2,000-3,000Bq/kg or below.

In terms of the trend, levels in rivers generally fell or remained constant, while there was some variation in the fluctuation seen in lakes and headwaters. In particular, although substantial fluctuations could be seen at some locations, such as the area around the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station, no major increases were observed overall.

[Coast (1-2km)]

Overall, levels were lower than in rivers and lakes, generally being around 200-600Bq/kg or below.

In terms of the trend, although there was some variation, levels generally remained constant or fell overall.

[Survey Method]

1 Outline

(1) Sample Collection

| Samples | | Outline |
|---|---|---|
| Rivers | Water | While standing on a bridge, collect around 5L in a bucket.<br>If it cannot be collected from a bridge, collect using a dipper while standing on the river bank. |
| | Sediment | Throw an Ekman-Birge bottom sampler into the river from a bridge and collect the sample.<br>If it cannot be collected from a bridge, collect using a dipper, etc. while standing on the river bank (collect sediment 3 times, then mix the samples together). |
| | Surrounding environment (soil) | Use a soil sampler to collect samples of the soil in the surface layer (0-5cm), from areas close to the bridge on both banks of the river (5 points on each bank) |
| | Spatial dose-rate | Use an NaI(Tl) scintillation survey meter to measure the spatial dose-rate at a height of 1m from the ground at the points from which the soil samples were collected. |
| Lakes and headwaters | Water | From a boat, etc., use a Van Dorn sampler to collect a sample from the surface layer at a depth of 0.5m and from the bottom layer at a height of 1m from the lake bottom.<br>If a boat is not available, collect using a dipper, etc. while standing on the lake shore. |
| | Sediment | From a boat, etc., use an Ekman-Birge bottom sampler to collect samples (collect sediment 3 times, then mix the samples together).<br>If a boat is not available, collect using a dipper, etc. while standing on the lake shore. |
| | Surrounding environment (soil) | Use a soil sampler to collect samples of the soil in the surface layer (0-5cm), from the lake shore (5 points). |
| | Spatial dose-rate | Use an NaI(Tl) scintillation survey meter or a GM survey meter to measure the spatial dose-rate at a height of 1m from the ground at the points from which the soil samples were collected. |
| Coastal areas | Water | From a boat, use a Van Dorn sampler to collect a sample from the surface layer at a depth of 0.5m and from the bottom layer at a height of 1m from the sea floor. |
| | Sediment | From a boat, use an Ekman-Birge bottom sampler (or a Smith-McIntyre grab sampler or cylindrical dredge sampler) to collect samples (collect sediment 3 times, then mix the samples together). |

(2) Sample Preparation (Samples for Gamma-ray Spectrometry)

| Sample | Outline |
|---|---|
| Water | Place in 2L Marinelli beakers. |
| Sediment | Use No.2 filter paper to filter the moisture, then place in U-8 containers (100mL containers).<br>At the same time, take about 30g, dry at 105°C, and ascertain the mud content. |
| Surrounding environment (soil) | Place in U-8 containers.<br>At the same time, take about 30g, dry at 105°C, and ascertain the dry mud content. |

(3) Methods of Analysis

| Analysis | Sample | Details |
|---|---|---|
| Gamma-ray spectrometry | Water | Using a germanium-based semiconductor detector, measure for 1,800 seconds, as a general rule |
| | Sediment and soil | Using a germanium-based semiconductor detector, measure for 3,600 seconds, as a general rule |
| $^{90}$Sr analysis | Sediment and soil | Acid leaching - carbonate separation - oxalate separation - ion exchange separation - scavenging - leave for 2 weeks - milking - measurement of β-rays |
| Other | Water | Suspended solids (SS), turbidity |
| | Sediment | Mechanical composition, moisture content (mud content), soil particle density |

## 2 Details

### (1) Sample collection

#### ① Rivers

##### i. Water

While on a bridge, boat, or the river bank at the survey location, a sample of water from the surface layer was collected using a bucket or dipper.

The field observation items for water were as follows:

- Full depth, sampling depth, water temperature, color, odor, transparency, conductivity

##### ii. Sediment

While on a bridge, boat, or the river bank at the survey location, a sample of mud from the surface layer of sediment (around 0-15cm) was collected at least 3 times using an Ekman-Birge bottom sampler (Figure 1) or a dipper, etc. and mixed well. The samples collected were placed in plastic bags before being placed in an airtight container.

The field observation items for sediment were as follows:

- Sampling depth, properties, color, mud temperature, odor

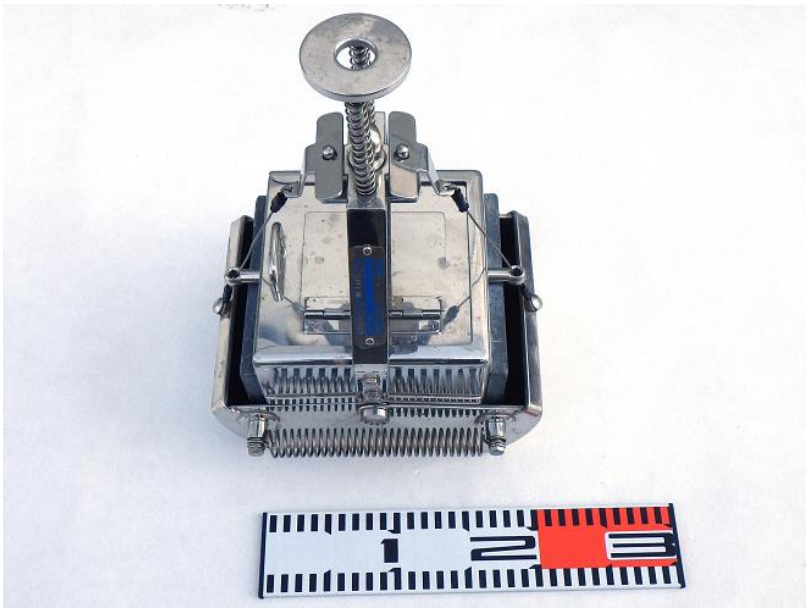


Figure 1 Ekman-Birge Bottom Sampler

##### iii. Surrounding environment (soil)

In the case of the surrounding environment (soil), samples were collected from the river terrace, etc. in one place on both the left and the right banks of the survey location (two places in total), as a general rule.

When collecting the samples, the area surrounding the point from which each sample was taken was measured with a survey meter and, after checking that there were no places where the radiation dose spiked, the flattest and most spacious area

of land was chosen. If there was a great deal of vegetation, a sickle or similar tool was used to remove the grass on the surface.

Using a 5cm diameter soil sampler (Figure 2), soil in the surface layer (0-5cm) was collected from five points withing a 3-5m square, as a general rule. (Example of soil collection: Figure 3) The area within which samples were collected (3-5m) and the layout of the collection points (5 points) was adjusted as necessary, according to the situation at the site.

The soil collected from the 5 points was placed in a plastic bag and mixed well.

The field observation items for soil were as follows.

● Properties, color, odor


Figure 2 Soil Sampler

Soil samples were not collected in the following situations:

- If it was private property (a house, agricultural land, the site of a facility, etc.) or a road
- If soil was not exposed because of a concrete revetment, etc.
- If soil was not exposed because of snow having accumulated

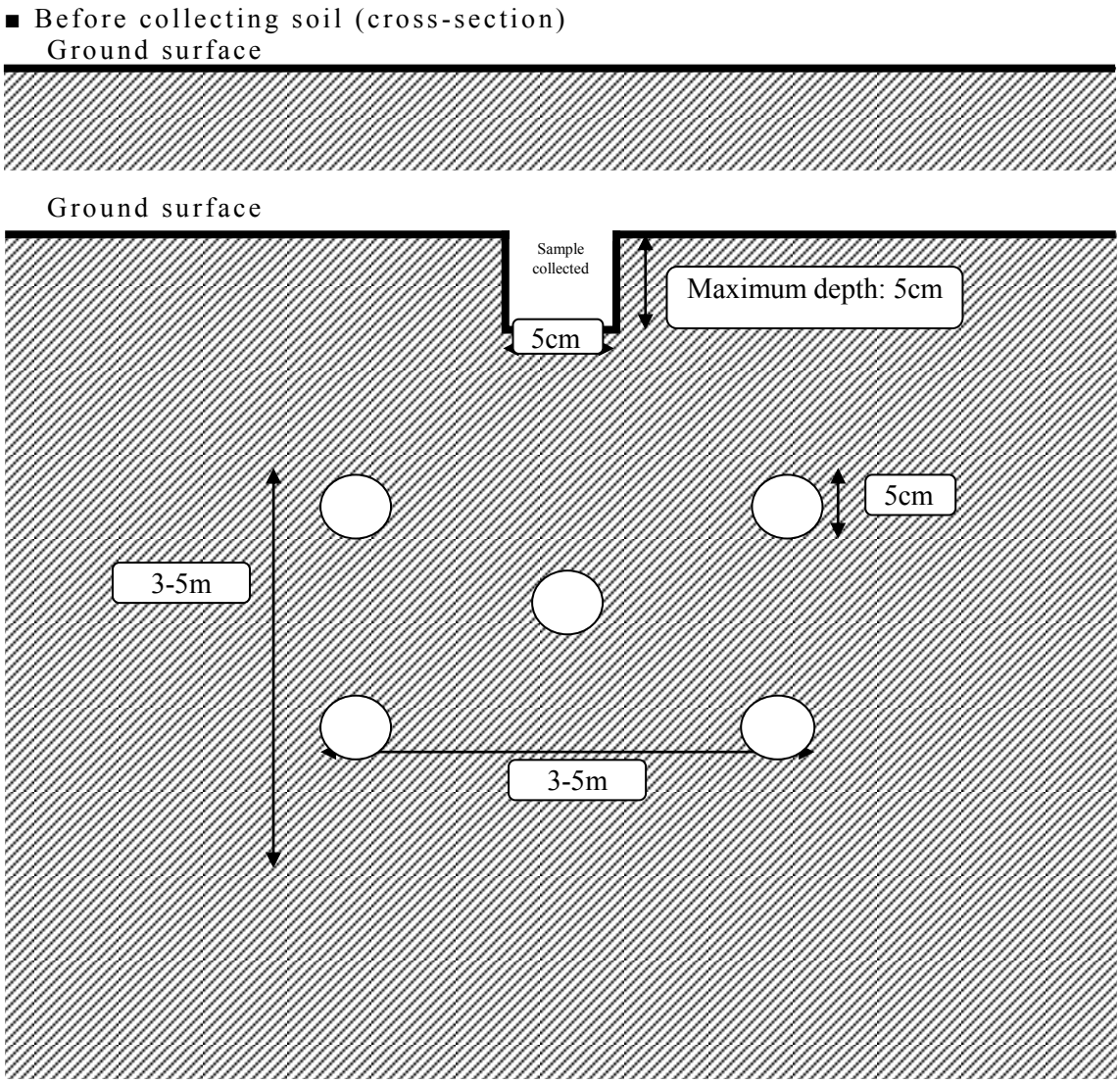



Figure 3 Example of Soil Collection

iv.Measurement of spatial dose-rate

At one of the points (the middle one, as a general rule) from which soil was collected, a survey meter (NaI (Tl) scintillation survey meter, etc.) was used to measure the spatial dose-rate. (Figure 4)

Keeping the detector component of the survey meter horizontal, the spatial dose-rate at a height of about 1m above ground was measured. The time constant was set at 30 seconds (10 seconds in the case of 0.1μSv/h or above) and, after holding the detector in place for a duration of 5 times the time constant, readings were taken 5 times with an interval equivalent to the time constant between each reading. The mean value was multiplied by the calibration constant to obtain the spatial dose-rate.

Figure 4 Measurement of Spatial Dose-rate (Example)

At locations where soil collection was not possible, a location near where the water and mud samples were taken was chosen at will and the spatial dose-rate measured. The requirements for the location were as follows:

- A flat, open area without any major obstacles in the vicinity.
- A site with as little vegetation as possible.
- A site that is on soil, wherever possible, and not on asphalt or concrete.

Moreover, spatial dose-rate was not measured if soil was not exposed due to snow having accumulated.

Table 1 and Figure 5 show the survey meters used to measure spatial dose-rate.

Table 1 Types of Survey Meter

| Manufacturer | Model, etc. |
|---|---|
| Hitachi-Aloka Medical, Ltd. | TCS-171, TCS-172 |
| Hitachi-Aloka Medical, Ltd. | TGS-121 |


TCS-171 TGS-121

Figure 5 Survey Meters (Examples)

② Lakes and headwaters

i. Water

While on a boat at the survey location, a sample of water was collected from the surface layer (at a depth of 0.5m) and another from the bottom layer (at a height of 1m from the lake bottom) using a Van Dorn sampler (Figure 6); alternatively, a dipper was used to collect a sample from the surface layer while standing on the lake shore. The survey was not carried out if the surface of the water was frozen.

The field observation items for water were as follows:

● Full depth, sampling depth, water temperature, color, odor, Secchi disk depth, conductivity

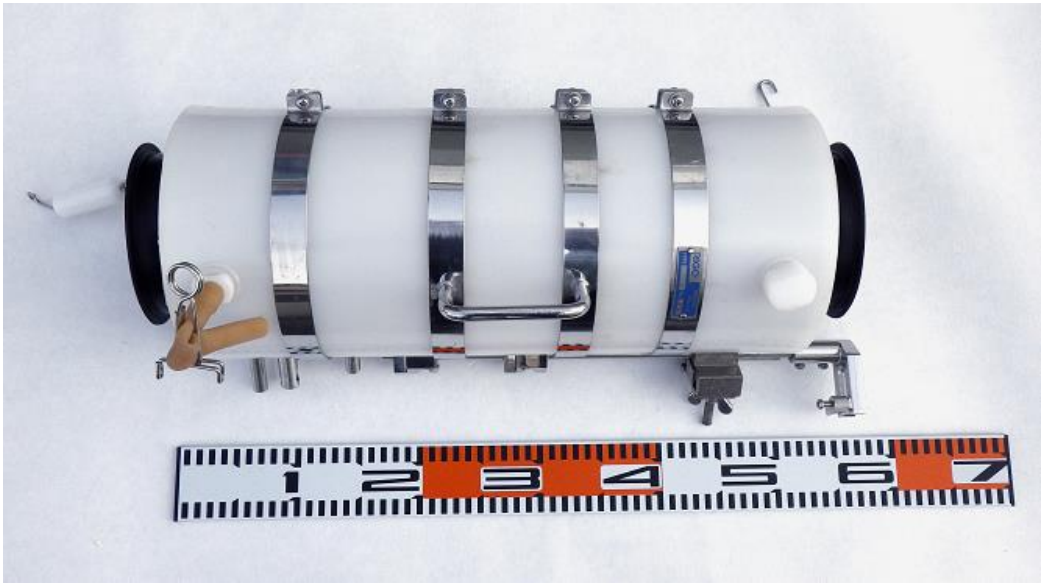



Figure 6 Van Dorn Sampler

ii. Sediment

While on a boat or the lake shore at the survey location, a sample of mud from the surface layer of sediment (around 0-15cm) was collected at least 3 times using an Ekman-Birge bottom sampler or a dipper and they are mixed well. The survey was not carried out if the surface of the water was frozen.

The field observation items for sediment were as follows:

● Sampling depth, properties, color, mud temperature, odor

iii. Surrounding environment (soil)

At lakes, dam reservoirs, ponds and the like, a sample was collected from one location where the soil was exposed on the lake shore or pond margin. No sample was collected if this was not possible due to the whole circumference being covered with a concrete revetment or similar.

The survey method used was as detailed in "Surrounding environment (soil)" in "Rivers" above.

iv.Measurement of spatial dose-rate

At the point from which soil was collected, a survey meter was used to measure the spatial dose-rate.

The survey method used was as detailed in the relevant section of "Rivers" above.

③ Coastal areas

i. Water

While on a boat at the survey location, a sample of water was collected from the surface layer (at a depth of 0.5m) and another from the bottom layer (at a height of 1m from the lake bottom) using a Van Dorn sampler.

The field observation items for water were as follows:

● Full depth, sampling depth, water temperature, color, odor, Secchi disk depth, salinity

ii. Sediment

While on a boat at the survey location, a sample of mud from the surface layer of mud (around 0-15cm) was collected at least 3 times using an Ekman-Birge bottom sampler (or a Smith-McIntyre grab sampler or cylindrical dredge sampler) and they are mixed well.

The field observation items for sediment were as follows.

● Sampling depth, properties, color, mud temperature, odor

(2) Field Survey

Tables 2-4 show the field survey methods used.

Table 2 Field Survey Methods (Water)

| Item | Survey Method | Survey Subject | | |
|---|---|---|---|---|
| | | Rivers | Lakes and Headwaters | Coastal Areas |
| Weather | Visual evaluation | ○ | ○ | ○ |
| Air temperature | Electronic thermometer (resolution 0.1°C) | ○ | ○ | ○ |
| Full depth | Measuring rope, hydrobarometer, etc. | ○ | ○ | ○ |
| Sampling depth | Measuring rope, hydrobarometer, etc. | ○ | ○ | ○ |
| Water temperature | Horiba, Ltd. ES-51 | ○ | ○ | ○ |
| Color | Evaluation using JIS Names of Colours | ○ | ○ | ○ |
| Odor | Olfactory evaluation | ○ | ○ | ○ |
| Transparency | Transparency meter | ○ | – | – |
| Secchi disk depth | 30cm white Secchi disk | – | ○ | ○ |
| Conductivity | Measured using a conductivity meter (Horiba, Ltd. ES-51) | ○ | ○ | – |
| Salinity | Measured using a conductivity meter (Horiba, Ltd. ES-51; used in salinity measurement mode) | – | – | ○ |

Table 3 Field Survey Methods (Sediment)

| Item | Survey method | Survey Subject | | |
|---|---|---|---|---|
| | | Rivers | Lakes and Headwaters | Coastal Areas |
| Sampling depth | Visual evaluation | ○ | ○ | ○ |
| Properties | Visual evaluation | ○ | ○ | ○ |
| Color | Evaluation using JIS Names of Colours | ○ | ○ | ○ |
| Mud temperature | Electronic thermometer (resolution 0.1°C) | ○ | ○ | ○ |
| Odor | Olfactory evaluation | ○ | ○ | ○ |

Table 4 Field Survey Methods (Surrounding Environment)

| Item | Survey Method | Survey Subject | | |
|---|---|---|---|---|
| | | Rivers | Lakes and Headwaters | Coastal Areas |
| Properties | Visual evaluation | ○ | ○ | ○ |
| Color | Evaluation using JIS Names of Colours | ○ | ○ | ○ |
| Odor | Olfactory evaluation | ○ | ○ | ○ |

(3) Methods of analysis

① Sample preparation

Sample preparation was carried out in accordance with “Sample Pretreatment for Gamma-ray Spectrometry in a Radiological Emergency” (Ministry of Education, Culture, Sports, Science and Technology (MEXT) Radiation Measurement Method Series No.24; August 1992) and "Gamma-ray Spectrum Analysis in a Radiological Emergency" (MEXT Radiation Measurement Method Series No.29; February 2004). The following provides an outline of the procedure.

The water was placed in 2L Marinelli beakers for use as gamma-ray spectrometry samples.

The soil and suction-filtered sediment was placed in U-8 containers (height 6cm, diameter 5cm) and used as gamma-ray spectrometry samples.

A portion of the suction-filtered sediment was set aside for use as samples for radiostrontium analysis.

② Gamma-ray spectrometry

Carried out in accordance with “Gamma-ray Spectrometry using Germanium Semiconductor Detectors” (MEXT Radiation Measurement Method Series No.7; revised August 1992) and "Gamma-ray Spectrum Analysis in a Radiological Emergency" (MEXT Radiation Measurement Method Series No.29; February 2004). The following provides an outline of the procedure.

i. Measurement

Measurement was carried out using a germanium semiconductor detector for around 1,800 seconds in the case of water, and around 3,600 seconds, in the case of

sediment and soil, and the radioactivity concentration was then calculated. Measurement was carried out over a longer period in the case of sediment and soil in which the level of Cs-137 was below the lower detection limit. As a general rule, the nuclear data used were taken from Atomic Data and Nuclear Data Tables (1983).

ii. Measuring instruments
Germanium semiconductor detectors
CANBERRA Industries Inc. GC3020-7500SL (5 detectors)
CANBERRA Industries Inc. GC3520-7500SL (4 detectors)
CANBERRA Industries Inc. GC3522-7500SL (1 detector)

③ Radiostrontium analysis

Measurement was carried out in accordance with "Radiostrontium Analysis" (MEXT Radiation Measurement Method Series No.2; revised July 2003). The following provides an outline of the procedure.

i. Chemical separation

A strontium carrier was added to the samples, then hydrochloric acid was added and thermal extraction was carried out. 90Y was removed (scavenging) from the strontium separated and refined via the ion exchange method, then the sample was left for two weeks and the newly-formed 90Y was precipitated along with iron hydroxide (III) precipitation (milking). The substance remaining was used as the test portion.

ii. Measurement

Measurement of the sample was carried out using a low background beta counter for around 3,600 seconds, as a general rule, and the concentration of 90Sr was then calculated.

iii. Measuring instruments
Low background beta counters
Hitachi-Aloka Medical, Ltd. LBC-471Q (6 counters)
Hitachi-Aloka Medical, Ltd. LBC-4201 (2 counters)

④ Other items analyzed

Table 5 shows the methods used to analyze other items.

Table 5 Method of Analyzing Other Items

| Item | | Method of Analysis | Unit | Lower Determination Limit |
|---|---|---|---|---|
| Water | Suspended solids (SS) | Method given in Annex Table 9 in Environment Agency Notice No.59, December 1971 (Environmental Quality Standards for Water Pollution) | mg/L | 1 |
| | Turbidity | Japan Industrial Standard K 0101 9.4 | ° | 0.1 |
| Sediment | Mechanical composition | ・ Japan Industrial Standard A 1204<br>・ Horiba, Ltd. LA950 (Laser Diffraction Particle Size Distribution Analyzer) | % | 0.1 |
| | Moisture content (mud content) | Japan Industrial Standard A 1203 | % | – |
| | Soil particle density | Japan Industrial Standard A 1202 | $g/cm^3$ | – |