The Series of Environmental Radioactivity Measuring Methods

AP-E
(No.24)

Preparation of Samples for Gamma-ray Spectrometry in Emergencies

Amendment of March 2019
Radiation Monitoring Division
Radiation Protection Department
The Secretariat of
Nuclear Regulation Authority

NRA JAPAN
Nuclear Regulation Authority

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Chapter 1 Introduction

Emergency monitoring refers to environmental radiation monitoring that is to be conducted in cases of actual or potential abnormal release of radioactive materials or radiation, as stipulated by the Nuclear Emergency Preparedness and Response Guidelines (hereinafter referred to as the "Nuclear Emergency Guidelines") issued by the Nuclear Regulation Authority (NRA) in 2018 (Reference 1). According to the Nuclear Emergency Guidelines, preparation for emergency monitoring is to be made during a state of alert and the actual monitoring is to begin when therelevant facility enters a state of emergency. The Nuclear Emergency Guidelines also states that emergency monitoring is divided into three stages, namely, initial stage monitoring for the determination of appropriate protective measures, middle stage monitoring for the evaluation and identification of overall impact on the surroundings, and recovery stage monitoring. In addition, emergency monitoring is discussed in the "Emergency Monitoring" (supplementary reference material of the Nuclear Emergency Preparedness and Response Guidelines) issued by the Radiation Monitoring Division, Radiation Protection Department, NRA in 2017 (Reference 2). Matters addressed in the "Emergency Monitoring" include the purpose of emergency monitoring, implementation system, and monitoring items. The Preparation of Samples for Gamma-ray Spectrometry in Emergencies (hereinafter referred to as "this document") provides the methods of preparation of samples in initial stage monitoring, but is also useful in cases where the investigation conducted in the initial stage monitoring is to be continued in the middle stage and recovery stage monitoring.

The published radioactivity measurement series that concern sample preparation and pretreatment methods include Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Semiconductor Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). This document was published in August 1992 as the Radioactivity Measurement Series No. 24 that describes the method to prepare samples for gamma-ray spectrometry in emergencies, specifically targeting several-dozen types of environmental samples. The background of establishing this document goes back to the accident at the Chernobyl Nuclear Power Plant that occurred in 1986 and associated surveys on the effects of radioactivity. This event triggered discussions on the need for swift determination of measures against radiation and evaluation of dose equivalent in emergency situations, and the demand for establishing a manual on emergency monitoring.

Immediately following the accident at the Fukushima Daiichi Nuclear Power Plant in the Great East Japan Earthquake that struck on March 11, 2011 (hereinafter referred to as the "Fukushima Daiichi Nuclear Accident"), gamma-ray spectrometry using germanium detectors was widely utilized in emergency monitoring at various analysis institutions. However, it was found that many of the laboratories which participated in the monitoring program did not have sufficient experience regarding radioactivity analysis under nuclear emergency, especially how to handle environmental samples collected under such circumstances.

This document describes several issues concerning measurement of radioactive materials under nuclear emergencies, which include selection of samples, contamination prevention measures, sample preparation methods, and quantifiable levels, and summarizes how to address each issue. This revision includes additional specific descriptions and photographs, together with arrangements for broadly sharing the knowledge gained through the experience associated with the Fukushima Daiichi Nuclear Accident and actual cases of emergency monitoring.

The preparation methods provided in this document prescribe standard operational methods aimed at making the measurement results uniform. Therefore, autonomous monitoring conducted by municipalities and research institutions in emergencies is expected to conform to this document in principle. However, in regards to monitoring performed for a specific purpose, this does not preclude the use of preparation methods other than those provided in this document, so long as the preparation method is appropriate for the said purpose.

The content of this document is to be revised as necessary, according to the status of revision of the basal documents (the Nuclear Emergency Guidelines and the supplementary reference material of the Nuclear Emergency Preparedness and Response Guidelines) and the advancement in monitoring technologies and techniques.

Chapter 2 Concept of Preparation of Samples in Emergencies

2.1 Emergency monitoring

Emergency monitoring is addressed in detail in the "Emergency Monitoring" (supplementary reference material of the Nuclear Emergency Preparedness and Response Guidelines) issued by the Radiation Monitoring Division, Radiation Protection Department, NRA in 2017 (Reference 2). The "Emergency Monitoring" specifies two types of monitoring items related to this document, namely, the measurement of concentration of radioactive materials in the atmosphere and the measurement of concentration of radioactive materials in environmental samples.

2.1.1 Measurement of concentration of radioactive materials in the atmosphere

The main purposes of this measurement are to collect information about the status of environmental radiation due to a nuclear emergency and to provide the information to evaluate the effects of the radiation on the local residents and the environment. In this measurement, spreading of radioactive materials is checked using a monitoring system and the monitoring data is utilized for the evaluation of exposure. The normal means of monitoring is an atmosphere monitoring device (enables ascertaining the temporally continuous changes in concentration of radioactive materials in the atmosphere) or an iodine sampler with an automatic sample changer (continuously samples gaseous and particulate iodine while regularly replacing the filter and active carbon cartridge).

2.1.2 Measurement of concentration of radioactive materials in environmental samples

Environmental samples covered in this document are classified into precipitation, soils, and food and drinks. Soils include soil, inland water, seawater, river sediment, lake sediment, sea sediment, and indicator organisms.

(1) Measurement of concentration of radioactive materials in soils

The main purposes of this measurement are to check the spreading of radioactive materials deposited on the ground and to ascertain their nuclide composition. For that reason, in the stage of initial response to a nuclear emergency, soil is sampled and analyzed or measured without delay for areas near the monitoring stations at which an ambient radiation dose rate exceeds the Operational Intervention Level2 (OIL2) [*1] first.

(2) Measurement of concentration of radioactive materials in food and drinks

The main purposes of this measurement are to provide the materials for determining the necessity for implementing protective measures and for evaluating the effects of radiation on the local residents and the environment due to a nuclear emergency.

[*1]: The standard at which intake of regional produces is restricted and residents are temporarily relocated within about one week after a nuclear emergency for the purpose of preventing exposure due to radiation from the ground surface, inhalation of radioactive materials that were released back into the air, and careless oral intake of contaminated food and drinks (corresponds to an ambient radiation dose rate of 20 μSv/h as measured at a height of 1 m from the ground).

(a) Before commencing inspection of radioactive materials in food and drinks based on OIL6 [*2]

When release of radioactive materials is confirmed for a region, to ascertain the effects of the radioactive materials on drinking water, potable water supplied from the sources available in the region is to be sampled and analyzed without delay. This is usually done for water supplied from waterworks and small water supply systems that are possibly contaminated with radioactive materials.

(b) Inspection of radioactive materials in food and drinks based on OIL6

For a region at which the ambient radiation dose rate exceeds 0.5 μSv/h, the concentration of radioactive materials is to be measured for the food and drinks produced in the region.

Table 2.1 OIL6 (initial set values)[*3]

Nuclides	Drinking water, cow's milk, dairy products	Vegetables, grains, meat,eggs, fish, other
Radioactive iodine	300 Bq/kg	2,000 Bq/kg※
Radioactive cesium	200 Bq/kg	500 Bq/kg

※ Applicable to vegetables excluding root vegetables and potatoes.

Regarding the measurement to be performed in order to determine the necessity of implementing protective measures based on OIL6, attention needs to be paid to obtaining the measurement results by the time when the result of emergency monitoring is required, taking into account the time required formeasurements that vary depending on the nuclide. Information 1 describes the approach to OIL6 and the measuring time in gamma-ray spectrometry in emergencies.

2.2 Samples to be measured

In the previous version of this document, the samples to be measured were the atmosphere, fallout and precipitation, drinking water and source water, cow's milk, dairy products, leaf vegetables, seaweeds, fish, seawater, and soil, referring to the previous Guide for Environmental Radiation Monitoring in Emergency (Nuclear Safety Commission) and other relevant documents. They also included grains, peas and beans, meats and eggs that would become necessary for environmental radiation monitoring. In addition, the previous version covered the samples that are likely to undergo the same preparation method as those for the samples listed above. In this version, the samples to be measured are the environmental samples listed in the previous version of this document as well as the environmental samples listed in the "Emergency Monitoring" (Reference 2). In addition, fruit is added to the samples to be measured, based on the experience from the Fukushima Daiichi Nuclear Accident.

Further, in this version, the samples are classified into 18 groups taking into account their characteristics and preparation methods, and the sample name has been changed for some samples.

[*2]: The standard at which intake of food and drinks is restricted for the purpose of preventing exposure due tooral intake (shown in Table 2.1).

[*3]: Nuclear Emergency Preparedness and Response Guidelines, Nuclear Regulation Authority (2018)(Reference 1)

2.3 Contamination prevention measures

In emergency monitoring, many kinds of radionuclides are detected at high concentrations, contrary to normal time monitoring where they are not detected at all, or detected at extremely low levels. Such high concentration samples can easily contaminate other samples, measurement containers, laboratory equipment, or laboratory facilities, and have to be handled carefully at all times, not just in laboratories. Measures to prevent these potential contaminations are classified into those that need to be prepared in advance (e.g., having necessary laboratory equipment (tools) available and ready for use, designing the layout of workplaces for efficient work) and those that need to be carried out on site by the persons engaged in the analysis or measurement (e.g., performing contamination inspection, covering the surfaces, wearing rubber gloves and lab coat). One has to carefully examine the flow of work and establish the means and procedures necessary for realizing the contamination prevention measures stated below.

It must be noted that, in emergency situations, radioactive iodine and radioactive cesium are likely to be detected at high concentrations, and these radionuclides require special attention.

Radioactive iodine is highly volatile, and its chemical behavior is complicated. Radioactive cesium has a longer half-life than radioactive iodine and its effects last longer. Therefore, when pretreating and handling samples that may contain such substances, extra caution will have to be taken in preventing contamination of laboratories and cross-contamination between samples, as the affected areas and the scale of contamination can be unpredictable.

The major premise of any radioactivity measurement is that the items used in the process are not contaminated; it is important to perform contamination inspection of the items before work, after work, and when there was a possibility of contamination. Especially, instruments and tools that are used repeatedly require contamination inspection and other necessary measures to prevent cross- contamination. In addition, measures to reduce spreading of contamination to other work areas need to be taken, including allocating special shoes to each laboratory to be worn only in the laboratory, placing a sticky mat at the entrance of laboratories, and regularly cleaning around the laboratories.[*4] Further, it is important to prevent contamination from outdoor air by, for example, sealing the gaps around the windows and doors of laboratories using adhesive tape[*5] and wrapping transportation containers with a polyethylene bag if a sample is to be transported between laboratories via an outdoor environment.

Based on these understandings, the subsections below discuss the matters to be noted regarding prevention of contamination and exposure to workers, cross-contamination between samples, and contamination of measurement containers, in the stages of sample acceptance, pretreatment, and filling into measurement containers. As for high-concentration samples that call for special attention, Information 2 provides the matters to be noted when handling them during sampling and measurement.

2.3.1 Matters to be noted in the sample acceptance stage

The radioactivity concentrations in environmental samples are likely to change depending on the state of contamination of the environmental around the sampling locations. Therefore, when accepting samples, the analysis institution needs to check the sample information such as the sampling location and ascertain the radiation level of the whole sample, including the

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[*4]: Yoshiyuki Kurita, Jun Saegusa, Satoshi Maeda, Survey and countermeasures on radiocesium inflow into a laboratory building for radioactivity analysis, Japanese Journal of Radiation Safety Management, 15(2)(2016) (Reference 5)

[*5]: Some gaps need to be left unsealed for fire safety reasons. Check whether they can be sealed or not before sealing them.

bags, etc. containing the sample using survey meters[*6]. (Photographs 2.1 and 2.2)

Once accepted, samples are to be managed and stored with paying utmost attention to prevention of cross-contamination. The samples should be grouped by radiation level as part of cross-contamination prevention measures. For samples with high radiation levels, the analysis institution needs to ensure that all necessary measures to minimize exposure to workers are taken for the work environment, including storing them in a place where workers do not usually enter. Also, in emergency monitoring, it is likely that a large number of samples need to be handled in a short period of time, and the workers that handle the samples may be different from the workers that handle the samples in normal time monitoring. Therefore, a sample management method needs to be established in advance to prevent a mix-up of samples.[*7]

Photograph 2.1
Measurement of samples usinga survey meter on acceptance (spinach)

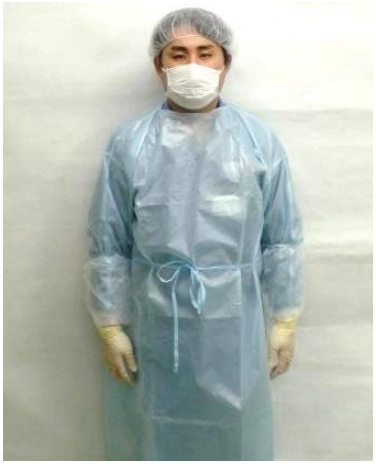
Photograph 2.2
Measurement of samples usinga survey meter on acceptance (closer view)

In addition, environmental samples with high radiation levels may serve as material for determiningthe preparation method, as a small sample volume may be enough for analysis or measurement.

When performing these operations, workers have to wear disposable rubber gloves, lab coat, mask, etc., and assume that the bags, etc. containing the samples are contaminated. (Photograph 2.3) If it is known in advance that the bags, etc. containing the samples are contaminated, additional measures (e.g.,wrapping double using polyethylene bags) will be required to prevent cross-contamination of samples.

[*6]: Scintillation survey meters for gamma rays may be used for ascertaining the radiation level, and GM tube survey meters for contamination inspection.

[*7]: An example sample management method is use of sample tags and labels. In such a case, using barcodeor two-dimensional code would be helpful.



Photograph 2.3
Contamination prevention measures applied to worker
(Disposable open back lab coat is worn)

Contamination prevention measures shall be taken for survey meters as well by, for example, coveringthem with polyethylene bags before use and replacing the polyethylene bags as necessary.

2.3.2 Matters to be noted in sample preparation

After receiving samples, the analysis institution needs to pay attention to potential contamination dueto the samples, outdoor air, or other causes for the laboratory rooms and around the tables to prepare the samples for measurement. To that end, as for the laboratory rooms and tables to be used, it is important to prevent contamination of their surfaces using covering sheets[*8] such as polyethylene filters and blue poly tarp. (Photographs 2.4 and 2.5) In such a case, it is desirable to cover sample- handling facilities, etc. as much as possible, including work spaces and their surroundings with covering sheet. Note that, depending on the situation, covering sheets[*9] may have to be doubled as it is possible that a covering sheet breaks during use.

Further, some extra measures, such as replacing covering sheets for each sample, have to be taken to prevent radionuclides from being mixed in and samples from being cross-contaminated.

When handling samples, workers are required to wear disposable rubber gloves, lab coat, surgical mask, etc., to prevent cross-contamination of samples, internal exposure of the workers, and adhesion of radionuclides on the workers.

As for the covering sheets for laboratory tables, etc. and disposable rubber gloves worn by workers, it is important to use new ones for each sample as part of contamination prevention measures. If there has been possible contamination, they may have to be replaced, even in the middle of preparation work.

[*8]: Include disposable sheets.

[*9]: There has been a case of using non-contaminated old newspaper when covering sheets ran short.

Photograph 2.4
Contamination prevention measures taken
(covering using polyethylene filters)

Photograph 2.5
Contamination prevention measures taken
(covering using blue poly tarps)

In the preparation of samples, tools such as kitchen knives, cutters, and trays used for chopping samples (Photograph 2.6) are to be carefully washed if they are reused. However, in some emergency cases, circumstances may not allow washing them thoroughly. Therefore, use of disposable kitchen knives, cutters, paper plates, etc. is a valid means as a measure to prevent cross-contamination due to insufficient washing. In that case, extra attention needs to be paid to the safety of preparation work as disposable kitchen knives and cutters are not commonly used in sample preparations in normal times.

In addition, for liquid samples such as drinking water, contamination spreading prevention measures(e.g., laying filter paper in a tray and working on it) are to be taken where necessary.

Photograph 2.6
Chopping a sample using a cutter on a paper plate
(Chinese cabbage)

As for the tap water and pure water used for washing samples and tools, their contamination status is to be checked before use. The method to check the contamination status shall conform to the method described in Chapter 6. If the tap water is found to contain radioactive materials and likely to contaminate the samples, pure water is to be used instead.

2.3.3 Matters to be noted when filling a measurement container with a sample

The measurement containers adopted in this document are Marinelli beakers and small plastic containers[*10]. A Marinelli beaker[*11] is to be used with an inner bag specially designed to fit its inner shape. As for small containers, they are not to be reused.

If special inner bag is not available, a polyethylene bag can be used instead. In such a case, the polyethylene bag shall be placed tightly against the inner wall of the Marinelli beaker so as to not allow air to be present between the bag and beaker wall as much as possible.

When filling a measurement container with a sample (Photographs 2.7 and 2.8), the workers need to take measures to prevent contamination of the outer surface of the measurement container. An example method to achieve that is to divide workers into those that handle the sample ("hot" workers) and those that do not handle the sample ("cold" workers), and split the work so that the "hot" workers do not come into contact with the outer surface of the measurement container.[*12]

Photograph 2.7
Filling a Marinelli beaker with a sample(Chinese cabbage)

Photograph 2.8
Filling a small container with a sample (Chinese cabbage)

Once a sample is sealed up inside a measurement container, the outer surface of the measurement container is to be decontaminated by wiping with a paper towel moistened with water or ethanol[*13] . After wiping the outer surface, the measurement container is to be placed in a polyethylene bag in a size suitable for the container as a measure to prevent contamination arising from the measurement container itself, and then served for measurement.

2.4 Preparation method

In this document, the basic approach to emergency monitoring is to measure a sample as sampled or as a raw sample, whenever possible, to ensure swift measurement and to prevent spreading of contamination that may occur in emergency situations.

2.4.1 Preparation of food and drinks

Measurement results for food and drinks in emergencies are used for making a decision related to OIL6 (see Table 2.1). Therefore, the preparation method was made consistent with the method to test radioactive materials in food specified by the Ministry of Health, Labour and Welfare[*14] and other relevant methods, with the understanding that it is to conform to the

[*10]: A typical small container is U-8 container.
[*11]: Check the contamination status of Marinelli beaker before use.
[*12]: Recommended work splitting is a system in which hot workers place measurement containers on the laboratory table and fill them with the sample, and cold workers transport the measurement containers.
[*13]: Acrylic container can be damaged by ethanol causing swell or crack.
[*14]: Manual for Measuring Radioactivity of Foods in Case of Emergency, Inspection and Safety Division, Department of Food

general treatment method of food and drinks for consumption. In this document, such samples are to be brushed to remove soil, etc. and washed with water[*15] [*16] to simulate preparation for consumption. Note that the quantity (ratio) of radioactive materials removed from vegetables by washing varies depending on the washing method. Readers are directed to Information 7 for the result of a study about washing vegetables.

2.4.2 Storage of samples

Sample storage methods are summarized from the viewpoints of "storage for a relatively short period of time" and "long-term storage," with clear descriptions on the concepts of storage that take into account the time elapsed after the measurement of samples. In the case of storing for a relatively short period of time, it is desirable that perishable samples are refrigerated or frozen. Whether it is for a shortor long period of time, when storing samples, it is important to record the sampling date, sampling location (including the information of latitude and longitude and photographs whenever possible), information about the person(s) who collected the sample, pretreatment, and the content and result of measurement. Be particularly mindful that some environmental samples collected for emergency monitoring cannot be disposed of casually. Information 4 provides the matters to be noted for disposal of environmental samples.

2.4.2.1 Storage for relatively short period of time

It is possible that samples are stored for a relatively short period of time to perform re-measurement for various reasons (e.g., double checking of measurement results obtained by gamma-ray spectrometryin emergencies). The expected period of storage is from several days to several months.

In the case of storing samples for a relatively short period of time, as a preservative, formalin was added in the past to prevent decomposition of samples such as cow's milk, dairy products and eggs. However, formalin is no longer used because of the health risk. Additionally, the previous version of this document prescribed to add sodium chloride to precipitation and inland water samples to prevent adsorption on the container. In this version, based on literature and results of the study shown in Explanation B, it was decided to add sodium thiosulfate[*17], in order to prevent adsorption of radioactive iodine on measurement containers.[*18] Note that, once sodium thiosulfate is added, the sample solution is to be handled solely as a sample for re-measuring radioactive iodine, and not to be transferred to another storage container for measuring other radioactive materials.

Sanitation, Pharmaceutical and Medical Safety Bureau, Ministry of Health, Labour and Welfare (2002) (Reference 6)

[*15]: Matter of Note for Inspection Based on the Manual for Measuring Radioactivity of Foods in Case of Emergency (Announcement), Inspection and Safety Division, Department of Food Sanitation, Pharmaceutical and Medical Safety Bureau, Ministry of Health, Labour and Welfare (2011) (Reference 7)

[*16]: As for tap water and pure water used for washing samples and tools, contamination status will be checkedbefore use. The method to check the contamination status shall conform to the method described in Chapter 6.

[*17]: The oxidation state of reducible ions and compounds (e.g., iron) in a sample may change due to thereducing action of sodium thiosulfate: pay attention to the change in the state of sample solution.

[*18]: To prevent adsorption or volatilization of radioactive materials in the sample container, it is desirable to carry out preparation and measurement as quickly as possible.

2.4.2.2 Long-term storage

Some samples collected for emergency monitoring may be valuable. The section below describes the methods to store such samples for a long period of time. The expected period of storage is in the order of years.

In the case of samples with little possibility of decomposing (e.g., soil), the samples are to be stored as they are. For samples that may decompose, ashing treatment is to be applied. When performing ashing,radioactive materials may be lost through vaporization etc. depending on the nuclide or chemical structure. Attentionneeds to be paid to changes in the radioactivity concentration in samples and contamination of other samples and equipment used. For water samples, acid is to be added to the container for long-term storage for applying the storage method for normal time monitoring. Information 3 describes the specific long-term storage methods of samples. For details of ashing treatment and addition of acid to water samples, refer to the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4).

2.5 Quantifiable levels

Tables 2.2 and 2.3 show the quantifiable levels of ^{131}I, ^{134}Cs and ^{137}Cs that were obtained by gamma-ray spectrometry using the method described in this document.

The detection limit in gamma-ray spectrometry varies depending on the concentration of radioactivity in environmental samples. Therefore, the detection limit was calculated each by the type of environmental sample and measuring time using spectra actually measured using environmental samples(fallout, soil or air) collected after the Fukushima Daiichi Nuclear Accident which were filled into a Marinelli beaker or small container. For the calculation, the relative efficiency of detectors was assumed to be about 30%, the general relative efficiency of germanium semiconductor detectors currently available. Explanation A gives the details of the calculation method of quantifiable levels. The obtained limits of detection were categorized by sample and designated as the quantifiable levels of ^{131}I, ^{134}Cs and ^{137}Cs by measuring time.

The calculation method of detection limit was as prescribed in the Radioactivity Measurement Series No. 7 Gamma-ray Spectrometry using Germanium Detector (Reference 8).

Information 1 describes the basic concept of implementation items and content of emergency monitoring, including the relation between the quantifiable levels obtained here and OIL6, the thresholdof food and drink intake restrictions.

Note that the quantifiable levels shown in Tables 2.2 and 2.3 are guides and vary depending on the type of radionuclides contained in the measurement container or their concentration. Especially, ^{131}I has a short half-life of 8 days and attention needs to be paid to the number of days elapsed from sampling to the commencement of measurement.

To determine the actual measurement conditions, preliminary measurement, etc. are to be conducted. Additionally, consideration needs to be given to checking and changing measurement conditions that sufficiently satisfy the reference values, as necessary. Analysis institutions are required to take preparatory measures (e.g., collection and accumulation of relevant data) in preparation of emergency situations.

Table 2.2 Chart between the measuring time and quantifiable level in emergency measurement (multi-nuclide detection) using a Marinelli beaker (2 L)

Name of sample	Sample volume (g)	^{131}I quantifiable level				^{137}Cs quantifiable level				^{134}Cs quantifiable level				Unit
		10 min	30 min	1 h	10 h	10 min	30 min	1 h	10 h	10 min	30 min	1 h	10 h	
Fallout Precipitation	2000 g	110	70	50	20	90	60	40	20	100	60	50	20	Bq/kg
Drinking water Cow's milk	2000 g	110	70	50	20	90	60	40	20	100	60	50	20	Bq/kg
Soil	3100 g	80	50	30	10	70	40	30	8	70	40	30	9	Bq/kg
Vegetables	1000 g	200	120	80	30	170	100	70	30	180	110	80	30	Bq/kg
Meats Eggs Seafood	1900 g	120	70	50	20	100	60	40	20	110	60	50	20	Bq/kg

The values are calculated with setting the relative efficiency of germanium semiconductor detector to 38%.For vegetables, meats, eggs, and seafood, the values are radioactivity concentration per raw weight.

Table 2.3 Chart between the measuring time and quantifiable level in emergency measurement (multi-nuclide detection) using a small container (50 mmφ × 50 mm)

Name ofsample	Sample volume (g or m^3)	^{131}I quantifiable level				^{137}Cs quantifiable level				^{134}Cs quantifiable level				Unit
		10 min	30 min	1 h	10 h	10 min	30 min	1 h	10 h	10 min	30 min	1 h	10 h	
Air	1 m^3	6	4	3	0.8	6	3	2	0.7	8	5	3	1	Bq/m^3
	10 m^3	0.6	0.4	0.3	0.08	0.6	0.3	0.2	0.07	0.8	0.5	0.3	0.1	
	1000 m^3	0.006	0.004	0.003	0.0008	0.006	0.003	0.002	0.0007	0.008	0.005	0.003	0.001	
Fallout Precipitation	89 g	350	200	150	50	280	170	120	40	310	180	130	40	Bq/kg
Drinking water Cow's milk	89 g	350	200	150	50	280	170	120	40	310	180	130	40	Bq/kg
Soil	140 g	240	140	100	30	190	110	80	30	200	120	90	30	Bq/kg
Vegetables	47 g	610	350	250	80	500	290	210	70	550	320	230	70	Bq/kg
Meats Eggs Seafood	86 g	360	210	150	50	290	170	120	40	320	180	130	40	Bq/kg

The values are calculated with setting the relative efficiency of germanium semiconductor detector to 31%. However, for the air, the values are calculated with setting therelative efficiency to 27%.
For vegetables, meats, eggs, and seafood, the values are radioactivity concentration per raw weight.

2.6 Sample preparation

Samples prepared conforming to this document are measured by gamma-ray spectrometry using germanium detectors. In gamma-ray spectrometry, obtained counts are divided by the peak efficiency to derive the net gamma-ray emission rate. Geometrical conditions (e.g., shape, height) and density of sample are some of the factors used to determine the peak efficiency, and the state of the sample after preparation greatly affects the resultant quantitative values. Therefore, factors that unnecessarily changequantitative values need to be eliminated as much as possible.

Containers typically used in gamma-ray spectrometry are Marinelli beakers [*19] (Figures 2.1 and 2.2) and small containers (Figure 2.3). For details, refer to the Radioactivity Measurement Series No. 7 Gamma-ray Spectrometry using Germanium Detector (Reference 8). This subsection discusses mattersto be noted when preparing samples conforming to this document in the case of Marinelli beakers and small containers.

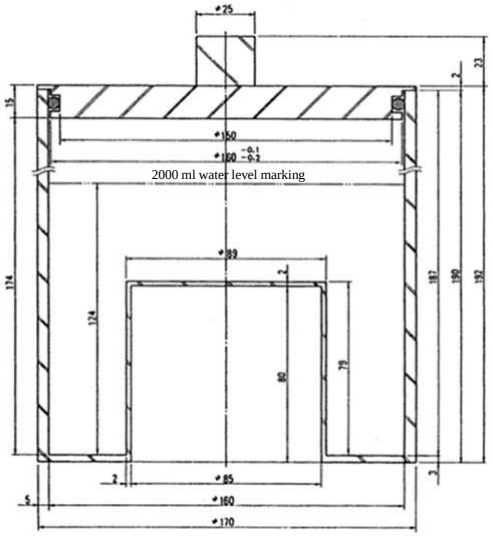


Figure 2.1 2 L Marinelli beaker

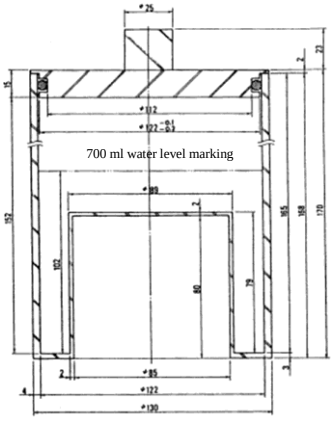


Figure 2.2 700 mL Marinelli beaker

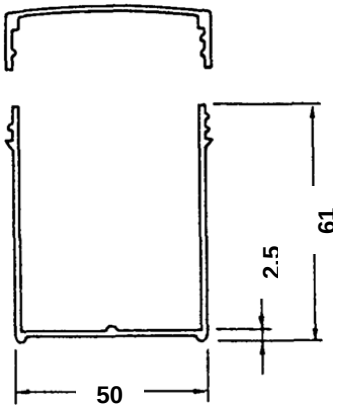


Figure 2.3 Small container

[*19]: Recently, 1 L Marinelli beakers have also become commercially available. However, the shape may bedifferent even if the capacity is the same: pay attention when performing efficiency calibration.

2.6.1 In the case of using Marinelli beakers

Attention needs to be paid to samples that are solid and not fine, and therefore difficult to form into acertain shape, such as soil, vegetables, grains, meats, dairy products, and seafood. Figure 2.4 illustrates (a) the shape of Marinelli beaker, (b) the state where a sample is sealed in an inner bag for Marinelli beakers used in the method described in this document, and (c) the state where air voids are generated between sample pieces.

In preparing a sample for measurement, it is important that the shape of the inner bag for Marinelli beakers that contain the sample is the same as that of the inner wall of the Marinelli beaker. Also, as shown in Figure 2.4 (b), the sample needs to be sealed in the inner bag for Marinelli beakers without airvoids between the sample pieces.

When placing a special inner bag into a Marinelli beaker, it is advisable to apply talc, etc.[*20] to the outer surface of the inner bag to facilitate the insertion. It is also a good idea to place 2 L of water into an inner bag placed in a Marinelli beaker using a graduated cylinder and mark the water level as an indicator of 2 L.

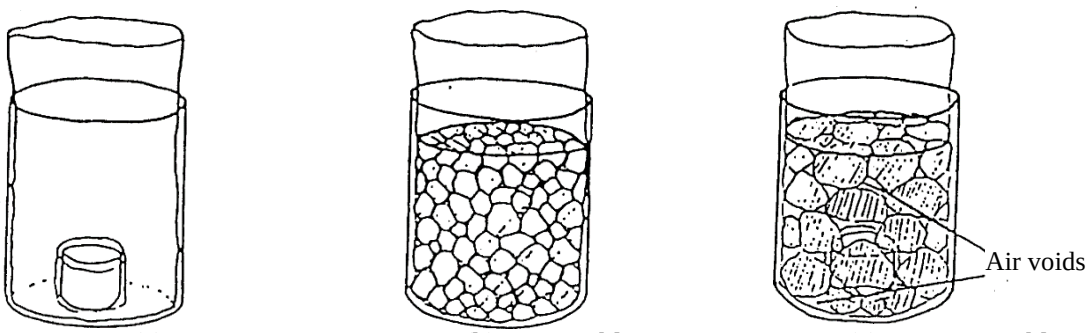
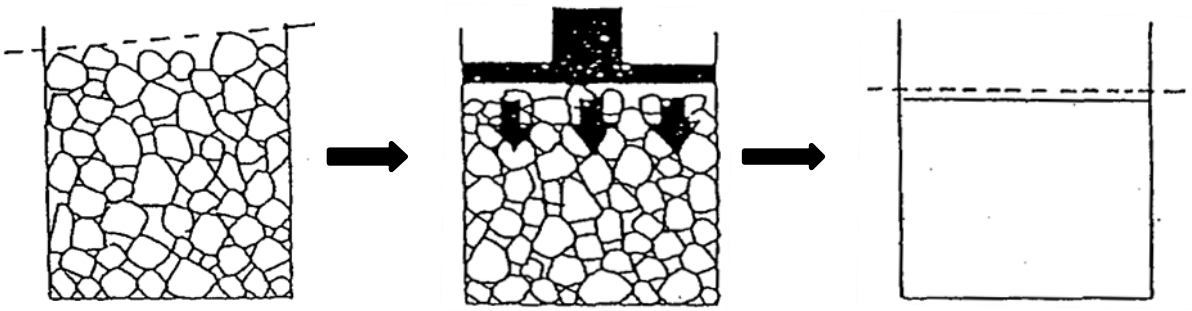


Figure 2.4 Filling a Marinelli beaker with a sample

2.6.2 In the case of using small containers

Similarly to the case of using Marinelli beakers, when sealing a solid sample, care shall be taken so as to avoid air voids to generate. However, samples like vegetables and seaweeds may not move easilyand air voids may not disappear even when they are pressed firmly. Such samples may require some extra treatment such as chopping into small pieces. Additionally, since the height of sample in a measurement container affects the peak efficiency, it is recommended to apply pressure on the top surface of the sample using a laboratory spoon, jig, or rubber-gloved finger pad to level the surface and ensure homogeneous density throughout the sample. For a particulate sample, attention needs to be paid as filling a container with the sample while hitting the container may cause small particles to move down and affect the measurement results. Figure 2.5 shows the method to fill a small container with a sample.

[*20]: An extender pigment produced by crushing talc. Commercially available baby powders may be usedinstead.



Place the sample in a small container.

Lightly press the top surface of the sample.

Level both the top and bottom surfaces of the sample.

Figure 2.5 Filling a small container with a sample

It is advisable to mark small containers in advance at about 80% of the height of the container,as a guideline for workers to fill when sealing a sample.

Chapter 3 Glossary

This chapter provides the definitions and explanations of terms used in this document and those considered important in sample preparation.

Nuclear Emergency Preparedness and Response Guidelines (Reference 1)

Guidelines that stipulate specialized and technical matter to assist a nuclear operator, national government, local government, etc. in making scientific and objective decisions when formulating and implementing a plan pertaining to nuclear emergency measures.

Emergency monitoring (Reference 1)

Environmental radiation monitoring that is to be conducted in cases of abnormal release or possible abnormal release of radioactive materials or radiation.

Normal time monitoring (Reference 9)

Ascertaining air radiation dose rate and concentration of radioactive materials in the surroundings ofnuclear facilities in normal times to be prepared for emergency monitoring, as well as for early detection of abnormality in nuclear facilities and evaluation of impact on local residents and surroundings.

Atmosphere monitoring device (Reference 2)

A device to continuously measure concentration of radioactive materials (alpha-emitting nuclides, beta-emitting nuclides, or both of them) in the atmosphere by suctioning airborne particles along with the air using a pump and counting radiation from particles collected on filters using a radiation detector.

Environmental sample

Sample used for measuring environmental radioactivity. Typical environmental samples include airborne particles, fallout, inland water, soil, polished rice, vegetable, tea, cow’s milk, commonly consumed food, seawater, sea sediment, saltwater fish, freshwater fish, shellfish, and seaweeds.

Iodine sampler (Reference 10)

A device to collect iodine using a filtration material for collecting iodine for the purpose of deriving radioactivity concentration in the air arising from airborne radioactive iodine.

Monitoring station (References 11 and 12)

Fixed outdoor facility to continuously monitor air absorbed dose rates, air kerma rates or ambient dose equivalent rates of environmental gamma-rays, or neutron fluence rates.

Survey meter (Reference 13)

Portable radiation measurement equipment. Aims to measure ambient radiation dose rate or surface contamination. Available in an ionization chamber type, GM tube type, NaI scintillation type, and plastic scintillation type, each of which have unique characteristics. It is required to select the suitable equipment according to the environment to be used

Germanium semiconductor detector (Reference 13)

A kind of semiconductor radiation detector, in which a single crystal of germanium is used as a detection element. It utilizes the nature of a semiconductor generating ionized current pulses when it issubjected to radiation while voltage is applied to it in the anti-rectification direction. This enables detecting gamma-rays and X-rays with high sensitivity and energy resolution.

Detection limit (References 8 and 14)

The lowest concentration (quantity) of analyte nuclide that can be detected for the given sample and measurement conditions (e.g., measurement equipment, measuring time). Among the various conceptsto calculate the detection limit proposed, the Cooper's method was adopted in this document.

Quantifiable level

A level at which quantification is deemed possible for the same sample type, sample volume and analysis conditions (e.g., measuring time), specified based on data on detection limit. In this document, the detection limit was calculated for each type of environmental sample and measuring time using spectra that were actually measured using environmental samples (fallout, soil or air) collected after the Fukushima Daiichi Nuclear Accident which were filled into a Marinelli beaker or small container, and the result was specified as the quantifiable level. Note that this is different in concept from the limit of quantification commonly used in the field of analytical chemistry (ten times the standard deviation of background measurement values).

Peak efficiency (Reference 8)

A collective term for relative peak efficiency, reference peak efficiency, and absolute peak efficiency that includes correction factors such as self-absorption.

Constant mass (Reference 14)

A state in which the difference in the measured mass of a substance before and after a cycle of treatment has become at or below a specified value when the substance is repeatedly subjected to a certain set of operations (e.g., heating, allowing to cool, and weighing) under the same conditions.

Dead time (Reference 15)

The time spent to convert the injected gamma-rays into signals. The detector cannot processsubsequent injection of gamma-rays during this interval (being dead).

Thus, dead time is obtained by subtracting the live time from real time (i.e., true time).

Reference

1 「原子力災害対策指針」原子力規制委員会（2018）
2 「緊急時モニタリングについて（原子力災害対策指針補足参考資料）」
原子力規制庁監視情報課（2017）
8 放射能測定法シリーズ No.7「ゲルマニウム半導体検出器によるガンマ線
スペクトロメトリー」
9 「平常時モニタリングについて（原子力災害対策指針補足参考資料）」
原子力規制庁監視情報課（2018）
10 JIS Z4336：2010 放射性ヨウ素サンプラ
11 放射能測定法シリーズ No.17「連続モニタによる環境 γ 線測定法」
12 JIS Z4325：2008 環境γ線連続モニタ
13 JIS K0216：2014 分析化学用語（環境部門）
14 JIS K0211：2013 分析化学用語（基礎部門）
15 放射能測定法シリーズ No.29「緊急時におけるゲルマニウム半導体検出器による
γ線スペクトル解析法」

Chapter 4 Atmosphere

This chapter describes how to prepare and store glass fiber filters, long filters and active carbon cartridges as samples for measurement of radioactive materials, especially radioactive iodine[*1], in the atmosphere. Measurement containers used are Marinelli beakers or small containers.

4.1 Equipment, tools, etc.to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Plastic tape
- Paper towels
- Ethanol
- Pure water[*2]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*3] (With the operation panel, top plate, etc. covered by wrap films to prevent contamination of the surface)

4.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the sampling location, sampling period, sampling conditions, etc. and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or less as much as possible, and select a measurement container sized for the sample volume.[*4] Select small containers for measurement if the radiation levels from the samples are high.

[*1]: Radioactive iodine exists in the atmosphere in particulate and gaseous forms. Particulate iodine consists of iodine salts, etc. contained in airborne particles, and gaseous iodine inorganic iodine (e.g., I_2) and organic iodine (e.g., methyl iodide). Particulate iodine is collected by glass fiber filters, and gaseousiodine by active carbon cartridges.

[*2]: Confirm in advance the pure water is free of radioactive materials.

[*3]: Use balances that are properly controlled (e.g., periodically inspected and calibrated).

[*4]: For the relationship between dose rates at the surface of sample measured using a survey meter andradioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce the workers exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

4.3 Sample preparation method

4.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and work on them separately for each sample.[*5]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact with the sample from cold work through indirect contact with the sample, and separate workers and workbenches between hot work and cold work as much as possible.

4.3.2 Filling measurement container with sample

(1) In the case of using small containers

(a) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.

(b) While paying attention to the homogeneity of the sample, place pretreated (e.g., folded) filters[*6] into the small container prepared in (1). In so doing, try not to make gaps between samples andthe container wall. (Photograph 4.1) For small filters and punched filters, place them with the airborne particle-attached side facing the bottom.[*7] (Photograph 4.2)

(c) Place a cap on the small container, measure the height of the sample and record it.

(d) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water,ethanol, etc.

(e) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

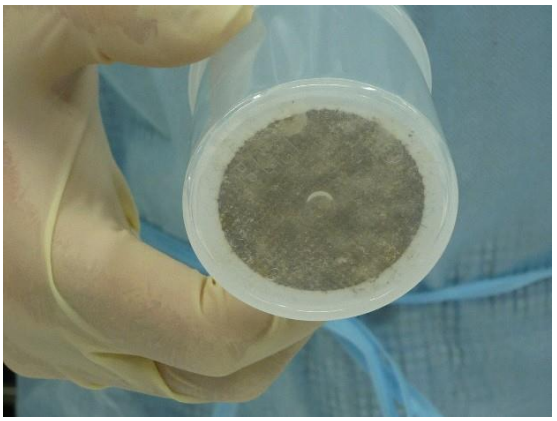
(f) To prevent contamination of measurement equipment, cover the small container with a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement. (Photograph 4.3)

[*5]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*6]: Example methods of pretreatment are provided in 4.5.

[*7]: If multiple sheets of filters are provided as a sample, stack them.

Photograph 4.1
Small container with a sample placed in it(glass fiber filter)



Photograph 4.2
Airborne particle-attached side facing the bottom(glass fiber filter)

Photograph 4.3
The small container covered in a polyethylene bag (glass fiber filter)

(2) In the case of using Marinelli beakers[*8]

(a) Place an inner bag in a Marinelli beaker without any gaps. (Use disposable bags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker, and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place pretreated (e.g., folded, cut out)filters[*9] into the Marinelli beaker up to the marked line. In so doing, try not to make gaps between samples and from the container wall as much as possible. (Photograph 4.4) After placing the sample, measure the weight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(d) Seal the inner bag of Marinelli beaker using plastic tape.[*10] (Photograph 4.5)

(e) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photographs 4.6 and 4.7)

[*8]: This method is intended for swiftly measuring a large quantity of filters. If a person desires to measure dust collected sections only, the method to place a sample in a small container is available as shown in 4.3.2 (1).

[*9]: Example methods of pretreatment are provided in 4.5.

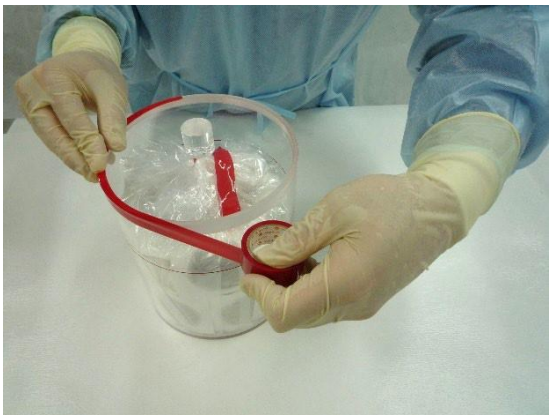
[*10]: A rubber band, cable tie, etc. may be used instead.

(f) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(g) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement. (Photograph 4.8)

Photograph 4.4
Marinelli beaker filled with a sample(long filter)

Photograph 4.5
Sealing the inner back with plastic tape (long filter)



Photograph 4.6
Fixing the lid with plastic tape (long filter)

Photograph 4.7
Fixing the lid with plastic tape (long filter)

Photograph 4.8
The Marinelli beaker covered in a polyethylene bag (long filter)

4.3.3 Preparation of active carbon cartridge[*11]

In an emergency, to prevent contamination from the collecting material, it is preferable to measure the active carbon cartridge as it is[*12], without taking the collecting material out of the active carbon cartridge. However, if a standard radiation source that fits the form of the active carbon cartridge is notavailable, the collecting material is to be taken out by the following method and presented as a sample for measurement.

(1) In the case of using small containers

(a) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.

(b) Take the collecting material out of the active carbon cartridge and place in the small container. (Photograph 4.9) In so doing, pay extra attention to the collecting material scattering around dueto static electricity, etc.[*13]

(c) Place a cap on the small container, measure the height of the sample and record it. (Photograph 4.10)

(d) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water,ethanol, etc.

(e) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(f) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

Photograph 4.9
Taking active carbon out

Photograph 4.10
Small container with a sample placed in it(active carbon)

4.4 Storage of samples

4.4.1 Storage for a relatively short period of time

(a) Samples prepared using small containers: place sample-containing inner bags into a polyethylenebag or a container.

(b) Samples prepared using Marinelli beakers: place sample-containing measurement containers intoa polyethylene bag or a container.

(c) Cartridges that were measured without taking collecting material out: place them into a

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[*11]: The pretreatment method for active carbon filters is the same as that for glass fiber filters.

[*12]: In some cases, an active carbon cartridge is measured with filters placed next to it. In such a case, ensure the suctioned side faces the detector.

[*13]: To prevent spreading of contamination or scattering of sample, it is advisable to apply a static eliminatoror aluminum foil.

polyethylene bag or a container.

4.4.2 Long-term storage

(a) Samples prepared using small containers: place sample-containing inner bags into a polyethylenebag or a container.

(b) Samples prepared using Marinelli beakers: place sample-containing measurement containers intoa polyethylene bag or a container.

(c) Cartridges that were measured without taking collecting material out: place them into a polyethylene bag or a container.

(d) Samples may be ashed by the methods provided in the Radioactivity Measurement Series No. 13Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials(Reference 4). In such a case, contamination of other samples needs to be prevented by, for example, washing and cleaning instruments, tools and equipment after use. Ashed samples are to be stored in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

4.5 Pretreatment methods for long (continuous) filters and large filters and their characteristics

Long (continuous) filters and large filters used in atmosphere monitoring devices are treated by various pretreatment methods. In emergency monitoring, in principle, a small amount of filter is to be measured using a small container, and a filter that is too large to fit into a small container is to be measured using a Marinelli beaker. The pretreatment methods shown below have their own unique characteristics. The most adequate method that suits the purpose needs to be selected.[*14]

(1) Folding[*15]

This is a method to prepare a sample by folding a large filter and placing it in a measurement container.

A filter is folded with the airborne particle-attached side facing inside so that the filter fits into a measurement container.[*16 *17]

Advantages: Specific instruments or tools are not required, and therefore the risk of sample cross- contamination and environmental contamination is relatively low.

Disadvantages: The filling rate into measurement container tends to have large individual differences. Airborne particles may attach to a section of filter which was free fromairborne particles.

(2) Cutting out or punching out[*15]

This is a method to prepare a sample by cutting out an airborne particle-attached section of a long (continuous) filter or large filter using a pair of scissors or punching such a section out using a special instrument or tool and placing it in a measurement container.

Cutting out or punching out a filter into the diameter of measurement container makes it easy

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[*14]: Note that efficiency calibration according to the state of sample needs to be performed.

[*15]: Refer to the Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials(Reference 4).

[*16]: In cases of large filters, they may be cut into an appropriate size before folding.

[*17]: Scattering of sample may be prevented, where necessary, by covering with a polyethylene bag or laminatefilm.

to placethe filter into the measurement container.[*18] When placing into a measurement container, the airborne particle-attached side shall be facing downward.[*19]

Advantages: The filling rate into measurement container (small container) is high, and the fillingrate tends to have little individual differences.

Disadvantages: Attention needs to be paid to prevention of cross-contamination via instruments andtools used for cutting or punching.

(3) Ashing[*20]

This is a method to folding a long (continuous) filter or large filter with the airborne particle-attachedside facing inside (or in a wound-up state[*21]), place in a porcelain plate, ash using an electric furnace, etc., and measure.[*22]

Advantages: This method enables preparing a sample from a large quantity of filters that cannot be otherwise placed in a measurement container. The homogeneity of sample is high compared as other methods.

Disadvantages: Contamination of other samples needs to be prevented by, for example, washing and cleaning instruments, tools and equipment after use. Not applicable to volatile nuclides. An abnormal rise in the temperature of the electric furnace above the set value may cause volatilization of radionuclides to which ashing is supposed to be applicable. Pretreatment takes time, making this method less swift compared as other methods.

[*18]: The area of the suctioned section and cut out (punched out) section will be required for calculatingradioactivity concentration.

[*19]: If multiple sheets of filters are provided as a sample, stack them.

[*20]: Ashing cannot be applied to some filters, such as filter roll for iCAM (Canberra).

[*21]: The core is to be removed in advance.

[*22]: Refer to the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3).

Chapter 5 Fallout and precipitation

This chapter describes how to prepare samples of fallout collected by a large reservoir, etc. and preparation collected by a rainwater sampler, etc. Measurement containers used are Marinelli beakersor small containers.

5.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Piston pipette
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Sodium thiosulfate
- Pure water[*1]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Tray
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*2] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

5.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and labcoats to prevent exposure and contamination.

(b) Check the sampling location, sampling period, sampling amount, sampling conditions, etc. and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radioactivity levels tofind samples with potentially high radioactivity. The required amount of sample is 100 g or more (the volume will be 100 mL or more) for small containers and 2 kg or more (the volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or less as much as possible, and select a measurement container sized for the sample

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[*1]: Confirm in advance the pure water is free of radioactive materials.

[*2]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

volume.[*3] Select small containers for measurement if the radiation levels from the samples are high.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

(e) To prevent adsorption or volatilization of radioactive materials in the sample container, it is desirable to carry out preparation and measurement as quickly as possible.

5.3 Sample preparation method[*4]

5.3.1 Matters to be noted in sample

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carriedin.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and work on them separately for each sample. Lay filter paper in a tray and work on as necessary.[*5]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact with the sample from cold work through indirect contact, and separate workers and workbenches fbetween hot work and cold work as much as possible.

5.3.2 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposablebags to prevent contamination of the wall of the measurement container.)

(b) Write and attach the necessary data (e.g., sample identification number) to the Marinelli beaker, then measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) Mix the sample well, and place it in the Marinelli beaker prepared in (2) up to the marked line.Use a piston pipette to finely adjust to the marked line.

(d) To prevent adhesion of nuclides to the inner wall of container, add 80-100 mg of sodium thiosulfate per 1 L of sample.[*6]

[*3]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*4]: See Chapter 6 for the photographs of preparation.

[*5]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*6]: Manual for Measuring Radioactivity of Tap Water, etc., Ministry of Health, Labour and Welfare (2011) (Reference 17)

(e) Measure the weight of the Marinelli beaker and lid along with the sample, derive the weight ofthe sample by subtracting the tare weight measured above, and record it.
(f) Seal the inner bag of Marinelli beaker using plastic tape.[*7]
(g) Place the lid on the Marinelli beaker, and seal with plastic tape.
(h) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.
(i) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.
(j) Derive the portioning rate from the sampling amount and sample volume using the following formula:

$$\text{Portioning rate (\%)} = \frac{\text{Sample volume (g)}}{\text{Sampling amount (g)}} \times 100$$

(2) In the case of using small containers
(a) Mix the sample solution well in advance to make contained foreign matter (e.g., dust) uniform.
(b) To prevent leakage, wrap thread seal tape around the threaded part of small container.
(c) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.
(d) Place approximately 80 g of sample into the small container prepared in (3). Use a pistonpipette to finely adjust the volume. Place the entire sample if the sample volume is small.
(e) To prevent adhesion of nuclides to the inner wall of container, add 80-100 mg of sodiumthiosulfate per 1 L of sample (6.4-8.0 mg per 80 g of sample).[*8]
(f) Place a cap on the small container, measure the height of the sample and record it.
(g) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.
(h) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.
(i) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.
(j) Derive the portioning rate from the sampling amount and sample volume using the following formula:

$$\text{Portioning rate (\%)} = \frac{\text{Sample volume (g)}}{\text{Sampling amount (g)}} \times 100$$

5.4 Storage of samples
5.4.1 Storage for a relatively short period of time
(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into apolyethylene bag or a container.
(b) Samples prepared using small containers: place sample-containing measurement containers into a polyethylene bag or a container.

[*7]: A rubber band, cable tie, etc. may be used instead.

[*8]: Manual for Measuring Radioactivity of Tap Water, etc., Ministry of Health, Labour and Welfare (2011)(Reference 17)

(c) In either case, store samples in a refrigerator or cool dark place to prevent decomposition.

5.4.2 Long-term storage

(a) To prevent adhesion of nuclides to the inner wall of container during long-term storage, if iodine is not included in the nuclides to be measured, add about 1 mL of hydrochloric acid (~12mol/L) or nitric acid (~13 mol/L) per 1 L of sample.[*9] [*10]

(b) Store samples in a refrigerator or cool dark place to prevent decomposition.

[*9]: According to the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4).

[*10]: Do not add acid if iodine is included in the nuclides to be measured. (Iodine becomes volatile when acid is added.)

Chapter 6 Drinking water and inland water

Different methods are applied to emergency monitoring of drinking water (e.g., tap water, well water, rainwater) and inland water (e.g., river water, lake water), depending on the purpose of monitoring and the phase of nuclear emergency.[*1] This Chapter describes how to prepare and store drinking water and inland water samples without separating dissolved matter and suspended matter. Measurement containers used are Marinelli beakers or small containers. If separation of dissolved matter and suspended matter is required, refer to Information 5.

6.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Piston pipette
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Sodium thiosulfate
- Pure water [*2]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Tray
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer) [*3](With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

[*1]: In an emergency situation, usually separation is not performed in order to prioritize swift measurement and ease of operation. However, there has been a case of separating them to study the difference in the behavior of dissolved matter and suspended matter. Takahiro Nakanishi, Kazuyuki Sakuma, Trend of ^{137}Cs concentration in river water in the medium term and future following the Fukushima nuclear accident, Chemosphere, 295 (2019) (Reference 18)

[*2]: Confirm in advance the pure water is free of radioactive materials.

[*3]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

6.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the sampling location, sampling date, sampling conditions, etc. and assign identificationnumbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or less to the extent as much as possible, and selecta measurement container sized for the sample volume.[*4] Select small containers for measurement if the radiation levels from the samples are high.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take proper measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

(e) To prevent adsorption or volatilization of radioactive materials in the sample container, it is desirable to carry out preparation and measurement as quickly as possible.

6.3 Sample preparation method

6.3.1 Matter to be noted in sample preparation

(1) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(2) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(3) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(4) Place a plastic sheet on a covered workbench, further place large filters on top of it, and work on them separately for each sample. Lay filter paper in a tray and work on as necessary.[*5]

(5) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact with the sample from cold work through indirect contact with the sample, and separate workers and workbenches between hot work and cold work as far as possible.

[*4]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*5]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

6.3.2 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposablebags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) Mix the sample well, and place it in the Marinelli beaker prepared in (2) up to the marked line.(Photograph 6.1) Use a piston pipette to finely adjust to the marked line.

(d) To prevent adhesion of nuclides to the inner wall of container, add 80-100 mg of sodiumthiosulfate per 1 L of sample.[*6]

(e) Measure the weight of the Marinelli beaker and lid along with the sample, derive the weight ofthe sample by subtracting the tare weight measured above, and record it.

(f) Seal the inner bag of Marinelli beaker using plastic tape.[*7] (Photograph 6.2)

(g) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photographs 6.3 and 6.4)

(h) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(i) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement. (Photograph 6.5)

Photograph 6.1
Marinelli beaker filled with a sample(drinking water)

Photograph 6.2
Sealing the inner back with plastic tape(drinking water)

[*6]: Manual for Measuring Radioactivity of Tap Water, etc., Ministry of Health, Labour and Welfare (2011) (Reference 17)

[*7]: A rubber band, cable tie, etc. may be used instead.

Photograph 6.3
Fixing the lid with plastic tape
(drinking water)

Photograph 6.4
Fixing the lid with plastic
tape(drinking water)

Photograph 6.5
The Marinelli beaker covered in a
polyethylene bag(drinking water)

(2) In the case of using small containers

(a) To prevent leakage, wrap seal tape around the threaded part of small container. (Photograph 6.6)

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.

(c) Mix the sample well, and place approximately 80 g of sample into the small container preparedin (2). (Photograph 6.7) Use a piston pipette to finely adjust the volume.

(d) To prevent adhesion of nuclides to the inner wall of container, add 80-100 mg of sodiumthiosulfate per 1 L of sample (6.4-8.0 mg per 80 g of sample).[*8]

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

[*8] Manual for Measuring Radioactivity of Tap Water, etc., Ministry of Health, Labour and Welfare (2011) (Reference 17)

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement. (Photograph 6.8)

Photograph 6.6
Wrapping thread seal tape around the threaded part(drinking water)

Photograph 6.7
Small container containing a sample(drinking water)

Photograph 6.8
The small container covered in a polyethylene bag(drinking water)

6.4 Storage of samples

6.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator or cool dark place to prevent decomposition.

6.4.2 Long-term storage

(a) To prevent adhesion of nuclides to the inner wall of container during long-term storage, if iodine is not included in the nuclides to be measured, add about 1 mL of hydrochloric acid (~12 mol/L) or nitric acid (~13 mol/L) per 1 L of sample. [*9] [*10]

(b) Store samples in a refrigerator or cool dark place to prevent decomposition.

[*9] According to the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16Method for Sampling Environmental Materials (Reference 4).

[*10] Do not add acid if iodine is included in the nuclides to be measured. (Iodine becomes volatile when acid is added.)

Chapter 7 Seawater

This chapter describes how to prepare and store seawater as samples for measurement. Obvious foreign matters (e.g., seaweeds) are to be removed by a sedimentation method, but further treatment such as filtration is not to be applied. Measurement containers used are Marinelli beakers or small containers.

7.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Piston pipette
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water [*11]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Tray, etc.
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferablywith a recording function such as a printer)[*2] (With the operation panel, top plate, etc. coveredby wrap films, etc. to prevent contamination of the surface)

7.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the sampling location, sampling period, sampling amount, sampling conditions, etc. and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible. and selecta measurement container sized for the sample volume.[*3] Select small containers for measurement if the radiation levels from the samples are high.

[*1]: Confirm in advance the pure water is free of radioactive materials.

[*2]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

[*3]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

7.3 Sample preparation method[*4]

7.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and work on them separately for each sample. Lay filter paper in a tray and work on it as necessary.[*5]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact with the sample from cold work through indirect contact, and it is desirable to separate workers and workbenches between hot work and cold work.

7.3.2 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposablebags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) Mix the sample well, and place it in the Marinelli beaker prepared in (2) up to the marked line.Use a piston pipette to finely adjust to the marked line.

(d) Measure the weight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*6]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape.

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

[*4]: See Chapter 6 for the photographs of preparation.

[*5]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*6]: A rubber band, cable tie, etc. may be used instead.

(2) In the case of using small containers

(a) To prevent leakage, wrap seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.

(c) Mix the sample well, and place approximately 80 g of sample into the small container preparedin (2). Use a piston pipette to finely adjust the volume.

(d) Place a cap on the small container, measure the height of the sample and record it.

(e) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(f) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(g) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

7.4 Storage of samples

7.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into apolyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator or cool dark place to prevent decomposition.

7.4.2 Long-term storage

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containers into a polyethylene bag or a container.

(c) In either case, samples may be transferred into a storage container as necessary.[*7] To prevent adhesion of nuclides to the inner wall, if iodine is not included in the nuclides to be measured, add about 1 mL of hydrochloric acid (~12 mol/L) or nitric acid (~13 mol/L) per 1 L of sample.[*8] [*9]

(d) Store samples in a refrigerator or cool dark place to prevent decomposition.

[*7]: When a sample is to be transferred, pay attention to the homogeneity of the sample and transfer the entiresample if possible.

[*8]: According to the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4).

[*9]: Do not add acid if iodine is included in the nuclides to be measured. (Iodine becomes volatile when acid is added.)

Chapter 8 Soil

Different methods are applied to emergency monitoring of soil, depending on the purpose of monitoring and the phase of emergency. For the main method among them, Information 6 describes the standard sampling and preparation methods and matters to be noted. This chapter describes how to prepare and store surface soil samples for measuring radioactivity concentration and deposits. In the method provided in this chapter, wet soil is to be measured as is without drying, in order to prevent contamination inside rooms, and measurement containers used are small containers. This method is also applicable to river sediment, lake sediment, and sea sediment.

8.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Small containers (capacity: about 100 mL)
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Ethanol
- Pure water[*1]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*2] (With the operation panel, top plate, etc. coveredby wrap films, etc. to prevent contamination of the surface)

8.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the sampling location, sampling date, sampling conditions, etc.[*3] [*4] and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. Assume the dead time for when measured using a germanium semiconductor detector based on the sample volume and

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[*1] Confirm in advance the pure water is free of radioactive materials.

[*2] Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

[*3]: Note that sampling area is required for deriving deposits. For the calculation method, refer to 8.6.

[*4]: A method to directly collect samples by pressing small containers into the ground surface is available, but samples collected in this manner have significant unevenness in radioactivity concentration unless mixed well, as shown in Figure 6.1 in Information 6.

Therefore, to ensure the homogeneity of the sample, there has been a case of taking collected samplesout of small containers into polyethylene bags, mixing the samples well in the bags, and placing the samples back into the small containers to present as samples for measurement.

radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume. [*5] Select small containers for measurement if the radiation levels from the samples are high.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take proper measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

8.3 Sample preparation method

8.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. Place a plastic sheet on a covered workbench, further place large filters on top of it, and work on them separately for each sample.[*6]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact with the sample from cold work through indirect contact, and to separate workers and workbenches for hot work and cold work as far as possible.

[*5]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*6]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

8.3.2 Filling measurement container with sample

(a) Measure the weight of samples carried in, and record it.[*7]

(b) Remove any large plant pieces, tree roots, stones, etc. from the samples.[*8] (Photograph 8.1)

(c) Mix the sample well in a bag[*9] . (Photograph 8.2)

(d) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.

(e) While paying attention to the homogeneity of the sample, fill the small container with thesample without gaps using a laboratory spoon. (Photograph 8.3)

(f) Lightly press and level the surface of the sample.

(g) Place a cap on the small container, measure the height of the sample and record it.

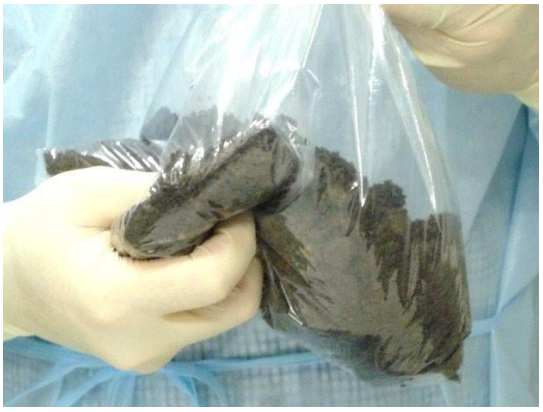
(h) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(i) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(j) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

(k) If necessary, calculate the dry soil rate by the method described in 8.5.

Photograph 8.1
Foreign matters removed

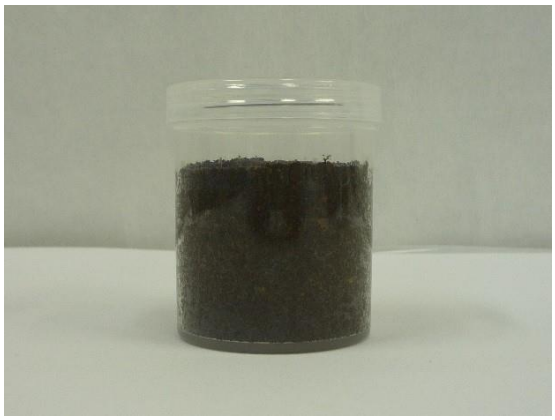


Photograph 8.2
Mixing a sample

[*7]: If the samples are watery, remove water following 8.4.

[*8]: Remove relatively large pieces of foreign matter. If monitoring is performed for the purpose of measuring deposits at multiple locations, some sampling sites may not be ideal bare lands and samples may always contain grass. In such a case, samples are to be prepared without removing plants. In addition, in some cases samples are collected separately for soil surface plants and litter (e.g., fallen leaves and branches on the ground) and soil to measure radioactivity concentration of each sample. Ifthat is the case, sampling and pretreatment need to be performed according to the purpose of the study.

[*9]: If the samples are placed in polyethylene jars, take them out into polyethylene bags.



Photograph 8.3
Small container filled with a sample (soil)

8.4 Pretreatment of watery samples

8.4.1 Instruments and tools to be used

- Instruments and tools listed in 8.1
- Büchner funnel
- Filtration flask
- Aspirator
- Filter paper (preferably those conforming to JIS Standard No. 2)

8.4.2 Removal of water

(a) Measure the weight of samples carried in, and record it.
(b) Assemble a Büchner funnel, filtration flask and aspirator, and place filter paper inside thefunnel. (Photograph 8.4)
(c) Place a sample in the funnel, and start filtration.[*10] (Photograph 8.5)
(d) When filtration is completed, place the sample into a polyethylene bag and measure the wetsoil weight. (Photograph 8.6)
(e) Follow the step (3) onward in 8.3.2.
(f) Calculate the dry soil rate by the method described in 8.5.[*11]

[*10]: Handle the filtrate with care, as its radioactivity concentration may be high.

[*11]: If measurement using a survey meter, etc. suggests that the sample's radioactivity concentration is high, pay extra attention not to contaminate other samples.

Photograph 8.4
Büchner funnel with filter paper placed inside

Photograph 8.5
Filtration in progress (sea sediment)

Photograph 8.6

Sample dewatered by filtration
(sea sediment)

8.5 Calculation of dry soil rate

8.5.1 Instruments and tools to be used

- Instruments and tools listed in 8.1
- Drying oven
- Desiccator
- Glass beaker or porcelain crucible
- Heat-resistant tray

8.5.2 Procedure

(a) Measure the tare weight of glass beaker.

(b) Place at least 10 g of wet soil sample in the glass beaker, and measure the weight. Calculate thewet soil weight by subtracting the tare weight measured in (1) from this weight.

(c) Dry the sample in a drying oven set to 105°C until the sample's mass becomes constant.[*12] [*13] (Photograph 8.7)

(d) Place the sample in a desiccator, and measure the weight after cooling. Derive the dry soilweight by subtracting the tare weight measured in (1) from this

[*12]: Placing the glass beaker on a heat-resistant tray may help in preventing the drying oven from being contaminated.

[*13]: If a hot air dryer is to be used, radioactive particles may scatter around and contaminate the dryer or the laboratory. Pay attention to the air flow rate, and perform decontamination (wiping) inside the dryer as necessary.

weight.

(e) Dry soil rate is defined as the ratio of dry soil weight to wet soil weight ([Dry soil weight]/[Wetsoil weight] × 100 (%)).

Photograph 8.7
Dried soil sample (sea sediment)

8.6 Calculation of deposits

After measurement using a germanium semiconductor detector, calculate the deposits per square meter using the formula below. Note that this formula requires a sampling area, which needs to be checked when the sample is carried in.

$$A_s \pm \Delta A_s = (A_w \pm \Delta A_w) \times \mathrm{W} \times \frac{1}{S} \times 10^4$$

A_s : Deposits per square meter (Bq/m^2)
ΔA_s : Counting statistics-based uncertainty of A_S
A_w : Radioactivity concentration per 1 kg of sample (Bq/kg)
ΔA_w : Counting statistics-based uncertainty of A_w
W : Collected sample weight (kg)
S : Sampling area (cm^2)

8.7 Storage of samples

8.7.1 Storage for a relatively short period of time

Store sample-containing small containers as they are, or placing them into a polyethylene bag or acontainer.

8.7.2 Long-term storage

(a) Store sample-containing small containers as they are or placing them into a polyethylene bagor a container, or dry the samples following the method provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3). Note that contamination of other samples needs to be prevented by, for example, washing and cleaning instruments, tools and equipment after use, if samples with high radioactivity concentration are to be dried.

(b) When storing dried samples, place them in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 9 Vegetables

This chapter describes how to prepare and store vegetables as samples for measurement. In the method provided in this chapter, assuming assay of radioactive materials in food and drinks based on OIL6, vegetables are washed with water to remove soil, etc. and chopped into small pieces. As a reference, the results of a study on how much radioactive materials are removed from vegetables by washing with water are provided in Information 7. Measurement containers used are Marinelli beakersor small containers. Table 9.1 shows examples of vegetables to be used as samples. Note that this method is applicable to yomogi (*Artemisia princeps*), etc. when they are consumed, but the method described in Chapter 21 shall be followed if they are analyzed as an indicator organism.

Table 9.1 Example vegetables

Category	Examples
Fruit vegetables	Tomato, bell pepper
Immature peas and beans	Green bean, green pea
Non-heading leaf vegetables	Spinach, Japanese mustard spinach
Heading leaf vegetables	Chinese cabbage, cabbage
Stem vegetables (excluding allium vegetables)	Asparagus
Flower vegetables	Broccoli, cauliflower
Allium vegetables	Scallion, onion
Potatoes	Potato, taro
Root vegetables (excluding potatoes)	Carrot, white radish (root part)

9.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Cutter[*1], scissors, kitchen knife[*2] (preferably disposable type)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water[*3]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers

[*1]: Wash cutter blades with ethanol, etc. before use, because some cutter blades are coated with oil to prevent rusting. Disposable scalpels may be used instead.

[*2]: It is desirable to use disposable cutter blades to avoid cross-contamination, but a kitchen knife may have to be used to cut hard samples. Use cutting tools as appropriate with paying extra attention to safety.

[*3]: Confirm in advance the pure water is free of radioactive materials.

・Disposable masks
・Large filter (roughly 60 cm × 60 cm)
・Plastic sheet (plastic bag may be used instead)
・Paper plate (substitute for cutting board and tray)
・Ruler
・Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*4] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

9.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 50 g or more (thevolume will be 100 mL or more) for small containers and 1 kg or more (the volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*5] Select small containers for measurement if the radiation levels from the samples are high.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

9.3 Sample preparation method

9.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and

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[*4]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

[*5] For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

work on them separately for each sample.[*6]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work thatinvolves direct contact of the sample from cold work that does not involve direct contact, and it is desirable to separate workers and workbenches between hot work and cold work.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.[*7]

9.3.2 Sample washing and separation of edible part

(1) Fruit vegetables, immature peas and beans, non-heading leaf vegetables, heading leaf vegetables, stem vegetables (excluding allium vegetables), flower vegetables, and allium vegetables

(a) Brush off any excess soil at the root part in advance.

(b) Referring to the edible part column in Table 9.2, remove any parts that are not usually presented for consumption (for fruit vegetables, remove non-edible parts after washing). (Photograph 9.1)

(c) Referring to the washing method column in Table 9.2, wash the sample.[*8] (Photograph 9.2)

(d) Visually confirm that soil, etc. has been removed from the sample to the level suitable to bepresented for consumption.

(e) Remove excess water using paper towels. (Photograph 9.3)

(f) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc.[*9] (Photograph 9.4)

Photograph 9.1
Parts not presented
for consumption removed
(Chinese cabbage)

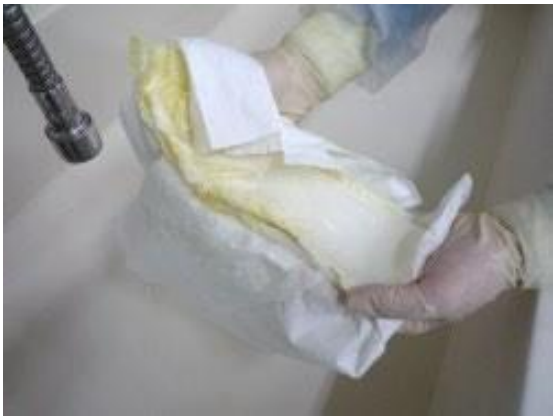
Photograph 9.2
Washing with water
(Chinese cabbage)

[*6] Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*7] Discard disposable cutter blades, etc. separately.

[*8] Confirm in advance the tap water to be used for washing is free of radioactive materials. If tap water contains radioactive materials, use pure water instead after confirming no radioactive materials are contained.

[*9] If the samples are soft, they may be broken into small pieces by hand.



Photograph 9.3
Removing water
(Chinese cabbage)

Photograph 9.4
Sample cut into small pieces
(Chinese cabbage)

(2) Potatoes and root vegetables (excluding potatoes)

(a) Brush off soil, and separate into the root part and stem and leaf part.

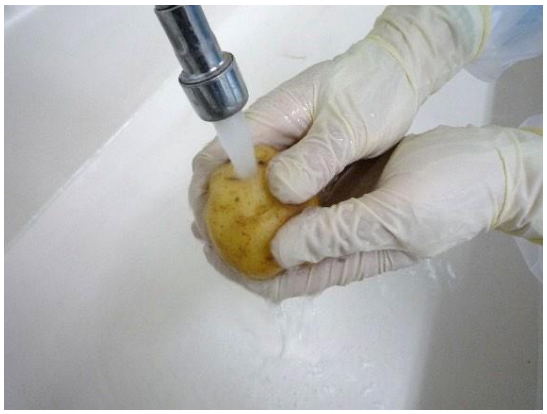
(b) Referring to the washing method column in Table 9.2, wash the sample. (Photograph 9.5)

(c) Visually confirm that soil, etc. has been removed from the sample to the level suitable to bepresented for consumption.

(d) Remove excess water using paper towels. (Photograph 9.6)

(e) Referring to the edible part column in Table 9.2, remove any parts that are not usually presented for consumption. (Photograph 9.7)

(f) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc. (Photograph 9.8)



Photograph 9.5
Washing with water
(potato)

Photograph 9.6
Removing water
(potato)

Photograph 9.7
Parts not presented
for consumption Removed
(potato)

Photograph 9.8
Sample cut into small pieces
(potato)

Table 9.2 Edible part sectioning method and washing method by vegetable category

Category	Examples	Edible part sectioning method	Washing method
Fruit vegetables	Tomato, bell pepper	After washing, remove all parts (e.g., calyx, seeds) that are not served for consumption. (Photograph 9.9)	Wash under running tap waterfor about 20 seconds.
Immature peas and beans	Green bean, green pea	Remove the calyx.	
Non-heading leaf vegetables	Spinach, Japanesemustard spinach	Cut off the root part. (For spinach, remove fibrous roots.)	
Heading leaf vegetables	Chinese cabbage, cabbage	Remove outer leaves and the core that is not for consumption.	
Stem vegetables (excluding allium vegetables)	Asparagus	Stem	
Flower vegetables	Broccoli, cauliflower	Remove leaves. (Photograph 9.10)	
Allium vegetables	Scallion, onion	Remove inedible scale leaves and fibrous roots.	
Potatoes	Potato, taro	As is if the skin is consumed, or peel the skin if the skin is not consumed.	Wash with tap water to remove soil, etc.
Root vegetables (excluding potatoes)	Carrot, white radish	Remove fibrous roots, and as is if the skin is consumed or peel the skin if the skin is not consumed.	

Photograph 9.9
Edible part separated
(bell pepper)

Photograph 9.10
Edible part separated
(broccoli)

9.3.3 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposablebags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker, and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 9.11)

(d) Lightly press and level the surface of the sample at the marked line. Then, measure the weight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*10]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 9.12)

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

Photograph 9.11
Marinelli beaker filled with a
sample(bell pepper)

Photograph 9.12
The lid fixed with plastic tape
(bell pepper)

[*10]: A rubber band, cable tie, etc. may be used instead.

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.

(c) While paying attention to the homogeneity of the sample, fill the small container with the sample without gaps using a laboratory spoon. (Photographs 9.13 to 9.18)

(d) Lightly press and level the surface of the sample.

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

Photograph 9.13
Small container filled with a sample (green bean)

Photograph 9.14
Small container filled with a sample (spinach)

Photograph 9.15
Small container filled with a sample (asparagus)

Photograph 9.16
Small container filled with a sample (broccoli)

Photograph 9.17
Small container filled with a sample
(potato)

Photograph 9.18
Small container filled with a sample
(carrot)

9.4 Storage of samples

9.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

9.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washingand cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 10 Fruit

This chapter describes how to prepare and store fruit (e.g., mandarin orange, apple, persimmon, grape, strawberry) as samples for measurement. In the method provided in this chapter, samples are washed with water to remove dust, etc. and chopped into small pieces. Measurement containers used are Marinelli beakers or small containers.

10.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Cutter [*1], scissors, kitchen knife[*2] (preferably disposable type)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water[*3]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Paper plate (substitute for cutting board and tray)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*4] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

10.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 50 g or more (thevolume will be 100 mL or more) for small containers and 1 kg or more (the

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[*1]: Wash cutter blades with ethanol, etc. before use, because some cutter blades are coated with oil to prevent rusting. Disposable scalpels may be used instead.

[*2]: It is desirable to use disposable cutter blades to avoid cross-contamination, but a kitchen knife may have to be used to cut hard samples. Use cutting tools as appropriate with paying extra attention to safety.

[*3]: Confirm in advance the pure water is free of radioactive materials.

[*4]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*5] Select small containers for measurement if the radiation levels from the samples are high.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

10.3 Sample preparation method

10.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and work on them separately for each sample.[*6]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact of the sample from cold work through indirect contact, and it is desirable to separate workers and workbenches between hot work and cold work

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.[*7]

10.3.2 Sample washing and separation of edible part

(a) Wash with tap water[*8] to remove dust. (Photograph 10.1)
Note that washing is not required for fruit whose peel is not presented for consumption, such asmandarin orange and banana.

(b) Visually confirm that soil, etc. has been removed from the sample to the level suitable to be presented for consumption.

(c) Remove excess water using paper towels. (Photograph 10.2)

(d) Referring to Table 10.1, remove any parts that are not usually presented for consumption.(Photograph 10.3)

[*5]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*6]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*7]: Discard disposable cutter blades, etc. separately.

[*8]: Confirm in advance the tap water to be used for washing is free of radioactive materials. If tap water contains radioactive materials, use pure water instead after confirming no radioactive materials are contained.

(e) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc.[*9]
(Photograph 10.4)

Photograph 10.1
Washing with water
(grape)

Photograph 10.2
Removing water
(grape)

Photograph 10.3
Parts not presented for consumption
removed(grape)

Photograph 10.4
Sample cut into small pieces
(grape)

Table 10.1 Edible part sectioning

Example sample	Edible part sectioning method
Mandarin orange, etc.	Remove peels.
Apple, etc.	Remove the calyx, core, and base part of peduncle [*1010] . (Photograph 10.5)
Persimmon	Remove the calyx and seeds. (Photograph 10.6)
Grape	Remove the peduncle [10] . (Photograph 10.7)Remove seeds as necessary.
Strawberry	Remove the calyx. (Photograph 10.8)
Other	Remove parts not presented for consumption.

[*9]: If the samples are soft, they may be broken into small pieces by hand.
[*10]: The part where the stalk joins the fruit.

Photograph 10.5
Edible part separated
(apple)

Photograph 10.6
Edible part separated (persimmon)

Photograph 10.7
Edible part separated
(grape)

Photograph 10.8
Edible part separated
(strawberry)

10.3.3 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposablebags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker, and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 10.9)

(d) Lightly press and level the surface of the sample at the marked line. Then, measure the weight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*11]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 10.10)

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

[*11]: A rubber band, cable tie, etc. may be used instead.

Photograph 10.9
Marinelli beaker filled with a sample
(strawberry)

Photograph 10.10
The lid fixed with plastic tape
(strawberry)

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, and measure and record the tare weight of the small container.

(c) While paying attention to the homogeneity of the sample, fill the small container with the sample without gaps using a laboratory spoon.(Photographs 10.11 to 10.13)

(d) Lightly press and level the surface of the sample.

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

Photograph 10.11
Small container filled with a sample
(apple)

Photograph 10.12
Small container filled with a sample
(grape)

Photograph 10.13
Small container filled with a sample
(strawberry)

10.4 Storage of samples

10.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into apolyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containers into a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

10.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washingand cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 11 Tea leaves

This chapter describes how to prepare and store tea leaves as samples for measurement. In the method provided in this chapter, samples are to be filled into measurement containers as they are, in a raw state, without washing.[*1] Measurement containers used are Marinelli beakers or small containers.

11.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water[*2]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Paper plate (substitute for tray)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*3] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

11.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Check and record the sample status (fresh or dried; raw tea or crude tea). Also be mindful of the unit of radioactivity concentration to be reported (examples: Bq/kg fresh, Bq/kg dry).

(d) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 50 g or more (thevolume will be 100 mL or more) for small containers and 1 kg or more (the

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[*1] Tea leaves are not washed because processing of tea leaves usually does not have a washing process. If tea leaves are to be used for drinking, conduct measurement on liquid tea according to the Testing Methods for Radioactive Cesium in Food, Ministry of Health, Labour and Welfare (2012) (Reference 19).

[*2] Confirm in advance the pure water is free of radioactive materials.

[*3] Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*4] Select small containers for measurement if the radiation levels from the samples are high.

(e) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

11.3 Sample preparation method

11.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and work on them separately for each sample.[*5]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact of the sample from cold work through indirect contact, and it is desirable to separate workers and workbenches between hot work and cold work.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.

11.3.2 Sample washing and separation of edible part

(a) Do not wash samples. (Photograph 11.1)

(b) If the samples were provided in a state of buds and leaves attached to branches, pick the budsand leaves off the branches by hand. (Photograph 11.2)

(c) Present buds and leaves without foreign matters (e.g., spider web) as a sample (remove anyparts with foreign matters from the sample). (Photographs 11.3 and 11.4)

[*4] For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*5] Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

Photograph 11.1
Sample (as carried in)
(tea leaves)

Photograph 11.2
Picking buds and leaves
(tea leaves)

Photograph 11.3
Foreign matters removed
(tea leaves)

Photograph 11.4
Sample after picking buds,leaves, and foreign matters(tea leaves)

11.3.3 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposablebags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker, and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps.

(d) Lightly press and level the surface of the sample at the marked line. Then, measure the weight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*6]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape.

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

[*6]: A rubber band, cable tie, etc. may be used instead.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.

(c) While paying attention to the homogeneity of the sample, fill the small container with the sample without gaps using a laboratory spoon. (Photograph 11.5)

(d) Lightly press and level the surface of the sample.

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

Photograph 11.5
Small container filled with a sample
(tea leaves)

11.4 Storage of samples

11.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

11.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washingand cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 12 Grains

This chapter describes how to prepare and store grains as samples for measurement. In the method provided in this chapter, samples are to be filled into measurement containers as they are, without washing. Measurement containers used are Marinelli beakers or small containers. Note that, when samples are collected during the harvest season, the method provided in this chapter is applicable not only to polished rice (white rice) and unpolished rice (brown rice) but also, as necessary, to unhulled rice, wheats and buckwheats.

12.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water[*1]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Paper plate (substitute for tray)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*2] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

12.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 100 g or more (the volume will be 100 mL or more) for small containers and 2 kg or more (the volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and selecta measurement container sized for the sample

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[*1]: Confirm in advance the pure water is free of radioactive materials.

[*2]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

volume.[*3] Select small containers for measurement if the radiation levels from the samples are high.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

12.3 Sample preparation method

12.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and work on them separately for each sample.[*4]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work thatinvolves direct contact of the sample from cold work that does not involve direct contact, and it is desirable to separate workers and workbenches between hot work and cold work.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.

12.3.2 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposablebags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker, and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 12.1)

(d) Lightly press and level the surface of the sample at the marked line. Then, measure the weight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*5]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 12.2)

[*3] For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*4] Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*5] A rubber band, cable tie, etc. may be used instead.

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.
(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

Photograph 12.1
Marinelli beaker filled with a sample
(polished rice)

Photograph 12.2
The lid fixed with plastic tape
(polished rice)

(2) In the case of using small containers
(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.
(b) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.
(c) While paying attention to the homogeneity of the sample, fill the small container with thesample without gaps using a laboratory spoon. (Photograph 12.3)
(d) Lightly press and level the surface of the sample.
(e) Place a cap on the small container, measure the height of the sample and record it.
(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.
(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.
(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

Photograph 12.3
Small container filled with a sample
(polished rice)

12.4 Storage of samples

12.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into apolyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

12.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washingand cleaning instruments, tools and equipment after use, if the radioactivity concentration ofthe sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 13 Peas and beans

This chapter describes how to prepare and store peas and beans as samples for measurement. Inthe method provided in this chapter, samples are to be filled into measurement containers as they are, without washing. Measurement containers used are Marinelli beakers or small containers. For peas and beans presented in the pod for consumption (e.g., green bean), follow the method provided in Chapter 9.

13.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Cutter [*1], scissors, kitchen knife [*2] (preferably disposable type)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water[*3]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Paper plate (substitute for cutting board and tray)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*4] (With the operation panel, top plate,etc. covered by wrap films, etc. to prevent contamination of the surface)

13.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 50 g or more (the volume will be 100 mL or more) for small containers and 1 kg or more (the

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[*1]: Wash cutter blades with ethanol, etc. before use, because some cutter blades are coated with oil to prevent rusting. Disposable scalpels may be used instead.

[*2]: It is desirable to use disposable cutter blades to avoid cross-contamination, but a kitchen knife mayhave to be used to cut hard samples. Use cutting tools as appropriate with paying extra attention to safety.

[*3]: Confirm in advance the pure water is free of radioactive materials.

[*4]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*5] Select small containers for measurement if the radiation levels from the samples are high .

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

13.3 Sample preparation method

13.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and workon them separately for each sample.[*6]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact of the sample from cold work through direct contact,and it is desirable to separate workers and workbenches between hot work and cold work.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.[*7]

13.3.2 Sample washing and separation of edible part

(a) Do not wash samples.

(b) If the samples are in the pod, take the edible part out using a cutter, etc. (Photographs 13.1and 13.2)

(c) If necessary, place the samples in a plastic bag, etc. and crush them into small pieces to facilitate filling into measurement containers.(Photograph 13.3)

[*5]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*6]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*7]: Discard disposable cutter blades, etc. separately.

Photograph 13.1
Taking out of the pod
(green soybeans)

Photograph 13.2
Parts not presented
for consumption removed
(green soybeans)

Photograph 13.3
Samples after crushing in a plastic bag
(green soybeans)

13.3.3 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposable bags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 13.4)

(d) Lightly press and level the surface of the sample at the marked line. Then, measure the weight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*8]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 13.5)

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

[*8]: A rubber band, cable tie, etc. may be used instead.

Photograph 13.4
Marinelli beaker filled with a sample
(green soybeans)

Photograph 13.5
The lid fixed with plastic tape
(green soybeans)

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, and measure and record the tare weight of the small container.

(c) While paying attention to the homogeneity of the sample, fill the small container with the sample without gaps using a laboratory spoon.(Photograph 13.6)

(d) Lightly press and level the surface of the sample.

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

Photograph 13.6
Small container filled with a sample
(green soybeans)

13.4 Storage of samples

13.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

13.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No.13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washing and cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 14 Mushrooms

This chapter describes how to prepare and store mushrooms (e.g., shiitake, maitake (hen of the woods)) as samples for measurement. In the method provided in this chapter, samples are lightly wiped and chopped into small pieces. Measurement containers used are Marinelli beakers or small containers.

14.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Cutter[*1], scissors, kitchen knife[*2] (preferably disposable type)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water[*3]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Paper plate (substitute for cutting board and tray)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*4] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

14.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 50 g or more (the volume will be 100 mL or more) for small containers and 1 kg or more (the volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured

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[*1]: Wash cutter blades with ethanol, etc. before use, because some cutter blades are coated with oil toprevent rusting. Disposable scalpels may be used instead.

[*2]: It is desirable to use disposable cutter blades to avoid cross-contamination, but a kitchen knife mayhave to be used to cut hard samples. Use cutting tools as appropriate with paying extra attention to safety.

[*3]: Confirm in advance the pure water is free of radioactive materials.

[*4] Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*5] Select small containers for measurement if the radiation levels from the samples are high.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

14.3 Sample preparation method

14.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and workon them separately for each sample.[*6]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact of the sample from cold work through indirect contact, and it is desirable to separate workers and workbenches between hot work and cold work to the extent possible.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.[*7]

14.3.2 Sample washing and separation of edible part

(a) Remove the hard base part. (Photograph 14.1)

(b) Lightly wipe the surface using paper towels moistened with tap water [*8].
(Photograph 14.2)

(c) Visually confirm that soil, etc. has been removed from the sample to the level suitable to bepresented for consumption.

(d) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc.[*9]
(Photographs 14.3 and14.4)

[*5]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*6]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*7]: Discard disposable cutter blades, etc. separately.

[*8]: Confirm in advance the tap water to be used for washing is free of radioactive materials. If tap watercontains radioactive materials, use pure water instead after confirming no radioactive materials are contained.

[*9]: If the samples are soft, they may be broken into small pieces by hand.

Photograph 14.1
Hard base part removed
(shiitake)

Photograph 14.2
Wiping (shiitake)

Photograph 14.3
Cutting sample into small pieces
(shiitake)

Photograph 14.4
Sample cut into small pieces
(shiitake)

14.3.3 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposable bags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 14.5)

(d) Lightly press and level the surface of the sample at the marked line. Then, measure theweight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*10]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 14.6)

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

[*10]: A rubber band, cable tie, etc. may be used instead.

Photograph 14.5
Marinelli beaker filled with a sample
(shiitake)

Photograph 14.6
The lid fixed with plastic tape
(shiitake)

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, and measure and record the tare weight of the small container.

(c) While paying attention to the homogeneity of the sample, fill the small container with the sample without gaps using a laboratory spoon.(Photograph 14.7)

(d) Lightly press and level the surface of the sample.

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottomof the container), and present it as a sample for measurement.

Photograph 14.7
Small container filled
with a sample(shiitake)

14.4 Storage of samples

14.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

14.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No.13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washing and cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 15 Seaweeds

This chapter describes how to prepare and store seaweeds (e.g., kelp, seaweed, hijiki, Gelidiaceae (agar weed)) as samples for measurement. In the method provided in this chapter, samples are washed with water to remove sand, etc. and chopped into small pieces. Measurement containers used are Marinelli beakers or small containers. Note that, when samples like hondawara (*Sargassum fulvellum*) are analyzed as an indicator organism, the method described in Chapter 21 shall be followed.

15.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Cutter[*1], scissors, kitchen knife[*2] (preferably disposable type)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Strainer, etc. (for draining water)
- Ethanol
- Pure water[*3]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Paper plate (substitute for cutting board and tray)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*4] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

15.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

[*1]: Wash cutter blades with ethanol, etc. before use, because some cutter blades are coated with oil toprevent rusting. Disposable scalpels may be used instead.

[*2]: It is desirable to use disposable cutter blades to avoid cross-contamination, but a kitchen knife mayhave to be used to cut hard samples. Use cutting tools as appropriate with paying extra attention to safety.

[*3]: Confirm in advance the pure water is free of radioactive materials.

[*4]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 50 g or more (the volume will be 100 mL or more) for small containers and 1 kg or more (the volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*5] Select small containers for measurement if the radiation levels from the samples are high .

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure.

15.3 Sample preparation method

15.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and workon them separately for each sample.[*6]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact of the sample from cold work through indirect contact,and it is desirable to separate workers and workbenches for between work and cold work to the extent possible.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.[*7]

15.3.2 Sample washing and separation of edible part

(a) Remove the base part and any foreign matters.[*8]

(b) Wash well using tap water[*9] [*10]. (Photograph 15.1)

(c) Visually confirm that sand, etc. has been removed from the sample to the level suitable to bepresented for consumption.

[*5]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*6]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*7]: Discard disposable cutter blades, etc. separately.

[*8]: Seaweeds often have other flora and fauna attached on the body and small rock pieces at the base; carefully remove them.

[*9]: Confirm in advance the tap water to be used for washing is free of radioactive materials. If tap water contains radioactive materials, use pure water instead after confirming no radioactive materials are contained.

[*10]: Do not leave the sample in tap water for a long period of time.

(d) Drain well using a strainer, etc. (Photograph 15.2)
(e) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc. (Photographs 15.3 and15.4)

Photograph 15.1
Washing with water
(seaweed)

Photograph 15.2
Draining water
(seaweed)

Photograph 15.3
Cutting sample into small pieces
(seaweed)

Photograph 15.4
Sample cut into small pieces
(seaweed)

15.3.3 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposable bags to prevent contamination of the wall of the measurement container.)
(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.
(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 15.5)
(d) Lightly press and level the surface of the sample at the marked line. Then, measure theweight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.
(e) Seal the inner bag of Marinelli beaker using plastic tape.[*11]
(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 15.6)
(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened

[*11]: A rubber band, cable tie, etc. may be used instead.

with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

Photograph 15.5
Marinelli beaker filled with a sample
(seaweed)

Photograph 15.6
The lid fixed with plastic tape
(seaweed)

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container,and measure and record the tare weight of the small container.

(c) While paying attention to the homogeneity of the sample, fill the small container with thesample without gaps using a laboratory spoon. (Photograph 15.7)

(d) Lightly press and level the surface of the sample.

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottomof the container), and present it as a sample for measurement.

Photograph 15.7
Small container filled with a sample
(seaweed)

15.4 Storage of samples

15.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

15.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No.13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washing and cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 16 Meats

This chapter describes how to prepare and store meats (e.g., beef, pork, chicken) as samples for measurement. In the method provided in this chapter, samples are boned and chopped into small pieces. Measurement containers used are Marinelli beakers or small containers.

16.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Cutter[*1], scissors, kitchen knife[*2] (preferably disposable type)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water[*3]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Paper plate (substitute for cutting board and tray)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*4] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

16.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 100 g or more (the volume will be 100 mL or more) for small containers and 2 kg or more (the volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and

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[*1]: Wash cutter blades with ethanol, etc. before use, because some cutter blades are coated with oil to prevent rusting. Disposable scalpels may be used instead.

[*2]: It is desirable to use disposable cutter blades to avoid cross-contamination, but a kitchen knife mayhave to be used to cut hard samples. Use cutting tools as appropriate with paying extra attention to safety.

[*3]: Confirm in advance the pure water is free of radioactive materials.

[*4]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*5] Select small containers for measurement if the radiation levels from the samples are high.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

16.3 Sample preparation method

16.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and workon them separately for each sample.[*6]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact of the sample from cold work through indirect contact,and it is desirable to separate workers and workbenches between hot work and cold.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.[*7]

16.3.2 Sample washing and separation of edible part

(a) Do not wash samples.

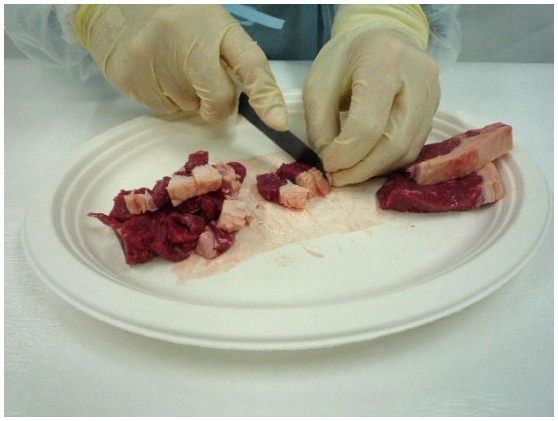
(b) If the samples have bones, remove the bones.

[*5]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*6]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Usingsimplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*7]: Discard disposable cutter blades, etc. separately.

(c) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc. (Photographs 16.1 and16.2)



Photograph 16.1
Cutting sample into small pieces
(beef)

Photograph 16.2
Sample cut into small pieces
(beef)

16.3.3 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposable bags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 16.3)

(d) Lightly press and level the surface of the sample at the marked line. Then, measure theweight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*8]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 16.4)

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

[*8]: A rubber band, cable tie, etc. may be used instead.

Photograph 16.3
Marinelli beaker filled with a sample
(beef)

Photograph 16.4
The lid fixed with plastic tape
(beef)

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container,and measure and record the tare weight of the small container.

(c) While paying attention to the homogeneity of the sample, fill the small container with thesample without gaps using a laboratory spoon. (Photograph 16.5)

(d) Lightly press and level the surface of the sample.

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottomof the container), and present it as a sample for measurement.

Photograph 16.5
Small container filled with a sample
(beef)

16.4 Storage of samples

16.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

16.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No.13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washing and cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 17 Cow's milk

This chapter describes how to prepare and store raw milk and pasteurized and homogenized commercial milk as samples for measurement. Measurement containers used are Marinelli beakers orsmall containers.

17.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Piston pipette
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water [*1]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*2] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

17.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 100 g or more (the volume will be 100 mL or more) for small containers and 2 kg or more (the volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*3]

[*1]: Confirm in advance the pure water is free of radioactive materials.

[*2]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

[*3]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

Select small containers for measurement if the radiation levels from the samples are high.

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

17.3 Sample preparation method

17.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and workon them separately for each sample.[*4]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact of the sample from cold work through indirect contact,and it is desirable to separate workers and workbenches between hot work and cold work to the extent possible.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools withlarge filters and discard.

17.3.2 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposable bags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) Mix the sample well, and place it in the Marinelli beaker prepared in (2) up to the markedline. (Photograph 17.1) Use a piston pipette to finely adjust to the marked line.

(d) Measure the weight of the Marinelli beaker and lid along with the sample, derive the weightof the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*5]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 17.2)

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

[*4]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*5]: A rubber band, cable tie, etc. may be used instead.

Photograph 17.1
Marinelli beaker filled with a sample (cow's milk)

Photograph 17.2
The lid fixed with plastic tape(cow's milk)

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, and measure and record the tare weight of the small container.

(c) Mix the sample well, and place approximately 80 g of sample into the small container prepared in (2). (Photograph 17.3) Use a piston pipette to finely adjust the volume.

(d) Place a cap on the small container, measure the height of the sample and record it.

(e) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(f) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(g) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottomof the container), and present it as a sample for measurement.

Photograph 17.3
Small container filled with a sample (cow's milk)

17.4 Storage of samples

17.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator or cool dark place to prevent decomposition.

17.4.2 Long-term storage

(a) Dry and ash cow's milk samples by the methods provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for SamplingEnvironmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washing and cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 18 Dairy products

This chapter describes how to prepare and store dairy products (e.g., powdered milk, cheese, butter) as samples for measurement. Dairy products come in various forms, such as powder, solid block and liquid, and the preparation method varies depending on the form. Solid block products are to be cut into small pieces. Measurement containers used are Marinelli beakers or small containers.

18.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Cutter[*1], scissors, kitchen knife[*2] (preferably disposable type)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Graduated cylinder (2 L or 100 mL)
- Piston pipette
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water[*3]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Paper plate (substitute for cutting board and tray)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*4] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

18.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to

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[*1]: Wash cutter blades with ethanol, etc. before use, because some cutter blades are coated with oil to prevent rusting. Disposable scalpels may be used instead.

[*2]: It is desirable to use disposable cutter blades to avoid cross-contamination, but a kitchen knife may have to be used to cut hard samples. Use cutting tools as appropriate with paying extra attention to safety.

[*3]: Confirm in advance the pure water is free of radioactive materials.

[*4]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

find samples with potentially high radioactivity. The required amount of sample is 100 g or more (the volume will be 100 mL or more) for small containers and 2 kg or more (the volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjustthe sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*5] Select small containers for measurement if the radiation levels from the samples are high .

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

18.3 Sample preparation method

18.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and workon them separately for each sample.[*6]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work that involves direct contact of the sample from cold work that does not involve direct contact,and it is desirable to separate workers and workbenches between hot work and cold work to the extent possible.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.[*7]

18.3.2 Powder products (e.g., powdered milk)

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposable bags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

[*5]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*6]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*7]: Discard disposable cutter blades, etc. separately.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 18.1)
(d) Lightly press and level the surface of the sample at the marked line. Then, measure theweight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.
(e) Seal the inner bag of Marinelli beaker using plastic tape.[*8]
(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 18.2)
(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.
(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

Photograph 18.1
Marinelli beaker filled with a sample
(powdered milk)

Photograph 18.2
The lid fixed with plastic tape
(powdered milk)

(2) In the case of using small containers
(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.
(b) Write or attach the necessary data (e.g., sample identification number) to a small container,and measure and record the tare weight of the small container.
(c) While paying attention to the homogeneity of the sample, fill the small container with thesample without gaps using a laboratory spoon.
(d) Lightly press and level the surface of the sample.
(e) Place a cap on the small container, measure the height of the sample and record it.
(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.
(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.
(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

[*8]: A rubber band, cable tie, etc. may be used instead.

18.3.3 Solid block products (e.g., cheese, butter)

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Usedisposable bags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc.

(d) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps.

(e) Lightly press and level the surface of the sample at the marked line. Then, measure theweight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(f) Seal the inner bag of Marinelli beaker using plastic tape. *[6]

(g) Place the lid on the Marinelli beaker, and seal with plastic tape.

(h) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(i) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container,and measure and record the tare weight of the small container.

(c) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc. (Photograph 18.3)

(d) While paying attention to the homogeneity of the sample, fill the small container with thesample without gaps using a laboratory spoon. (Photograph 18.4)

(e) Lightly press and level the surface of the sample.

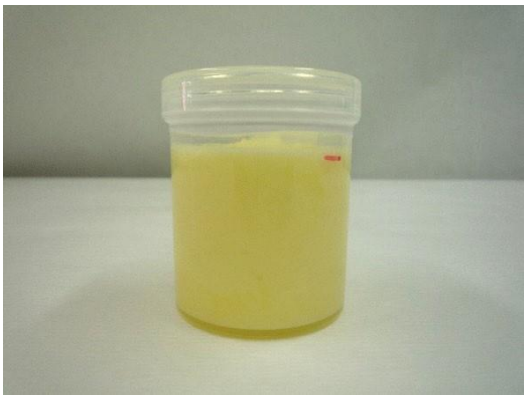
(f) Place a cap on the small container, measure the height of the sample and record it.

(g) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(h) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(i) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

Photograph 18.3
Cutting sample into small pieces
(butter)



Photograph 18.4
Small container filled with a sample
(butter)

18.3.4 Liquid products (e.g., condensed milk)
Follow the method described in Chapter 17.

18.4 Storage of samples

18.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

18.4.2 Long-term storage

(d) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No.13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washing and cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(e) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 19 Eggs

This chapter describes how to prepare and store chicken eggs as samples for measurement. Measurement containers used are Marinelli beakers or small containers.

19.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Container (e.g., beaker, mixing bowl)
- Piston pipette
- Plastic tape
- Thread seal tape
- Paper towels
- Ethanol
- Pure water[*1]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*2] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)

19.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 100 g or more (about 2 eggs) for small containers and 2 kg or more (about 30-40 eggs) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*3] Select small containers

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[*1]: Confirm in advance the pure water is free of radioactive materials.

[*2]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

[*3]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

for measurement if the radiation levels from the samples are high .

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

19.3 Sample preparation method

19.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and workon them separately for each sample.[*4]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact of the sample from cold work through indirect contact,and it is desirable to separate workers and workbenches between hot work and cold work to the extent possible.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.

19.3.2 Filling sample for measurement

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposable bags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) Crack eggs into a container (e.g., beaker, mixing bowl) and mix well.

(d) Mix the sample well and place it in the Marinelli beaker prepared in (2) up to the marked line.(Photograph 19.1) Use a piston pipette to finely adjust to the marked line.

(e) Measure the weight of the Marinelli beaker and lid along with the sample, derive the weightof the sample by subtracting the tare weight measured above, and record it.

(f) Seal the inner bag of Marinelli beaker using plastic tape.[*5]

(g) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 19.2)

(h) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(i) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for

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[*4]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

[*5]: A rubber band, cable tie, etc. may be used instead.

measurement.

Photograph 19.1
Marinelli beaker filled with a sample
(chicken egg)

Photograph 19.2
The lid fixed with plastic tape
(chicken egg)

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container,and measure and record the tare weight of the small container.

(c) Crack eggs into a container (e.g., beaker, mixing bowl) and mix well.

(d) Mix the sample well, and place it into the small container prepared in (2). (Photograph 19.3)Use a piston pipette to finely adjust the volume.

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottomof the container), and present it as a sample for measurement.

Photograph 19.3
Small container filled with a sample
(chicken egg)

19.4 Storage of samples

19.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a refrigerator, freezer, or cool dark place to prevent decomposition.

19.4.2 Long-term storage

(a) Dry and ash egg samples by the methods provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washing and cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 20 Seafood

This chapter describes how to prepare and store seafood as samples for measurement. Some seafood is presented without removing any part for the whole to be consumed, while other seafood is presented after removing viscera. In the latter case, attention needs to be paid to loss of blood, body fluids, etc. during preparation and associated contamination of other samples. Measurement containers used are Marinelli beakers or small containers. Table 20.1 shows examples of seafood to be used as samples.

Table 20.1 Seafood example

Category	Examples
Fish	*Spratelloides gracilis*, whitebait (the whole is consumed)
	Caranginae, mackerel, righteye flounder (the muscle part is consumed)
Shellfish	Asari (Venerupis philippinarum), oyster, shijimi (Corbiculidae)
Cephalopoda	Squid, octopus
Crustaceans	Prawn, shrimp, crab
Echinoderms	Sea cucumber, sea urchin

20.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Cutter[*1], scissors, kitchen knife[*2] (preferably disposable type)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Strainer, etc. (for draining water)
- Ethanol
- Pure water[*3]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)

[*1]: Wash cutter blades with ethanol, etc. before use, because some cutter blades are coated with oil to prevent rusting. Disposable scalpels may be used instead.

[*2]: It is desirable to use disposable cutter blades to avoid cross-contamination, but a kitchen knife mayhave to be used to cut hard samples. Use cutting tools as appropriate with paying extra attention to safety.

[*3]: Confirm in advance the pure water is free of radioactive materials.

・Plastic sheet (plastic bag may be used instead)
・Paper plate (substitute for cutting board and tray)
・Ruler
・Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer) [*44] (With the operation panel, top plate, etc. covered by wrap films, etc. to prevent contamination of the surface)
・

20.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.
(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.
(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. The required amount of sample is 100 g or more (the volume will be 100 mL or more) for small containers and 2 kg or more (the volume will be 2 L or more) for Marinelli beakers Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*5] Select small containers for measurement if the radiation levels from the samples are high .
(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

20.3 Sample preparation method

20.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.
(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.
(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.
(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and workon them separately for each sample.[*6]
(e) To prevent spreading of contamination from the sample, it is desirable to separate hot

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[*4]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

[*5]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*6]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

work through direct contact of the sample from cold work through indirect contact,and it is desirable to separate workers and workbenches between hot work and cold work to the extent possible.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools with large filters and discard.[*7]

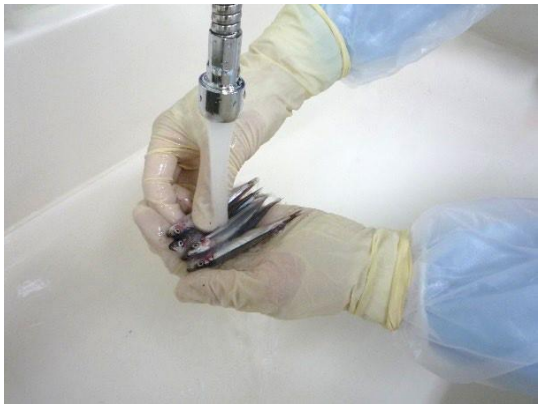
20.3.2 Sample washing and separation of edible part

(1) Fish for which the whole is presented for consumption, such as *Spratelloides gracilis*

(a) Quickly wash with tap water[*8] to remove any foreign matter on the surface as early aspossible. (Photograph 20.1)

(b) Place in a strainer, etc. for 10-15 minutes to drain water. (Photograph 20.2)

(c) Fill the drained samples as they are (Photograph 20.3) or after cutting into small pieces(about 1-2 cm) (Photograph 20.4) into measurement containers.



Photograph 20.1
Washing with water
(*Spratelloides gracilis*)

Photograph 20.2
Draining water
(*Spratelloides gracilis*)

Photograph 20.3
Sample to be filled into measurement container(as is)
(*Spratelloides gracilis*)

Photograph 20.4
Sample to be filled into measurement container
(cut into small pieces)
(*Spratelloides gracilis*)

[*7]: Discard disposable cutter blades, etc. separately.

[*8]: Confirm in advance the tap water to be used for washing is free of radioactive materials. If tap water contains radioactive materials, use pure water instead after confirming no radioactive materials are contained.

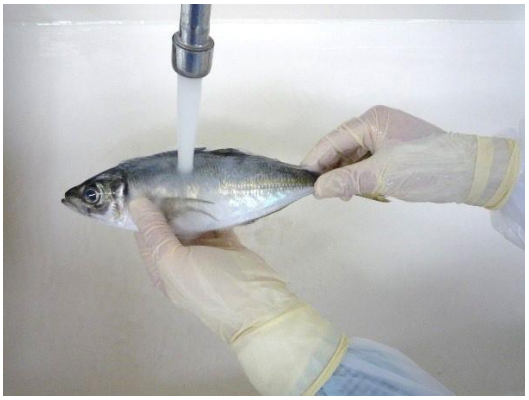
(2) Fish for which the muscle part is presented for consumption, such as Caranginae

(a) Quickly wash with tap water to remove any foreign matter on the surface as early as possible.(Photograph 20.5)

(b) Remove water using paper towels. (Photograph 20.6)

(c) Remove the head, viscera, bones, etc. to have only the muscle part left.[*9] (Photograph 20.7)

(d) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc. (Photograph 20.8)



Photograph 20.5
Washing with water(Caranginae)

Photograph 20.6
Wiping (Caranginae)

Photograph 20.7
Parts not presented
for consumption removed
(Caranginae)

Photograph 20.8
Sample cut into small pieces
(Caranginae)

[*9]: Pay attention when separating muscles and viscera to contamination of other tissues by damagingviscera or loss due to release of body fluids.

(3) Shellfish (e.g., asari)

(a) In principle, do not remove sand in an emergency, but remove sand if necessary.[*10] Record in a form whether sand was removed or not.

(b) Quickly wash with tap water to remove any foreign matter on the surface as early as possible.(Photograph 20.9)

(c) Remove water using paper towels. (Photograph 20.10)

(d) Shuck the samples to have only the meat part left.[*11] Do not wash the meat part with water.(Photographs 20.11 and 20.12)

(e) If the samples are large-type shellfish and viscera, etc. are not presented for consumption, cut out the edible part only using a cutter, etc.

Photograph 20.9
Washing with water
(asari)

Photograph 20.10
Wiping
(asari)

Photograph 20.11
Shucking(asari)

Photograph 20.12
Shucked sample(asari)

[*10] Let shellfish to expel sand or mud by immersing overnight freshwater shellfish in fresh water and saltwater shellfish in seawater collected near the sampling site.

[*11] In some methods, shellfish is shucked after freezing or using a microwave oven. However, if volatile nuclides such as radioactive iodine are included in the nuclides to be measured, take appropriate measures (e.g., reduce the output (Watt) of microwave oven not to overheat the sample) to prevent volatile nuclides from volatilizing.

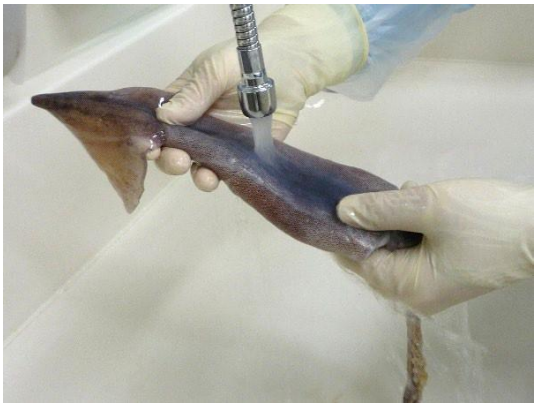
(4) Cephalopoda (e.g., squid)

(a) Quickly wash with tap water to remove any foreign matter on the surface as early as possible.(Photograph 20.13)

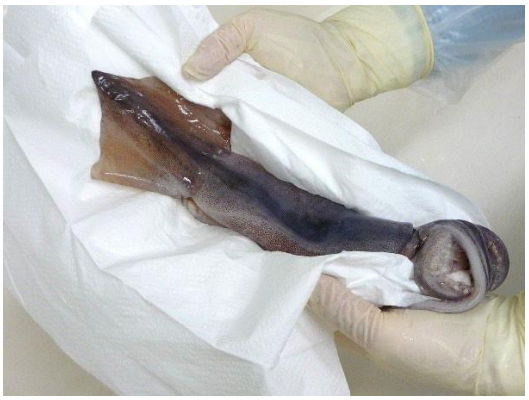
(b) Remove water and slime using paper towels. (Photograph 20.14)

(c) Remove the viscera, etc. to have only the muscle part left.[*12] (Photograph 20.15)

(d) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc. (Photograph 20.16)



Photograph 20.13
Washing with water(squid)



Photograph 20.14
Wiping(squid)

Photograph 20.15
Parts not presented for consumption removed(squid)

Photograph 20.16
Cutting sample into small pieces (squid)

[*12] Pay attention when separating muscles and viscera to contamination of other tissues by damagingviscera or loss due to release of body fluids.

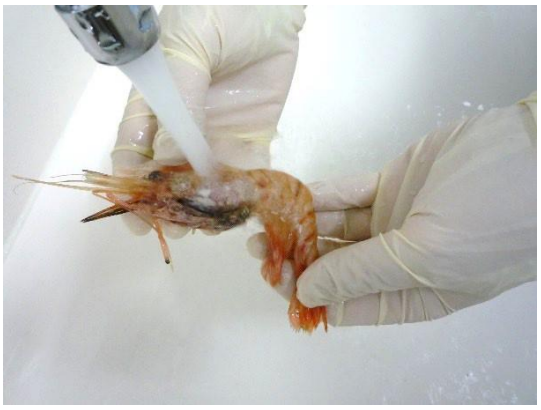
(5) Crustaceans (e.g., prawn)

(a) Quickly wash with tap water to remove any foreign matter on the surface as early as possible.(Photograph 20.17)

(b) Remove water using paper towels. (Photograph 20.18) Place samples for which the whole is presented for consumption (e.g., shrimp) in a strainer, etc. for 10-15 minutes to drain water.

(c) Shuck the samples to have only the meat part left. (Photograph 20.19) Do not wash the meat part with water. Fill samples for which the whole is presented for consumption (e.g., shrimp) into measurement containers as they are without removing the shell.

(d) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc., as necessary. (Photograph 20.20)



Photograph 20.17
Washing with water
(prawn)

Photograph 20.18
Wiping
(prawn)

Photograph 20.19
Parts not presented for consumption removed(prawn)

Photograph 20.20
Sample cut into small pieces
(prawn)

(6) Echinoderms (e.g., sea cucumber)

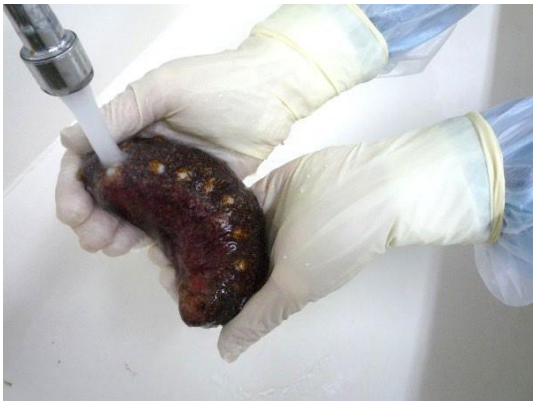
(a) If needed according to the condition of sampling, let the samples to expel sand or mud by immersing overnight in seawater collected near the sampling site. Record in a form whether sand was removed or not.

(b) Quickly wash with tap water to remove any foreign matter on the surface as early as possible.(Photograph 20.21)

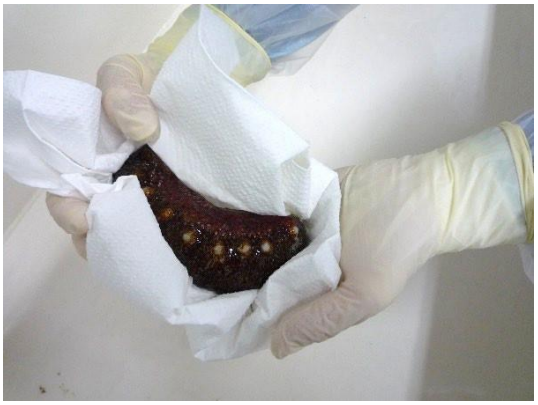
(c) Remove water using paper towels. (Photograph 20.22)

(d) If viscera, etc. are not presented for consumption, cut out the edible part only using a cutter,etc.[*13] (Photograph 20.23)

(e) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc. (Photograph 20.24)



Photograph 20.21
Washing with water(sea cucumber)



Photograph 20.22
Removing water(sea cucumber)

Photograph 20.23
Parts not presented for consumption removed(sea cucumber)

Photograph 20.24
Sample cut into small pieces (sea cucumber)

[*13]: Pay attention when separating muscles and viscera to contamination of other tissues by damagingviscera or loss due to release of body fluids.

20.3.3 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposable bags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker,and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 20.25)

(d) Lightly press and level the surface of the sample at the marked line. Then, measure theweight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag of Marinelli beaker using plastic tape.[*14]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 20.26)

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.[*15]

Photograph 20.25 Marinelli beaker filled with a sample (Caranginae)

Photograph 20.26 The lid fixed with plastic tape (Caranginae)

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, and measure and record the tare weight of the small container.

(c) While paying attention to the homogeneity of the sample, fill the small container with the sample without gaps using a laboratory spoon. (Photographs 20.27 to 20.32)

(d) Lightly press and level the surface of the sample.

(e) Place a cap on the small container, measure the height of the sample and record it.

(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

[*14]: A rubber band, cable tie, etc. may be used instead.

[*15]: If the samples were carried in frozen, return the samples and measurement containers to roomtemperature prior to measurement to prevent dew condensation during the measurement.

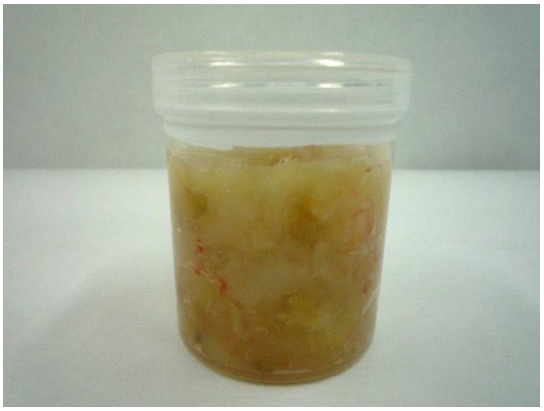
(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottomof the container), and present it as a sample for measurement. [*15]

Photograph 20.27
Small container filled with a sample
(*Spratelloides gracilis*)

Photograph 20.28
Small container filled with a sample
(Caranginae)

Photograph 20.29
Small container filled with a sample
(asari)

Photograph 20.30
Small container filled with a sample
(squid)



Photograph 20.31
Small container filled with a sample
(prawn)

Photograph 20.32
Small container filled with a sample(sea
cucumber)

20.4 Storage of samples

20.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into a polyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) In either case, store samples in a freezer.

20.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No.13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washing and cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Chapter 21 Indicator organisms (including pasture plants)

This chapter describes how to prepare and store indicator organisms as samples for measurement. Measurement containers used are Marinelli beakers or small containers. Table 21.1 shows examples of indicator organisms to be used as samples. Note that, if yomogi (*Artemisia princeps*), seaweeds and mussels are to be analyzed as food, the method described in Chapters 9, 15, and 20 shall be followed, respectively.

Table 21.1 Example indicator organisms

Category	Examples
Inland indicator organisms	Yomogi, pine needle, cedar leaf
Marine indicator organisms	Hondawara, kajime, arame, mussels
Pasture plants	Pasture plants

21.1 Equipment, tools, etc. to be needed

- Scintillation survey meter for gamma-rays (covered by a large plastic bag to prevent contamination of the surface)
- Marinelli beakers (capacity: 2 L) or small containers (capacity: about 100 mL)
- Cutter[*1], scissors, kitchen knife[*2] (preferably disposable type)
- Inner bags for Marinelli beaker
- Polyethylene bags for sealing measurement containers
- Laboratory spoon (preferably disposable type)
- Plastic tape
- Thread seal tape
- Paper towels
- Strainer, etc. (for draining water)
- Ethanol
- Pure water[*3]
- Lab coat (preferably disposable type)
- Disposable polyethylene or rubber gloves
- Arm covers
- Disposable masks
- Large filter (roughly 60 cm × 60 cm)
- Plastic sheet (plastic bag may be used instead)
- Paper plate (substitute for cutting board and tray)
- Ruler
- Electronic balances (shall be able to measure in grams, to the second decimal place; preferably with a recording function such as a printer)[*4] (With the operation panel, top plate, etc. coveredby wrap films, etc. to prevent contamination of the surface)

[*1]: Wash cutter blades with ethanol, etc. before use, because some cutter blades are coated with oil to prevent rusting. Disposable scalpels may be used instead.

[*2]: It is desirable to use disposable cutter blades to avoid cross-contamination, but a kitchen knife may have to be used to cut hard samples. Use cutting tools as appropriate with paying extra attention to safety.

[*3]: Confirm in advance the pure water is free of radioactive materials.

[*4]: Use balances that are properly controlled (e.g., periodically inspected and calibrated). Also, it is recommended to routinely inspect the balances by, for example, checking the condition using weights before and after use.

21.2 Precautions for carrying in samples

(a) When carrying in samples, make sure that all workers are wearing disposable gloves and lab coats to prevent exposure and contamination.

(b) Check the location and date of purchase or the location of production and date of collection, and assign identification numbers to the samples.

(c) Place a survey meter as close as possible to the samples and measure radiation levels to find samples with potentially high radioactivity. For inland indicator organisms, some marine indicator organisms such as hondawara, kajime (*Ecklonia cava*) and arame (*Eisenia bicyclis*), and pasture plants, the required amount of sample is 50 g or more (the volume will be 100 mL or more) for small containers and 1 kg or more (the volume will be 2 L or more) for Marinelli beakers. For other marine indicator organisms such as mussels, the required amount of sample is 100 g or more (the volume will be 100 mL or more) for small containers and 2 kg or more (the volume will be 2 L or more) for Marinelli beakers. Assume the dead time when measured using a germanium semiconductor detector based on the sample volume and radiation level, and adjust the sample volume so that the dead time can be about 10% or lower as much as possible, and select a measurement container sized for the sample volume.[*5] Selectsmall containers for measurement if the radiation levels from the samples are high .

(d) Ascertain the contamination situation of the sample from the result of measurement using the survey meter, and take measures accordingly. Measures include storing high radiation level samples that are separated from low radiation level samples, and controlling the time for workers to handle the samples to reduce exposure. The samples which are expected to have high radioactivity should be treated separately to prevent unnecessary exposure and cross contamination.

21.3 Sample preparation method

21.3.1 Matters to be noted in sample preparation

(a) To prevent cross-contamination, determine in advance the order of samples to be prepared, based on the results of survey meter measurements conducted when the samples were carried in.

(b) If the radiation level of sample is high, in order to minimize the time of handling the sample as much as possible, workers are to check and familiarize themselves with the work flow in advance.

(c) Before starting the work, cover the surfaces inside the room (e.g., floor, workbench) by the method described in Chapter 2.

(d) Place a plastic sheet on a covered workbench, further place large filters on top of it, and work on them separately for each sample.[*6]

(e) To prevent spreading of contamination from the sample, it is desirable to separate hot work through direct contact of the sample from cold work through indirect contact, and it is desirable to separate workers and workbenches between hot work and cold work to the extent possible.

(f) Once preparation is completed for one sample, wrap disposable instruments and tools

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[*5]: For the relationship between dose rates at the surface of sample measured using a survey meter and radioactivity concentration, refer to the Calibration of NaI (Tl) Scintillation Survey Meter Used for Measurement of Radioactive Cesium in Food in Emergencies (2nd Edition) issued by the Japan Radioisotope Association in 2011 (Reference 16), which provides data for each model.

[*6]: Replacing coverings of workbench and floor surfaces requires a considerable amount of labor. Using simplified disposable coverings for each sample will reduce the frequency of covering replacement.

with large filters and discard.[*7]

21.3.2 Sample washing and part selection

(1) Inland indicator organisms (e.g., yomogi, pine needles)

(a) Present those without withered leaves and foreign matter as a sample (remove withered leaves and any parts with foreign matter from the sample). Samples are not to be washed in principle. (Photograph 21.1)

(b) If the samples were provided with branches and stalks, pick off leaves only. (Photograph 21.2)

(c) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc. (Photographs 21.3 and 21.4)

Photograph 21.1
Withered leaves, foreign matters, etc. removed(pine needles)

Photograph 21.2
Removing branches and stalks (pine needles)

Photograph 21.3
Cutting sample into small pieces (pine needles)

Photograph 21.4
Sample cut into small pieces (pine needles)

[*7]: Discard disposable cutter blades, etc. separately.

(2) Marine indicator organisms (e.g., hondawara, kajime, arame)

(a) Drain well using a strainer, etc. Samples are not to be washed in principle. (Photograph 21.5)

(b) Remove the base part and any foreign matter.[*8] (Photograph 21.6)

(c) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc. (Photographs 21.7 and21.8)

Photograph 21.5
Draining water(hondawara)

Photograph 21.6
Removing the base part and foreign matter(hondawara)

Photograph 21.7
Parts to be presented as a sample selected (hondawara)

Photograph 21.8
Sample cut into small pieces (hondawara)

(3) Marine indicator organisms (e.g., mussels)

Shuck the samples to have only the meat part left. Do not wash the meat part with water.

(4) Pasture plants

(a) Brush off any excess soil at the root part in advance.

(b) Present those without withered leaves and foreign matter as a sample (remove withered leavesand any parts with foreign matter from the sample). Samples are not to be washed in principle.

(c) Cut the samples into small pieces (about 1-2 cm) using a cutter, etc.

[*8]: Seaweeds often have other flora and fauna attached on the body and small rock pieces at the base;carefully remove them.

21.3.3 Filling measurement container with sample

(1) In the case of using Marinelli beakers

(a) Place an inner bag for Marinelli beaker in a Marinelli beaker without any gaps. (Use disposablebags to prevent contamination of the wall of the measurement container.)

(b) Write or attach the necessary data (e.g., sample identification number) to the Marinelli beaker, and measure and record the tare weight of the Marinelli beaker, lid and inner bag.

(c) While paying attention to the homogeneity of the sample, place a sample into the Marinelli beaker up to the marked line without gaps. (Photograph 21.9)

(d) Lightly press and level the surface of the sample at the marked line. Then, measure the weight of the Marinelli beaker and lid along with the sample, derive the weight of the sample by subtracting the tare weight measured above, and record it.

(e) Seal the inner bag for Marinelli beaker using plastic tape.[*9]

(f) Place the lid on the Marinelli beaker, and seal with plastic tape. (Photograph 21.10)

(g) Thoroughly wipe the outer surface of the Marinelli beaker with a paper towel moistened with pure water, ethanol, etc.

(h) To prevent contamination of measurement equipment, place the Marinelli beaker in a polyethylene bag, remove air, tie the bag opening to seal it, and present it as a sample for measurement.

Photograph 21.9
Marinelli beaker filled with a sample (pine needles)

Photograph 21.10
The lid fixed with plastic tape(pine needles)

(2) In the case of using small containers

(a) To prevent leakage, wrap thread seal tape around the threaded part of small container.

(b) Write or attach the necessary data (e.g., sample identification number) to a small container, andmeasure and record the tare weight of the small container.

(c) While paying attention to the homogeneity of the sample, fill the small container with the sample without gaps using a laboratory spoon. (Photographs 21.11 and 21.12)

(d) Lightly press and level the surface of the sample.

(e) Place a cap on the small container, measure the height of the sample and record it.

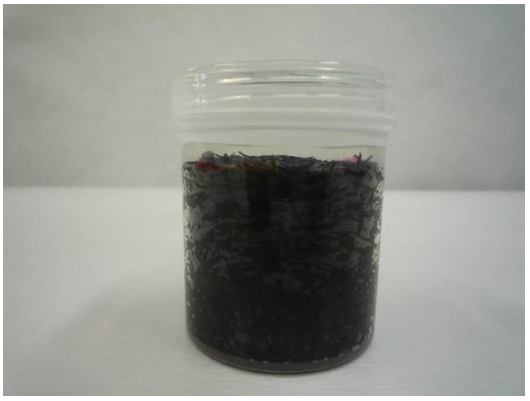
(f) Thoroughly wipe the outer surface of the container with a paper towel moistened with pure water, ethanol, etc.

(g) Measure the weight of the small container, derive the weight of the sample by subtracting the tare weight measured above, and record it.

[*9]: A rubber band, cable tie, etc. may be used instead.

(h) To prevent contamination of measurement equipment, place the small container in a polyethylene bag, remove air, tie the bag opening to seal it (ensure no creases at the bottom of the container), and present it as a sample for measurement.

Photograph 21.11
Small container filled with a sample
(pine needles)



Photograph 21.12
Small container filled with a sample
(hondawara)

21.4 Storage of samples

21.4.1 Storage for a relatively short period of time

(a) Samples prepared using Marinelli beakers: place sample-containing inner bags into apolyethylene bag or a container.

(b) Samples prepared using small containers: place sample-containing measurement containersinto a polyethylene bag or a container.

(c) Store measurement samples of inland indicator organisms and pasture plants in a refrigerator,freezer, or cool dark place to prevent decomposition.

(d) Store measurement samples of marine indicator organisms in a freezer.

21.4.2 Long-term storage

(a) Dry and ash samples by the methods provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). (Prevent contamination of other samples by, for example, washingand cleaning instruments, tools and equipment after use, if the radioactivity concentration of the sample is high.)

(b) Place ashed samples in a polyethylene bag or a container, and store in a low-humidity environment (e.g., inside a desiccator) or by taking measures to prevent contact with air as much as possible.

Explanation

Explanation A Calculation of quantifiable levels

Explanation A.1 Introduction

In this revision, quantifiable levels were calculated anew.

In the previous versions, quantifiable levels were calculated based on germanium semiconductor detectors with relative efficiency of 15%. However, in recent years, relative efficiency of commonly-used germanium semiconductor detectors has been improved to around 30%, and the quantifiable level calculation condition was changed accordingly. Also, in this version, ^{134}Cs was added to nuclides for which quantifiable levels are to be calculated, based on the results of monitoring conducted after the Fukushima Daiichi Nuclear Accident.

Explanation A.2 Calculation method

Spectra used for the calculation of quantifiable levels were obtained from environmental samples collected after the Fukushima Daiichi Nuclear Accident which were filled into a Marinelli beaker (2 L) or small container (100 mL: 50 mmφ × 50 mm) and measured using a germanium semiconductor detector with a relative efficiency of around 30%. Setting a spectrum with appropriate dead time as thereference, detection limits (^{131}I, ^{137}Cs and ^{134}Cs) derived for various measuring times and sample groups were specified as the quantifiable levels for the measuring time and sample group. The detection limits were calculated for various measuring times and sample groups, following the Radioactivity Measurement Series No. 7 Gamma-ray Spectrometry using Germanium Detector (Reference 8).

(1) In the case of using 2 L Marinelli beakers in an emergency

Setting a spectrum that was measured using a germanium semiconductor detector with a relative efficiency of around 30% and had the lowest possible dead time as the reference, limits of detection (^{131}I, ^{137}Cs, ^{134}Cs) derived for various measuring times and sample groups were specified as the quantifiable levels.

(a) The data obtained by measuring a fallout sample at the Fukushima Prefectural Center for Environmental Creation was used as the reference spectrum. The relative efficiency of detectorused in the measurement was 38%, and dead time was 54%. The measurement conditions are:
weight of measured sample (w_1), density (ρ), peak efficiency (ε_1), measuring time (t_1), detection limits (DL_1).

(b) Quantifiable levels were calculated for various measuring time.
$DL_i = DL_1/\sqrt{(t_i/t_1)}$
Measuring time (t_i): 10 minutes, 30 minutes, 1 hour, 10 hours

(c) For a selected sample group, the weight of measured sample (w_j) filled into a 2 L Marinelli beaker was calculated from the density (ρ_j).

(d) For the selected sample group, the peak efficiency (ε_j) when filled into a 2 L Marinelli beaker was calculated using on the software with changing the parameters, density (ρ_j) and weight of measured sample (w_j). The measurement conditions are:
weight of measured sample (w_j), density (ρ_j), peak efficiency (ε_j), measuring time (t_i), detection limit (DL_j).

(e) The quantifiable level was calculated for the selected sample group.
$DL_j = DL_i/\{(w_j/w_1) \times (\varepsilon_j/\varepsilon_1)\}$

Samples were divided into 5 groups, "Fallout and precipitation", "Drinking water and cow's milk", "Soil", "Vegetables" and "Meats, eggs, and seafood", referring to OIL6 in the Nuclear Emergency Guidelines and other relevant information.

(2) In the case of using small containers in an emergency

(a) The data obtained by measuring a soil sample at the Japan Chemical Analysis Center was used as the reference spectrum. The relative efficiency of detector used in the measurement was 31%, and dead time was 10%. The measurement conditions are:
weight of measured sample (w_1), density (ρ), peak efficiency (ε_1), measuring time (t_1), detection limit (DL_1).

(b) The weight of measured sample (w_2) filled into a small container to a height of 5 cm was calculated from the density.

(c) The peak efficiency (ε_2) when filled into a small container to a height of 5 cm was calculated using the software with changing the parameters, sample height and weight of measuredsample (w_2). The measurement conditions are:
weight of measured sample (w_2), density (ρ), peak efficiency (ε_2).

(d) Quantifiable levels were calculated by: $DL_2 = DL_1/\{(w_2/w_1) \times (\varepsilon_2/\varepsilon_1)\}$

(e) Quantifiable levels were calculated for various measuring time.
$DL_i = DL_2/\sqrt{(t_i/t_1)}$
Measuring time (t_i): 10 minutes, 30 minutes, 1 hour, 10 hours

(f) For a selected sample group, the weight of measured sample (w_j) when filled into a small container to a height of 5 cm was calculated from the density (ρ_j). In addition, the peak efficiency (ε_j) was calculated using the software, and the parameters, material and density (including weight of measured sample), were changed. The conditions are:
weight of measured sample (w_j), density (ρ_j), peak efficiency (ε_j), measuring time (t_i), detection limit (DL_j).

(g) The quantifiable level was calculated for the selected sample group.
$DL_j = DL_i/\{(w_j/w_2) \times (\varepsilon_j/\varepsilon_2)\}$
Samples were classified into 6 groups, "Atmosphere", "Fallout and precipitation", "Drinking water and cow's milk", "Soil", "Vegetables" and "Meats, eggs, and seafood", referring to OIL6in the Nuclear Emergency Guidelines and other relevant information.

For atmospheric samples, setting a spectrum of active carbon cartridge (sample volume: 140.044 m^3) that was measured using a germanium semiconductor detector with a relative efficiency of 27% and dead time of 3.3% as the reference, detection limits were calculated using the following formula through the software analysis assuming small containers filled with filters (sample volume: 1 m^3):
[Filter DL] = [Active carbon DL] / {(1/140.044) × ([Peak efficiency of filter]/[Peak efficiency of active carbon])}

From this formula, detection limits were calculated for selected sample volumes (1 m^3, 10 m^3, and 1000 m^3) and measuring time (10 minutes, 30 minutes, 1 hour, and 10 hours).

Explanation A.3 Calculation results

Tables 2.2 and 2.3 in Chapter 2 show the calculation results of quantifiable levels in the cases of using a Marinelli beaker (2 L) and small container. The calculation results are shown in one or two effective digits. For ^{134}Cs, calculation was conducted for 605 and 796 keV, and higher calculation results out of two peaks were adopted.[*1]

In the case of using a Marinelli beaker (2 L), the calculation results of quantifiable levels shown in this version were higher than the values shown in the previous version. In the calculation in this version, the measured spectrum of fallout sample was set as the reference and the measurement had dead time of 54%, indicating that the sample had many nuclides. This may have caused an increase inthe background of nuclides to be measured, affected by factors including Compton scattering, resulting in higher quantifiable levels.

In the case of using a small container, for an atmosphere sample, in both ^{131}I and ^{137}Cs, the calculation results of quantifiable levels shown in this version were lower than those shown in the previous version, for all measuring time from 10 minutes to 10 hours. This was caused by the difference in the relative efficiency of germanium semiconductor detectors, which previously was 15% while it is 27% for the calculation conducted in this version, and the higher relative efficiency resulted in lower quantifiable levels. For samples other than the atmosphere, the calculation results ofquantifiable levels shown in this version were equivalent to or higher than those shown in the previous version for all samples and measuring time. This was likely caused by the difference in the spectra used for calculation. In the calculation in this version, a measured spectrum of soil samplewas adopted. The measurement of the spectrum had dead time of 10%, indicating that the sample hadmany nuclides. Similar to the case of using a Marinelli beaker, it was likely caused by factors such asCompton scattering.

Explanation A.4 Matters to be noted

The calculation results of quantifiable levels in this version were derived by adopting and applying thespectra of environmental samples (atmosphere, fallout, and soil) collected after the Fukushima Daiichi Nuclear Accident to other samples. Additionally, the state of the sample may vary dependingon the situation of contamination, etc. in emergencies. Therefore, the results shown here shall be regarded as a guide.[*1] An analysis institution will be required to swiftly measure a large number of samples in an emergency. To be prepared to handle such a situation and operate measurement equipment efficiently, the institution needs to evaluate and summarize the relations between sample conditions, measuring time, and quantifiable levels in normal times. One also needs to be aware that actual measurement involves counting statistics-based uncertainty (counting error), and it is impractical to simply compare them with reference values. For that reason, if reference values have been specified for various purposes of emergency survey, analysis institutions are advised to check the reference values for each measurement of samples. Further, the calculation results of quantifiable levels do not take into account the time elapsed from sampling to measurement, and therefore they may be higher than the actual quantifiable levels if it takes time from sampling to measurement, due to decay of radioactive materials. Especially, attention needs to be paid to ^{131}I since its physical half-life is shorter than ^{134}Cs and ^{137}Cs.

[*1]: This method was adopted because, for ^{134}Cs, different analysis institutions use different peaks inanalysis.

[*1]: In normal times, quantifiable levels (limits of detection) are usually calculated based on a backgroundspectrum that does not contain artificial radionuclides.

Explanation A.5 Reference spectra used for calculation

The reference spectrum charts used for calculating quantifiable levels are shown below. (FiguresA.1 to A.3)

In these spectrum charts, 1 keV is converted to 2 channels, and the main peaks of ^{131}I, ^{134}Cs, and ^{137}Cs are indicated.

(1) 2 L Marinelli beaker

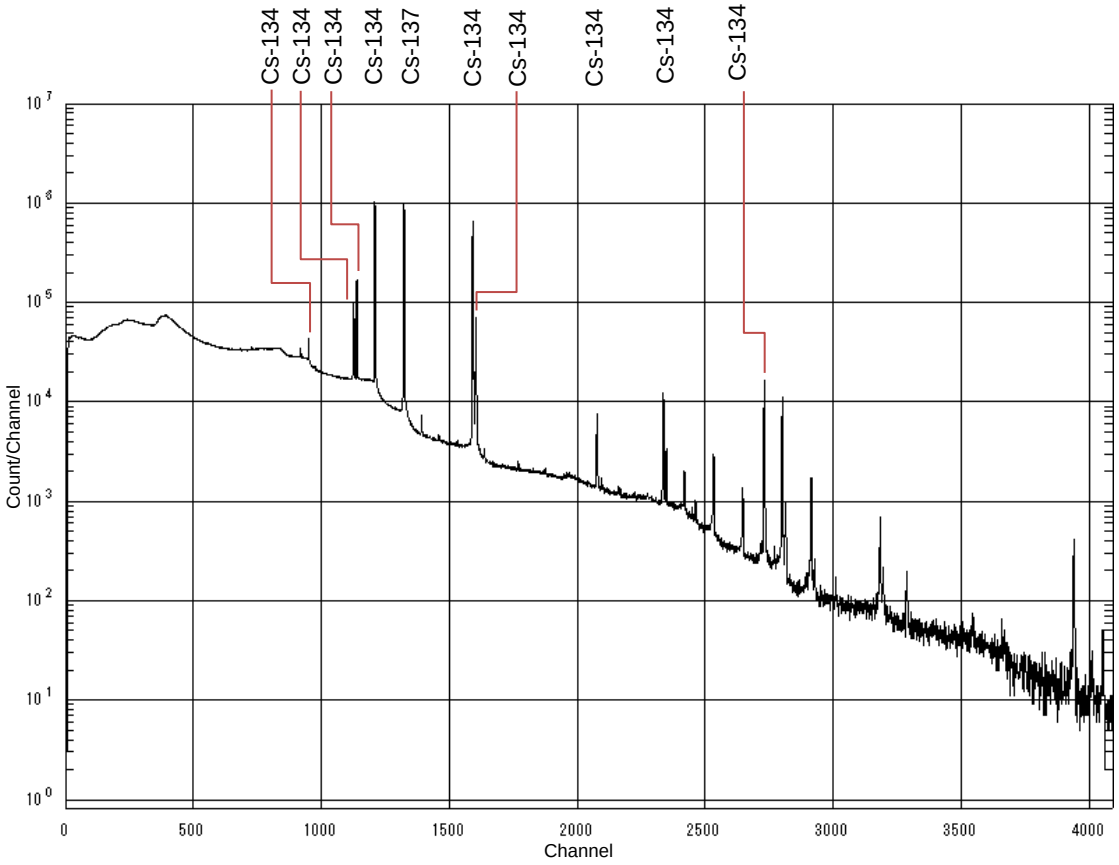


Figure A.1 Gamma-ray spectrum of fallout sample
(Sampling location: Fukushima Prefectural Center for Environmental Creation (Fukushima City, Fukushima Prefecture))

(2) Small container

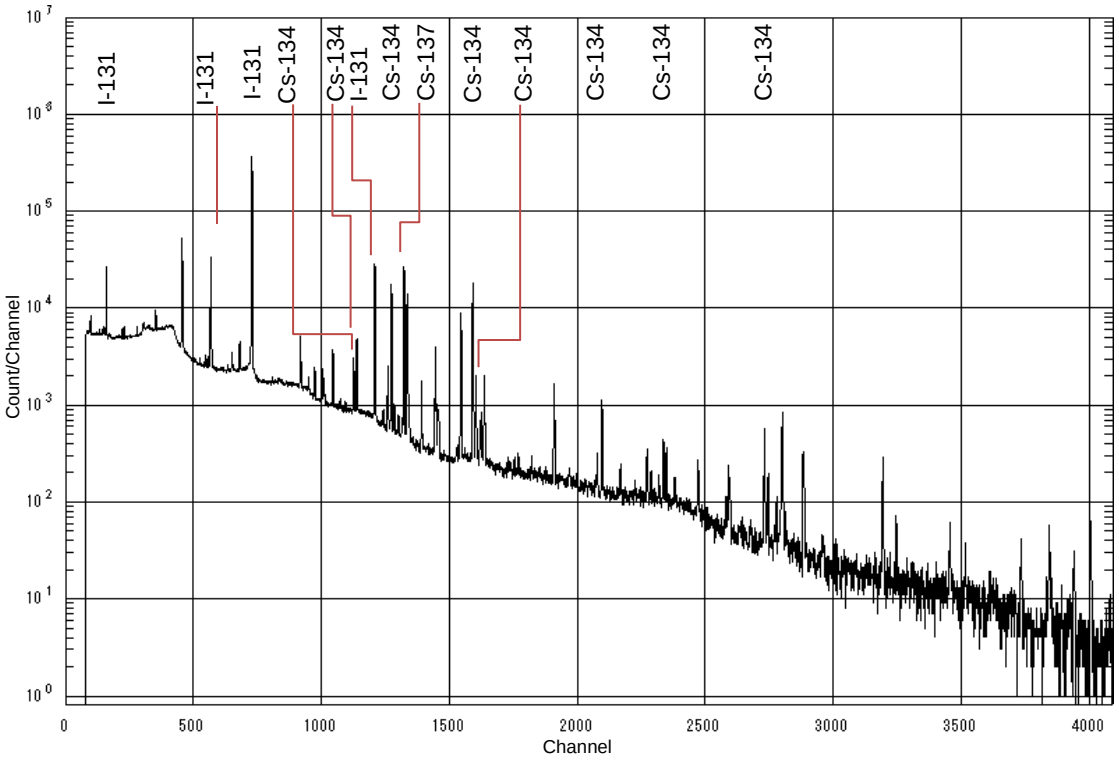


Figure A.2 Gamma-ray spectrum of soil sample
(Sampling location: Japan Chemical Analysis Center
(Chiba City, Chiba Prefecture))

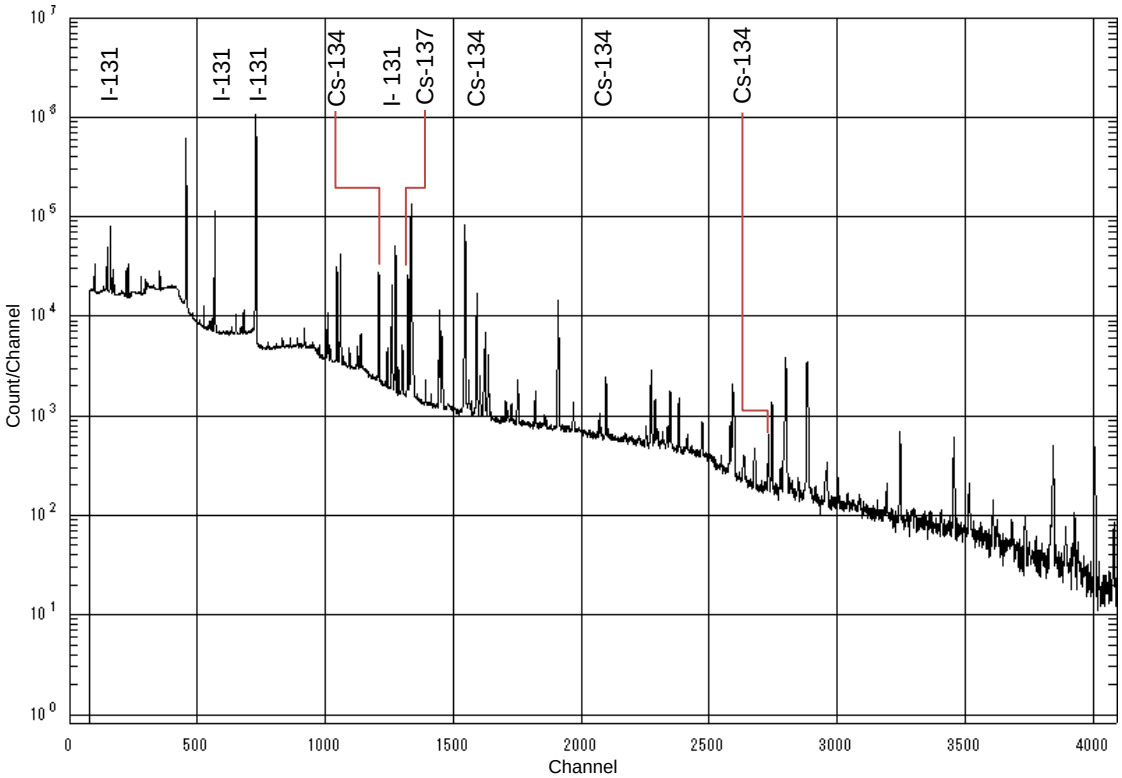


Figure A.3 Gamma-ray spectrum of atmosphere sample
(Sampling location: Japan Chemical Analysis Center
(Chiba City, Chiba Prefecture))

Explanation B Results of study on adsorption of radionuclides on measurement container wall

Explanation B.1 Purpose of study

The previous version of this document prescribed to add sodium chloride as a pretreatment method for fallout, precipitation, drinking water, and source water, in order to prevent adsorption of radionuclides on the wall of measurement containers such as Marinelli beakers. Taking the opportunityof this revision, for the fact that sodium chloride was added in a limited number of actual emergency cases and no data demonstrate its effect in preventing adsorption of radionuclides, a study was conducted to compare the state of adsorption of radionuclides with and without sodium chloride. In addition, based on the descriptions in the Manual for Measuring Radioactivity of Tap Water, etc., Ministry of Health, Labour and Welfare (2011) (Reference 17) and the U.S. Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)[*11] , an investigative experiment was conducted with the method below on the possibility of using sodium thiosulfate for radioactive iodine and nitric acid for radioactive cesium in place of sodium chloride.

Explanation B.2 Study method

(1) Target nuclides

Iodine-131, cesium-137

(2) Type of container

2 L Marinelli beaker (with polyvinyl chloride (PVC) inner bag)

(3) Method

(a) Four 2 L Marinelli beakers were placed on a laboratory bench, 2 L of tap water was poured into each, and the respective weight was measured.

(b) To three out of the four 2 L Marinelli beakers, 3 g of sodium chloride, 100 mg of sodium thiosulfate, or 1 mL of nitric acid (13 mol/L) per 1 L of sample was added. One beaker was left without adding anything as a contrast.

(c) An appropriate amount of an aqueous solution with known radioactivity concentrations of iodine-131 and cesium-137 was added to each of the 2 L Marinelli beakers. (Iodine-131: 11 Bq/L, cesium-137: 4.2 Bq/L)

(d) Measurement was performed for each 2 L Marinelli beakers using a germanium semiconductor detector at a specified measurement time, considering the time required for radionuclides to be adsorbed on containers and the decay of iodine-131 (half-life: 8.021 days). (Measurement time: 0, 1, 2, 5, 10, and 15 days after preparation)

(e) The effect of presence of additives was investigated by checking the transition in radioactivity concentration, assuming that geometric conditions between the detector and radiation source vary due to accumulation of radionuclides on the wall surface if the radionuclides adsorb onthe wall of measurement container.

(f) After 15 days after preparation, the content was taken out of the Marinelli beakers, and the inner bags of Marinelli beaker were washed using deionized water. The washed inner bags were measured to check whether the target nuclides present on the surface of the inner bags.

(g) The inside of the inner bags was washed with a nitric acid solution (6.5 mol/L) to desorb radionuclides adsorbed on the surface of the inner bags. The washed inner bags were placed in small containers (U-8 containers) and measured using a germanium semiconductor detector to investigate the difference in the state of adsorption on

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[*1]: Multi-Agency Radiological Laboratory Analytical Protocols Manual, NUREG-1576, EPA402-B-04-001B, NTIS PB2004-105421 (2004) (Reference20)

container depending on the additive.

Explanation B.3 Study results

Figure B.1 shows the transition in iodine-131 concentration for different additive. For the samples to which sodium chloride, nitric acid, or no additive was added, the measured iodine-131 concentrations transitioned slightly higher than the added radioactivity concentration (11 Bq/L). For the sample to which sodium thiosulfate was added, the measured iodine-131 concentrations were almost the same as the added radioactivity concentration, showing a trend different from the results for other samples. To confirm this trend for the sample to which sodium thiosulfate was added, another sample with additional sodium thiosulfate was prepared and measured in the same manner (measurement time: 0, 1, 4, 7, 12, and 15 days after preparation), and the results showed the same trend of exhibiting almost the same iodine-131 concentrations as the added radioactivity concentration. Figure B.2 shows the transition in iodine-131 concentration for different additives, expressed in the ratios to the measurement result on day 0. In all samples, the ratios transitioned within ±5%.

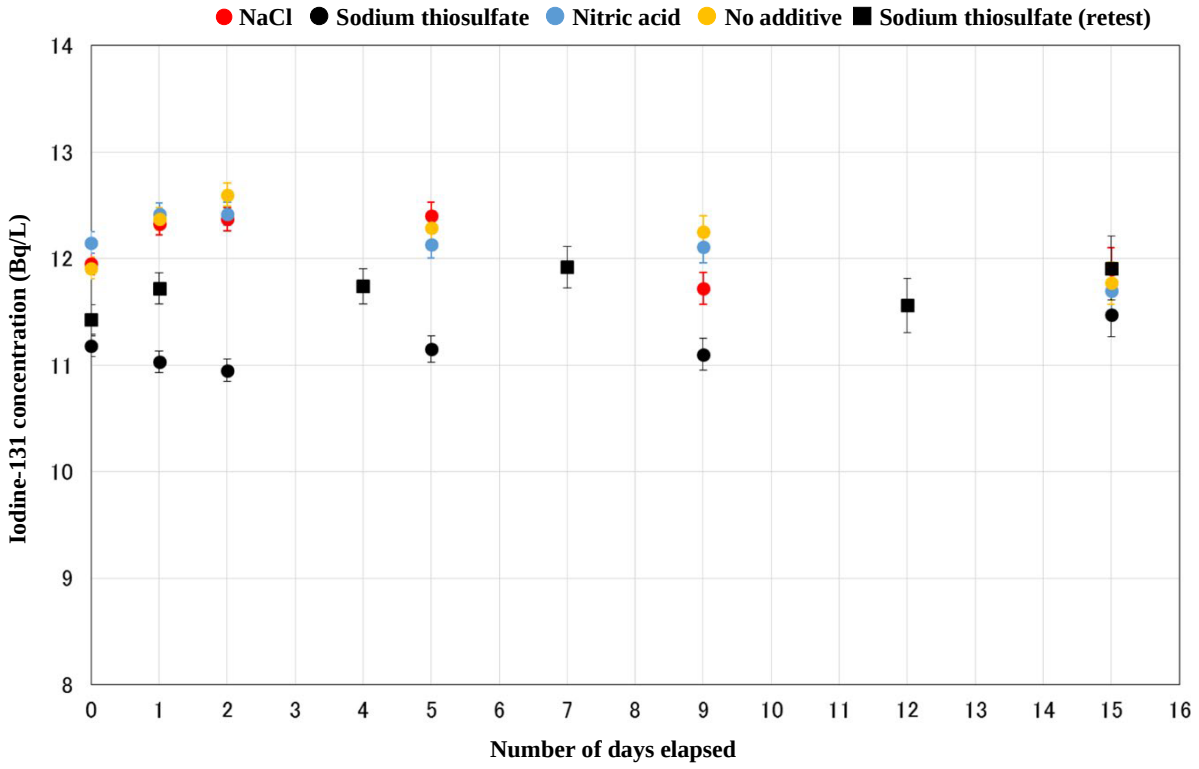


Figure B.1 Transition in iodine-131 concentration for different additives[*2]
(Iodine-131 addition amount: 11 Bq/L; the error bars show counting errors)

[*2]: The measurement for sodium thiosulfate (retest) was performed after the measurements for othersamples, and counting errors are larger than other samples due to decay.

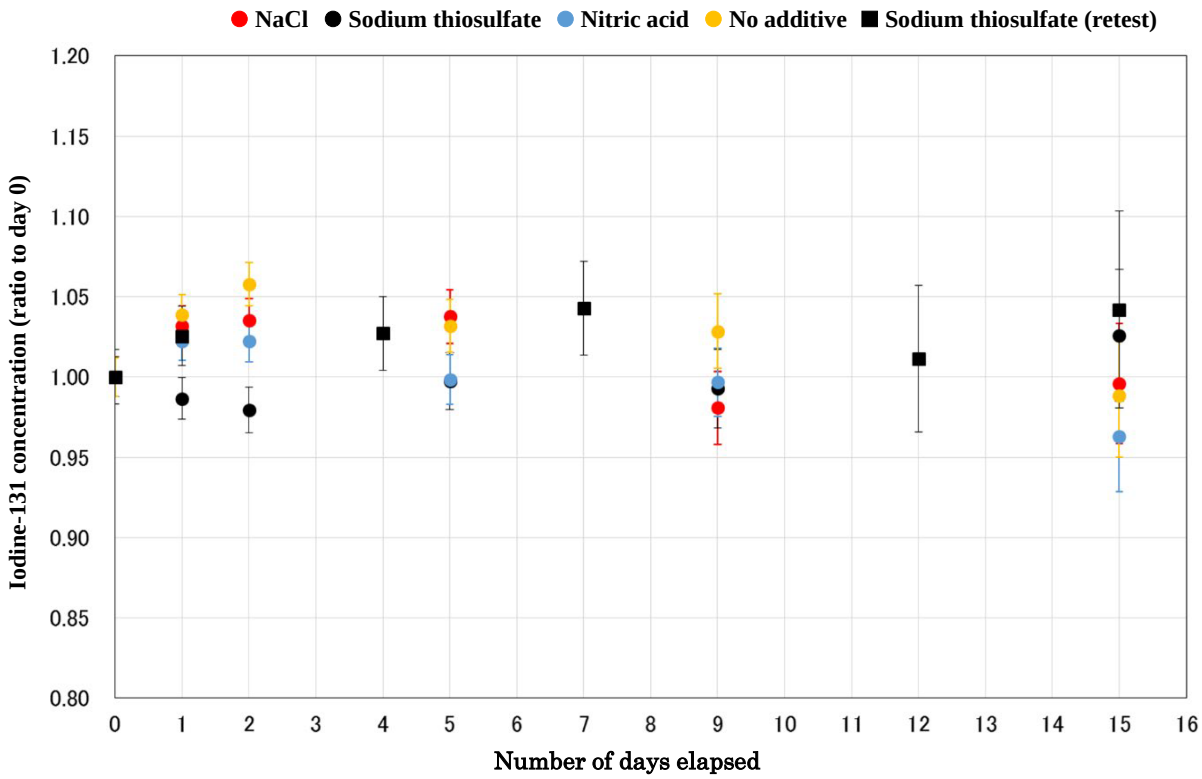


Figure B.2 Transition in iodine-131 concentration for different additives [*3]
(Normalized to the concentration on day 0)

Figure B.3 shows the transition in cesium-137 concentration for different additives. In all samples, the measured concentrations transitioned within ±5% of the added cesium-137 radioactivity concentration (4.2 Bq/L). Figure B.4 shows the transition in cesium-137 concentration for different additives, expressed in the ratios to the measurement result on day 0. In all samples, the ratios transitioned within ±5%.

[*3]: The measurement for sodium thiosulfate (retest) was performed after the measurements for othersamples, and counting errors are larger than other samples due to decay.

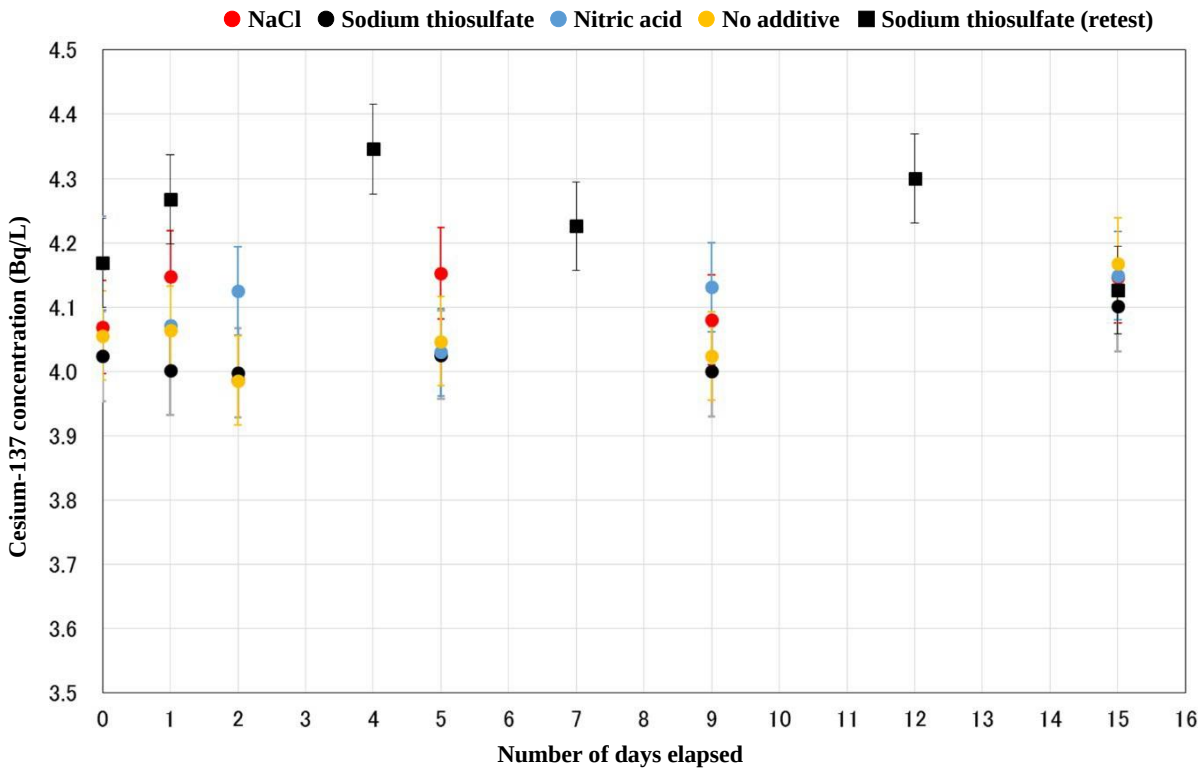


Figure B.3 Transition in cesium-137 concentration for different additives
(Cesium-137 addition amount: 4.2 Bq/L; the error bars show counting errors)

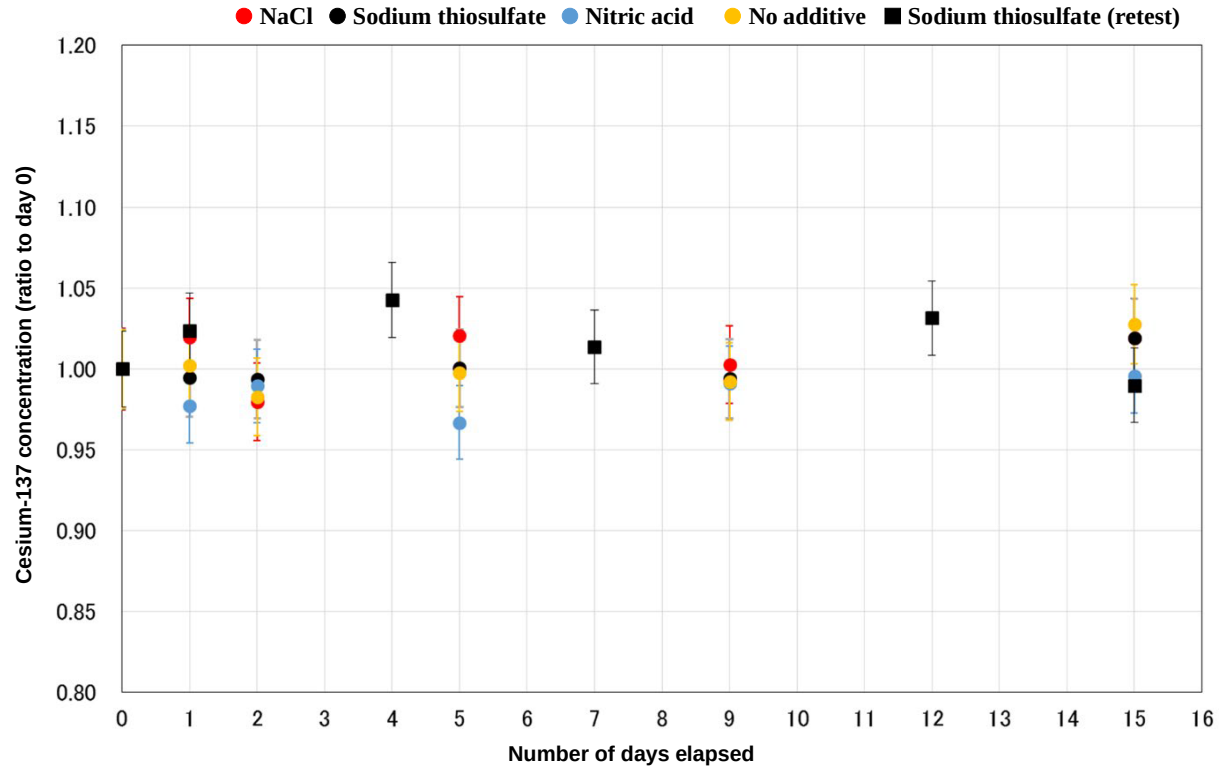


Figure B.4 Transition in cesium-137 concentration for different additives
(Normalized to the concentration on day 0)

Figures B.5 and B.6 show the spectra of PVC inner bags washed by ion-exchange water which were measured using a germanium semiconductor detector. When sodium chloride was added, as shown inFigure B.5, iodine-131 was detected while cesium-137 was not detected, indicating that iodine-131 adsorbed on the inner bag. Similar results were obtained for the samples with nitric acid added and no additives. Meanwhile, when sodium thiosulfate was added, as shown in Figure B.6, both iodine-131 and cesium-137 were not detected, indicating no adsorption on the inner bag. Table B.1 summarizes the difference in the state of adsorption depending on the additive. In this table, the ratio of adsorption on PVC inner bag shown in parentheses was estimated by the computational simulation for the state of adsorption described in Explanation B.5. When sodium chloride was not added, about 50% of iodine-131 was considered to have been adsorbed on the inner bag, indicating that addition of sodium thiosulfate is effective in preventing adsorption of iodine-131.

Additionally, when the iodine-131 adsorbing PVC inner bags in Marinelli beaker were washed with a nitric acid solution, iodine-131 and cesium-137 were not detected from the wash-solution. Further, iodine-131 was detected when measurement was performed for the acid-washed inner bags, indicating that iodine-131 was strongly adsorbed in the PVC inner bags.

Based on these results, using tap water with sodium thiosulfate added to which certain amounts of iodine-131 and cesium-137 were added, an additional experiment was performed on a Marinelli beaker and U-8 container with polyethylene inner bags, to investigate adsorption of radionuclides. When the containers were measured using a germanium semiconductor detector 5 days after placing the sample solution, the measurement results were almost the same as the addition amount for both containers. Additionally, when the content was taken out of the containers, and the polyethylene innerbags and small container were washed with ion-exchange water and measured using a germanium semiconductor detector, iodine-131 and cesium-137 were not detected. These results also demonstrated that addition of sodium thiosulfate is effective in preventing adsorption of iodine-131.

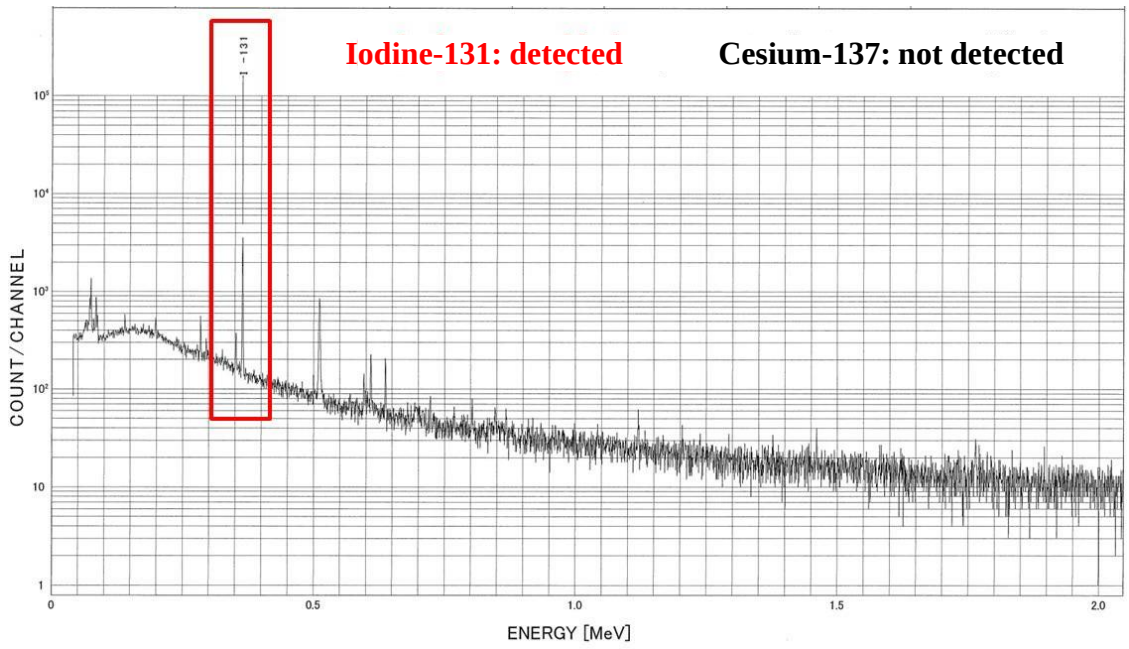


Figure B.5 Measured spectrum of inner bag for Marinelli beaker
(sample to which sodium chloride was added)

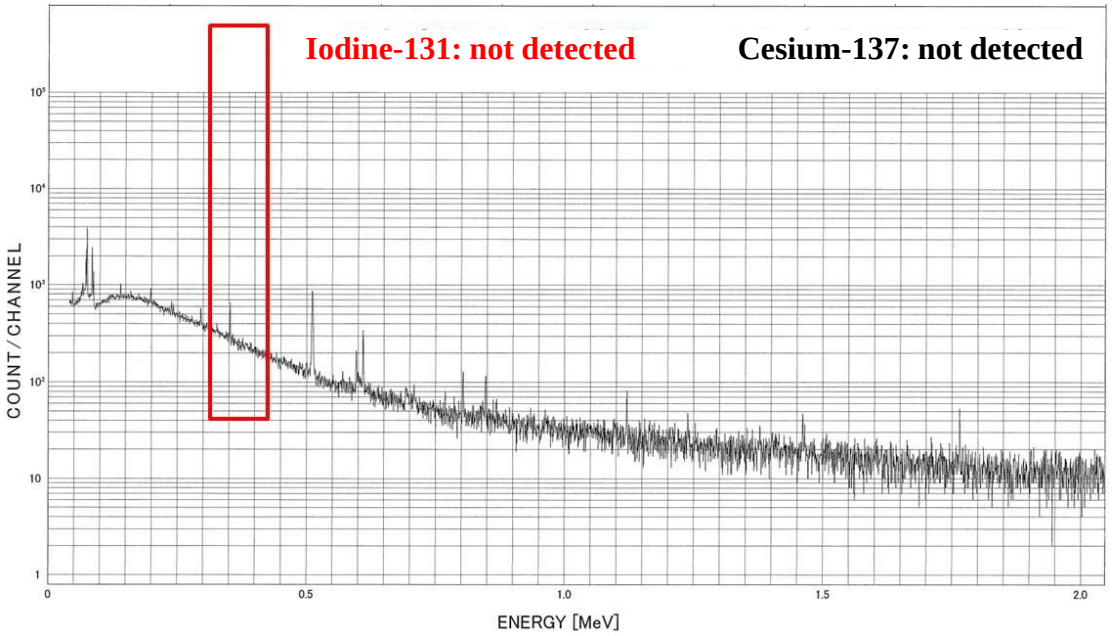


Figure B.6 Measured spectrum of inner bag for Marinelli beaker(sample to which sodium thiosulfate was added)

Table B.1 Difference in the state of adsorption depending on additive

Additive	Sodium chloride	Sodium thiosulfate	Nitric acid	None
Iodine-131	Adsorbed (49%)*1	No adsorption	Adsorbed (52%)*1	Adsorbed (53%) *1
Cesium-137	No adsorption	No adsorption	No adsorption	No adsorption

*1 Values in parentheses are ratios of absorption on PVC inner bag estimated from the results of computational simulation for the state of adsorption described in Explanation B.5.

Explanation B.4 Evaluation of peak counting efficiency by computational simulation

(1) Conditions of computational simulation

Peak counting efficiency of germanium semiconductor detectors was evaluated through computational simulation for two cases; when iodine-131 and cesium-137 are evenly distributed in a water sample (2 L Marinelli beaker, U-8 container), and when iodine-131 and cesium-137 are adsorbed onto container or inner bag. Figure B.7 shows the geometry of computational simulation. Computational simulation has been conducted and relevant diagrams were provided through the courtesy of Mr. Jun Saegusa of Japan Atomic Energy Agency.

・Code used: MCNP-6.1
・Detector, sample (radiation source), etc. are 3-dimensionally simulated,and peak counting efficiency is compared

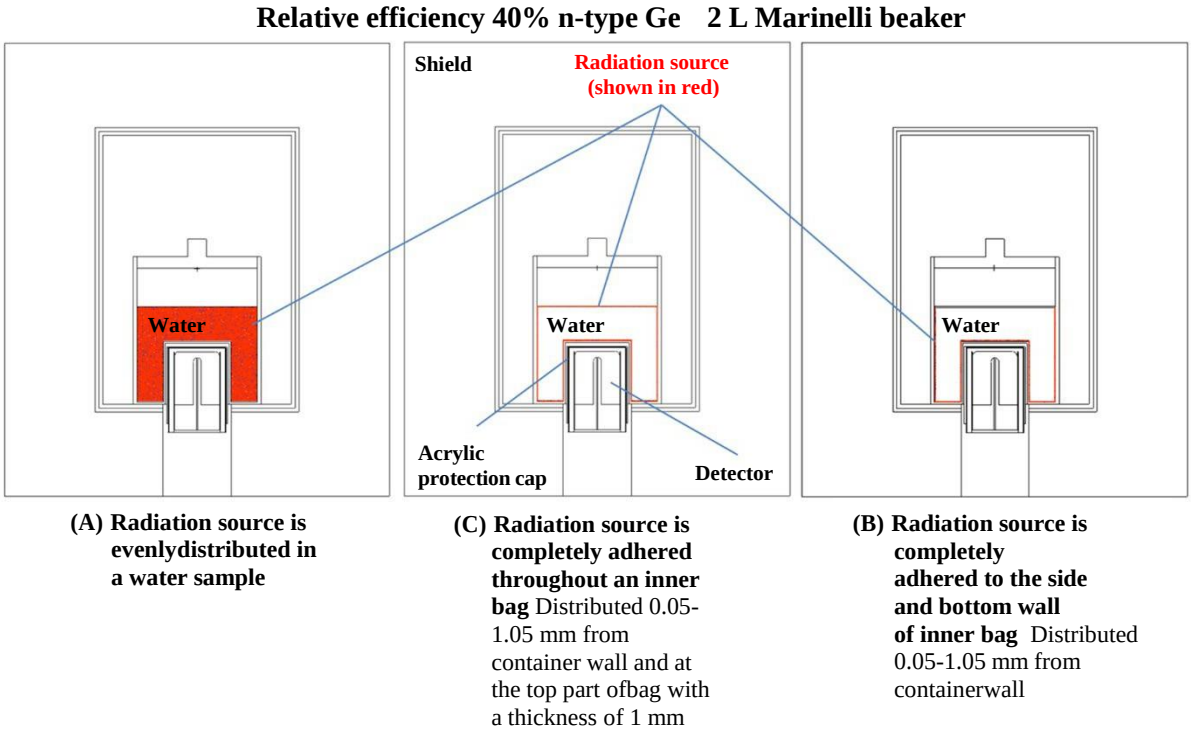


Figure B.7 Setup of computational simulation

(2) Results of computational simulation

Table B.2 summarizes the results of computational simulation conducted under the conditions shown in (1). Calculation was conducted for two types of Marinelli beaker inner bag materials: polyvinyl chloride (PVC) and polyethylene (PE). Compared with Setup (A) where the radiation source was evenly distributed in a water sample, in Setup (B) where the radiation source was completely adhered throughout an inner bag, peak counting efficiency of iodine-131 and cesium-137 was higher by approximately 7% and 6%, respectively. In addition, compared with Setup (A), in Setup (C) where the radiation source was completely adhered to the side and bottom wall of inner bag, peak counting efficiency of iodine-131 and cesium-137 was higher by approximately 21% and 19%, respectively. No significant difference in peak counting efficiency was observed between the inner bag materials, as shown in Table B.2.

Table B.3 summarizes the results of computational simulation conducted under similar radiation source distribution conditions using a p-type germanium semiconductor detector (relatie efficiency: 25%) that was used in the a forementioned investigative experiment. The inner bag material selected was polyvinyl chloride that was mainly used in the investigative experiment. Compared with Setup (A), in Setup (B), peak counting efficiency of iodine-131 and cesium-137 was higher by 3.1% and 0.38%, respectively. In addition, compared with Setup (A), in Setup (C), peak counting efficiency of iodine-131 and cesium-137 was higher by 17% and 12%, respectively.

Table B.2 Results of simulation of peak counting efficiency for each setup (In the case of relative efficiency 40% n-type Ge and 2 L Marinelli beaker)

Nuclide (Energy)	Evenly distributed in water (A)	All adhered to inner bag (including top part) (B)		All adhered to inner bag (excluding top part) (C)	$\frac{(B)-(A)}{(A)}$	$\frac{(C)-(A)}{(A)}$
I-131 (365 keV)	2.20×10^{-2}	PVC	2.35×10^{-2}	2.67×10^{-2}	+6.8%	+21%
		PE	2.35×10^{-2}	2.67×10^{-2}	+6.9%	+21%
Cs-137 (662 keV)	1.45×10^{-2}	PVC	1.53×10^{-2}	1.73×10^{-2}	+5.8%	+19%
		PE	1.53×10^{-2}	1.73×10^{-2}	+5.8%	+19%

Table B.3 Results of simulation of peak counting efficiency for each setup (In the case of the same conditions as investigative experiment, relative efficiency 25% p-type Ge and 2 L Marinelli beaker)

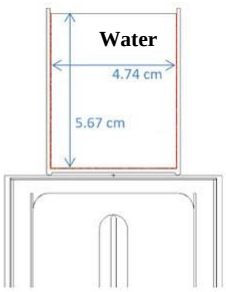
Nuclide (Energy)	Evenly distributed in water (A)	Adhered to inner bag (including top part) (B)		Adhered to inner bag (excluding top part) (C)	$\frac{(B)-(A)}{(A)}$	$\frac{(C)-(A)}{(A)}$
I-131 (365 keV)	1.56×10^{-2} (1.17×10^{-2})	PVC	1.61×10^{-2}	1.82×10^{-2}	+3.1%	+17%
Cs-137 (662 keV)	1.02×10^{-2} (7.54×10^{-3})	PVC	1.02×10^{-2}	1.14×10^{-2}	+0.38%	+12%

Values in parentheses are the actual measurement values obtained in the investigative experiment.

Also, computational simulation of peak counting efficiency was conducted for U-8 containers, for Setup (A) where the radiation source is evenly distributed in a water sample and Setup (C) where the radiation source is completely adhered to the wall and bottom of container. Figure B.8 shows the setup of computational simulation, and Table B.4 summarizes the results of computational simulation. Compared with Setup (A), in Setup (C), peak counting efficiency of iodine-131 and cesium-137 was higher by 23% and 24%, respectively.

Relative efficiency 40% n-type Ge, U-8 container

(A) Radiation source is evenly distributed in a water sample



(C) Radiation source is completely adhered to the wall and bottom of container

Figure B.8 Geometry of computational simulation

Table B.4 Results of simulation of peak counting efficiency for each setup
(In the case of relative efficiency 40% n-type Ge and U-8 container container)

Nuclide (Energy)	Evenly distributed in water (A)	Adhered to wall and bottom of container (C)	$\frac{(C)-(A)}{(A)}$
I-131 (365 keV)	3.23×10^{-2}	3.99×10^{-2}	+23%
Cs-137 (662 keV)	2.03×10^{-2}	2.52×10^{-2}	+24%

(3) Summary of computational simulation results

Peak counting efficiency, y, with a ratio of transition of radiation source to Marinelli beaker innerbag (deposition rate), p, is expressed by the following formula:

$$y = (1-p)\,a + p \times b,$$

where a and b are peak counting efficiency in the case of radiation source being evenly distributed in a water sample and in the case of radiation source being fully deposited onto an inner bag, respectively. Figure B.9 shows this equation plotted with applying the results of computational simulation for Setup (A) and Setup (C) in Table B.3 that correspond to the same conditions as the a forementioned investigative experiment. Figure B.9 indicates that, under these conditions, iodine-131concentration is overestimated by 8.5% when deposition ratio to inner bag is 50% (p = 0.5) and by approximately 17% when radiation source is fully deposited to an inner bag (p = 1). Note that separate evaluation is required for other sample shapes, special detector, or different deposit distribution.

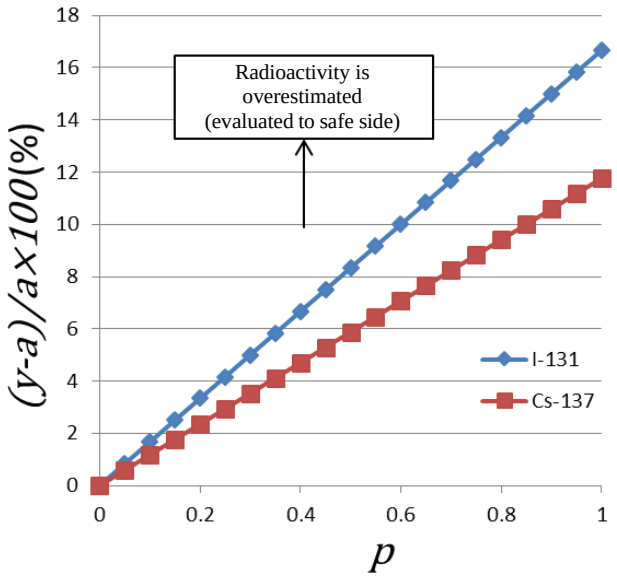


Figure B.9 Chart between transition ratio, p, and efficiency increase ratio
(Relative efficiency 25% p-type Ge, 2 L Marinelli beaker, excluding the top part of inner bag)

Explanation B.5 Summary of study results

The state of adsorption was investigated for iodine-131 and cesium-137 using polyvinyl chloride inner bag in 2 L Marinelli beaker. As additional experiment, the state of adsorption was investigated for polyethylene inner bag and polypropylene small container (U-8 container). Regarding iodine-131, when sodium thiosulfate was used as an additive, the experimental results indicated no adsorption on polyvinyl chloride. When sodium chloride, nitric acid, or no additive was added, on the other hand, the experimental results indicated adsorption on polyvinyl chloride inner bag. As for cesium-137, regardless of the type of additive, the experimental results indicated no adsorption into polyvinyl chloride inner bag, polyethylene inner bag, or polypropylene small container. From the results of computational simulation on the state of adsorption, it was estimated that approximately 50% of iodine-131 adsorbed in polyvinyl chloride inner bag when sodium thiosulfate was not added, indicating that addition of sodium thiosulfate is effective in preventing adsorption of iodine-131.

Based on these findings, for fallout and precipitation samples in Chapter 5 and drinking water and inland water samples in Chapter 6, it was decided to add sodium thiosulfate in order to prevent adsorption of iodine-131 into the wall of measurement containers. The addition amount is to be the same as those prescribed in the Manual for Measuring Radioactivity of Tap Water, etc. (Reference 17). The timing of addition is to be when filling a sample into a measurement container, similar to thecurrent pretreatment method. If sodium thiosulfate-added samples are to be stored for a relatively short period of time, they are to be stored in a state of being placed in measurement containers. Since sodium thiosulfate has already been added, no new additive is to be added. If sodium thiosulfate-added samples are to be stored for a long period of time, acid is to be added to them to prevent adsorption of radioactive cesium. The method of addition shall conform to the methods provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4). For seawater and cow’s milk samples, the Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4) shall be followed.

Appendix

Appendix 1 Equipment, tools, reagents, etc. to be made available and ready for use at all times

Name of equipment, tool, reagent	Description
Scintillation survey meter for gamma-rays	To be used for checking radiation levels of samples on acceptanceor carry-in, before starting preparation of samples for measurement, for the purpose of preventing cross-contamination of samples, preventing exposure of workers, and determining sample volume. Whether they arefunctioning properly shall be periodically checked in accordance with the user's manual.
Marinelli beaker	Plastic cylindrical measurement container, which enables sealing in a relatively large quantity of sample. Radioactivity Measurement Series No. 7 Gamma-ray Spectrometry using Germanium Detector (Reference 8) provides details about 2 L and 700 mL Marinelli beakers.Recently, 1 L Marinelli beakers have also become commercially available.
Inner bag for Marinelli beaker	Polyethylene or polyvinyl chloride bag that is used to seal a sample inside to prevent contamination of the inner wall of Marinelli beaker. Samples may be stored sealed in inner bagsafter measurement.
Small container	Cylindrical measurement container, usually with a capacity ofabout 100 mL. Polypropylene or polystyrene products called U-8 containers are widely used. Radioactivity Measurement Series No. 7 Gamma-ray Spectrometry using Germanium Detector (Reference 8)provides details about several types of small containers.
Polyethylene bag	To be used to cover measurement containers to prevent contamination of measurement equipment. They are also usedfor many other purposes. Several types of polyethylene bags shall be made available to suit the given situation and purposeof use.
Cutter, scissors, kitchen knife, etc.	To be used for cutting vegetables, fruit, tea leaves, peas and beans,seaweeds, meats, dairy products, seafood, etc. into small pieces. The right tool shall be selected depending on the size andshape of the sample.
Laboratory spoon	To be used for filling sample into measurement container andtreatment of soil samples. Those with a length of around 20 cm are suitable.
Piston pipette	To be used for portioning, volume adjustment, etc. of liquidsamples. It is preferable to have products with a volume of 1-10 mL tobe used according to the purpose.

Gloves (rubber or polyethylene)	Worn to prevent cross-contamination of samples and exposureof workers. Disposable general-purpose gloves are often used.
Paper towel	Disposable product commonly used in chemical experimentfor the purpose of decontamination and prevention of spreading of contamination.
Container (e.g., beaker, mixing bowl)	To be used for mixing eggs.
Refrigerator, freezer	To be used for storing samples that are prone to decomposition.Samples are stored either in a refrigerator or freezer depending on the nature of the sample.
Graduated cylinder	To be used for measuring the volume of sample. They may also beused for checking the capacity of Marinelli beakers.
Ethanol	To be used to decontaminate measurement containers, etc. by wiping them with paper towels moistened with ethanol. Applying ethanol to acrylic equipment or tool may cause it tocrack due to swelling.
Sodium thiosulfate	Added to fallout, precipitation, drinking water, and inland water samples for the purpose of preventing radioactive iodinefrom adsorbing on measurement container.
Hydrochloric acid or nitric acid	Added to fallout, precipitation, drinking water, inland water, and seawater samples for the purpose of preventing nuclides from adsorbing on measurement container, when the sample isto be stored for a long period of time.

Appendix 2 Marinelli beaker and inner bag for Marinelli beaker

Photograph 2.1 and Figure 2.1 show a Marinelli beaker. Photographs 2.2 and 2.3 show an inner bag for Marinelli beaker.

In the method provided in this document, in principle, samples are to be sealed in a polyethylene inner bag for Marinelli beaker to be presented for measurement. As shown in Photographs 2.4 to 2.6, an inner bag for Marinelli beaker shall fit perfectly into the Marinelli beaker without any gaps. Inner bags shall also be adequately strong not to cause spreading of contamination due to breaking, etc.

Photograph 2.1
2 L Marinelli beaker

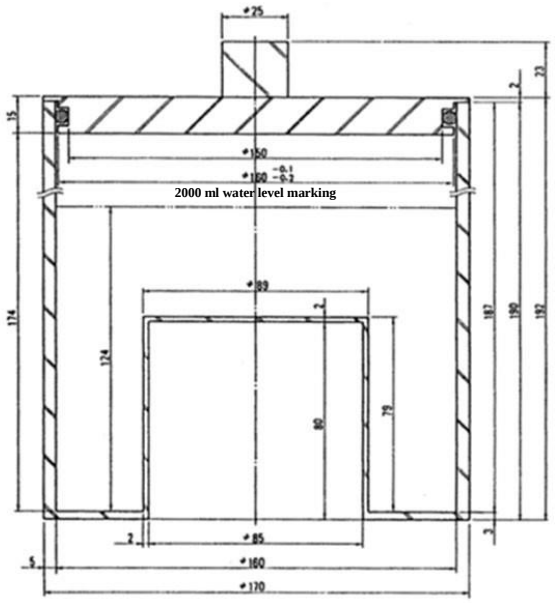
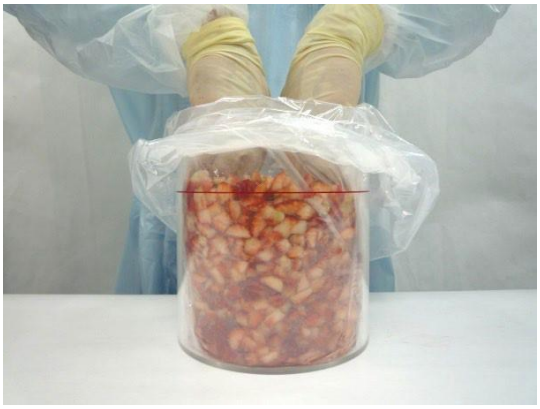


Figure 2.1
2 L Marinelli beaker

Photograph 2.2
Inner bag for 2 L Marinelli beaker

Photograph 2.3
Inner bag for 2 L Marinelli beaker inserted in 2L Marinelli beaker

Photograph 2.4
Polyethylene inner bag for Marinelli beaker
with a sample inside
(strawberry)



Photograph 2.5
Filling an inner bag-installed Marinelli
beakerwith a sample
(strawberry)

Photograph 2.6
2 L Marinelli beaker filled
with a sample
(strawberry)

Appendix 3 Small container

Photograph 3.1 and Figure 3.1 show small containers.
Photographs 3.2 and 3.3 show a small container filled with a sample.

Photograph 3.1
Small container (U-8)

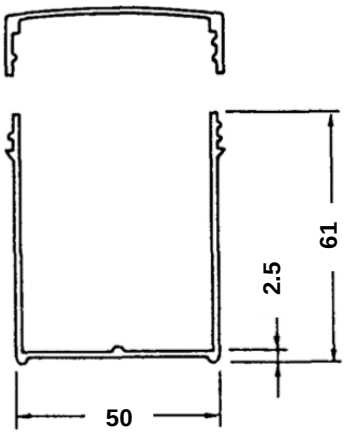


Figure 3.1
Small container

Photograph 3.2
Filling a small container with a sample(strawberry)

Photograph 3.3
Small container filled with a sample(strawberry)

Information

Information 1 Concept of implementation items and content of emergency monitoring

The basic concept of implementation items and content of emergency monitoring is provided in the Nuclear Emergency Preparedness and Response Guidelines, NRA (2018) (Reference 1) and "Emergency Monitoring" (supplementary reference material of the Nuclear Emergency Preparedness and Response Guidelines), Radiation Monitoring Division, Radiation Protection Department, NRA (2017) (Reference 2). Analysis and measurement of environmental samples are conducted based on the concept.

Information 1.1 Chart with food and drink intake restrictions

Concentration of radionuclides in food and drinks is to be measured and analyzed within about 1 week of occurrence of a nuclear emergency, and intake restrictions are to be swiftly implemented if the concentration exceeds OIL6, the operational intervention level of food and drink intake restrictions.[*1]

Analysis and measurement conditions such as analysis sample volume, sample pretreatment method, and measuring time need to be determined, taking into account the OIL6 and quantifiable levels[*2]. Tables 1.1 and 1.2 show a comparison between quantifiable levels and OIL6. Values shown in the tables are calculated based on the spectra presented in Explanation A. Note that quantifiable levels are summed up for ^{134}Cs and ^{137}Cs because OIL6 for radioactive cesium is applied as a sum of ^{134}Cs and ^{137}Cs.

Table 1.1 Comparison between quantifiable levels and OIL6 (drinking water, cow's milk)

Name of sample	Measurement container	^{131}I quantifiable level				^{134}Cs + ^{137}Cs quantifiable level(sum)				Unit
		10 min	30 min	1 h	10 h	10 min	30 min	1 h	10 h	
Drinking water Cow'smilk	Marinelli beaker (2 L)	110	70	50	20	190	120	90	40	Bq/kg
	Small container	350	200	150	50	590	350	250	80	
OIL6 value		300				200				Bq/kg

Shaded cell: Quantifiable level exceeding OIL6 value

Table 1.1 indicates that, when drinking water or cow's milk is measured using Marinelli beakers (2L) as measurement containers for determining the necessity of implementing intake restrictions, a measuring time of 10 minutes is enough for both radioactive iodine and radioactive cesium. Meanwhile, if small containers are used as measurement containers, a measuring time of 30 minutes and about 10 hours is required for radioactive iodine and radioactive cesium, respectively.

From the above, for liquid samples such as drinking water and cow's milk, because they do not require any specific pretreatment (e.g., cutting into small pieces), if sample volume is sufficiently available, it is anticipated that using Marinelli beakers allows measuring a large number of samples in a short period of time, compared with biological samples such as vegetables.

[*1]: See Table 2.1 in Chapter 2.

[*2]: See Tables 2.2 and 2.3 in Chapter 2.

Table 1.2 Comparison between quantifiable levels and OIL6 (vegetables, seafood, etc.)

Name of sample	Measurement container	^{131}I quantifiable level				^{134}Cs + ^{137}Cs quantifiable level (sum)				Unit
		10 min	30 min	1 h	10 h	10 min	30 min	1 h	10 h	
Vegetables	Marinelli beaker (2 L)	200	120	80	30	350	210	150	60	Bq/kg
	Small container	610	350	250	80	1050	610	440	140	Bq/kg
Meats Eggs Seafood	Marinelli beaker (2 L)	120	70	50	20	210	120	90	40	Bq/kg
	Small container	360	210	150	50	610	350	250	80	Bq/kg
OIL6 value		2,000				500				Bq/kg

Shaded cell: Quantifiable level exceeding OIL6 value

Table 1.2 indicates that, when biological samples such as vegetables, meats and seafood are measured using Marinelli beakers (2 L) as measurement containers for determining the necessity of implementing intake restrictions, a measuring time of 10 minutes is enough for both radioactive iodine and radioactive cesium. Meanwhile, if small containers are used as measurement containers, a measuring time of 10 minutes is required for radioactive iodine, and for radioactive cesium, a measuring time of about 1 hour is required for vegetables and about 30 minutes for meats, seafood, etc.

These samples require pretreatment (e.g., cutting into small pieces), and pretreatment to fill a Marinelli beaker (2 L) is more time consuming than filling a small container. Therefore, considering the time required for pretreatment and measurement, this table suggests that analysis and measurement would be more efficient when small containers are used as measurement containers.

Information 1.2 Chart with evaluation of internal exposure doses

Evaluation of internal exposure doses in emergency monitoring is mentioned in the "Emergency Monitoring" (supplementary reference material of the Nuclear Emergency Preparedness and Response Guidelines), Radiation Monitoring Division, Radiation Protection Department, NRA (2017) (Reference 2). Reference 2 states that concentration of radioactive materials in environmental samples needs to be determined as part of monitoring for providing information to evaluate the effects of radiation on local residents and the environment. In so doing, according to Reference 2, it is important to measure the concentration of nuclides such as ^{134}Cs and ^{137}Cs, based on the lesson learned from the Fukushima Daiichi Nuclear Accident, in addition to the nuclides whose radiation doses in public are to be evaluated in case of an accident under safety review of nuclear facilities.

Evaluation of internal exposure doses is also discussed in the "Normal Time Monitoring" (supplementary reference material of the Nuclear Emergency Preparedness and Response Guidelines),Radiation Monitoring Division, Radiation Protection Department, NRA (2018) (Reference 9), which outlines views about evaluation methods of committed effective dose due to internal exposure. Although data of radioactive material concentration analysis used in emergency monitoring is handled differently from data for normal time monitoring, the methods provided in Reference 9 may be applicable as methods of dose evaluation in emergency monitoring.

The necessary levels of radioactive material concentration analysis vary depending on the purpose of evaluation of internal exposure doses. However, in some emergency cases, analysis and measuring methods similar to those used in normal time monitoring may have to be adopted.

Information 1.3 Chart with environmental impact survey in emergency

When a nuclear emergency arises, relevant authorities are likely to conduct environmental impact surveys for the purpose of evaluating and ascertaining its overall impact on the surrounding environment. In such cases, methods conforming to the implementation content of normal time monitoring may be adopted depending on the conditions and the state of recovery from the nuclear emergency. Analysis institutions have to be aware that samples with unexpectedly high radioactivity concentration may be provided in such occasions, and need to take measures against cross-contamination of samples and contamination of laboratories before starting analysis and measurement.

Information 2 Handling high-concentration samples

Definitive data on radioactivity concentration of sample are not always available prior to analysis ormeasurement. However, in some cases, radioactivity concentration of environmental samples can be estimated from the condition of accident, data of ambient radiation dose rates in the surroundings, and/or measurement values obtained using radiation measurement equipment such as survey meters. The sections below discuss matters to be noted at the time of collection and measurement of samples whose radioactivity concentration is expected to be high.[*1]

Information 2.1 Matters to be noted in sample collection

When collecting environmental samples for emergency monitoring, in some cases, portable radiation measurement equipment such as a survey meter is used to measure ambient radiation dose rates around the sampling locations. If the measurement values are higher than normal measurement values, it is highly possible that the surrounding of the sampling location is contaminated with radioactive materials. When collecting environmental samples in such places, workers need to employ all necessary measures against exposure and contamination, including use of disposable rubber gloves and protective clothing. In addition, they shall consider taking measures to prevent internal exposure, as necessary, such as use of masks.

The collected samples shall be handled assuming that they are contaminated with radioactive materials, regardless of the measurement values obtained using the portable radiation measurement equipment. Additional contamination prevention measures to be taken for such samples include placing the collected samples in polyethylene bags, sealing the bags, and then further placing thebags in another polyethylene bag. If soil or other materials have attached to work wear or shoes, they shall be brushed off to prevent them (sources of contamination) from being taken into analysis sitesor laboratories. If any sampling tools are reused, to prevent cross-contamination of samples, they shall be cleaned using water or moistened paper towels prepared in advance before moving to the next sampling location.

Information 2.2 Matters to be noted in sample measurement

Gamma-ray spectrometry in emergencies sometimes necessitates measurement of high-concentration samples, resulting in a high-count-rate measurement. When this is the case, the number of incident gamma rays becomes significantly large, and electronic devices used for processing the signals will become overloaded.

A high-count-rate measurement is associated with the following problems:

- Increased dead time
- Pulse pile-up
- Random summing

Pulse pile-up and random summing cause the net count rate of gamma-ray peaks to decline and result in underestimation. For details of the problems in measurement that arise associated with increased dead time, including increased time required for measurement, refer to the Radioactivity Measurement Series No. 29 Gamma-ray Spectral Analysis Using Germanium Detector in Emergencies (Reference 15).

[*1]: For matters to be noted in the sample acceptance stage, sample preparation, and measurement container filling, refer to 2.3 in Chapter 2.

If the dead time is found to be long with starting the sample measurement (approximately 10% as a guide), it is necessary to implement appropriate measures such as reducing the sample volume toreduce the number of gamma rays emitted from the sample. When reducing the sample volume, observe the following points are to be noted:[*2]

- If measurement was performed using Marinelli beakers, the sample is to be transferred to small containers to reduce the sample volume.
- If measurement was performed using small containers, the sample volume inside the measurement containers is to be reduced.
- Regarding the new container to which the sample is to be transferred, efficiency calibration must be performed using a standard radiation source in the same container.

When transferring samples from Marinelli beakers to small containers or reducing sample volume inside small containers, pay extra attention to the homogeneity of the sample.

[*2]: For matters to be noted during preparation, refer to 2.3 in Chapter 2.

Information 3 Long-term storage methods of samples

Some environmental samples used for gamma-ray spectrometry in emergencies may be valuable, requiring long-term storage. Such valuable samples are highly likely to undergo other analyses and measurements in addition to gamma-ray spectrometry, which needs to be taken into account in the long-term storage.

If a sample is prone to decomposition or likely to adsorb on the sample storage container used, the sample shall be stored after applying a method of pretreatment for gamma-ray spectrometry or for radiochemical analysis of nuclides such as ^{90}Sr and $^{239+240}$Pu that is performed in normal time monitoring (Table 3.1). The sample pretreatment methods listed in Table 3.1 conform to the methods provided in the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3) and Radioactivity Measurement Series No. 16 Method for Sampling Environmental Materials (Reference 4).

Table 3.1 Pretreatment method of samples for long-term storage

No	Sample	Pretreatment method	No	Sample	Pretreatment method
1	Air	As is, or ashing	10	Peas and beans	Ashing (or drying)
2	Fallout and precipitation	Adding acid	11	Mushrooms	
3	Drinking water and inland water	Adding acid	12	Seaweeds	
4	Seawater	Adding acid	13	Meats	
5	Soil	As is, or drying	14	Cow's milk	
6	Vegetables	Ashing (or drying)	15	Dairy product	
7	Fruit		16	Eggs	
8	Tea leaves		17	Seafood	
9	Grains		18	Indicator organisms (including pasture plants)	

When simultaneously ashing multiple samples using an electric furnace, adequate attention needs to be paid to prevention of cross-contamination of samples. Measures to prevent cross-contamination include ashing samples with similar radioactivity concentrations and ashing a high-concentration sample alone, provided that measurement results of gamma-ray spectrometry in emergency areavailable. In addition, extra attention needs to be paid when handling an ashed sample because the sample has been concentrated and, accordingly, its radioactivity concentration has been increased. Further, contamination of the electric furnace shall be prevented.

Pretreated samples are unlikely to decompose compared to untreated samples, but mold may grow on them if they absorb moisture from the atmosphere. Therefore, pretreated samples shall be stored ina cool dark place or, if necessary, in a desiccator, to avoid high temperatures and high humidity.

If nuclides to be analyzed in the future are known at the time of storing a sample, consideration needs to be given to storing the sample by a suitable mean for the method of the analysis.

Information 4 Matters to be noted when discarding samples[*1]

Information 4.1 Matters to be noted when discarding samples

Environmental samples collected for emergency monitoring need to be discarded properly in compliance with relevant laws and regulations of the time.

After the Fukushima Daiichi Nuclear Accident, waste contaminated with radioactive materials is disposed of in accordance with the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated withthe Tohoku District-Off the Pacific Ocean Earthquake That Occurred on March 11, 2011 (hereinafter referred to as "the Act").

The Act stipulates that waste with radioactivity concentration exceeding a certain level (8,000 Bq/kg) and designated by the Minister of the Environment is to be disposed of as designated waste by an appropriate method under the responsibility of the national government.

When discarding environmental samples for emergency monitoring as industrial waste, the relevant organization needs to request a municipality or waste processing business operator to dispose of them after confirming that radioactivity concentration is not more than the level stipulated by the Act.

Information 4.2 Method of measurement of radioactivity concentration for contaminated waste

The Ministry of the Environment published a six-part guideline based on the Act, detailing Ordinances of the Ministry of the Environment and other relevant regulations stipulating the standards of storage and disposal of waste contaminated with radioactive materials discharged by the Fukushima Daiichi Nuclear Accident. Of which, Part V: Guidelines for Method of Measurement of Radioactive Concentration (2nd Edition), Ministry of the Environment (2013) (Reference 21) provides methods of measurement of radioactivity concentration, etc. for contaminated waste. Among the several types of target samples listed in the Guidelines, the section below cites the method to measure radioactivity concentration of discharged sludge since it is similar to soil sample discussed in this document.

· Discharged sludge

Discharged sludge corresponds to soil among the sample types discussed in this document.

The Guidelines provide that specimen sampling shall be conducted considering the representativeness of specimen, and all collected samples are to be placed into one container (a plastic bag with a fastener is acceptable) and mixed well. Analysis of radioactivity concentration is to be conducted through measurement using a germanium semiconductor detector, NaI (Tl) scintillation spectrometer, or $LaBr_3$ (Ce) scintillation spectrometer. Table 4.1 shows conditions for nuclide analysis by a germanium semiconductor detector, etc.

Table 4.1 Analysis conditions for discharged sludge

Measurement sample	Pretreatment	Sample container	Measuring time (reference)	Detection limit
Discharged sludge	None, or crushing	U-8 container	1,000 - 2,000 seconds	10 - 30 Bq/kg

[*1]: Cited from the Ministry of the Environment website about information on disposal of wastecontaminated with radioactive materials (http://shiteihaiki.env.go.jp/)

Information 5 State of cesium present in inland water

According to the results of the survey conducted for river water in the Kanto region and Fukushima Prefecture from 2011 to 2012 (Reference 22) , the total ^{137}Cs concentration (sum of cesium in dissolved and suspended forms; the same shall apply hereinafter) was 0.009-18.7 Bq/L, of which dissolved form accounted for 0.002-1.5 Bq/L and suspended form 0.007-18.2 Bq/L. Depending on the purpose of the monitoring survey[*1], dissolved cesium needs to be separated from suspended cesium.[*2] The section below describes typical separation methods and their characteristics. (Reference 23)

For dissolved matters, pretreatment is to be performed using an appropriate method such as evaporative concentration, in addition to the method (direct measurement) described in Chapter 6. (Reference 4)

For suspended matters collected on a filter, the filter is to be dried in a drier or desiccator, and pretreated following the method described in Chapter 4.

・Filtration method (pressurized filtration, vacuum filtration)

A method to filtrate water by passing water through a filter. Time required for filtration is reduced by pressurizing or vacuuming. Suspended matters are collected on a filter. The filter can be of any pore size and diameter, but usually filters with a pore size of 1 μm or 0.45 μm are used. (References 17, 23, and 24) This method is applicable either at sampling sites or laboratories, using general equipment. Filtrate can be used for concentration and analysis of dissolved matter.

・Multistage filter method

A method to filtrate water by passing water through 2-10 filters with a pore size of 0.45 μm and diameter of 150 mm (or 142 mm) arranged in parallel. Although it has the term “stage” in its name, this method passes branched source water through one of the filters once. Therefore, it allows filtrating a large amount of water (one hundred to several hundreds of liters, depending on the turbidity) at the same time. Due to its nature, this method is often used at sampling sites, but can be applied in laboratories as well. Filtrate can be used for concentration and analysis of dissolved matter.

・Cartridge filter method

A method to filtrate water by passing water through a non-woven cartridge filter with a pore size of 1 μm. Suspended matters are collected in the filter. This method is applicable either at sampling sites or laboratories. Filtrate can be used for concentration and analysis of dissolved matter.

[*1]: Concentration of cesium dissolved in water is important as the basic information for evaluating various matters related to radioactive cesium discharged by the Fukushima Dai-ichi Nuclear Accident, including its transition to crops, long-term environmental dynamics, and impact on aquatic organisms, and many surveys and studies have been conducted to date. (Reference 22)

[*2]: Behavior of dissolved matter in the environment is greatly different from that of suspended matter. Dissolved matter is easily absorbed by crops, while suspended matter is not easily absorbed by plants, in most cases. For that reason, environmental dynamics forecast, etc. requires both concentration of dissolved matters and concentration of suspended matters, and therefore they need to be separated. (Reference 23)

・Cross-flow filter method

A method to filtrate water by passing water through a cross-flow filter. Suspended matters are collected as a highly concentrated suspension. This method enables efficiently collecting suspended matters even if the sample water is a highly concentrated suspension of 100 mg/L or greater. (The recovery rate is 95% or greater at a water feed rate of 0.3 L/min.) Due to its nature, this method is often used at sampling sites, but can be applied in laboratories as well. Filtrate can be used for concentration and analysis of dissolved matter.

・Continuous flow centrifugation

A method to separate and collect suspended matters by passing water through a continuous flow centrifugation system. The form of suspended matters collected varies depending on the continuous flow centrifugation system used. This method enables processing a large amount of water (about 1,000 L - 2,000 L) at the same time, and filtrate can be used for concentration and analysis of dissolved matter. Due to its nature, this method is mostly used at sampling sites.

・Suspended sediment sampler method (Reference 25)

A method to collect a large quantity of suspended matters by installing a suspended sediment sampler in a river for a long period of time (several days to several months). A suspended sediment sampler can be easily made by capping both ends of a polyvinyl chloride tube and inserting a holed plastic tube. After collecting a sample, water needs to be removed from the sample through evaporation or filtration using a glass fiber filter. This method enables collecting a large quantity of suspended matters easily and at low cost, but does not necessarily collect all suspended matters that flow into the sampler. Note that this method does not allow analysis of dissolved matter, and cannot be used in laboratories due to its nature.

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Information 6 Concept of soil monitoring

Different methods are applied to emergency monitoring of soil, depending on the purpose of monitoring and the phase of nuclear emergency. For the main method among them, this section describes the standard sampling and preparation methods and relevant matters to be noted.

As commonly-applicable matters to be noted, it is important to: 1) take measures to prevent cross-contamination by using disposable gloves and frequently decontaminating equipment, and 2) establish a procedure by paying attention to the reduction of exposure as much as possible by, for example, transferring samples collected at a high air dose rate area to a low air dose rate area and mixing soil samples after taking all necessary measures to prevent spreading.

Information 6.1 Measurement of radioactivity concentration in depth direction from surface

(1) Method using soil sampler

A soil sampler is a cylindrical steel tube (inner diameter: 5-8 cm) with both ends open and a sharp blade being attached to one end (Photograph 6.1), which is to be vertically hammered into the groundto collect core samples. The sampling depth is 5, 20 or 100 cm from the ground surface, dependingon the purpose of survey. Collection of core samples using a soil sampler takes less time than sampling using a scraper plate described below, and is effective for evaluating depth distribution in a simplified manner. Meanwhile, this method may cause cross-contamination of samples between different layers, and does not allow high precision analysis. Usually, soil is collected from five tonine locations per sampling site, and samples collected for the same depth are gathered in a thick polyethylene bag. Note that, to derive coefficients to convert measured values to figures per unit area,the sampling area and fresh soil weight (dry soil weight and dry fine soil weight as well if samplesare to be dried and sieved) need to be measured.

A standard pretreatment method is to spread a collected sample on a tray and crush soil clods usingfingers while removing foreign matters. The sample is then mixed well until it becomes homogeneous, and presented for measurement. In addition, to derive radioactivity concentration per dry soil weight, a part of the sample is to be placed in a container such as a beaker, weighed, and placed in a drying oven set at 105°C to dry thoroughly. Once dried, the sample is to be weighed again to derive dry soil rate ([Dry soil weight]/[Wet soil weight]). The derived dry soil rate is to be used forconverting measurement results. If a sample is to be dried, the sample is to be pretreated to remove foreign matters, weighed (= wet soil weight), placed in a drying oven set at 105°C to dry thoroughly, and then weighed again (= dry soil weight). The dried sample is to be lightly ground using a suitable tool such as mortar and pestle, sieved using a 2-mm sieve, and plant roots, small rocks, etc. are to be removed from it. This is called dry fine soil, which is then weighed (= dry fine soil weight), mixed well until it becomes homogeneous, and presented for measurement. For details of drying and sievingto be performed in pretreatment of sample, refer to the Radioactivity Measurement Series No. 13 Pretreatment of Samples for Instrumental Analysis using Germanium Detector, etc. (Reference 3).

Photograph 6.1
Soil samplers

(2) Scraper plate

A scraper plate is a tool to sample soil by scraping the surface layer in the vertical direction at any intervals. It consists of a metal frame to be fixed into the ground and a metal plate to scrape soil inside the frame. (Photograph 6.2) Fixing a metal rod to the metal plate for any selected depth enables finely adjusting the sampling depth, and therefore this method is effective for precisely evaluating depth distribution.

A standard pretreatment method is to weigh each collected soil layer. The volume of soil is derivedfrom the internal area of frame and the layer thickness of collected soil, and soil density of each layer is calculated. Samples are mixed well in a container such as a polyethylene bag for each layer, filled in small containers as wet soil, and presented for measurement. For details of soil sampling and measurement sample preparation methods using a scraper plate, refer to the Radioactivity Measurement Series No. 33 In-situ Measurement Using Germanium Detector (Reference 26).

Photograph 6.2
Scraper plate

Information 6.2 Measurement of deposits

The methods described in Information 6.1 (1) and (2) are applicable to measurement of deposits aswell. In addition to the two methods above, the following method can also be used.

· Method using small container

After the Fukushima Daiichi Nuclear Accident, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) conducted a thorough survey on the distribution of radioactive materials in soil. [1] In the survey, for the so much soil samples to be collected from many sampling locations in a short period of time, MEXT adopted a simplified method to collect and prepare soil samples for measurement using small containers (U-8 containers), which is outlined below.

If the soil is soft, surface layer soil is collected by vertically inserting a small container into the ground and taking the container out using a shovel along with surrounding soil. After that, the container is turned upside down, the soil surface is leveled to remove excess soil, and the remaining soil is placed in a polyethylene bag and mixed well in the bag. The mixed soil is then returned to the small container and a cap is placed on the container. Any soil adhered to the outer surface of the small container is wiped off, and the small container is presented for measurement. If the soil is hard,surface layer soil is collected by vertically hammering a 100 ml metal sampling cylinder (Photograph 6.3) into the ground. The collected soil is transferred to small containers, the soil surface is leveled to remove excess soil, and the remaining processes follow the procedure for soft soil.

If measurement of deposits is involved, one has to be aware that sampling sites may not be always an ideal bare land and how to handle plants and grass may become a problem. In the survey mentioned above, some survey meshes had to be grasslands as a result of considering the requirements for taking measurements of air dose rates at same locations. In such cases, when soil samples had weed or roots layer mixed in them, the samples had been collected into small containers without removing such plants for measurement in past.[*1]

In this method, collected samples are filled into measurement containers at sampling sites, which raises a concern over homogeneity of samples. Accordingly, a study was conducted on homogeneityof samples in measurement containers collected by this method[*2]. The section below summarizesthe result of the study.

A comparison was made for three sampling methods: (a) samples were directly collected into small containers and radioactivity concentration was measured without mixing; (b) after directly collecting into small containers, samples were mixed using a disposable knife and agitated by applying vibration for 150 cycles; and (c) collected soil was placed in a bag, agitated by applying vibration while crushing soil clods in the bag, and transferred into small containers. As a result, the method (c) produced the least unevenness in radioactivity concentration. (Figure 6.1)

[*1]: Results of Investigative Study on Situation of Distribution, Etc., of Radioactive Materials Released by the Tokyo Electric Power Company's Fukushima Dai-ichi Nuclear Power Station (First Survey) Report on Preparation, Etc., of Radiation Dose, Etc., Distribution Maps (Volume 1), Nuclear Emergency Response and Support Headquarters, Ministry of Education, Culture, Sports, Science and Technology (2012) (Reference 27)

[*2]: 1st Meeting of Advisory Committee concerning Preparation of Radiation Dose, Etc., Distribution Map, Material No. 1-4-2-1, Preliminary Survey on Distribution Status of Radioactivity in Soil in Fukushima Prefecture, Nuclear Emergency Response and Support Headquarters, Ministry of Education, Culture, Sports, Science and Technology (2012) (Reference 28)

Information 6.3 Matters to be noted when selecting sampling locations

Usually, samples are collected from multiple points for each sampling site, and the number of points is determined according to the planned number of sampling sites and the swiftness required, while giving due consideration to even distribution of samples. Figure 6.2 shows a result of a study on the unevenness of radioactivity concentration (ratio of standard deviation to average radioactivityconcentration of five soil samples (coefficient of variation)) in multiple samples collected from one site, which was conducted as part of the survey mentioned above where samples were collectedfrom five points per sampling site (3 m × 3 m).[*3] The result confirmed an average coefficient of variation of 36%, in some cases exceeding 100%, exhibiting significant variations in radioactivity concentration in general. This indicates considerably uneven distribution of radioactive materials which fell to the ground surface after the accident, even inside a small area of several square meters, due to various factors including falling conditions, nature of soil sampled, and organic matters included in the soil. Note that, in this survey, samples were basically collected from five points per 3 m × 3 m area, but the number of sampling locations was reduced to between one and three for sampling sites inside restricted areas with high radiation doses, because workers did not stay in the restricted areas for a long period of time to control their exposure to radiation.

Photograph 6.3
100 ml metal sampling cylinder [*4]

[*3]: 1st Meeting of Advisory Committee concerning Preparation of Radiation Dose, Etc., Distribution Map, Material No. 1-4-2-1, Preliminary Survey on Distribution Status of Radioactivity in Soil in Fukushima Prefecture, Nuclear Emergency Response and Support Headquarters, Ministry of Education, Culture, Sports, Science and Technology (2012) (Reference 28)

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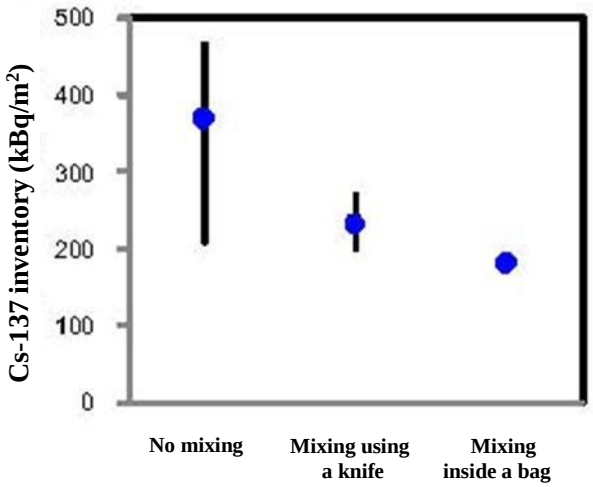

Figure 6.1
Chart between soil sample mixing method and radioisotope concentration (paddy soil)[*5]

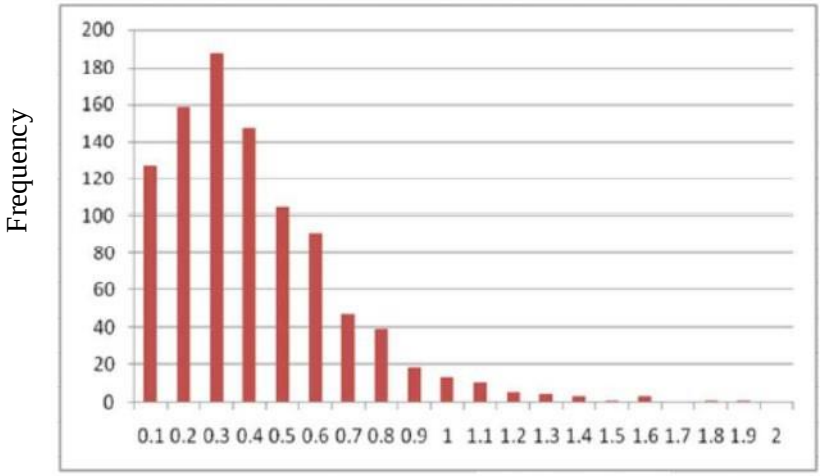

Figure 6.2
Frequency of coefficient of variation of
radioactivity concentrationfor five samples
collected from one site
(Coefficient of variation is standard deviation of radioactivity concentration for five samplescollected from one site divided by average radioactivity concentration)[*6]

[*5]: Cited from the 1st Meeting of Advisory Committee concerning Preparation of Radiation Dose, Etc., Distribution Map, Material No. 1-4-2-1, Preliminary Survey on Distribution Status of Radioactivity in Soil in Fukushima Prefecture, Nuclear Emergency Response and Support Headquarters, Ministry of Education, Culture, Sports, Science and Technology (2012) (Reference 28)

[*6]: Cited from the Results of Investigative Study on Situation of Distribution, Etc., of Radioactive Materials Released by the Tokyo Electric Power Company's Fukushima Dai-ichi Nuclear Power Station (First Survey) Report on Preparation, Etc., of Radiation Dose, Etc., Distribution Maps (Volume 1), Nuclear Emergency Response and Support Headquarters, Ministry of Education, Culture, Sports, Science and Technology (2012) (Reference 27)

Information 7 Masters to be noted when washing vegetables, etc.

The methods provided in this document specify that samples such as vegetables are to be washed with water, assuming assay of radioactive materials in food and drinks based on OIL6. For vegetables, a study was conducted on how much radioactive materials are removed by washing with water and cooking.[*1] Table 7.1 shows some of the results of the study. The removal rate of radioactive cesium and radioactive iodine from surface-contaminated spinach by washing was 32-71% and 12-50%, respectively. As reference, data for wild edible plants are also provided in Table 7.1. Note that, however,the removal rate varies depending on the nuclide and the state of the surface of vegetables.

Table 7.1 Removal rate of radionuclides from surface-contaminated samples by washing

Material Cooking/processing	Nuclide	Removal rate [%]	No. of samples
Spinach Washing under running water	Radioactive cesium	32 - 71 (56)	13
Wild edible plants (Dandelion, horsetail, wild rocambole, *Rumex japonicus*, butterbur, yomogi) Washing with water in tub	Radioactive cesium	0 - 52 (21)	6
Spinach Washing under running water	Radioactive iodine	12 - 50 (33)	13
Wild edible plants (Dandelion, horsetail, wild rocambole, *Rumex japonicus*, butterbur, yomogi) Washing with water in tub	Radioactive iodine	9 - 46 (22)	6
Wild edible plants (Dandelion, wild rocambole, *Rumex japonicus*, butterbur, yomogi) Washing with water in tub	Radioactive tellurium	0 - 57 (29)	5

Values in parentheses are averages.

[*1]: Radioactive Waste Management Funding and Research Center, Removal Rate of Radionuclides by Cooking and Processing of Food: Centering on Radiocesium Removal Rate Data in Japan, RWMC Report RWMC-TRJ-13001-2 (2013) (Reference 29) (Table partly amended)

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