Radioactivity Measurements Method for Crude Drugs

Crude drugs are natural products produced by harvesting cultivated plants/reared animals or collecting wild resources and processing them through washing and drying. This General Information describes the radioactivity measurement method of crude drugs that can be applied when there is a concern about the contamination of radioactive materials in more amounts exceeding that from natural origin.

The measurement methods described here are procedures to measure radioactivity by γ-ray spectrometry, and target nuclides are 131I, 134Cs and 137Cs.

1. Principle

In order to measure the radioactivity of a radionuclide in a sample, radioactive materials are identified based on the energy of radiation by measuring α-rays being helium nuclei, β-rays being electrons and γ-rays being photons, emitted when radionuclides decayed, and radioactivity is determined from the number of radiations counted per unit time. Radiations have different penetrating powers depending on their kind and energy. Generally, α-rays have weakest penetrating power and are shieldable by papers. β-Rays have stronger penetrating power than α-rays, being shieldable by a light metal plate with a few millimeters thickness, and are classified to the weak penetrating power radiation. On the other hand, γ-rays have strong penetrating power, and shielding them needs a substance with a few to 10 centimeters which has high atomic number and high density such as lead.

Difference in penetration of radiation is an important factor in the measurement of radiation/ radioactivity. γ-Rays are usually used to determine radionuclides. α- and β-rays are easily self-shielded (absorbed) because of their weak penetrating radiation. They are suitable for the measurement of surface contamination, but the identification of radionuclides by their spectroscopies needs professional techniques for sample preparation, etc., and is not easy. On the other hand, most γ-rays do not lose their energy when penetrating a substance even in emission from inside the substance, and the information of the emitted γ-ray energy is obtained from the measured spectrum. Since γ-ray energy emitted from a radionuclide is different for each radionuclide, it is relatively easy to identify the radionuclide based on the obtained energy spectrum. For the measurement of radioactivity concentration in crude drugs, it is necessary to identify the radionuclide contained in the crude drug and to measure the concentration of the radionuclide, therefore measurement methods by γ-ray spectroscopy are recommended.

Semiconductor detectors and scintillators are known as detectors used for the radioactivity measurement methods by γ-ray spectroscopy. By injection of radiation, the former produces electron-hole pairs and the latter emit a light. Scintillator exhibits scintillation (flash and fluorescence), but the intensity of the light is very weak. Therefore, it is used with the combination of a photomultiplier tube, etc. which amplify an electric signal converted from photon. A germanium semiconductor detector (hereinafter referred to as “Ge detector”), one of semiconductors, has the highest performance as a detector that can measure the radionuclide in crude drugs. In addition, a thallium activated sodium iodide scintillation detector (hereinafter referred to as “NaI (Tl) detector”) is easy to handle and can measure the radioactivity of crude drugs.

1.1. Target radionuclide

The target nuclides are 131I, 134Cs and 137Cs.

1.1.1. Ge detector

Radiation data necessary for measurement of radioactivity by γ-ray spectrometry using a Ge detector is shown in Table 1.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Half-life (days)</th>
<th>Energy (keV)</th>
<th>γ-ray Emission Rate</th>
<th>γ-ray that require correction of summing effect (γ-ray Emission Rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>131I</td>
<td>8.021</td>
<td>364.5keV</td>
<td>0.817</td>
<td>284.3keV(0.061), 637.0keV(0.027), etc.</td>
</tr>
<tr>
<td>134Cs</td>
<td>2.065</td>
<td>604.7keV</td>
<td>0.976</td>
<td>569.3keV(0.154), 801.9keV(0.087), etc.</td>
</tr>
<tr>
<td>137Cs</td>
<td>30.17</td>
<td>661.7keV</td>
<td>0.851</td>
<td>no (single γ-ray)</td>
</tr>
</tbody>
</table>

When resolution is not high, the peaks of 795.9keV and 801.9keV can be treated as one peak (0.942).

1.1.2. NaI (Tl) detector

Radiation data necessary for the measurement of radioactivity by γ-ray spectrometry using a NaI detector is shown in Table 2. In the measurement using a NaI detector, radioactive Cs is treated as the sum of 134Cs and 137Cs because it is difficult to quantify the radionuclides by precise distinction.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Half-life (days)</th>
<th>Energy (keV)</th>
<th>γ-ray Emission Rate</th>
<th>γ value that require correction of summing effect (γ-ray Emission Rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>131I</td>
<td>8.021</td>
<td>364.5keV</td>
<td>0.817</td>
<td>284.3keV(0.061), 637.0keV(0.027), etc.</td>
</tr>
<tr>
<td>134Cs</td>
<td>2.065</td>
<td>604.7keV</td>
<td>0.976</td>
<td>the peaks of 795.9keV and 801.9keV are treated as one peak (0.942).</td>
</tr>
<tr>
<td>137Cs</td>
<td>30.17</td>
<td>661.7keV</td>
<td>0.851</td>
<td>no (single γ-ray)</td>
</tr>
</tbody>
</table>

2. Apparatus
The system configuration of a γ-ray spectrometer is shown in Figure 1. The apparatus generally consists of a detector, a circuit part for measuring such as an amplifier, and an analysis part (personal computer: PC) (Figure 1). In some commercially available apparatuses, a circuit part for measuring such as a high voltage power supply, amplifier and multichannel analyzer is integrated with a detector, and the resultant detection part which include a shielding body are combined with a PC for analysis. Details will be described later.

The Ge detector has a cooling system using liquid nitrogen.

### 3. Sampling, preparation, storage and transport

#### 3.1. Sampling

##### 3.1.1. Sampling container, tool and label

- Fresh polyethylene bags are used for sampling containers.
- Auxiliary tools for sampling are made of stainless, polyethylene, or their equivalent materials. Parts which contact with samples should be protected with polyethylene bags to prevent contamination during transport. Because auxiliary tools are used at sampling sites, pay attention to contamination from these tools when sampling are conducted at multiple sites.
- Fill out immediately the following items on sampling containers before or after sampling.
  1. Sample number (lot)
  2. Sample name
  3. Production area of sample
  4. Sampling date
  5. Sampler name
  6. Special notes
  7. Others necessary for evaluation

##### 3.1.2. Sampling and handling of samples

Random sampling is performed to collect samples representing a unit for measurement, and collected samples are homogenized by through mixing. As a general rule, one sample is measured per one unit for measurement.

If direct sampling is difficult, collect samples using a shovel, and transfer them to sampling containers, using a funnel if necessary.

#### 3.1.3. Amount of sampling

About two times of amount required for testing is desirable.

#### 3.2. Preparation of sample

If necessary, adjust the size of samples to fit to each apparatus. Crude drugs are produced using various parts of plants, minerals, animals, and so on to cause various size, form and hardness, so they are cut and crushed according to their characteristics. Procedure such as washing that affect test results must not be done after sampling.

##### 3.3. Storage and transport of sample

Test immediately after sampling. Make sure that sampling containers are not broken and samples do not leak from sampling containers. When testing is not performed immediately, store samples avoiding moisture and insect damage.

#### 4. Measurement of sample

An example of analysis by a γ-ray spectrometer is shown in Figure 2.
4.1.3.1. Energy calibration

For energy calibration sources, correspondence relationship between γ-ray energy and a peak center channel is obtained as a linear equation according to the following procedure.

(1) Attach an energy calibration source to the regular position of a detector, and measure the spectrum until the peak area of a main γ-ray reaches several thousand counts.

(2) Assuming that γ-ray energy (E) and a peak center channel (p) are in linear relationship, the following formula is obtained using spectral analysis software.

\[ E = a + b \times p \]

By setting the energy range of γ-rays to 0 to 2000 keV and the channel full scale of a multichannel analyzer to 4000 ch, the region of interest can be set easily even when the count value is low, and in this case “a” in the above formula is close to 0, and “b” is as close to 0.500 as possible.

(3) Record and save the above data.

4.1.3.2. Efficiency calibration

In order to determine radioactivity from a measured γ-ray spectrum, counting efficiency to a peak (hereinafter referred to as “peak efficiency”) is necessary, and radioactivity analysis postulates that the peak efficiency is correctly calibrated.

For efficiency calibration, use efficiency calibration sources of which concentration are known. Usually, standard sources containing various nuclides are measured to obtain a peak efficiency function with energy as a variable so that it can be applied to the energy range of approximately 50 to 2000 keV. Since the peak efficiency varies depending on a sample container, it is necessary to perform efficiency calibration for each sample container when using multiple sample containers.

4.1.4. Procedure

4.1.4.1. Preparations in advance and points to be checked

(1) Operation check of apparatus and settings

Before measuring a sample, use spectral analysis software to analyze the spectrum of the energy calibration source and confirm that the peak center channel, half width and peak count rate are normal for major γ-rays.

(2) Background measurement

Measure a background under specified measurement conditions. In principle, the measurement is performed by placing a sample for background measurement (enclose the same amount of water that does not contain the target radionuclide in the same sample container) that has the same conditions as the sample.

Since the analytical result of a background spectrum measured recently is used for the radioactivity analysis of a sample, when a peak corresponding to the main γ-ray energy of a target nuclide shown in Table 1 is observed, calculate the count rate and the statistical uncertainty of count and save the result...
4.1.4.2. Measurement procedure

When filling a sample into a sample container, take care to make the gap as small and uniform as possible. Therefore, according to the characteristics of a crude drug to be measured, pretreat it by cutting or crushing as necessary.

Attach the same container filled with the same amount of a sample as the standard sample used for the efficiency calibration to the center of a detector. At this time, the deviation from the center should be within about 1 cm for Marinelli containers and within about 2 mm for cylindrical containers.

Start measurement after setting the measurement time of the sample so that a target detection limit value can be obtained based on the results of peak efficiency and background measurement. Note that a peak shape may deteriorate when a concentration is too high.

After the measurement, save the spectrum data.

4.1.4.3. Analysis procedure

(1) Setting of region of interest

After the measurement is completed, set the region of interest (ROI) for the γ-ray of the target nuclide using spectrum analysis software. At this time, if the count is insufficient, the variation of the count for each channel can be leveled by a smoothing process.

From the peak center channel (p) and the full width at half maximum (FWHM), it can be confirmed that the measured spectrum is normal, but the value may vary for weak peaks.

(2) Calculation of peak area

Peak areas (Nₐ) are calculated based on a peak search in ROI automatic setting by analysis software, but for especially weak peaks, confirm whether the position and width of the ROI are appropriate.

- Figure 3 Setting of region of interest (ROI), and calculation of peak area (Nₐ) and background area (Nᵦ)

(3) Subtraction of background count rate and calculation of statistical uncertainty of count

In usual γ-ray spectrometry, it is not always necessary to subtract a background count rate nᵦ (hereinafter referred to as "BG count rate"), but if a detector and the inside of a shield body are contaminated, it is necessary to subtract the BG count rate. A net count rate n(s⁻¹) is obtained by subtracting the BG count rate in the same ROI from the sample count rate (nₛ = Nₛ / tₛ).

\[ n = nₛ - nᵦ \]

The relation of a count error σₙ and a count rate (n) is expressed as the following formula:

\[ n \pm σₙ = n ± (nᵦ)¹² \]

The statistical uncertainty of count to a net count rate, σₙ (s⁻¹), is expressed as the root sum squares of statistical uncertainties (σₛ and σᵦ) of each count rate, shown as follows:

\[ σₙ = (σₛ^2 + σᵦ^2)¹² \]

(4) Calculation of radioactivity

The radioactivity A (Bq) and the radioactive concentration C (Bq/kg) of a sample are obtained by the following formulae:

\[ A = \frac{n}{αf_{SUM}} \]

\[ C = \frac{A}{M} \]

In the above formulae, the abbreviations are as follows:

- n: Count rate
- α: γ-Ray emission rate (Bq⁻¹) shown in Table 1
- ε: Peak efficiency
- f_{SUM}: Correction factor for summing effect
- M: Mass (kg) of a sample in a sample container

However, when the measurement is compared with a standard sample, "α"", ε", and "f_{SUM}" are the same, so there is no need to consider. In other words, when the radioactivity of the standard sample is A_{STD} and the count rate is n_{STD}, the radioactivity A is obtained by A = (n / n_{STD}) A_{STD}.

(5) Uncertainty of detection

If it is not necessary to consider the uncertainty of the mass of a sample in a sample container, the statistical uncertainty of count σₙ (Bq) of the radioactivity of the sample and the statistical uncertainty of count σₖ (Bq/kg) of the radioactive concentration are obtained by the following formulae:

\[ δₙ = \frac{σₙ}{n} A \]

\[ δₖ = \frac{δₙ}{M} \]
If the measured radioactive concentration $C$ exceeds $3\delta C$, it is considered statistically significant.

(6) Record of detection limit value

If no radioactivity is detected, record $3\delta C$ of the radioactivity value, which would be measured in the analysis, as the detection limit value.

The detection limit value is affected by a BG count rate, sample measurement time, and sample mass. In radioactivity measurement, methods to calculate radioactivity from the count rate of the background part of the peak to be measured (usually calculated from the baseline region beside the peak), BG count rate, sample measurement time and background measurement time, sample mass, etc. are widely used.

(7) Examination and evaluation of measurement results

Summarize measurement results for each target nuclide, and confirm that it is normal based on the statistical uncertainty of count, peak center channel, FWHM, etc. If there is any doubt in the confirmation of results, remeasure as necessary.

4.1.5. Points to note for measurement

4.1.5.1. Control of background

When the same nuclide as a target nuclide is detected from a background, it is necessary to confirm the cause and suppress the influence of the background as much as possible. In the case of indoor contamination, the influence can be suppressed by cleaning and checking shielding devices around an apparatus and performing appropriate shielding. If the inside of a shield body or a detector itself is contaminated, decontamination should be generally attempted. However, if decontamination is impossible, it is necessary to subtract the contribution from the background when calculating radioactivity.

4.1.5.2. Contamination prevention of apparatus, tool and so on

Cover a detector with polyethylene bag to prevent from contamination. If contamination should occur, cope by replacing the polyethylene packaging. If the surface of a detector is contaminated, wipe it off with a neutral detergent or gauze soaked in ethanol. Be careful not to let contaminants such as dust enter when opening a shield body.

Use a sample container after simple cleaning. When a sample is placed into a sample container, it is also important to prevent the sample from adhering around the sample container.

Use a disposable container when measuring a high concentration sample or when decontamination is difficult. When a sample container is used repeatedly, it is recommended to apply fluorine coating. It is also effective to use a plastic bag in a sample container.

4.1.5.3. Routine maintenance of apparatus

Regular performance tests of an entire measurement system is very important for the control of apparatuses. In the performance tests, a $\gamma$-ray source for checking is placed at a fixed position on a detector, and a peak center channel, FWHM and peak count rate are obtained for low, medium and high energy $\gamma$-rays. Save these data as time-series data. The performance tests should be preferably performed daily, at least prior to a series of sample measurement, so that accurate energy calibration can always be used.

In addition, it is confirmed that there is no contamination around a detector and a sample container by regularly performing measurement with no sample or by placing an empty container. One of detector troubles is vacuum loss in a cryostat. This can be judged from the consumption of liquid nitrogen, a decrease in energy resolution, and visual inspection (the existence of condensation at the neck of the cryostat).

4.2. Measurement by NaI (Tl) spectrometer

4.2.1. Characteristic of measurement method

Scintillation detectors calculate the energy and number of radiation by converting a weak light generated at the time when radiation enters a solid crystal called a scintillator, into an electric signal using a photomultiplier. As the advantages, it is relatively inexpensive compared to Ge detectors and can be used at room temperature. Another characteristic is that the detection efficiency is determined by the size of crystals because the size of commercially available solid crystals is standardized. Some solid crystals include NaI and LaBr$_3$.

4.2.2. Apparatus, tool and so on

A scintillation spectrometer is generally composed of a scintillation detector, a high-voltage power supply, an amplifier, a multichannel analyzer, and a PC for analysis. The scintillation spectrometer has the analytical function of a $\gamma$-ray spectrum and can perform processes from radioactive measurement to quantitative calculation.

(1) Detector

The energy resolution is not more than 8%.

(2) Shielding body

In order to reduce the influence of environmental radiation (background), it is desirable to have the structure of which detector surroundings are shielded with lead. It is more desirable to surround the all surface with lead because the reduction effect is low when shielding only the side surface of a detector.

(3) Sample stage

Set the sample stage that can fixes a detector and a sample in a fixed spatial relationship (geometry) and is stored in a shield body. In this case, it is desirable to place a beaker sample container perpendicularly just above the detector in terms of detection efficiency and stability during measurement. In the case of a rectangular sample container, it is also possible to make the side of the container and the sample stage closely contact with the detector horizontally.
4.2.2. Tool and so on

(1) Sample container
Marinelli containers, plastic bottles, polyethylene tanks, etc. are used as sample containers. In the case of an emergency, quantification is possible by inserting a detector in a bucket containing a sample. However, it is necessary to calculate detection efficiency for each measurement container in advance.

(2) Energy calibration source
Select some energy calibration sources to cover from 100 keV to 2000 keV such as $^{22}\text{Na} (511 \text{ keV}), ^{54}\text{Mn} (835 \text{ keV}), ^{60}\text{Co} (1173 \text{ keV}, 1332 \text{ keV}), ^{88}\text{Y} (898 \text{ keV}, 1836 \text{ keV}), ^{137}\text{Cs} (662 \text{ keV}),$ and $^{139}\text{Ce} (166 \text{ keV}).$ Obtain the relationship between the $\gamma$-ray energy and the peak center channel as a linear equation.

Because the energy resolution of NaI spectrometers is low unlike Ge detectors, the radiation source composed of some nuclides with close $\gamma$-ray energy is not used.

(3) Efficiency calibration source
For efficiency calibration, use the efficiency calibration source whose radioactivity is known. Since peak efficiency varies depending on a sample container, it is necessary to calibrate the efficiency for each sample container when using multiple sample containers. It is desirable to use the nuclide which emit one or two $\gamma$-rays, considering the energy resolution of a spectrometer. It is desirable that the source includes target nuclides, $^{134}\text{Cs}$ and $^{137}\text{Cs}$.

(4) Software for spectral analysis
Even if there is overlapping of peaks attributed to multiple nuclides, the software should be able to separate the peak of interest and calculate its area by peak function fitting, etc. It is desirable to be able to perform peak analysis conforming to "Radioactivity measurement series No.7, $\gamma$-Ray Spectrometry by Germanium Semiconductor Detector" 4). In addition, it is desirable to be able to calculate radioactive concentration from the radiation data of a nuclide to be quantified (half-life, $\gamma$-ray emission rate) and detection efficiency.

4.2.3. Apparatus calibration

4.2.3.1. Energy calibration
An energy calibration equation is obtained by using several energy calibration sources after the channel width of a multichannel analyzer is set to about 1000 ch and adjusted so that $\gamma$-rays up to 2000 keV can be measured.

There is the following relationship between the $\gamma$-ray energy ($E$) and the peak center channel ($p$):

$$ E = a + b \times p $$

In the above equation, "$a$" is desirable to be as close to 0 as possible, and "$b$" is to be as close to 2.0 as possible, considering the number of channels.

4.2.3.2. Efficiency calibration

Because counting efficiency differs depending on the energy of $\gamma$-rays, the efficiency calibration ($\varepsilon$) is obtained as the function of $\gamma$-ray energy ($E$) by using an efficiency calibration source composed of some nuclides with known amounts.

There is the following relationship in the region of several hundreds to 2000 keV.

$$ \log(\varepsilon) = a + b \times \log(E) $$

If there is a calibration source containing $^{134}\text{Cs}$ and $^{137}\text{Cs}$ for quantification, the counting efficiency for a target $\gamma$-ray peak can be obtained directly.

4.2.4. Procedure

4.2.4.1. Preparations in advance and points to be checked

(1) Operation check of apparatus and settings
Apply polarity and voltage specified by a manufacturer to a photomultiplier tube. When a source is brought close to a detector, it is desirable to check with an oscilloscope that output waveforms from a preamplifier meet specifications.

However, it is also acceptable to refer to an instruction manual for a model to be used. Or connect a detector to a multichannel analyzer, and confirm that there is no noise signals which are not normally observed and that a dead time meter does not scale out. The channel width of the multichannel analyzer is set to about 1000 ch. The range of measurement energy is to be about 100 keV to 2000 keV.

For energy calibration, confirm that reference $\gamma$-rays (for example, $^{137}\text{Cs}$ and $^{40}\text{K}$) can be detected in a channel set in advance at the time of power-on and every day. If there is a significant deviation from the set channel, adjust the gain of the amplifier.

(2) Background measurement
Perform measurement about once a week with an empty container, and confirm that there is no contamination around a detector and a sample container. If a peak is observed in the same channel as a $\gamma$-ray to be quantified and decontamination is impossible, the counting rate should be obtained and recorded.

4.2.4.2. Measurement procedure

Since the measurement procedure is basically the same as the method using a Ge detector, follow the operation of a $\gamma$-ray spectrometer using a Ge detector.

(1) Setting of measurement time: Determine the measurement time according to a target detection limit and the amount of a sample. To lower the detection limit, the reduction of a background is most effective.

(2) Start and end procedures of measurement, and record of the times.

(3) Store of spectral data: File names should be such that samples and measured dates can be identified.

4.2.4.3. Analysis procedure
Since the analysis procedure is basically the same as the method using a Ge detector, follow the operation of a γ-ray spectrometer using a Ge detector. Points to be noted in this analysis are as follows:

1. Setting of ROI
   - Set the ROI where a significant count against a background is obtained as the γ-ray peak used for quantification. If the variation is large because of an insufficient count and setting the region is difficult, set the ROI after leveling the count of each channel by smoothing process.

2. Identification of nuclide
   - Prepare to convert data by an energy calibration curve in order to determine which channel corresponds to the γ-ray of a nuclide to be quantified. Prepare nuclear data books and environmental radiation spectra, and if an unknown peak is detected, investigate the γ-ray energy, identify the nuclide, and examine possibility of interference of the γ-ray used for quantification.

3. Calculation of peak area
   - Subtract the count of a background under a peak from the total count of the peak region. If the peak is too multiple to quantify by the method, the peak area is calculated after peak separation using a peak function fitting method.

4. Calculation of radioactivity
   - In the calculation of radioactivity it is necessary to estimate the calculation result of radioactivity considering natural radioactive isotopes contained in a sample and a background.

5. In this case, a net count \((n)\) is obtained by subtracting a count in the region corresponding to the γ-ray peak of a nuclide used for quantification.

6. The radioactivity \(A\) (Bq) and the radioactive concentration \(C\) (Bq/kg) of a sample are obtained from the count rate \((n)\), which is obtained by dividing the net count by the measurement time, by the following formulae.

\[
A = \frac{n}{a_{f_{\text{SUM}}}} \\
C = \frac{A}{M}
\]

In the above formula, the abbreviations are as follows.

\(n\): Count rate

\(a\): γ-Ray emission rate (Bq\(^{-1}\)) shown in Table 2

\(f\): Peak efficiency

\(f_{\text{SUM}}\): Correction factor for summing effect. The summing effect must be corrected for \(^{134}\text{Cs}\), but if correction is not performed, state that.

\(M\): Mass (kg) of a sample in a sample container

5. Calculation of detection limit value
   - The detection limit value is calculated on the assumption that the γ-ray of the target nuclide exists in the channel of a background spectrum. The 3 folds value of the count error in background count of the peak region is expressed as the detection limit. The detection limit of commercially available spectrometers with a shield body is about 30 Bq/kg for \(^{131}\text{I}\) and \(^{137}\text{Cs}\), but differs largely depending on the detector size, shield thickness and sample volume.

The peak detection limit value in an actual sample depends largely on the spectrum of the sample. When other nuclides coexist in the sample, their Compton background may also affect the detection limit value to result in being large in some cases.

6. Examination and evaluation of measurement results
   - Summarize measurement results for each target nuclide, and confirm that it is normal based on statistical uncertainty of count, peak center channel, FWHM, etc. If there is any doubt in the confirmation of results, remeasure as necessary.

4.2.5. Points to note for measurement

4.2.5.1. Effect of temperature
   - In the case of a NaI (Tl) spectrometer, the peak center channel may vary depending on a temperature around a detector. In particular, keep room temperature constant because room temperature tends to vary at night and in winter. If a sample is stored at low temperature, return it to room temperature before measurement.

4.2.5.2. Control of background
   - Apply 4.1.5.1.

4.2.5.3. Contamination prevention of apparatus
   - Cover a detector with polyethylene bag to prevent from contamination. If contamination should occur, cope by replacing the polyethylene packaging. If the surface of a detector is contaminated, wipe it off with a neutral detergent or gauze soaked in ethanol. Be careful not to let contaminants such as dust enter when opening a shield body.

   Use a sample container after simple cleaning, if necessary. A polyethylene bag can be used in a container. When a sample solution is placed into a sample container, do not contaminate the surroundings of the sample container.

5. Report and record

   Examples of items to be described are as follows.

1. Information concerning apparatus used: Apparatus name (detector size, resolution), number of measurement channels, analysis software type, processing method

2. Sample information: Sample name (number), collection site, collection date and time, collection volume, type of collection container, name of person in charge of collection

3. Measurement conditions: Type of sample container, sample amount, geometry

4. Measurement records: Start date and time of measurement, measurement time (Live Time, Real Time)

5. Analysis records: Peak center channel, FWHM, peak area and its statistical uncertainty of count, sample count rate and its statistical uncertainty of count, BG count rate and its statistical uncertainty of count, peak efficiency,
attenuation correction coefficient, radioactivity and radioactive concentration and their statistical uncertainties of each count, radioactivity of detection limit or radioactive concentration of detection limit, name of person in charge of measurement/analysis.

For analysis records, the report of analysis software used can be used as it is to avoid transcription mistakes. For numerical values, the number of significant digits of radioactivity or radioactive concentration is “reduced” based on the number of significant digits of the statistical uncertainty of count.

⑥ Measurement result: Name of nuclide, radioactive concentration (Bq/kg), detection limit value

When measurement work is entrusted, in principle, write and report the measurement results in a format specified by the measurement work consignor, and store it together with the original data.

6. References


