Better Standards, Better Life

2021-FNCA

# Surveillance of radioactivity in terrestrial environment and quality control of data


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2. Current status of radioactivity monitoring
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CHAPTER 01

# Introduction

# Radioactivity outflow in the environment

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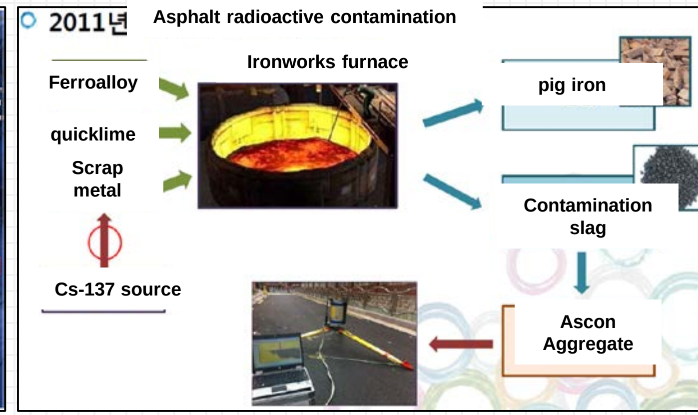
- ✓Following the Fukushima NPP disaster, Nuclear power plant operation and accidental release from the specific source, the concerns regarding radioactive contamination of terrestrial products have continued to spread to the general public
- ✓Thus leading to increased demand for intensive monitoring and survey of radioactivity in the environment.





# Major pathways of radioactive contamination to terrestrial

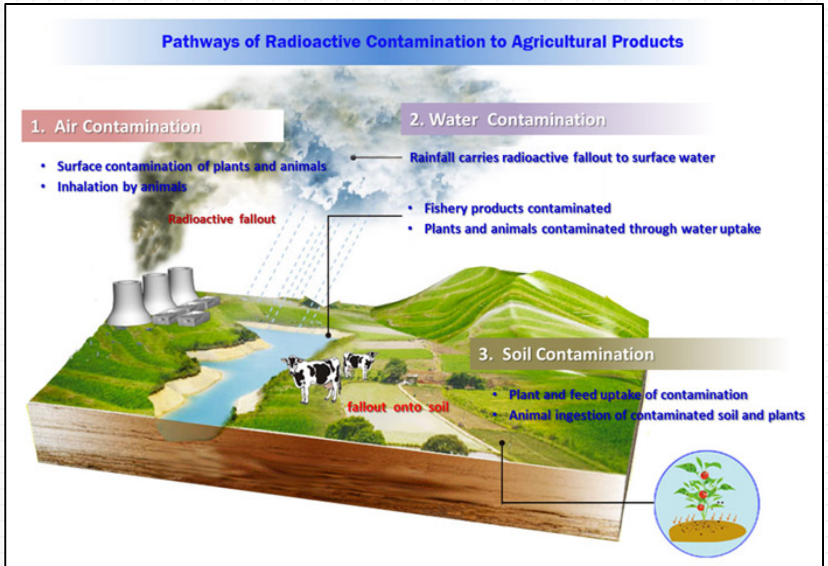
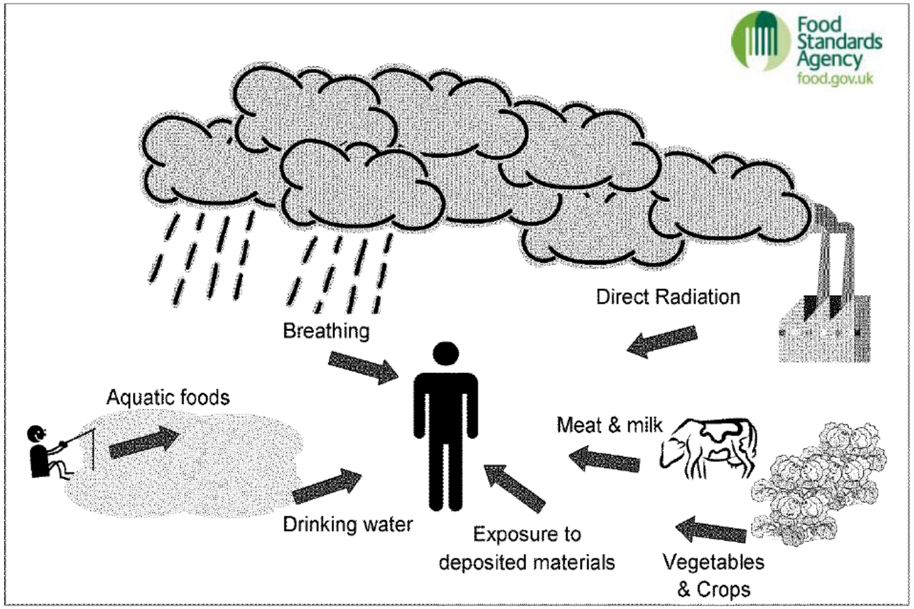


Figure 1. Major pathways of radioactive contamination to food

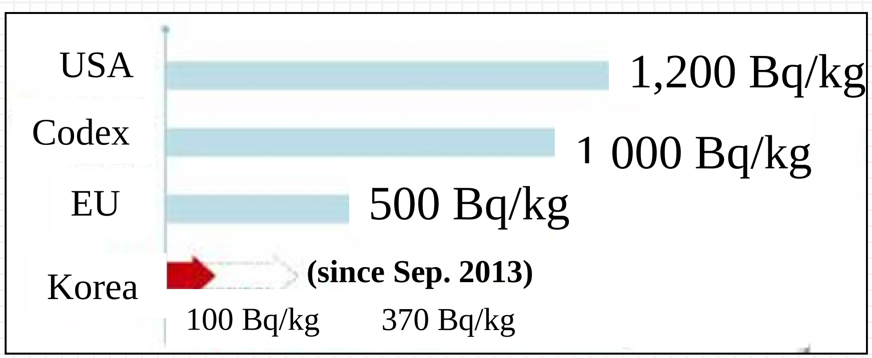
Radiation dose to man



# Guidance levels (Bq/kg) for I-131 and Cs isotopes in Korea

| radionuclide | Food | | Guidance level (Bq/kg, L) |
|---|---|---|---|
| $^{131}I$ | Infant foods | | 100 |
| | Milk | | 100 |
| | Foods other than infant | | 300 |
| $^{134}Cs$ + $^{137}Cs$ | General foods | | 100 |
| | Food imported from Japan | Drinks | 10 |
| | | Milk and milk products | 50 |
| | | General food | 100 |

**Cs-137**



# The Brief Information of NORM Regulation

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## Definition and Registration level

- **Reference**: IAEA RS-G-1.7, IAEA SRS-49
- **U-238 series, U-235 series, Th-232 series, and K-40**
- The handler (operator) **should be registered** if they deal with raw materials and residues **over registration levels**

| Sort | Definition | | Registration level | |
|---|---|---|---|---|
| | Bq/g | kBq | Bq/g | kBq |
| Raw materials | 0.1 (U, Th)<br>1 (K-40) | 100 | **1 (U, Th)<br>10 (K-40)** | **1,000<br>10,000** |
| Residues | 0.5 (U, Th)<br>5 (K-40) | - | **1 (U, Th)<br>10 (K-40)** | **1,000<br>10,000** |

CHAPTER 02

# Current status of radioactivity monitoring in South Korea

Why do we need monitoring on environment?

- ✓ Ensuring terrestrial environment is safe
- ✓ Public reassurance
- ✓ Check against statutory limits and target
- ✓ Carry out dose assessments
- ✓ Long-term trends of radioactivity in environment
- ✓ Identify early signs of change

# Network of national radioactivity monitoring system in S. Korea

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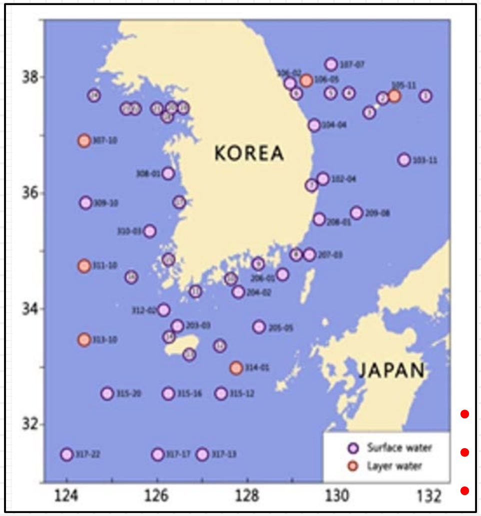



Marine

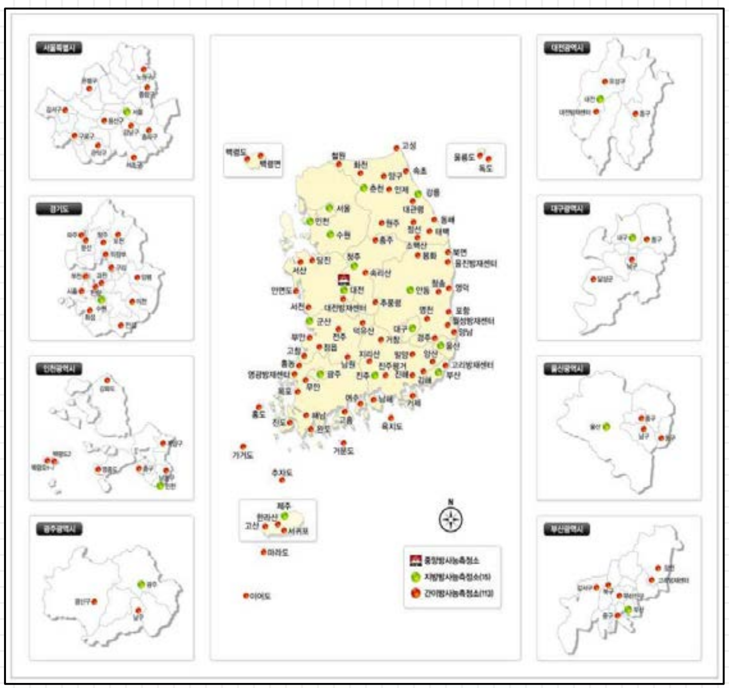
**Ministry of Ocean and Fisheries**

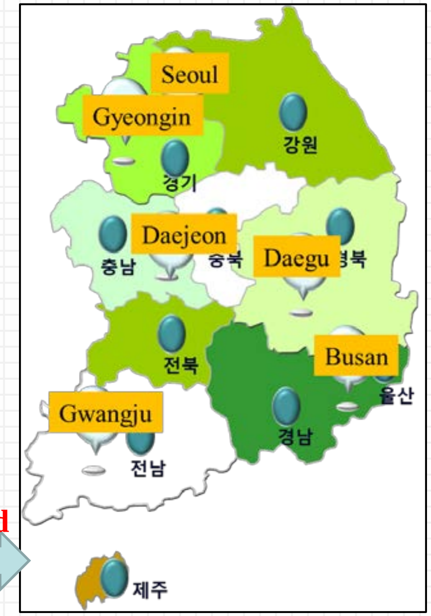
- Korea Marine Environment Management Corporation

**Nuclear Safety and Security Commission**

- KINS (Korea Institute of Nuclear Safety)
- KHNP(Korea Hydro & Nuclear Power Co.,Ltd)
- KORAD(Korea Radioactive Waste Agency)

- Marine
- Terrestrial
- Around nuclear power plant facilities






Food

**Ministry of Agriculture, Food and Rural Affairs**

- Animal and Plant Quarantine Agency

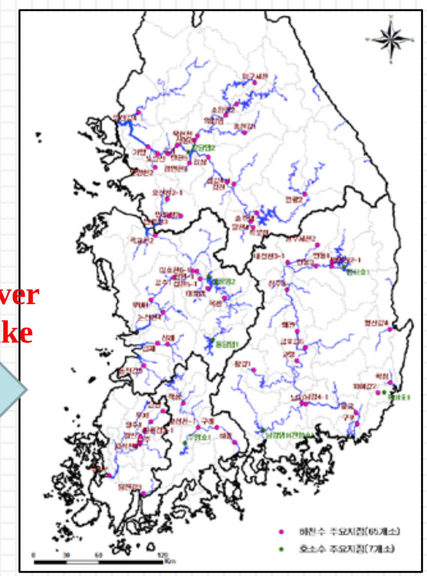
**Ministry of Food and Drug Agency**

- 6 branch MFDA
- 16 Research Institute of Public Health and Environment

River
Lake

**Ministry of Environment**

- National Institute of Environmental Research



Other relevant bodies such as N.G.O including government-funded research institutes (KRISS etc)

# Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research

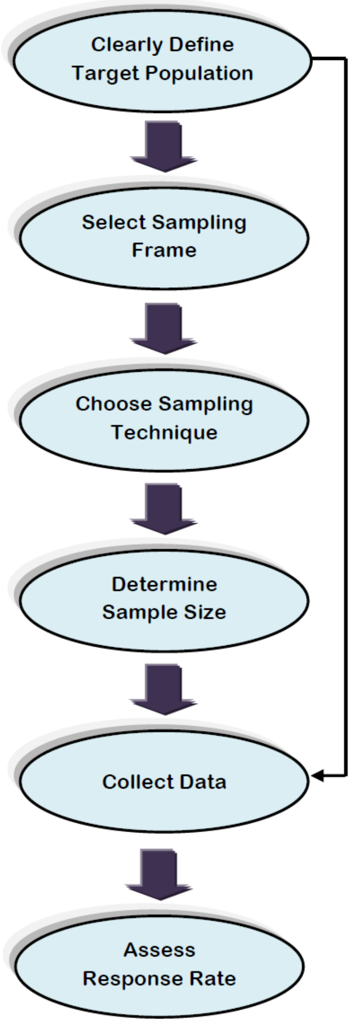



FIGURE 1: SAMPLING PROCESS STEPS

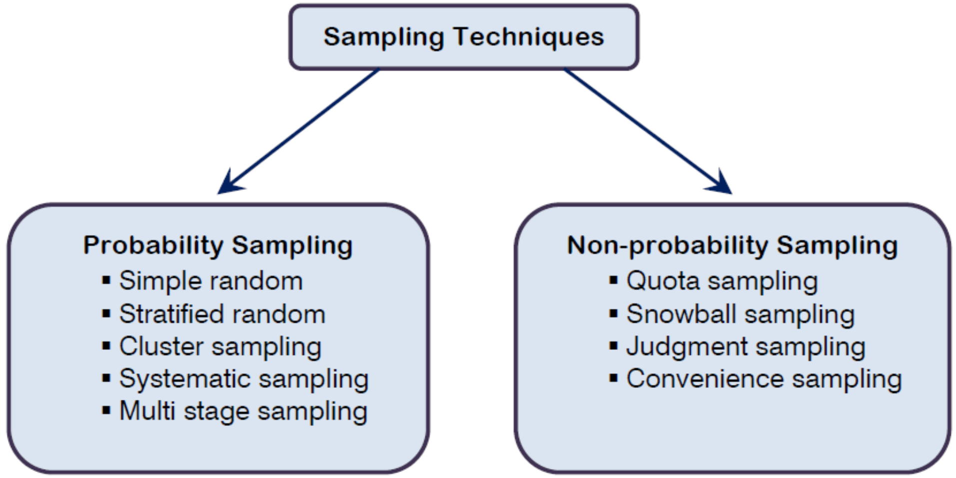



FIGURE I2: SAMPLING TECHNIQUES

ISO 24153

# Analytical Method

## 1. Non destructive methods

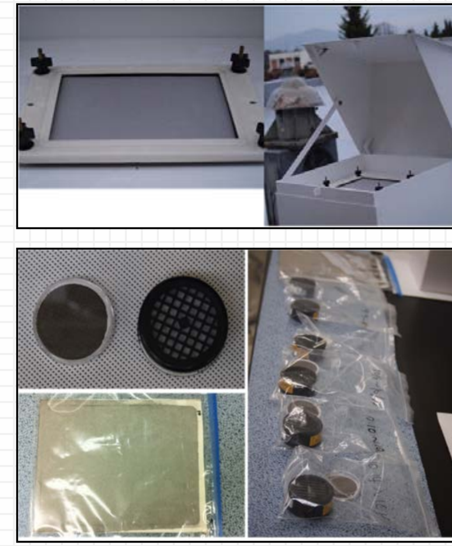
Gamma spectrometry (Cs-137, I-131)
Nuclear Activation Analysis, XRF etc.

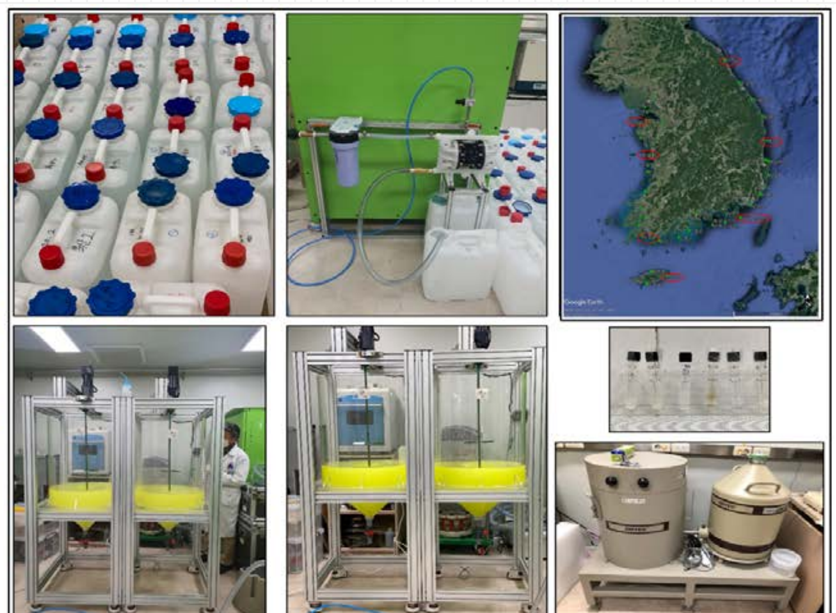
## 2. Destructive methods

Alpha spectrometry (U-238, Pu isotopes)
Beta spectrometry (Sr-90)
AAS
ICPMS etc. (Isotope mass)

# Soil sampling and analysis

# Aerosols, rainwater, undergroundwater



CHAPTER 03

# Case study (soil, foods and atmospheric materials)

# Surveillance of foods imported from Japan

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| Year | Number of samples tested | 0.1–<100 (Bq/kg) | $^{137}Cs$ (Bq/kg) |
|---|---|---|---|
| 2011 | 23,144 | 73 | 0.1–97.9 |
| 2012 | 26,608 | 167 | 0.33–24.7 |
| 2013 | 27,453 | 66 | 0.86–9.8 |
| 2014 | 27,567 | 15 | 0.92–26 |
| 2015 | 31,502 | 8 | 1.0–3.0 |
| 2016 | 32,946 | 7 | 1.0–2.0 |
| 2017 | 35,230 | 4 | 1.0 |
| 2018.8 | 24,850 | 3 | 1.0–28 |

# Mushroom sample (edible)












# The activity concentration of $^{137}Cs$ in the mushrooms

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| *Scientific name* | *Figure* | *Number of analyzes* | *Number of detections (>1 Bq/kg)* | *$^{137}Cs$ (Bq/kg, fresh)* |
|---|---|---|---|---|
| *Lentinula edodes* |  | 256 | 9 (6 from Jeju Island) | 1.4 ~ 23 |
| *Phellinus linteus* |  | 26 | 1 | 1.3 |
| *Umbilicaria esculenta* lichen |  | 3 | 3 | 5.9 ~ 10 |
| *Tricholoma Matsutake* |  | 14 | 5 | 1.3 ~ 2.2 |
| *Ramaria botrytis (Pers.) Ricken* |  | 3 | 3 | 4.0 ~ 20 |
| *Sarcodon aspratus* |  | 4 | 4 | 9.5 ~ 77 |
| *Inonotus Obliquus* |  | 6 | 6 | 9.1 ~ 36 |

# $^{137}Cs$ Contribution from Fukushima NPP

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✓ (Sampling site : Jeju Island, Korea)

| May 2017 | Cs-134 (Bq/kg, dry wt.) | Cs-137 (Bq/kg, dry wt.) | N |
|---|---|---|---|
| *Lentinula edodes* (Shiitake) | 0.17-0.29 | 27-37 | 3 |

| March 2011 (Decay corrected) | Cs-134 (Bq/kg, dry wt.) | Cs-137 (Bq/kg, dry wt.) | N |
|---|---|---|---|
| *Lentinula edodes* (Shiitake) | 0.9-1.5 | 31-43 | 3 |

✓ **The activity ratio of $^{137}Cs/^{134}Cs$ from Fukushima : *ca.* 1**

(Leon et al., 2012; Kim et al., 2012; Lujanien et al., 2012)

**Therefore, the $^{137}Cs$ contribution from Fukushima NPP accident could estimate to be *ca*. 3% of total $^{137}Cs$ content in the** *Lentinula edodes* in Jeju Island, Korea

# Radioactive impact to Korea from Fukushima NPP

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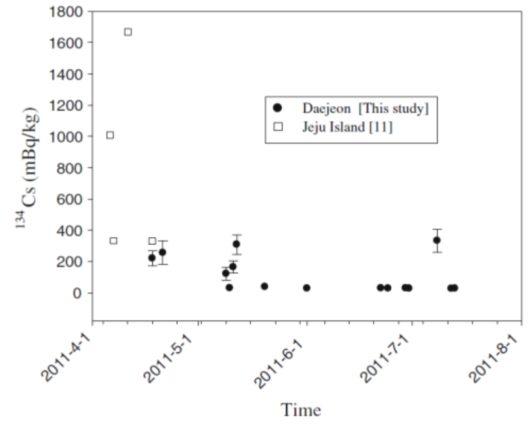



**Fig. 2** Temporal variation of $^{134}$Cs in the rainwater in Daejeon and Jeju Island, Korea

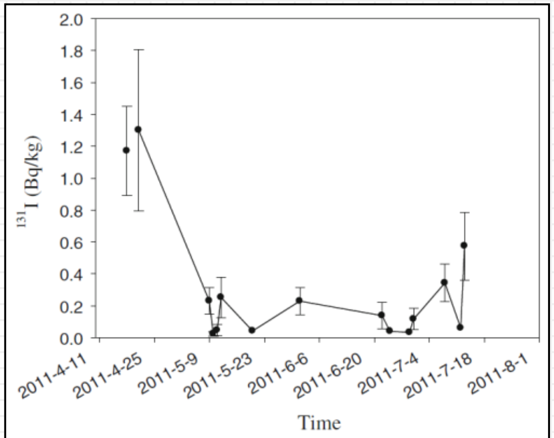



**Fig. 1** Temporal variation of $^{131}$I concentration in rainwater observed in Daejeon, Korea

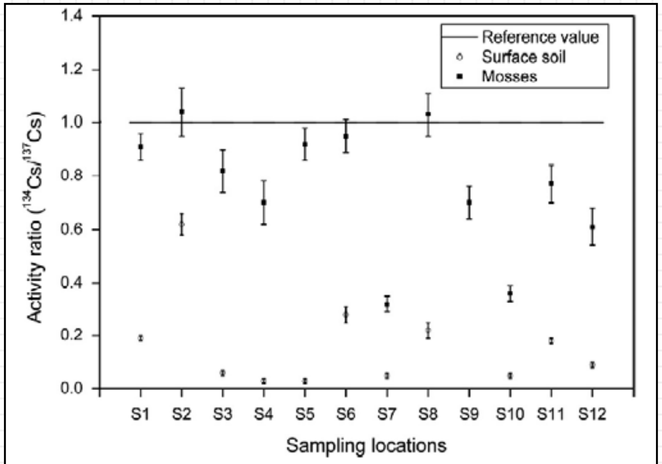



**Fig. 3.** Distribution of the activity ratio $^{134}$Cs/$^{137}$Cs in surface soil and moss samples.

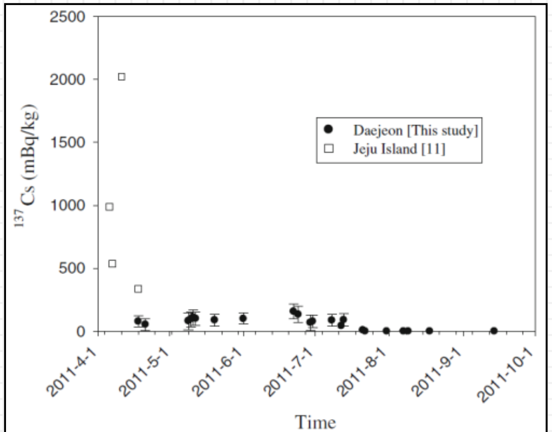



**Fig. 3** Temporal variation of $^{137}$Cs in the rainwater in Daejeon and Jeju Island, Korea

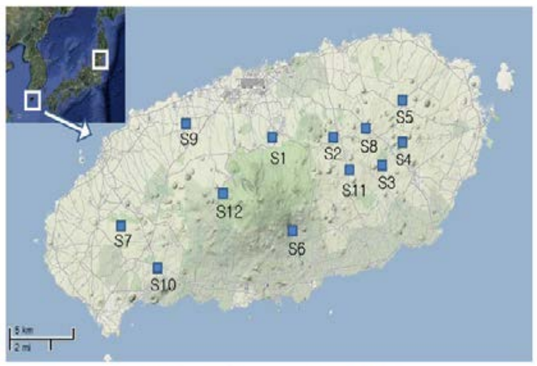



Fig. 1. Distribution of the sampling locations in Jeju Island.

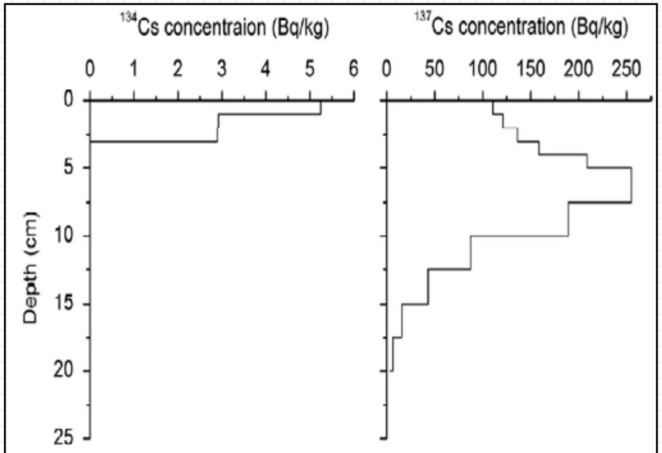
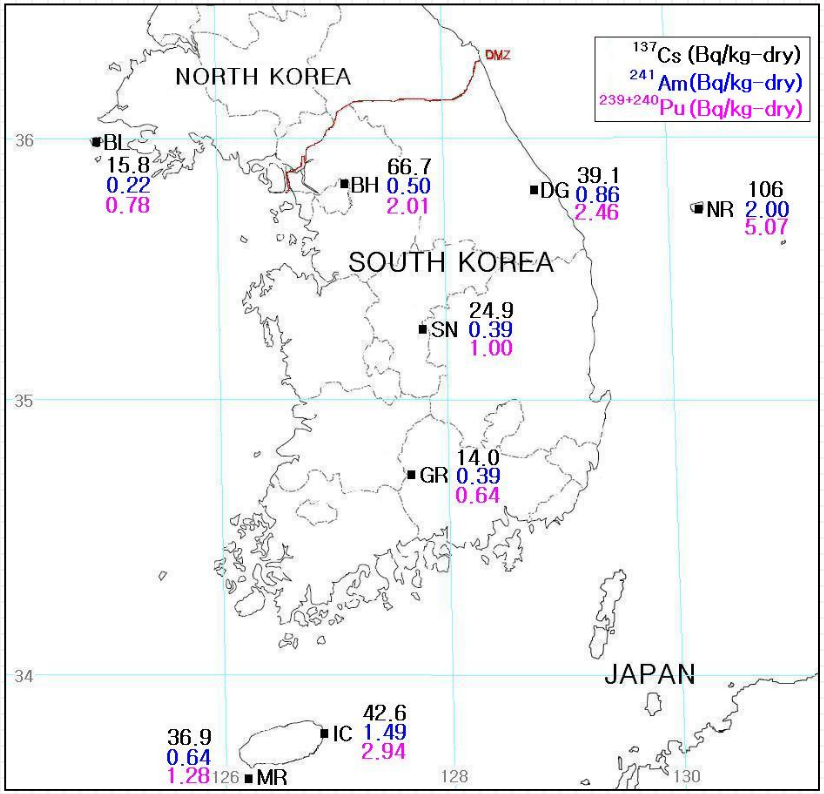



**Fig. 4.** Depth profiles of $^{134}$Cs and $^{137}$Cs in the soil of location S3.

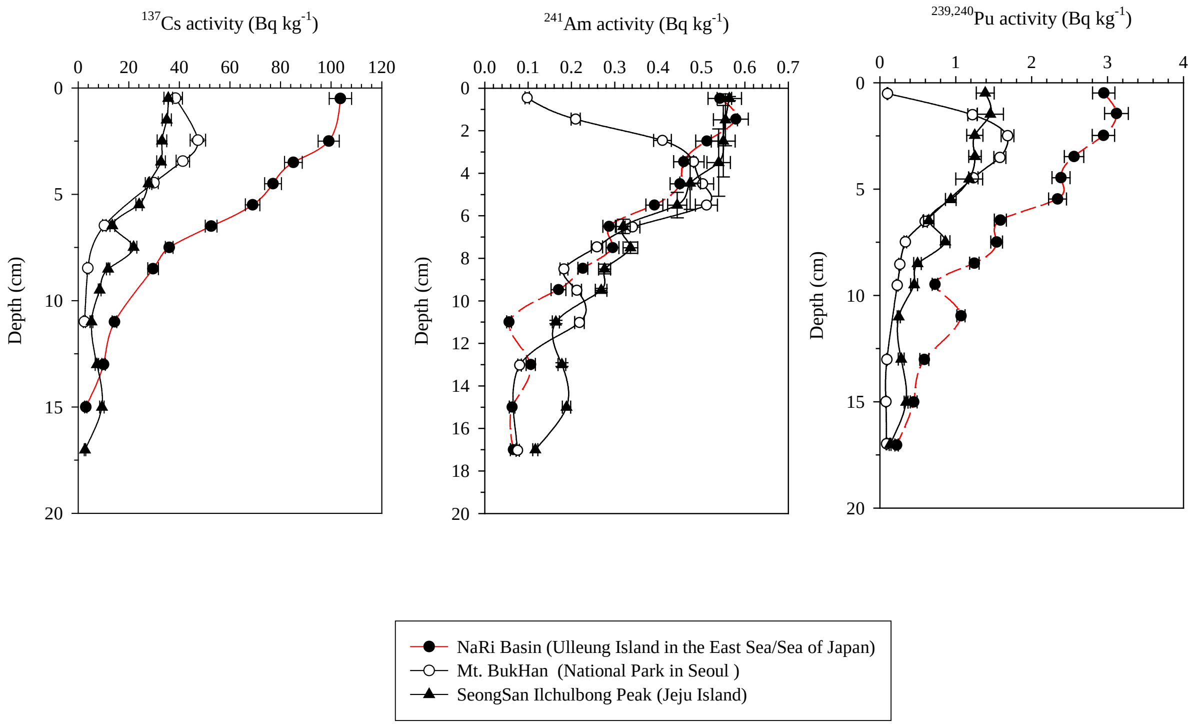
**Lee et al., 2013 ; Park et al., 2013**

# Distribution of $^{137}Cs$, $^{241}Am$ and $^{239,240}Pu$ isotopes in surface soils



# Comparison of vertical profile of radionuclide concentration in the soils






**Annual rainfall rate (mm/yr)**

**BH: 1000 mm**
**NR: 1900 mm**
**IC: 1300 mm**


Fig. 1. Sampling locations in the Korean Peninsula (Boxes represent the core samples).

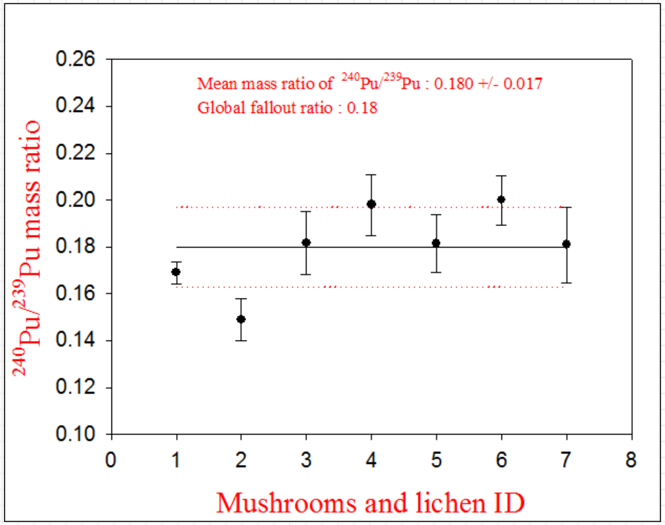
| | BH (Seoul) | NR (Ulleung Island) | IC (JeJu Island) | Global fallout (30-60° N) |
|---|---|---|---|---|
| $^{241}$Am | 46 | 70 | 30 | 20–30 |
| $^{239+240}$Pu | 110 | 190 | 75 | 50–70 |
| $^{137}$Cs | 2100 | 4300 | 1800 | 2000–3000 |

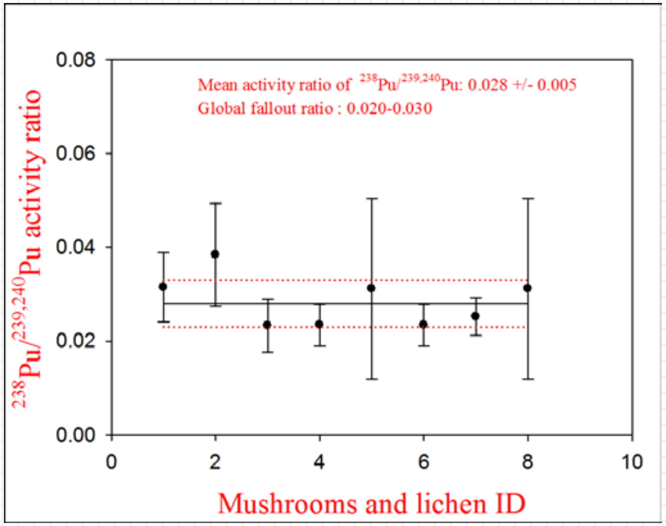
**Integrated deposition density (unit : Bq/m²)**

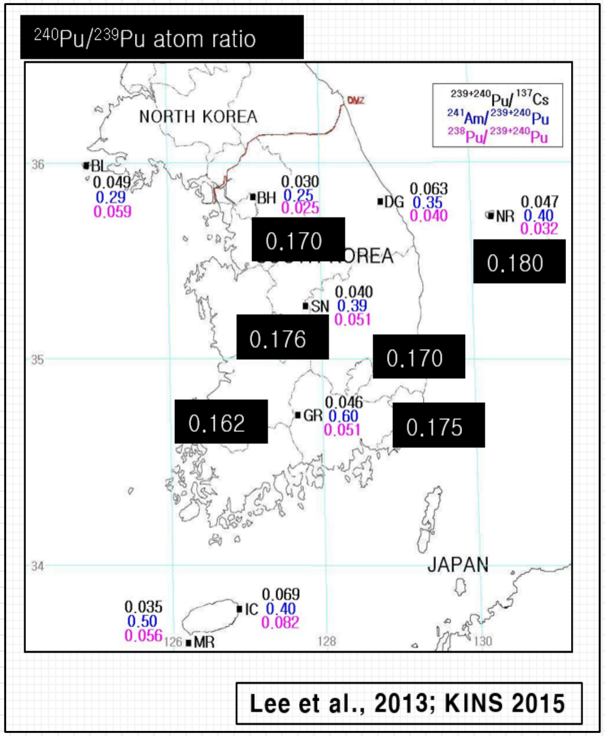
*S.H. Lee et al. / Applied Radiation and Isotopes 81 (2013) 315–320*

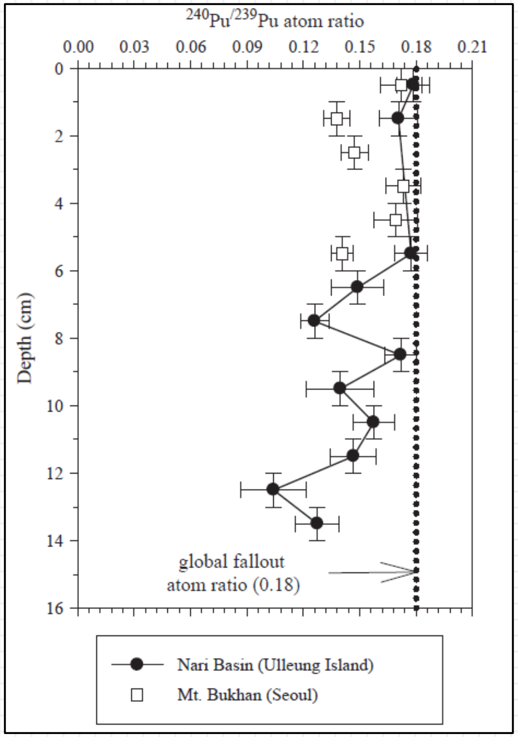
# Source of artificial radionuclide in food in Korea

## $^{238}Pu/^{239,240}Pu$ activity ratio and $^{240}Pu/^{239}Pu$ mass ratio



# Assessment of dose

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**Level of radioactivity in the food** (Bq per kg) × **Amount of food eaten** (kg per year) × **Dose coefficient** (μSv per kg = **Dose** (μSv per year)

Annual effective dose for a man in Korea experienced as a result of ingestion of $^{137}Cs$ from mushrooms and fish.

| Species | $^{137}Cs$ (Bq/kg of fresh wt.) | Effective dose coefficient[b] (Sv/Bq) | Annual intake[c] (kg/yr) | Annual committed effective dose (mSv/yr) |
|---|---|---|---|---|
| Mushroom | 8.40[a] | $1.30 \times 10^{-8}$ | 2 | $2.00 \times 10^{-4}$ |
| Fish | 0.12[a] | $1.30 \times 10^{-8}$ | 24 | $3.85 \times 10^{-5}$ |

[a] Mean activity concentration of $^{137}Cs$ measured in the mushrooms and fishes.
[b] ICRP 103(2007).
[c] National Food & Nutrition Statistics: based on Korea National Health and Nutrition Examination Survey.

# Measurement of I-131 in rainwater after Fukushima NPP accident

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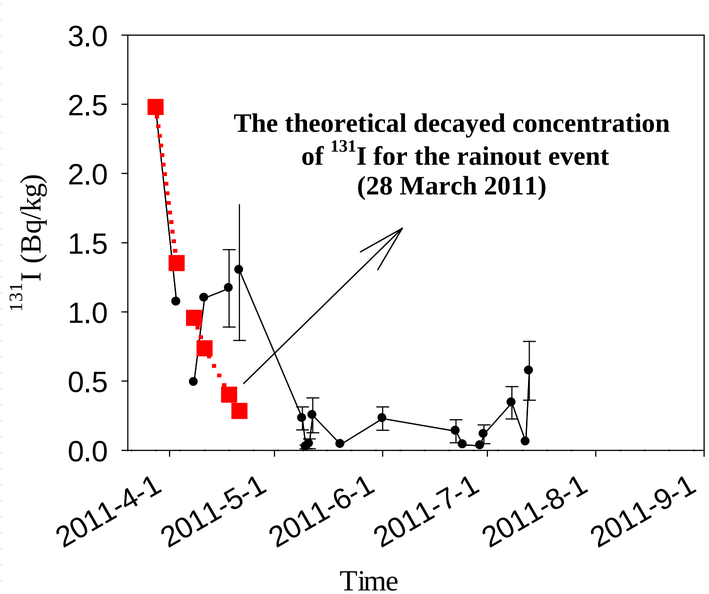
**Figure 1 Temporal variation of $^{131}$I concentration in rainwater in Daejeon, Korea**

| Date | $^{131}$I (mBq/kg) | Measured Time(s) |
|---|---|---|
| 2011-04-18 | 1,170 ± 24% | 86,400 |
| 2011-04-22 | 1,300 ± 39% | 86,400 |
| 2011-05-09 | 230 ± 36% | 71,600 |
| 2011-05-10 | 24.1 ± 59% | 85,000 |
| 2011-05-11 | 47.0± 76% | 86,400 |
| 2011-05-12 | 252 ± 50% | 86,400 |
| 2011-05-20 | <42.0 | 86,400 |
| 2011-06-01 | 229 ± 37% | 86,400 |
| 2011-06-22 | 138 ± 60% | 86,400 |
| 2011-06-24 | <40.3 | 74,600 |
| 2011-06-29 | <33.4 | 86,400 |
| 2011-06-30 | 116 ± 58% | 86,400 |
| 2011-07-08 | 343 ± 34% | 86,400 |
| 2011-07-12 | < 60.4 | 86,400 |
| 2011-07-13 | 574 ± 34% | 86,400 |



# Measurement of Cs-137 in rainwater after Fukushima NPP accident

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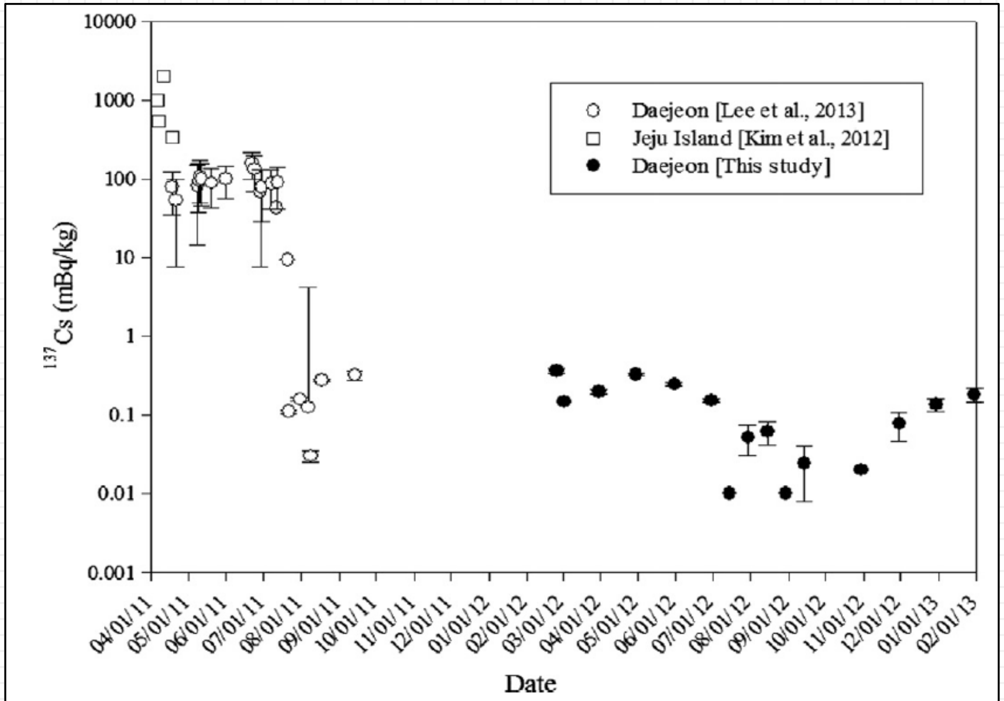
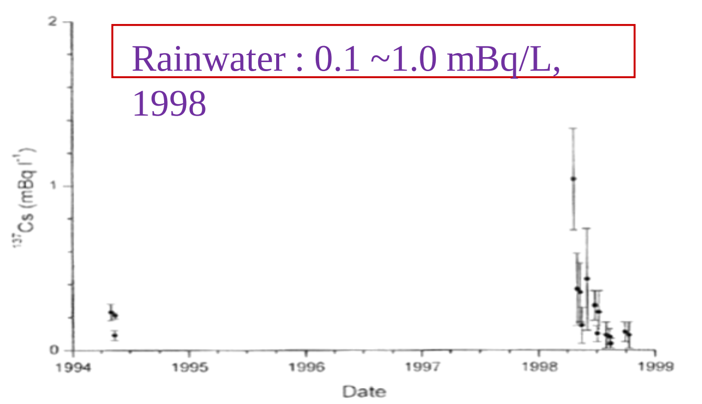
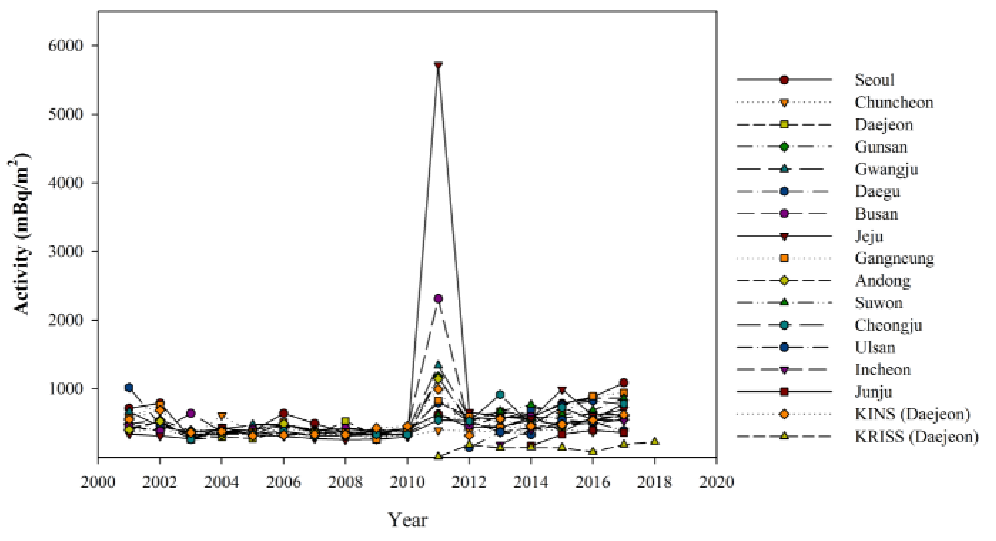


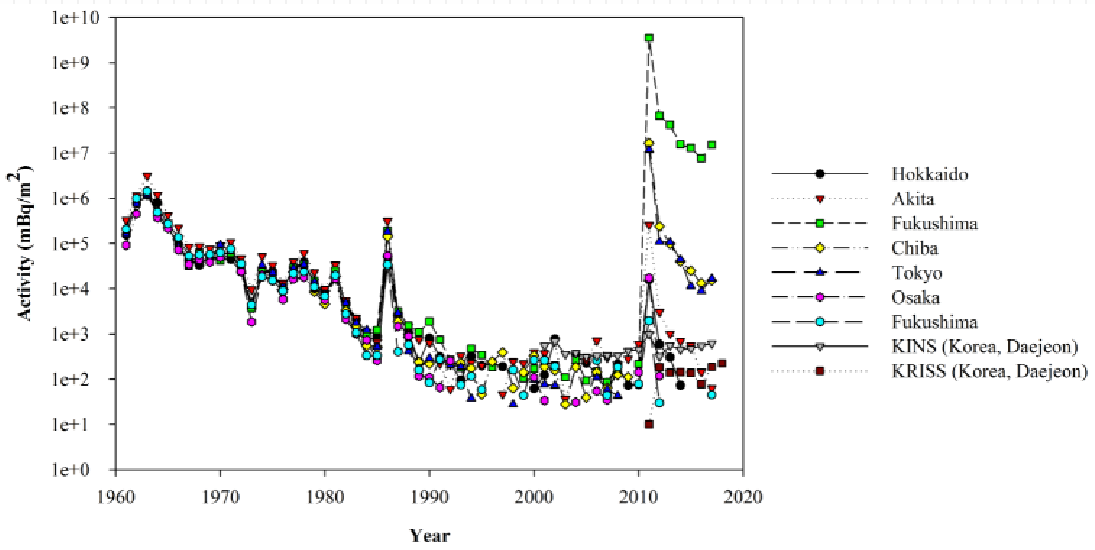

**Fig. 2.** Temporal variation of $^{137}$Cs in the rainwater in Daejeon and Jeju Island, Korea.




Hong et al., 2006

# Annual variation of Cs-137 in the fallout



# Concentration of Pu-239,240 in the rainwater

| Date of Sampling | Rainwater sample weight (kg) | $^{239,240}Pu$ | | |
|---|---|---|---|---|
| | | Activity (μBq/kg) | Uncertainty ($k=1$) | MDA (μBq/kg) |
| May 2012 | 31.34 | 7.7 | 2.6 | 1.77 |
| Jun. 2012 | 53.30 | 2.6 | 1.3 | 1.73 |
| Jul. 2012 a | 61.06 | <MDA | - | 2.52 |
| Jul. 2012 b | 65.71 | <MDA | - | 3.48 |
| Aug. 2012 a | 83.16 | <MDA | - | 2.37 |
| Aug. 2012 b | 73.38 | <MDA | - | 3.67 |
| Sep. 2012 a | 84.26 | <MDA | - | 2.21 |
| Sep. 2012 b | 97.14 | <MDA | - | 2.27 |

**Concentration of Pu isotopes in rainwater**

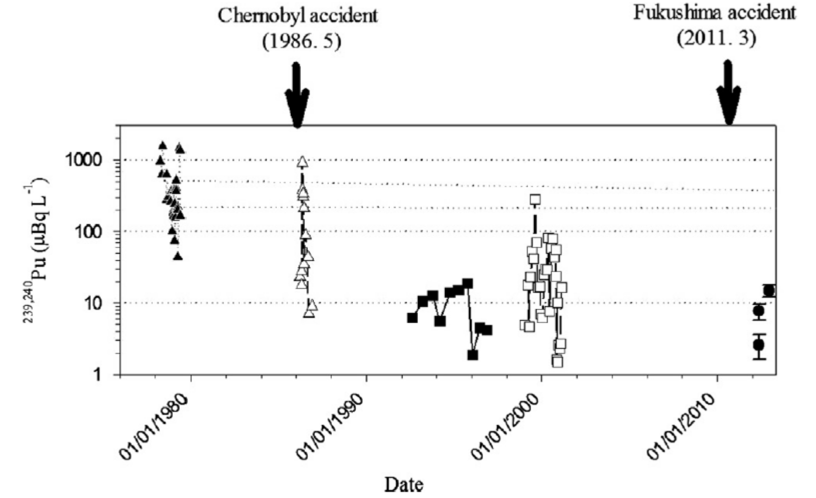



**Fig. 1.** Temporal variation of $^{239,240}Pu$ concentrations in rainwater (▲: Thein et al., 1980; Δ: Ballestra et al., 1987; ■: Rubio-Montero and Martin Sanchez, 2001; □: Lee et al., 2002; ●: this study).

# Concentration of Pu-239,240 in Dry deposition

| Date of Sampling | Dry deposition sample weight (g) | $^{239,240}Pu$ | | |
|---|---|---|---|---|
| | | Activity ($mBq/m^2$) | Uncertainty ($k=1$) | MDA (mBq/kg) |
| Nov. 2011 | 0.7742 | 0.137 | 0.102 | 0.119 |
| Dec. 2011 | 0.2913 | 0.153 | 0.092 | 0.089 |
| Jan. 2012 | 0.7239 | 0.246 | 0.103 | 0.068 |
| Feb. 2012 | 0.254 | <MDA | - | 0.121 |
| Mar. 2012 | 2.91 | 0.680 | 0.171 | 0.068 |
| Apr. 2012 | 3.02 | 0.669 | 0.203 | 0.097 |
| May 2012 | 1.76 | <MDA | - | 0.063 |
| Jun. 2012 | 2.33 | 0.478 | 0.166 | 0.117 |
| Jul. 2012 | 1.06 | 0.120 | 0.076 | 0.076 |
| Aug. 2012 | 0.77 | <MDA | - | 0.294 |

Concentration of Pu isotopes in dry deposition

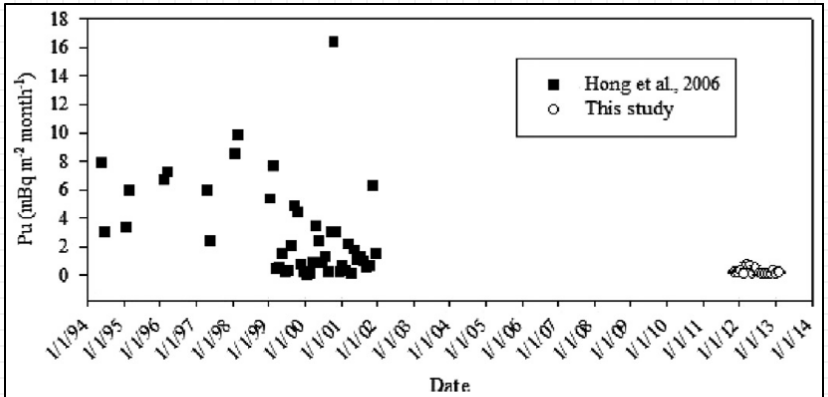



**Fig. 3.** Temporal variation of monthly deposition fluxes of $^{239,240}Pu$.

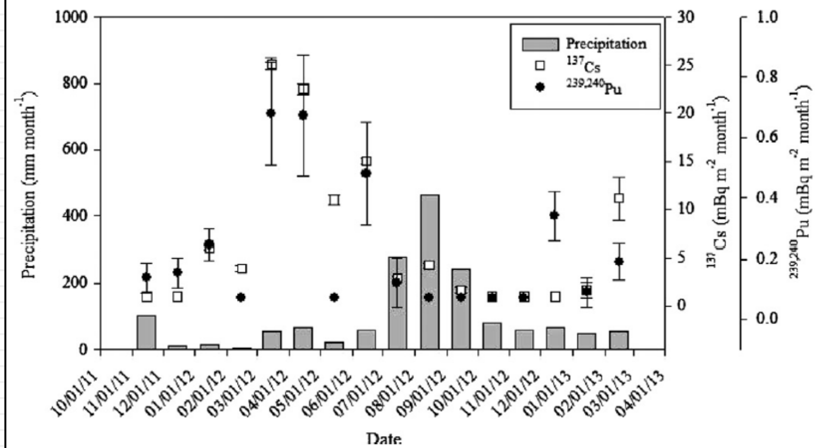



**Fig. 4.** Temporal variation of $^{239,240}Pu$ and $^{137}Cs$ in rainwater with precipitation in Daejeon, Korea.

CHAPTER

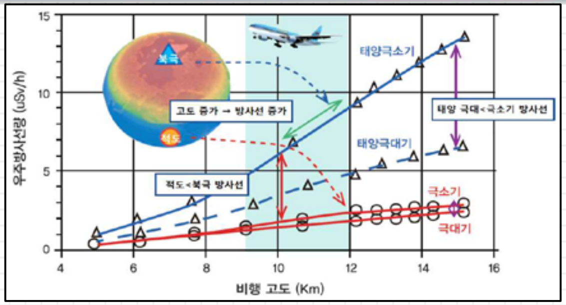
04

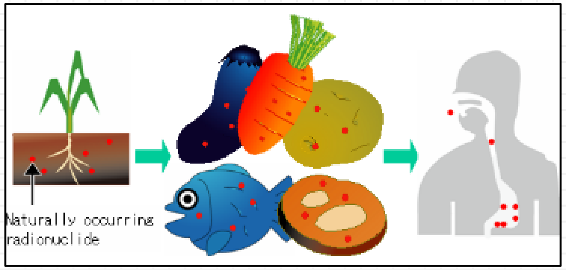
# Regulation of (TE)NORM in commodities

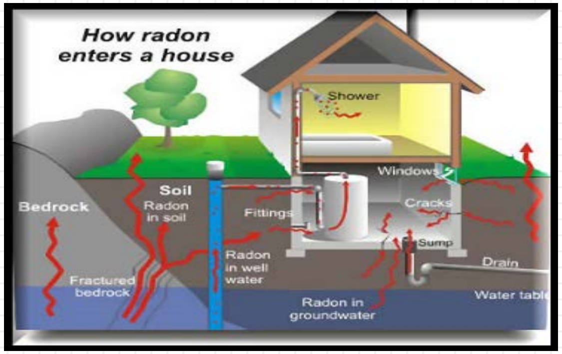
# Natural Radiation Source

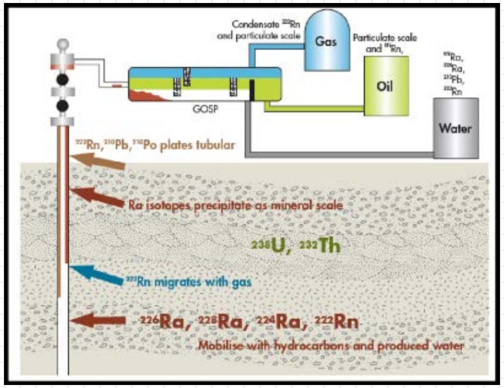


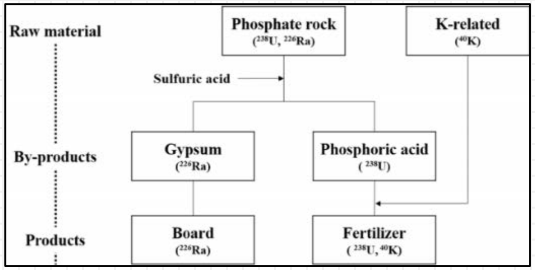
- **Cosmic radiation**
  - Cosmic rays : high-energy particles that originate in outer space
  - Cosmogenic radionuclides : $^{3}H$, $^{7}Be$, $^{14}C$, $^{22}Na$
- **Terrestrial Radiation**
  - External exposures : soils ($^{238}U$ series, $^{232}Th$ series, $^{40}K$), construction materials
  - Internal exposures : inhalation (air dust) & ingestion (food, water)
  - Radon : gaseous radioactive products (decay of the radium isotopes)
- **Enhanced exposures from industrial activities**
  - Phosphate processing, Metal ore processing, Uranium mining, Zircon sands, Titanium pigment production, Fossil fuels, Oil and gas extraction, Building materials, Thorium compounds, Scrap metal industry, Emissions.



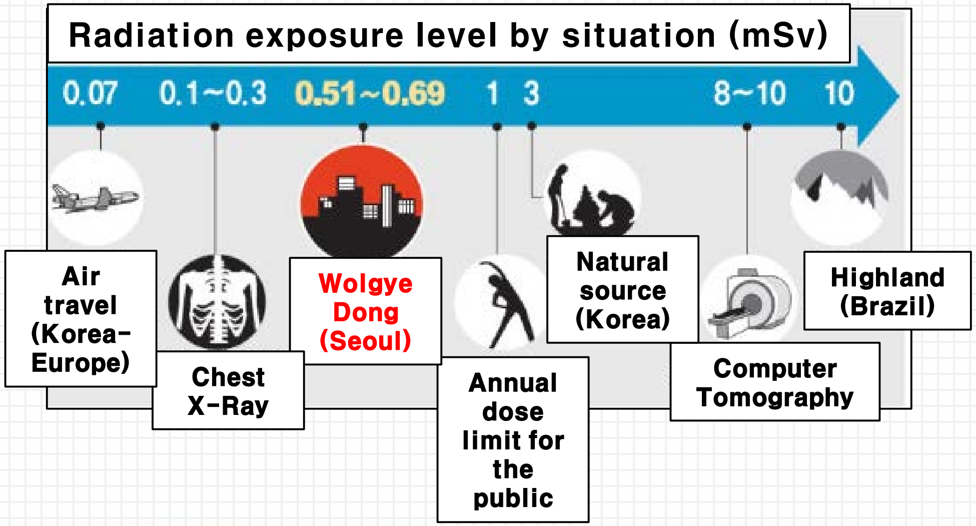



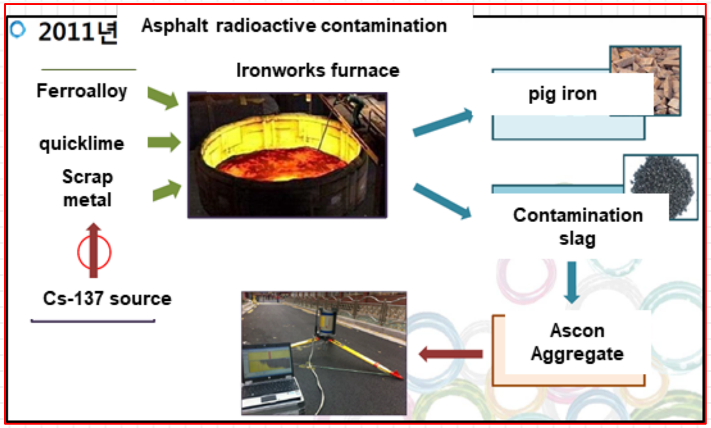



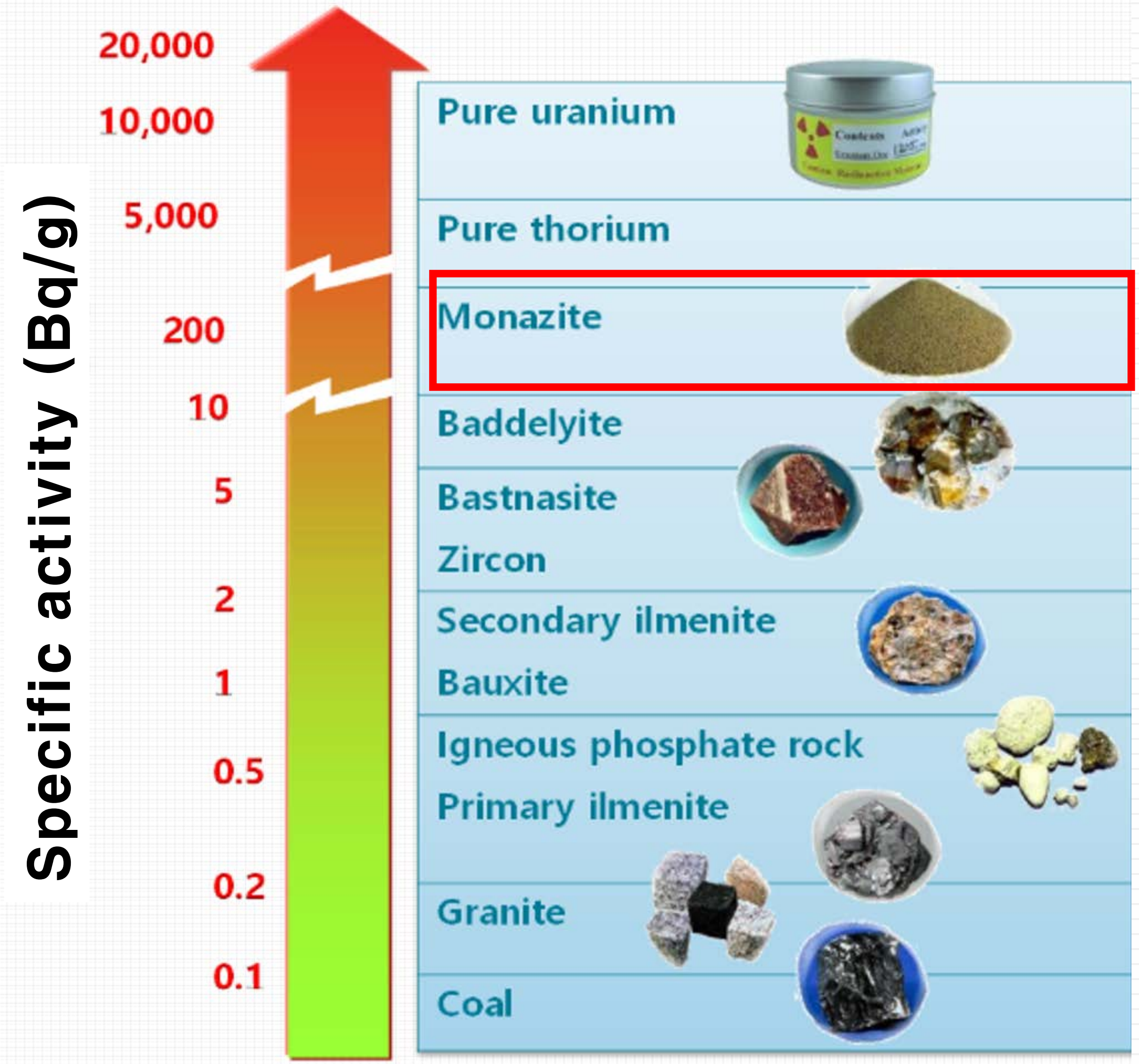
# Increased social interest due to radioactivity event (Radioactive asphalt)

- ✓ The annual radiation dose that can be received by people living in Wolgye 2-dong residential areas is measured as 0.51-0.69 mSv.
  (Annual radiation dose assumes that an adult male stays for 1 hour each day for 1 year).
- ✓ It is about a sixth to a quarter of the average annual radiation dose in Korea of 3 mSv, which is received from nature such as land, terrestrial , air, and space
- ✓ It is less than 1 mSv, the annual dose limit set by the Nuclear Safety Act.



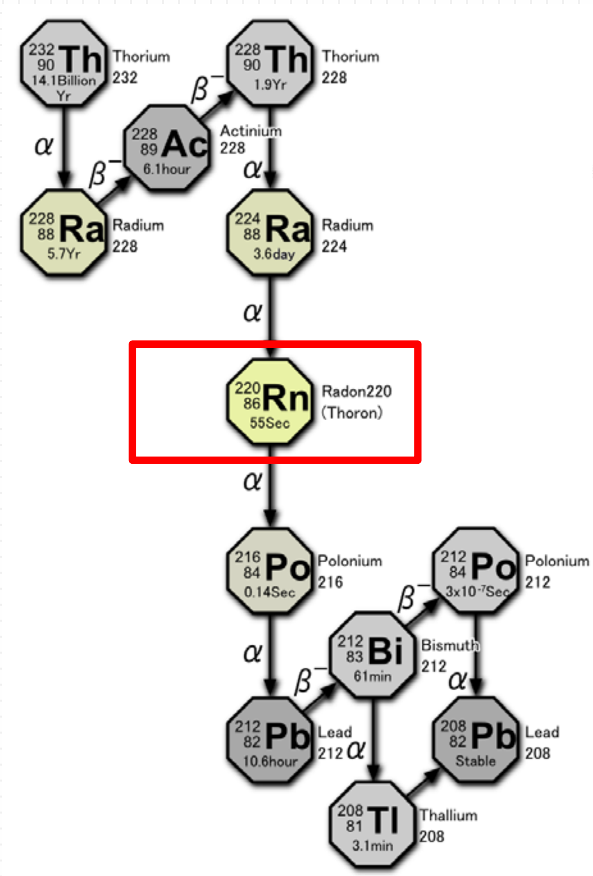



# Radiation levels of major industrial raw materials

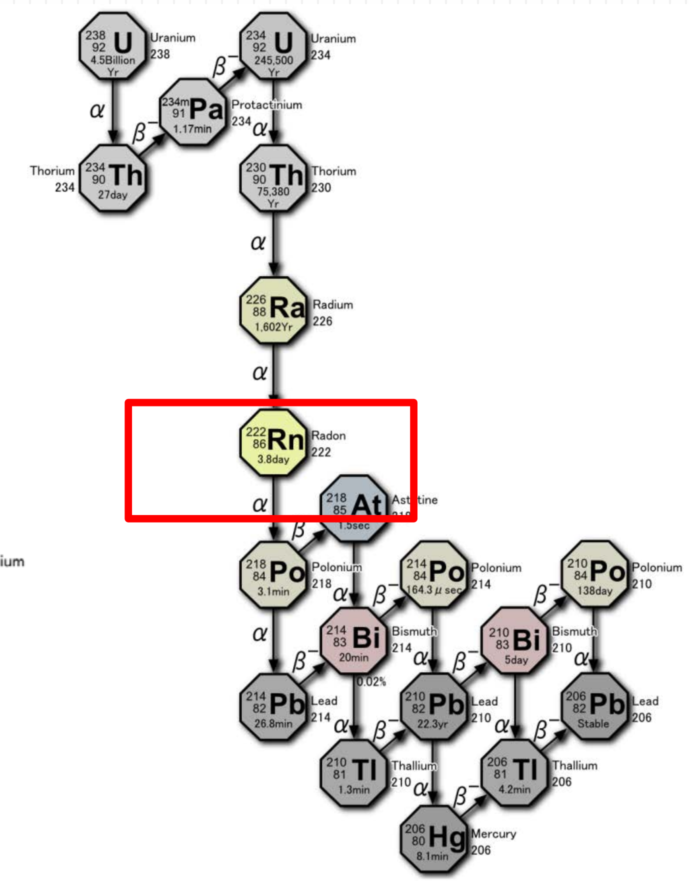


# Natural radionuclide decay series

$^{232}Th$




$^{238}U$



# Increased social interest due to radioactivity event (household products (or commodity) around daily life : anion effect




**Rumors spread that products that release anions are good for health ????**

# Increased social interest due to radioactivity event
# (household products (or commodity) around daily life : anion effect


국민일보

2009년 10월 09일 금요일 002 종합

## 건강팔찌·음이온매트 '방사능 범벅'

건축자재 생활용품 방사능 농도 검출 현황 (농도:Bq/g)

| | 팔찌(구슬) | 원형판(매트 재료) | 지압용 제품 | 음이온 타월 |
|---|---|---|---|---|
| 토륨(Th232) | 3.9 | 5.0 | 7.45 | 8.1 |
| 라듐(Ra226) | 0.6 | 1.3 | 2.14 | 0.7 |

(자료: 교육과학기술부)

### 암 유발 '토륨' 등 기준 초과– 건축자재서도 검출

## 초등교 發癌물질 '라돈' 과다검출

연세대 환경공해硏 조사

## 먹는샘물에 방사성물질

95~96년시판 3개사제품서 우라늄검출…대전 지하수도 오염

환경부 파자

"지하철 7호선 9개역 사



# The Brief Information of NORM Regulation

KRISS

## Purpose

- To prescribe those matters concerning safety management of radiation encountered in environments
- To protect the public health and the environment and improving quality of life while contributing to public safety

## Structure and other information

- 1 Act, 1 Enforcement Decree, 1 Enforcement Regulation, and 2 Notifications
- Enacted in 2011, and implemented in 2012 by Nuclear Safety and Security Commission(NSSC)

(Due to the issues of radiation exposure from the NORM products and Fukushima accident)

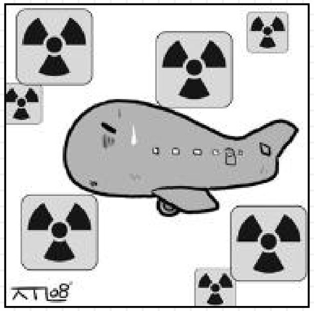
# The Brief Information of NORM Regulation

KRISS

## ● Target of radiation

- **NORM : Raw materials, Residues, The Product**
- Cosmic radiation (flight exposure to air crew)
- Terrestrial radiation (**radon excluded** because radon is already regulated by another act)
- Radioactive materials in the scrap metal

Cosmic ray

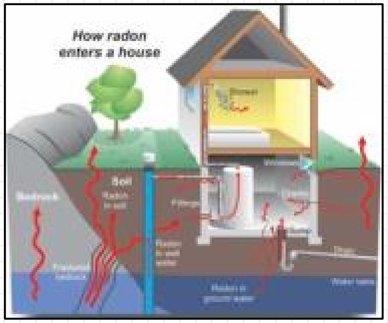


By-product

Recycled scrap metal

Raw materials

Terrestrial radiation



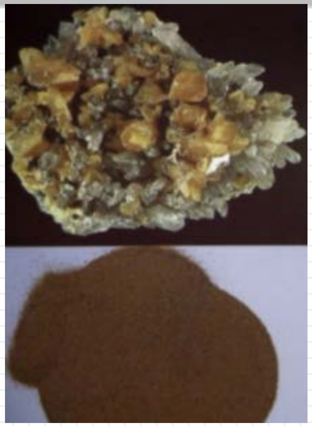
## Definition and Registration level

- **Reference**: IAEA RS-G-1.7, IAEA SRS-49
- **U-238 series, U-235 series, Th-232 series, and K-40**
- The handler (operator) **should be registered** if they deal with raw materials and residues **over registration levels**

| Sort | Definition | | Registration level | |
|---|---|---|---|---|
| | Bq/g | kBq | Bq/g | kBq |
| Raw materials | 0.1 (U, Th)<br>1 (K-40) | 100 | **1 (U, Th)<br>10 (K-40)** | **1,000<br>10,000** |
| Residues | 0.5 (U, Th)<br>5 (K-40) | - | **1 (U, Th)<br>10 (K-40)** | **1,000<br>10,000** |

# Assessment of dose-Raw material

KRISS




- ✓ The survey on raw materials and by-products was conducted for a total of 15 companies in four areas: workplaces handling raw materials, workplaces generating significant substances, facilities generating by-products, and workplaces suspected of significant substances.
- ✓ The maximum radiation dose rate in areas where there is a risk of external exposure was 0.62 μSv/h, and the maximum radiation dose was evaluated as low as 0.21 mSv/y for the total internal and external exposure.

(KINS/GR-547, 2019)

# Assessment of dose-Drinking water

- ✓ In the production of drinking water, $^{210}Pb$, a daughter nuclide of radon discharged with groundwater, can be concentrated in the filter.
- ✓ However, as a result of radioactivity analysis, it did not meet the criteria for defining by-products.
- ✓ In addition, the radiation dose to workers was 0.0039 mSv/y.

(KINS/GR-547, 2019)

# Assessment of dose-processed products




- ✓ The survey on processed products is conducted to analyze the concentration of radioactivity for a total of 513 products and evaluate the annual exposure dose.
- ✓ The radon and toron concentrations of all 513 products were measured, and internal exposure doses for 411 products were evaluated. (KINS/GR-547, 2019)
- ✓ Of the 411 products, 68 products exceeded the exposure dose of 1 mSv.
  (17 mattresses, 14 electric mats, 8 blankets, 6 pads, 6 thermal mats, 5 pillows, 4 suit-type underwear, 4 blankets, 2 latex mattresses, 1 hot water mat, 1 sofa, etc.)
  (KINS/GR-547, 2019)

# Assessment of dose-air transportation business

KRISS

- ✓ According to the survey on air transportation business operators in 2019, there are 9 business operators in Korea.
- ✓ The number of crew members was 22,484
- ✓ The business operator is using CARI-6/6M and NAIRAS as a program for evaluating the exposure dose by cosmic radiation.
- ✓ It was found that the annual average dose of crew members received 2.09 mSv.
- ✓ According to the safety instructions, the flight attendant is recommended that does not exceed 6 mSv
- ✓ Therefore, it is investigated that no one exceeds the value.

(KINS/GR-547, 2019)

CHAPTER

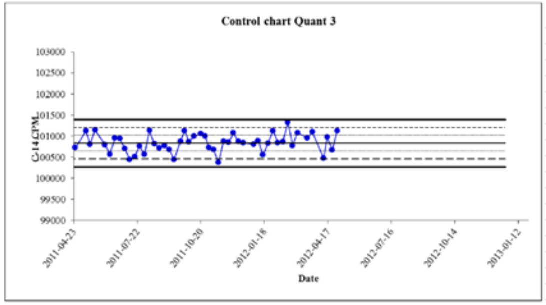
05

# QA/QC for radionuclide data

## ❖ Quality Assurance & Quality Control

➢ **QA** : The process used to create the deliverables, and can be performed by a manager, client, or even a third-party reviewer
(ex. checklist, audits, methodology and standards development)

➢ **QC** : Quality related activities associated with the creation of project deliverables. Quality control is used to verify that deliverables are of acceptable quality and that they are complete and correct
(ex. calibration, control charts, proficiency tests)



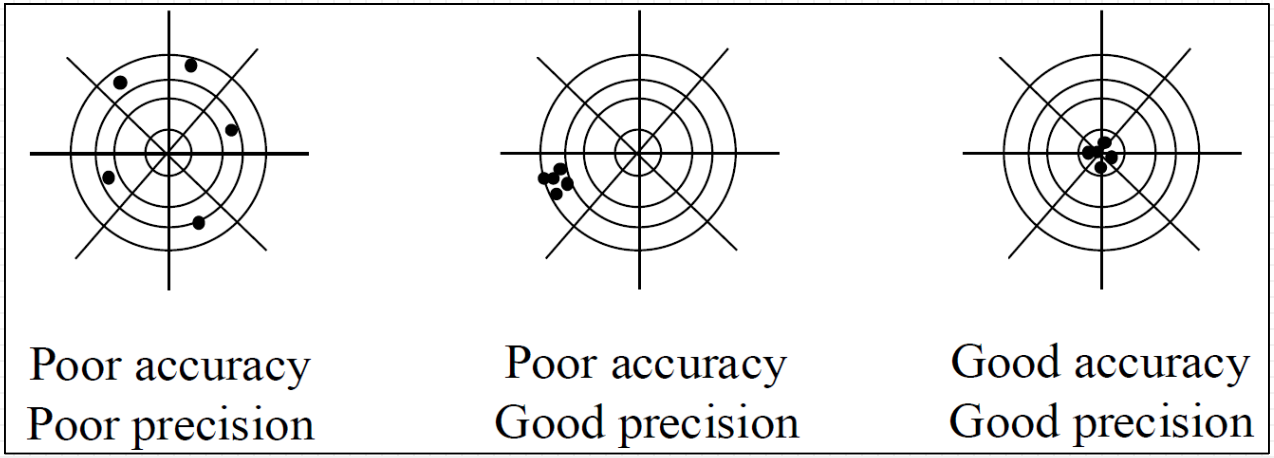
# Accuracy and Precision

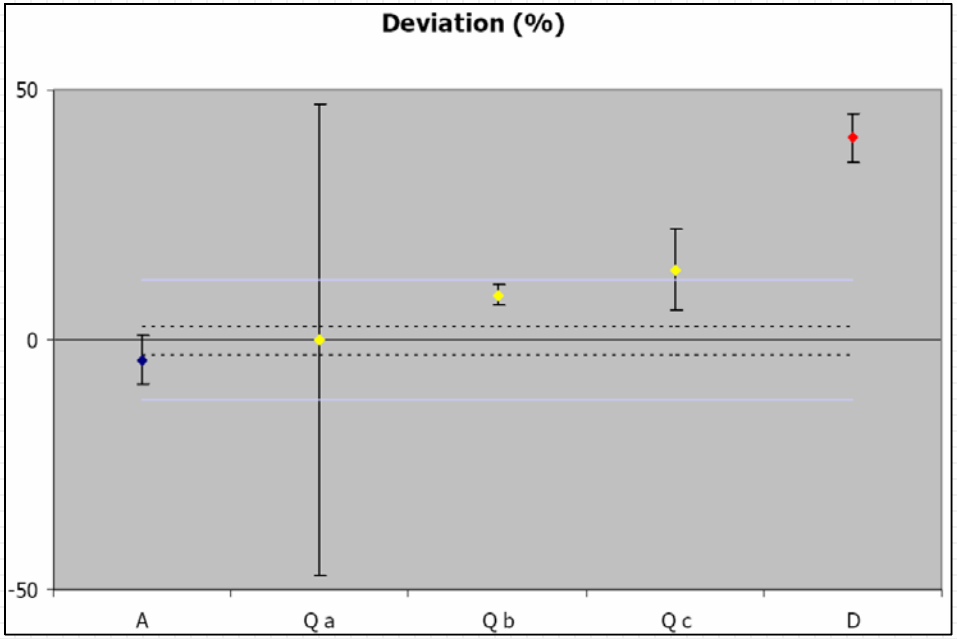
KRISS

- Accuracy is a measure of how close the measured value is to the 'true' result (Certified value or reference value)
- The accuracy of any technique is assessed through the measurement of CRMs (certified reference materials) and through participation in national and international proficiency tests.
- Where no standards or proficiency tests are available for the particular analyte of matrix, the accuracy of the measurement may be assessed by spiking a matrix-matched blank (containing none of the analyte) with a known quantity of a standard solution of the analyte and using this as a standard

- Precision is a measure of the scatter of results for repeated analyses.
- The precision of a technique will be dependent on the uncertainties associated with the technique and will deteriorate as the analyte concentration decreases.
- The precision of a technique is assessed by multiple analysis of a homogenous material containing the analyte of interest and determining the standard deviation on the mean of the measurement results.

# Accuracy and Precision



# Measurement uncertainty

KRISS

- For any analytical measurement, the reported result will be accompanied by a measurement uncertainty quoted with a given confidence level (usually 95% or 2 s.d.). The quoted uncertainty provides an indication of the precision of the measurement. The true value for the sample will lie (with the degree of confidence quoted) somewhere within the range specified by the uncertainty.

- For example a reported results of 10 ± 2 Bq/kg (2 s.d.) would indicate that there is a 95% probability that the true value is between 8 and 12 Bq/kg. However, there is a 5% chance that the true activity concentration is either lower than 8 or greater than 12 Bq/kg.

# Uncertainty component

KRISS

- **Counting statistical uncertainties**

Arising from the random nature of radioactive decay, these uncertainties are associated with the radiometric measurement of the purified source and instrument background. The uncertainties will decrease relative to the measured value with increasing counts detected (not count rate). Hence the uncertainties can be reduced by increasing the activity measured (e.g. by increasing the sample size taken) and increasing the count time.

- **Other method uncertainties**

Other uncertainties arising from the methodology and instrument calibration including

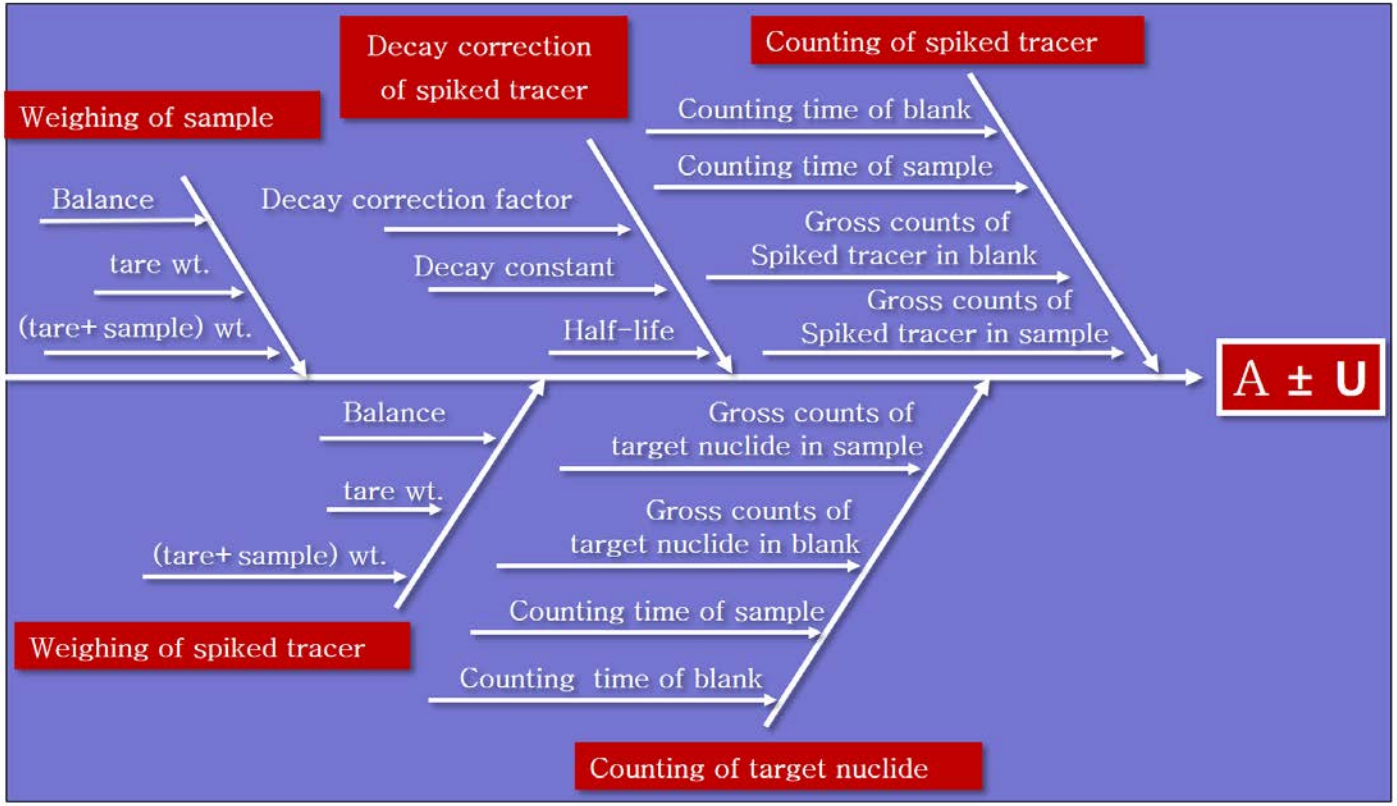
- Sub-sampling
- Weighing / pipetting operations
- Calibration of pipettes, balances or radiometric equipment
- Yield monitor concentration / activity
- Spectral deconvolution / peak fitting
- Decay correction half-life

* Fishbone

Uncertainties from all sources are combined to give the total expanded uncertainty. Typically, total expanded uncertainties are around the 5 – 10% of the measured value.

KRISS

## Expression of uncertainty in measurement results (fishbone)



## 5 steps to calculate uncertainty

**Equation**

$$m = x + c$$

**Uncertainty components**

$$u(x), \quad u(c)$$

**Standard uncertainty $u_i$**

Statistical: **A type**

Non-statistical: **B type**

**Factor $C_i$**

**Combined standard uncertainty $u_c$**

$$u_c(m) = \sqrt{u^2(x) + u^2(c)}$$

**Confidence level, Degree of freedom**

**Expanded uncertainty $U$**

$$U = 2 \times u_c(m)$$

# LOD and MDA

KRISS

- The **limit of detection (LOD)** is defined for a given measurement process as the smallest true net count rate that is ‘certain’ to be detected with a specified degree of confidence.

- The **minimum detectable activity (MDA)** is the detection limit corrected to units of Bq per unit volume or mass of sample.

- A number of factors affect the limit of detection

✓ Method used for calculation !
✓ Instrument background
✓ Counting efficiency
✓ Amount of sample analysed
✓ Length of count time

When planning an analytical programme it is important to determine the limits of detection required. In general, **lower limits of detection result in higher analytical costs** so in many instances project costs can be reduced by realistically setting limits of detection required rather than requesting ‘the lowest possible’ .

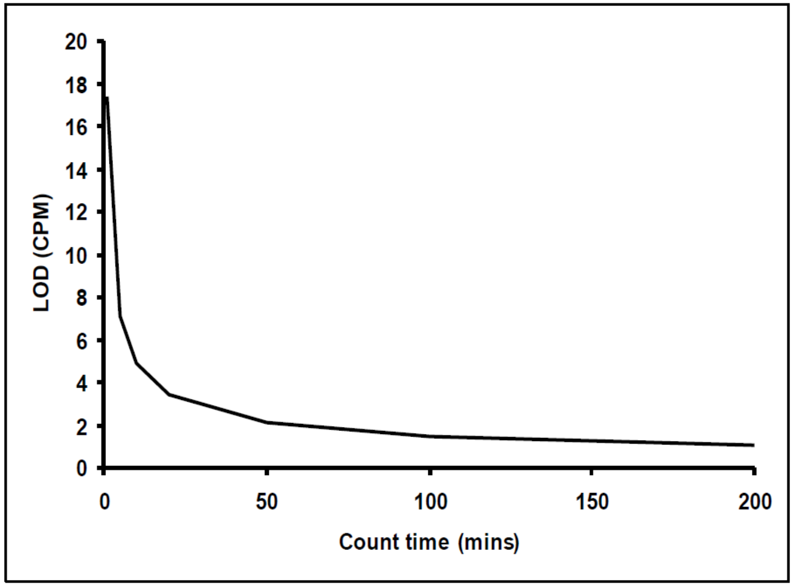
➢MDA (Bq/L, kg, g, mL etc)

$$MDA = \frac{(2.71 + 4.65\sqrt{(B \times t)})}{(E \times V \times t)}$$

*Where*

E = counting efficiency
V = Sample size (kg, L etc)
B = Background count rate
t = Counting time

Lloyd A. Currie (1968) Limits for Qualitative Detection and Quantitative Determination: Application to Radiochemistry, ***Anal. Chem.*** **40**, 586-593.



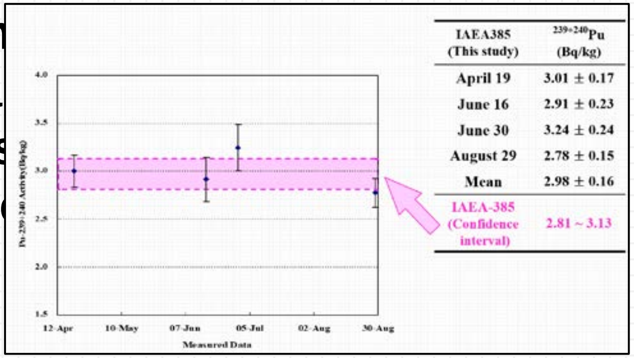

MDA may be reduced by increasing the counting time.

However, considerable increases in counting time may be required in order to achieve significant reductions in MDA.

# ISO/IEC 17025-Ensuring the validity of results

**The laboratory shall have a procedure for monitoring the validity of results. The resulting data shall be recorded in such a way that trends are detectable and, where practicable, statistical techniques shall be applied to review the results. This monitoring shall be planned and reviewed and shall include, where appropriate, but not be limited to:.**

**a) use of reference materials or quality control materials;**
**b) use of alternative instrumentation that has been calibrated to provide traceable results;**
**c) functional check(s) of measuring and testing equipment;**
**d) use of check or working standards with control charts, where applicable;**
**e) intermediate checks on measuring equipn**
**f) replicate tests or calibrations using the sa**
**g) retesting or recalibration of retained items**
**h) correlation of results for different characte**
**i) review of reported results;**
**j) intralaboratory comparisons;**
**k) testing of blind sample(s).**



# ISO/IEC 17025-Ensuring the validity of results

KRISS

**The laboratory shall monitor its performance by comparison with results of other laboratories, where available and appropriate. This monitoring shall be planned and reviewed and shall include, but not be limited to, either or both of the following:**

**a) participation in proficiency testing;**

**NOTE ISO/IEC 17043 contains additional information on proficiency tests and proficiency testing providers. Proficiency testing providers that meet the requirements of ISO/IEC 17043 are considered to be competent.**

**b) participation in interlaboratory comparisons other than proficiency testing.**

a) The difference, $D$, is calculated using Equation (B.1):

$$D = (x - X)$$

where

$x$ is the participant's result;

$X$ is the assigned value.

b) The percent difference, $D_{\%}$, is calculated using Equation (B.2):

$$D_{\%} = \frac{(x - X)}{X} \times 100$$

c) The $z$ scores are calculated using Equation (B.3):

$$z = \frac{x - X}{\hat{\sigma}} \quad \text{(B.3)}$$

where $\hat{\sigma}$ is the standard deviation for proficiency assessment.

As described in ISO 13528, $\hat{\sigma}$ can be calculated from the following:

— a fitness for purpose goal for performance, as determined by expert judgement or regulatory mandate (prescribed value);

— an estimate from previous rounds of proficiency testing or expectations based on experience (by perception);

— an estimate from a statistical model (general model);

— the results of a precision experiment; or

— participant results, i.e. a traditional or robust standard deviation based on participant results.

e) $E_n$ numbers are calculated using Equation (B.5):

$$E_n = \frac{x - X}{\sqrt{U_{\text{lab}}^2 + U_{\text{ref}}^2}}$$

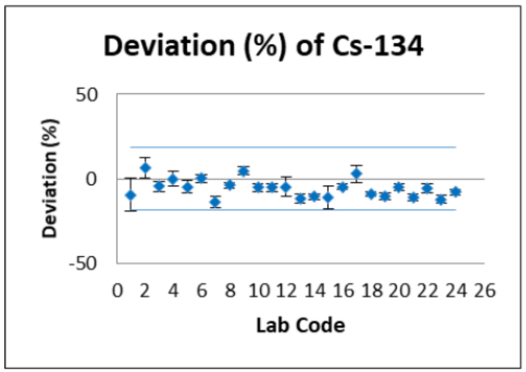
where

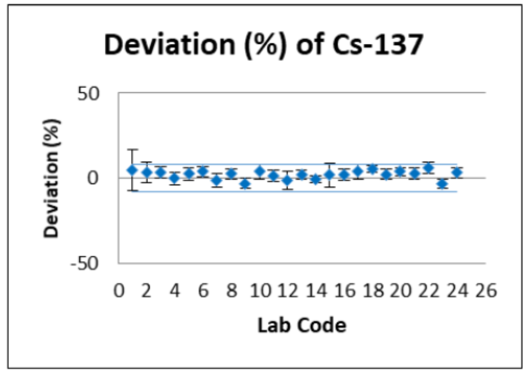
$U_{\text{lab}}$ is the expanded uncertainty of a participant's result;

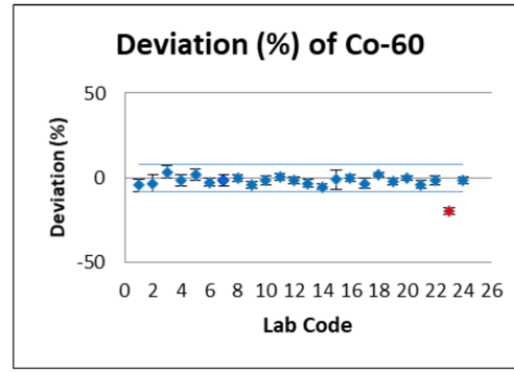
$U_{\text{ref}}$ is the expanded uncertainty of the reference laboratory's assigned value.

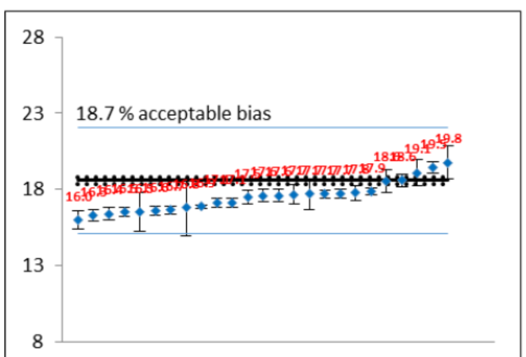
# Proficiency Test

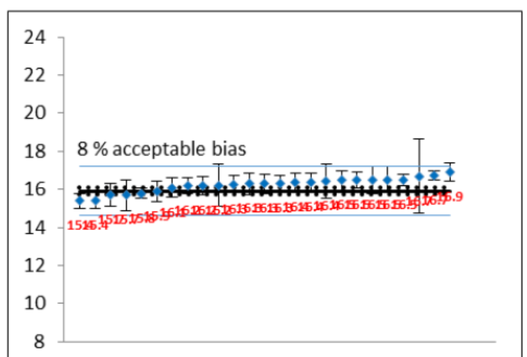


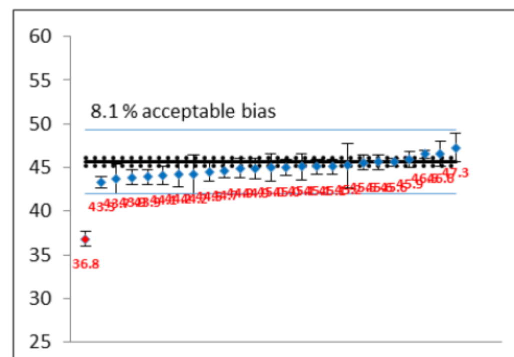





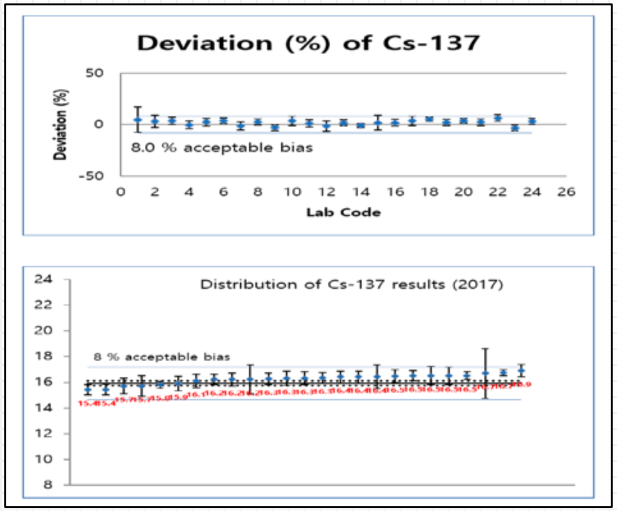






# Proficiency Test-seminar, symposium




한국인정기구 숙련도시험 프로그램
[PT 2018-35 방사능측정]

1. 목적

본 숙련도시험은 방사능측정에 대하여 KOLAS 인정 국제공인 시험기관, 그 외 방사능측정기관을 대상으로 측정능력을 확인하고 문제점을 분석하여 측정 정확도를 선진국 수준으로 향상시키는데 그 목적이 있다.

2. 측정시료

본 숙련도시험 프로그램에 참가한 기관들은 아래와 같은 시료를 전달받게 된다.

그림 1. 방사능측정 숙련도시험 시료

# Crucial activities for production for CRM

KRISS

## ISO Guide 30~35

**All or some of the following activities can be crucial in RM production and their quality assessment can be crucial to the quality of the final RM:**

- ✓ **Sourcing of materials including synthesis**
- ✓ **Processing of materials including purification, grinding, particle size separation**
- ✓ **Homogeneity and stability testing**
- ✓ **Development and validation of measurement procedures, including consideration of the traceability**
- ✓ **Measurement of property values and evaluation of measurement uncertainty**
- ✓ **Certification and sign off of the RM**

# Development of Oyster CRM (ISO Guide 35)



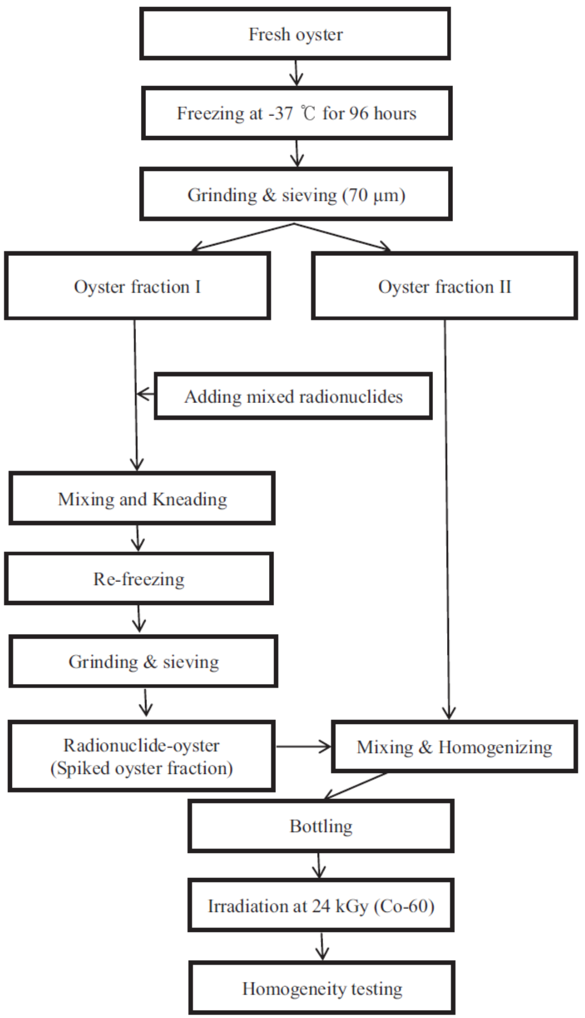
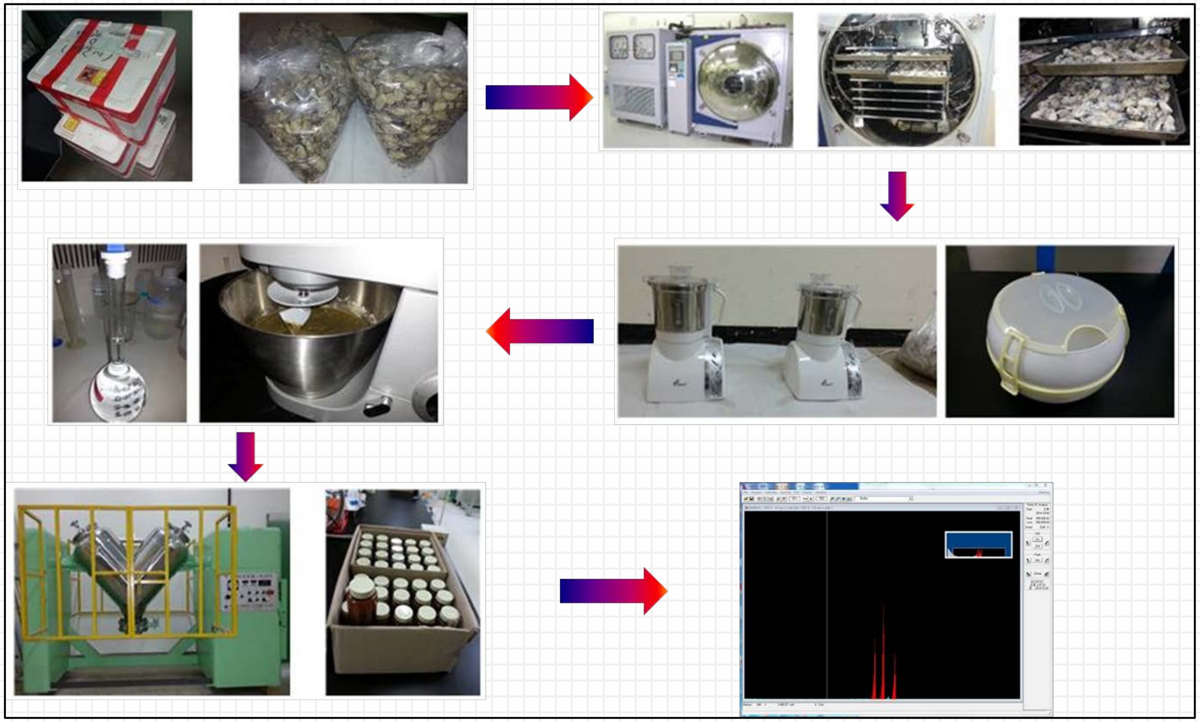



**Fig. 1.** Scheme of the oyster RM preparation.

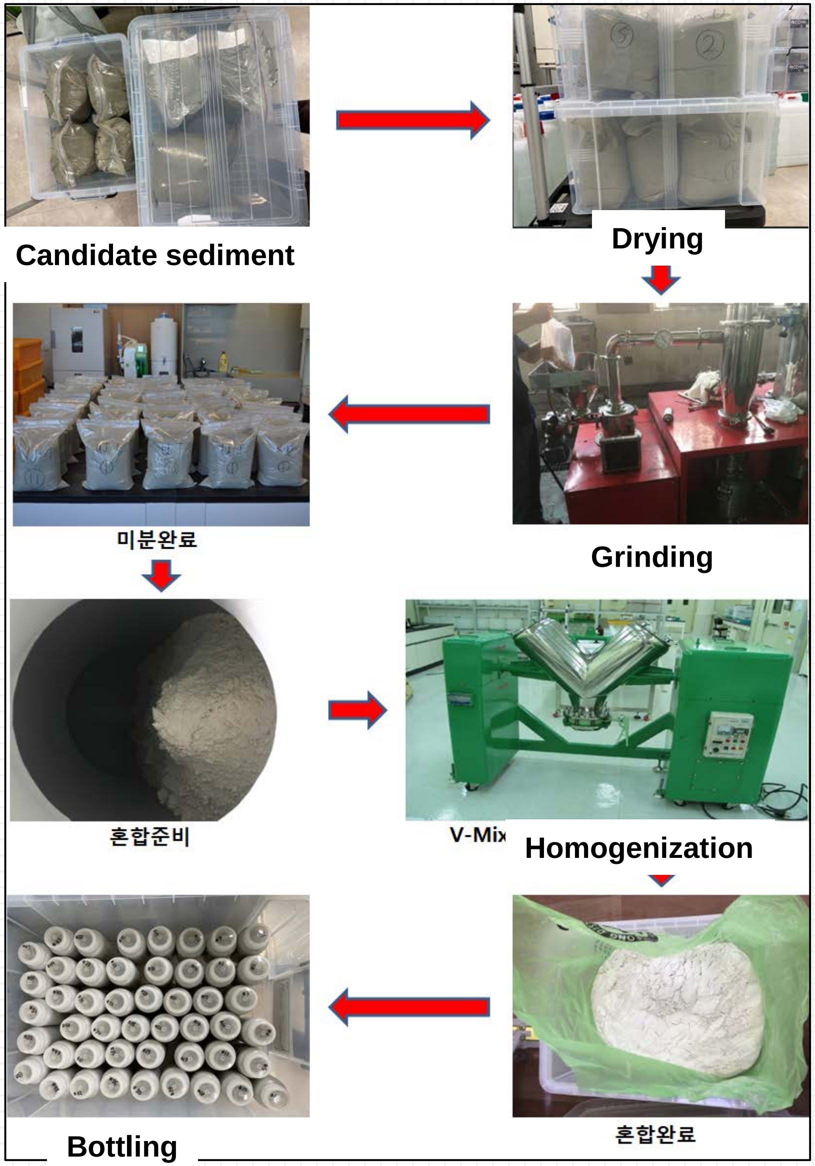


Analysis of variance (ANOVA) test for radionuclides.

| | Sources of variation | Sum of squares | Degree of freedom | Mean squares | *F*-value | *P*-value | Critical *F* values |
|---|---|---|---|---|---|---|---|
| Pu-239,240 (Bq/kg) | Treatment (Among) | 3.16 | 9 | 0.351 | 1.27 | 0.354 | 3.02 |
| | Residual (Within) | 2.76 | 10 | 0.276 | | | |
| | Total | 5.92 | 19 | | | | |
| Pu-238 (Bq/kg) | Treatment (Among) | 1.74 | 9 | 0.193 | 2.50 | 0.084 | 3.02 |
| | Residual (Within) | 0.77 | 10 | 0.077 | | | |
| | Total | 2.51 | 19 | | | | |
| Cs-137 (count rate) | Treatment (Among) | 17005 | 9 | 1889 | 0.305 | 0.956 | 3.02 |
| | Residual (Within) | 61945 | 10 | 6194 | | | |
| | Total | 78950 | 19 | | | | |
| Sr-90 (Bq/kg) | Treatment (Among) | 429 | 9 | 47.7 | 1.32 | 0.335 | 3.02 |
| | Residual (Within) | 362 | 10 | 36.2 | | | |
| | Total | 791 | 19 | | | | |

*S.-H. Lee et al. / Applied Radiation and Isotopes 109 (2016) 109–113*

# Development of Sediment CRM (ISO Guide 35)





Analysis of variance (ANOVA) test for radionuclides.

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| | Residual (Within) | 362 | 10 | 36.2 | | | |
| | Total | 791 | 19 | | | | |

Homogenization test

# CRMs and international comparison exercise

KRISS

❖ **International comparison exercise materials for radioactivity measurement of (mushroom) material developed by KRISS (BIPM CCRI(II)-S15)**

❖ **International comparison exercise materials for radioactivity measurement of (rice) material developed by KRISS (BIPM CCRI(II)-S9)**


| Radionuclide source ID | KRISS Seawater CRM |
|---|---|
| Source description | Seawater containing $^{137}Cs$ |
| Reference date | 1. Oct. 2012 |
| Specific activity (Bq/kg) | 100.1 |
| Total expanded uncertainty (%) | 1.44 |
| Half life (yr) | 30.05 |
| Measurement technique | HPGE gamma spectrometry |

ご清聴ありがとうございました


**Thank you for your attention!**

**감사합니다**

KRISS 한국표준과학연구원