NRRC Specific Regulations

Radiological Safety of Public Consumption Foodstuff in Existing Exposure Situations

NRRC-R-01-SR09

2023

هيئة الرقابة النووية والإشعاعية
Nuclear and Radiological Regulatory Commission

Specific Regulation

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Preamble

In accordance with the provisions of the Radiation Safety Regulation (NRRC-R-01), approved by the NRRC's Board of Directors in resolution No. (R/1/1/2022), dated 20 April 2022, chapter (16) section (105) article (287(b)). This specific regulation provides detailed requirements for provides the risk management and control measures needed to guarantee that foods intended for public consumption are radiologically safe.

This specific regulation has been prepared on the basis of International Atomic Energy Agency (IAEA) standards, World Health Organization recommendations, as well as the international best practices and the experiences of similar international regulatory bodies, and in accordance with the Kingdom's international commitments, and it has been approved by the NRRC's CEO resolution No. 1147, dated 25/4/2023.

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Chapter 1: Objective, Scope, and Definitions

Section 1: Objective

1. This specific regulation provides the control and risk management strategies to ensure radiologically safe foodstuff for public consumption. It sets the practical requirements to support taking appropriate action related to radioactivity in foodstuff that occurs during normal situations. These situations are where there could be consumption of foodstuff containing radionuclides over extended periods of time leading to prolonged radiation exposure of individuals. Exposure could continue for many years or even over a lifetime.

Section 2: Scope

2. Radionuclides of both natural and human-made origin are present at various concentrations in food, resulting in exposure to ionizing radiation and an internal radiation dose in non-emergency situations and are included in this Specific regulation.

3. This specific regulation applies relevant national foodstuff standards and implementation activities to the foodstuff produced locally or imported to the Kingdom, particularly when national standards are exceeded.

4. The target audience is the individuals and organizations that manage risks from radioactivity in foodstuff, foodstuff suppliers, foodstuff regulators, and radiation protection specialists. It is not written for communication to members of the public, although it may be helpful for such materials which shall be developed by food authorities.

5. This specific regulation is not intended to apply in case of nuclear and radiological emergency resulted to radioactive contamination of foods.

Section 3: Definitions

Activity Concentration

The activity per unit mass or volume of the material in which the radionuclides are essentially uniformly distributed.

Guidance level

The guidance levels are activity concentrations in drinking-water that can be measured at an operational level by water suppliers as part of drinkingwater monitoring and assessment.

Individual dose criterion (IDC)

The individual dose criterion (IDC) of 0.1 mSv y^{-1} is established for assessing health risks to an individual from prolonged exposure to radionuclides in drinkingwater. The guidance levels have been developed as practical operational criteria to be used to assess if the IDC is exceeded.

Reference level

For an emergency exposure situation or an existing exposure situation, the level of risk or activity (A) concentration above which it is not appropriate to plan to allow exposures to occur and below which optimization of protection and safety would continue to be implemented.

Screening level

The screening levels are activity concentrations that can be used to demonstrate if the IDC may be exceeded. If either of the screening levels are exceeded, the activity concentrations of individual radionuclides should be determined and compared with the guidance levels (see below).

Chapter 2: Approach Adopted for Assessing Public Health Risk from Radionuclides In Foodstuff

Section 4: The individual dose criterion (IDC)

6. The individual dose criterion (IDC) shall be equal to 0.1 mSv y^{-1} effective dose for assessing public health risks from prolonged exposure to radionuclides in foodstuff.

Section 5: Reference levels

7. In the case of radionuclides in food, the relevant dose quantity shall be the committed effective dose for ingestion. The dose cannot be measured directly, it can only be estimated by assessment. However, the activity concentrations of radionuclides in food that give rise to exposure and therefore deliver dose, can be measured directly. In the case of radionuclides in food, either the activity concentration of specific radionuclides in individual foods or in representative diet samples containing several individual foods are measured. There is, therefore, the option of defining reference levels in terms of individual dose (for the overall diet) or activity concentration (for individual foods).

8. The annual effective dose criterion of 1 mSv represents an individual dose that is somewhat higher than the annual ingested dose received by the majority of the general population from the diet. It is identified that there are seven radionuclides which to-gether represent over 90% of the dose from the diet. These are ^{210}Po, ^{210}Pb and ^{226}Ra from the uranium decay series, ^{228}Ra from the thorium decay series and radiocaesium ($^{137+134}Cs$), ^{90}Sr and ^{14}C. Although potassium (^{40}K) also contributes to the food ingestion dose it is not amenable to control.

TABLE 1: Radionuclides Present in the Foodstuff

Radionuclide	Origin
^{210}Po	Natural radioactivity - uranium decay series
^{210}Pb	Natural radioactivity - uranium decay series
^{226}Ra	Natural radioactivity - uranium decay series
^{228}Ra	Natural radioactivity – thorium decay series
radiocaesium ($^{137+134}Cs$)	Artificial - global fallout
^{90}Sr	Artificial - global fallout
^{14}C	Natural radioactivity – cosmic rays (^{14}N)

9. The guidance levels of radionuclide concentration in foodstuff shall be established as listed below in Table 2.

TABLE 2: Food Guidance Levels for Food Products (Bq/Kg) Corresponding to An Individual Dose Criterion of 0.1 mSv per year

Radionuclide	Committed effective dose per unit intake (mSv/Bq)	Guidance level for food products (Bq/kg) Calculated
Radionuclides of primary interest for food products		
^{228}Ra	6.9×10^{-4}	0.26
^{226}Ra	2.8×10^{-4}	0.65
^{210}Pb	6.9×10^{-4}	0.26
^{210}Po	1.2×10^{-3}	0.15
^{137}Cs	1.3×10^{-5}	14
^{134}Cs	1.9×10^{-5}	10
^{90}Sr	2.8×10^{-5}	6
^{14}C	5.8×10^{-7}	313
Other radionuclides		
^{3}H*	4.2×10^{-8}	4300
^{131}I	2.2×10^{-5}	8
^{234}U**	4.9×10^{-5}	3.7
^{238}U**	4.5×10^{-5}	4
$^{239+240}Pu$	2.5×10^{-4}	0.7
^{241}Am	2.0×10^{-4}	0.9
^{228}Th	7.2×10^{-5}	2.5
^{230}Th	2.1×10^{-4}	0.9
^{232}Th	2.3×10^{-4}	0.8

* Calculation of the food value has assumed that all tritium is organically bound tritium.

** Uranium is typically controlled on the basis of its chemical toxicity which is more restrictive than its radiotoxicity.

Chapter 3: Assessing Radionuclide Concentrations in Individual Foods

Section 6: Radionuclide reference levels

10. When considering individual foods and food products contaminated by naturally occur-ring radionuclides, 95th percentile activity concentration reference levels given by Table 3 shall be used.

Table 3.Summary of 95th Percentile values (Bq/kg) for ^{210}Po, ^{210}Pb, ^{228}Ra, ^{226}Ra in Individual Food Products

Food	Food product	95th Percentile activity concentration (Bq/kg)			
		^{210}Po	^{210}Pb	^{228}Ra	^{226}Ra
Terrestrial foods					
Fruit	Fruit	0.9	1.1	1.4	1.1
Grain	Grain	1.5	1.5	0.7	1.5
Liquid milk	Liquid milk	1.5	0.2	0.1	0.8*
Meat	Meat	0.4	0.8	0.5	0.2
Vegetables	Non-root vegetables	0.6	1.5	2.1	2.4
	Root vegetables	0.3	0.9	6.1	2.1
Aquatic foods					
Mollusks	Bivalves	134	7.4	0.7	1.1
	Cephalopods	12	11.2	N/D**	N/D**
	Gastropods	32	11.2	N/D**	N/D**
Crustaceans					
	Crabs	37	0.5***	N/D**	0.6***
	Lobster	25	0.5***	N/D**	0.6***
	Prawn and shrimp	32	0.5***	N/D**	0.6***
	Scampi (Norwegian	5.3	0.5***	N/D**	0.6***
Fish	Freshwater fish	6.7	1.5	1.2	1.1
	Saltwater fish	36	1.4	5.5	2.0
Seaweed	Seaweed	4.3	1.2	N/D**	N/D**

* This value is below the rounded guidance level for ^{226}Ra in Table 1

** N/D: not derived.

*** 0.5 Bq/kg ^{210}Pb and 0.6 Bq/kg ^{226}Ra are generic to "crustaceans" i.e. crabs, lobsters, prawns and shrimps plus scampi

Section 7: Summary Table

Table 4. Summary of Guidance Levels for Food Products that Shall be used to Assess Exposure from Radionuclides in Food Products

Radionuclide	Guidance Level for Food Products (Bq/kg)
^{210}Po*	95^{th} percentile or 0.15
^{210}Pb*	95^{th} percentile or 0.26
^{228}Ra*	95^{th} percentile or 0.26
^{226}Ra*	95^{th} percentile or 0.65
^{137}Cs	14
^{134}Cs	10
^{90}Sr	6
^{14}C	313
^{3}H	4300
^{131}I	8
$^{239+240}Pu$	0.7
^{241}Am	0.9
^{228}Th	2.5
^{230}Th	0.9
^{232}Th	0.8

* The 95th percentile values have been developed for the four natural radionuclides of ^{228}Ra, ^{226}Ra, ^{210}Pb and ^{210}Po for several different food subgroups and food products can be used (Table 3). If the 95th percentile values for the food group or food product of interest are not available, the calculated values for these four radionuclidescould be used.

Chapter 4: Monitoring Programmes for Radionuclides in Foods

11. In situations where the activity concentration of a specific radionuclide consistently exceeds the values in Tables 1 and 2, a long-term monitoring programme to follow changes in the activity concentration and to evaluate the doses to consumers shall be established. This would be particularly important if the food in question is a staple food widely consumed throughout the country. Along with regular analysis of food samples, the establishment of monitoring programmes will allow to provide factual public information and to quickly identify situations where further investigation, and possible actions, may need to be considered.

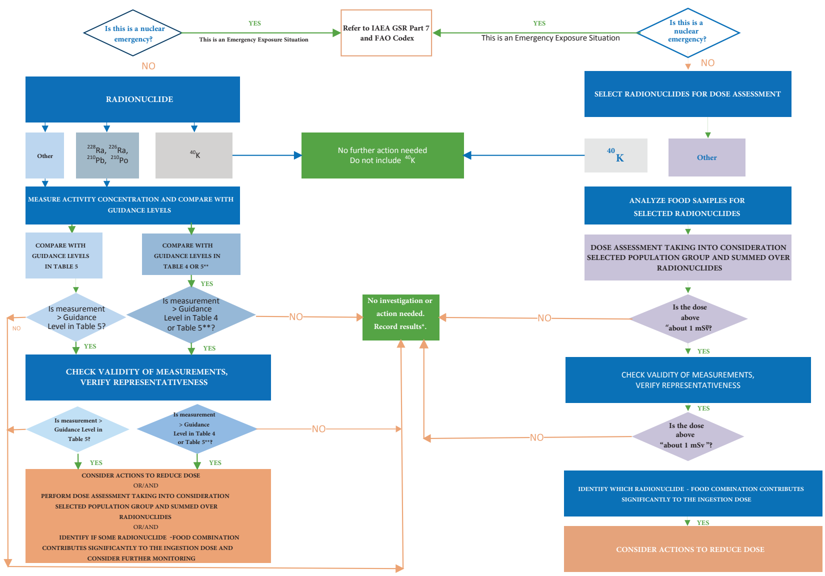
12. Various analytical methods for radioactivity in foods are summarized in Table 5. The measurement of activity concentration should be performed according to the approved standard methods of measurement, which can be used for concluding whether the reference levels are exceeded or not.

Table 5. Overview of Methods Used For Radioactivity Analysis in Food Samples

Radionuclide	Typical minimum detection limit* (Bq/kg)	Measurement technique	Radioanalytical technique
^{210}Po	0.002 – 0.02	Alpha spectrometry	Co-precipitation
			Spontaneous deposition
^{210}Pb	0.003 – 0.03	Gas proportional	Co-precipitation
			Extraction chromatography (Sr-resin)
		Liquid scintillation	Anion exchange chromato-graphy
^{228}Ra	0.1	Gamma spectrometry	Co-precipitation – barium sulphate
		Liquid scintillation	Extraction chromatography
^{226}Ra	0.0001– 0.001	Gamma spectrometry	Co-precipitation
		Liquid scintillation	Ion chromatography
		Alpha spectrometry	Extraction chromatography
$^{134+137}Cs$	0.5	Gamma spectrometry	Drying and homogenization
^{90}Sr	0.001– 0.02	Liquid scintillation	Extraction chromatography
		Cherenkov	Solvent extraction (HDHEP)
^{14}C	10	Liquid scintillation	Combustion

* The detection limit of the technique chosen for the analysis of specific radionuclides in food samples is proposed to be one order of magnitude lower than the guidance level.

Annex I: Diagram to assess exposures due to radionuclides in food in non-emergency situations



Annex II: Dose Assessment for Radionuclides in Food (Excluding ^{40}K) and Derivation of Guidance Levels

II-1. Dose Assessment on the Basis of Diet Sampling

In the case of a diet sample, the ingestion dose can be calculated from the following simplified equation:

$$\sum_{i}^{n} A_i * e_i * M(A) = Ingestion\ Dose\ (mSv\ per\ year) \qquad (II-1)$$

Where:

A_i is the activity concentration of the radionuclide of interest (i) in the diet (Bq/kg);

e_i is the committed effective dose per unit intake of radionuclide of interest (i) (mSv/Bq);

M(A) is the total mass of food consumed per year (kg per year) – default value is 550 kg per year.

If the calculated ingestion dose is "about 1 mSv" per year or below, then the estimated dose is below the reference level, and no further action is needed.

If the calculated ingestion dose is above "about 1 mSv" per year, the exceedance of the reference level needs to be investigated and actions need to be considered to reduce the dose if possible, taking into consideration health, nutrition and other societal factors.

II-1.1. Example

A diet sample collected from a local market gave the average activity concentrations listed in Table II–1.

TABLE II-1: Measured Radionuclide Activity Concentrations in a Diet Sample and Associated Committed Effective Dose per Unit Intake

Radionuclide	Activity concentration (Bq/kg)	Committed Effective Dose per Unit Intake (mSv/Bq) Calculated
^{228}Ra	0.16	$6.9\text{x } 10^{-4}$
^{226}Ra	0.20	$2.8 \text{ x } 10^{-4}$
^{210}Pb	0.5	$6.9\text{x } 10^{-4}$
^{210}Po	1.0	$1.2 \text{ x } 10^{-3}$
^{137}Cs	1.1	$1.3 \text{ x } 10^{-5}$
^{134}Cs	<LLD	$1.9 \text{ x } 10^{-5}$
^{90}Sr	2.0	$2.8 \text{ x } 10^{-5}$
^{14}C	50	$5.8 \text{ x } 10^{-7}$

Annual Ingestion Dose = [(0.16 x 6.9 x 10^{-4}) + (0.20 x 2.8 x 10^{-4}) + (0.5 x 6.9 x 10^{-4}) + (1.0 x 1.2 x 10^{-3}) + (1.1 x 1.3 x 10^{-5}) + (2.0 x 2.8 x 10^{-5}) + (50 x 5.8 x 10^{-7})] x 550 kg/year

= (1.1 + 0.56 + 3.45 + 12 + 0.14 + 0.56 + 0.29) x 10^{-4} x 550 = 18.1 x 10^{-4} x 550 kg/year = 0.99 mSv

The dose is 0.99 mSv , which is less than the reference level of 1 mSv, so the food can be used.

II-2. Derivation of a Guidance Level for a Given Radionuclide

Equation (II–2) can be modified to calculate the activity concentration of a given radionuclide that corresponds to a specific value of annual dose.

$$A_i = \frac{IDC\ (mSv\ per\ year)}{e_i\ M\ A} \qquad \text{(II-2)}$$

Where

A_i is the activity of the radionuclide of interest (i) in food (Bq/kg);

IDC: is the individual dose criterion (mSv/year);

M(A): is the mass of food consumed per year (kg/year);

e_i: is the committed effective dose per unit intake of radionuclide of interest (i) (mSv/Bq).

II-2.1. Example

The activity concentration of ^{226}Ra in a diet sample that corresponds to an annual dose of 0.1 mSv is:

$$\frac{0.1\ (mSv\ per\ year)}{2.8\,x\,10^{-4}\ \ (\,mSv\ per\ Bq\,)\ \ 550\,kg\ per\ year} = 0.65\ Bq\ per\ kg$$

II-3. Dose Assessment for Individual Foods

If the samples being analyzed are considered to be representative of the foods under investigation and the measurement technique has been appropriately validated, a detailed dose assessment is needed to estimate the ingestion dose to the representative person.

This more detailed assessment uses Eq. (II–3) to determine the ingestion dose from all radionuclides both natural and human-made (excluding ^{40}K). The mass of food consumed, and the age dependent ingestion committed effective dose per unit intake used need to be chosen to better reflect the consumption rate of the food of interest and the ingestion dose coefficient of the representative person.

$$\sum_{i}^{n}\ A_i * e_i * M(A) = Ingestion\ Dose\ (mSv\ per\ year) \qquad (II-3)$$

A_i : is the activity concentration of the radionuclide of interest (i) in food (Bq/kg);

M(A) : is the mass of food consumed per year (kg/year);

e_i: is the committed effective dose per unit intake of radionuclide of interest (i) (mSv/Bq).

If the calculated ingestion dose is “about 1 mSv” per year or below, then the estimated dose is below the reference level and no further action is needed.

If the calculated ingestion dose is above “about 1 mSv” per year, the exceedance of the reference level needs to be investigated and actions considered to reduce the dose if possible, taking into consideration health, nutrition, and other societal factors.

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