National Institute for Public Health
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Ministry of Health, Welfare and Sport

Monitoring of **radioactivity** in the Netherlands

Milk, Food and Feed – results 2020 and 2021

RIVM letter report 2023-0078
C.P. Tanzi

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Synopsis

Monitoring of radioactivity in the Netherlands

Milk, Food and Feed – results 2020 and 2021

In 2020 and 2021, the Netherlands fulfilled its annual European obligation to measure how much radioactivity is present in the environment and in food. Radioactivity levels in food and milk measured by Wageningen Food Safety Research (WFSR) were below the European export and consumption limits. The radioactivity levels in grass and feed were normal, as in previous years.

All countries of the European Union are required to perform these measurements each year under the terms of the Euratom Treaty of 1957. The Netherlands performs these measurements following the guidance issued in 2000.

The measurements represent the background values for radioactivity that are present under normal circumstances. They can be used as reference values, for instance, during a nuclear emergency.

The results on radioactivity in the environment are reported to the European Commission by the National Institute for Public Health and the Environment (RIVM) on behalf of the competent authority in the Netherlands.

Keywords: radioactivity, milk, food, feed

Publiekssamenvatting

Monitoring van radioactiviteit in Nederland

Melk, voedsel en veevoer – resultaten 2020 en 2021

In 2020 en 2021 voldeed Nederland aan de Europese verplichting om elk jaar te meten hoeveel radioactiviteit in het milieu en in voeding zit. De niveaus radioactiviteit in voedsel en melk gemeten door Wageningen Food Safety Research (WFSR) liggen net als in vorige jaren onder de Europese limieten voor consumptie en export. De radioactiviteitsniveaus in gras en veevoer laten een normaal beeld zien, net als de jaren ervoor.

Alle landen van de Europese Unie zijn volgens het Euratom-verdrag uit 1957 verplicht om deze metingen te doen. Nederland volgt daarbij de aanbevelingen uit 2000 op om de metingen op een bepaalde manier uit te voeren.

De metingen leveren achtergrondwaarden op, ofwel radioactiviteitsniveaus die er onder normale omstandigheden zijn. Deze waarden kunnen bij bijvoorbeeld calamiteiten of rampen als referentie dienen.

Het RIVM brengt namens de Autoriteit Nucleaire Veiligheid en Stralingsbescherming (ANVS) verslag uit aan de Europese Unie over radioactiviteit in het milieu.

Kernwoorden: radioactiviteit, melk, voedsel, veevoer

Origin of data in this report

All data and analysis in this report are provided by:

Wageningen Food Safety Research (WFSR)
ir. S.T. van Tuinen, D.V. Bubberman, S. Wijnbergen, ing.
A. Vos van Avezathe

The data, analysis, texts and figures in this report are based on the WFSR reports “Radioactive Substances in Milk, Food and Feed in the Netherlands: yearly bulletin 2020”, which was provided directly to RIVM, and the publicly available “Radioactive Substances in Food, Milk and Feed in the Netherlands: yearly bulletin 2021”, S.T. van Tuinen, D.V. Bubberman, A. Vos van Avezathe and S. Wijnbergen, WFSR-rep 2022.024, 2023.

Contents

Summary

Radioactivity was measured by Wageningen Food Safety Research (WFSR) in 673 cow's and 21 goat's milk samples in 2020, in 691 cow's and 34 goat's milk samples in 2021, and in about 2400 samples of food products in 2020 and more than 2350 samples in 2021. Of these food products, 16 samples of game in 2020 and 36 samples in 2021 contained ^{137}Cs above the detection level of 5 $Bq \cdot kg^{-1}$. The activity concentration of game varied from 5 to a maximum of 120 $Bq \cdot kg^{-1}$ in 2020 and from 5 to a maximum of 370 $Bq \cdot kg^{-1}$ in 2021. The limits for radiocesium (sum of ^{134}Cs and ^{137}Cs) in food (600 $Bq \cdot kg^{-1}$) and in milk and dairy products (370 $Bq \cdot kg^{-1}$) were not exceeded.

The measured activity concentrations of ^{90}Sr, ^{134}Cs and ^{137}Cs in food in $Bq \cdot kg^{-1}$ were converted to an average daily intake value per person per day ($Bq \cdot day^{-1}$) using food consumption patterns for each year. The average daily intake per person of ^{134}Cs, ^{137}Cs and ^{90}Sr is < 5 $Bq \cdot day^{-1}$, for each of the nuclides separately. The contribution to the effective yearly dose calculated from these average daily intake values is < 0.12 mSv. The actual daily intake of ^{134}Cs, ^{137}Cs and ^{90}Sr (and following dose contribution) is most likely much lower.

None of the grass and feed samples contained measurable levels of artificial radionuclides (^{60}Co, ^{131}I, ^{132}Te, ^{134}Cs and ^{137}Cs).

1 About the origin of data of this report and the contracting authority

All data, analysis and figures in this report have been provided by Wageningen Food Safety Research (WFSR). The Authority for Nuclear Safety and Radiation Protection (Autoriteit Nucleaire Veiligheid en Stralingsbescherming, ANVS) has given the task to the National Institute for Public Health and the Environment (RIVM, Centre for Environmental Safety and Security) to present the results of WFSR in order to fulfil its European obligation to measure how much radioactivity is present in the environment and in food. All countries of the European Union are required to perform these measurements each year under the terms of the Euratom Treaty of 1957.

2 Milk

Wageningen Food Safety Research[1] monitors radioactivity in milk on a weekly basis, mainly via the National Monitoring Network of Radioactivity in Food (Landelijk Meetnet Radioactiviteit in Voedsel, LMRV). The LMRV was set up as an emergency network for monitoring relatively high contamination levels in case of an accident. The LMRV is in addition a critical infrastructural information system for the response to radiation accidents.[2] The LMRV consists of 50 low-resolution γ spectrometers (NaI-detectors) located throughout the Netherlands. Of these 50, 24 were located at dairy factories in the year 2020, and 22 in the year 2021.
The results of the weekly samples of cow's milk taken from all locations are combined into a monthly average for the whole country. The monthly averages for 2020 are presented in Table 1 and for the year 2021 in Table 2. Figure 1 for the year 2020 and Figure 2 for the year 2021 show the spatial variation of the yearly average ^{40}K concentrations per region and the distribution of the sampling locations across the Netherlands.

Table 1 Monthly average activity concentrations (Bq·kg^{-1}) in cow's milk in 2020 via the LMRV network measured with low-resolution γ spectrometers (source: WFSR).

Month	No. of samples	^{40}K (1)	^{60}Co (2)	^{131}I (2)	^{134}Cs (2)	^{137}Cs (2)
January	50	51.4 ± 10.8	< 1.4	< 0.6	< 0.6	< 0.5
February	55	54.0 ± 11.6	< 1.4	< 0.6	< 0.6	< 0.5
March	59	51.9 ± 11.3	< 1.4	< 0.6	< 0.6	< 0.5
April	52	55.2 ± 10.8	< 1.4	< 0.6	< 0.6	< 0.5
May	52	50.5 ± 13.0	< 1.4	< 0.6	< 0.6	< 0.5
June	54	50.2 ± 11.5	< 1.4	< 0.6	< 0.6	< 0.5
July	53	54.2 ± 14.4	< 1.4	< 0.6	< 0.6	< 0.5
August	48	56.8 ± 12.6	< 1.4	< 0.6	< 0.6	< 0.5
September	50	51.6 ± 12.2	< 1.4	< 0.6	< 0.6	< 0.5
October	50	49.9 ± 10.1	< 1.4	< 0.6	< 0.6	< 0.5
November	46	50.8 ± 8.8	< 1.4	< 0.6	< 0.6	< 0.5
December	60	51.0 ± 9.5	< 1.4	< 0.6	< 0.6	< 0.5
Average	**629 (3)**	**52.3 ± 11.6**	**< 1.4**	**< 0.6**	**< 0.6**	**< 0.5**

(1) Standard deviation is given as 1σ.
(2) Calculated minimal detectable activity concentrations for the respective radionuclides, based on 1 litre Marinelli beaker measurements on the Food Monitor Systems.
(3) Yearly total.

[1] This report is based on the results from the WFSR reports "Radioactive Substances in Milk, Food and Feed in the Netherlands: yearly bulletin 2020", and "Radioactive Substances in Food, Milk and Feed in the Netherlands: yearly bulletin 2021", S.T. van Tuinen, D.V. Bubberman, A. Vos van Avezathe, S. Wijnbergen, WFSR-rep 2022.024, 2023.
[2] Until 30 April 2021 for the National Crisis Management Plan for Radiation Incidents (Nationaal Crisisplan Stralingsincidenten, NCS), and from 30 April 2021 onwards for the National Crisis Plan for Radiation Incidents (Landelijk Crisisplan Straling, LCP-S).

Table 2 Monthly average activity concentrations ($Bq{\cdot}kg^{-1}$) in cow's milk in 2021 via the LMRV network measured with low-resolution γ spectrometers (source: WFSR).

Month	No. of samples	^{40}K (1)	^{60}Co (2)	^{131}I (2)	^{134}Cs (2)	^{137}Cs (2)
January	48	49.2 ± 9.7	< 1.4	< 0.6	< 0.6	< 0.5
February	47	48.3 ± 9.0	< 1.4	< 0.6	< 0.6	< 0.5
March	57	49.5 ± 7.3	< 1.4	< 0.6	< 0.6	< 0.5
April	43	50.0 ± 9.2	< 1.4	< 0.6	< 0.6	< 0.5
May	55	48.8 ± 8.2	< 1.4	< 0.6	< 0.6	< 0.5
June	53	54.2 ± 9.3	< 1.4	< 0.6	< 0.6	< 0.5
July	55	52.9 ± 12.9	< 1.4	< 0.6	< 0.6	< 0.5
August	57	53.1 ± 10.7	< 1.4	< 0.6	< 0.6	< 0.5
September	52	52.0 ± 9.3	< 1.4	< 0.6	< 0.6	< 0.5
October	56	51.7 ± 9.3	< 1.4	< 0.6	< 0.6	< 0.5
November	75	52.8 ± 18.9	< 1.4	< 0.6	< 0.6	< 0.5
December	50	52.2 ± 10.9	< 1.4	< 0.6	< 0.6	< 0.5
Average	**648 (3)**	**51.2 ± 10.4**	**< 1.4**	**< 0.6**	**< 0.6**	**< 0.5**

(1) Standard deviation is given as 1σ.
(2) Calculated minimal detectable activity concentrations for the respective radionuclides, based on 1 litre Marinelli beaker measurements on the Food Monitor Systems.
(3) Yearly total.

For both years 2020 and 2021, no anthropogenic γ-emitters were measured above the minimal detectable activity in any of the samples, as is shown in Table 1 and Table 2, so the limit of 370 $Bq{\cdot}kg^{-1}$ for the radiocesium activity (sum of ^{134}Cs and ^{137}Cs) set by the European Union [3, 4, 5] was not exceeded. The activity concentration of the natural radionuclide ^{40}K is given as a reference value. The yearly average concentration was 52.3 ± 11.6 $Bq{\cdot}kg^{-1}$ in 2020 and 51.2 ± 10.4 $Bq{\cdot}kg^{-1}$ in 2021. These values are within the range of those found in previous years.

Additionally, 15 goat's milk samples were analysed in 2020, and 28 goat's milk samples in 2021, as is shown in Table 3 and Table 4. As in cow's milk, anthropogenic γ-emitters were not measured above the minimal detectable activity in goat's milk samples. The yearly average ^{40}K concentration in these samples was 65.2 ± 13.0 $Bq{\cdot}kg^{-1}$ in 2020 and 60.5 ± 12.3 $Bq{\cdot}kg^{-1}$ in 2021. These values are within the range of those found from 2014 to 2019.

In addition to the LMRV samples, 50 milk samples in 2020 (44 cow's milk and 6 goat's milk samples) and 49 milk samples in 2021 (43 cow's milk and 6 goat's milk samples) were analysed for a range of γ-emitters on a high-resolution gamma spectrometer in the WFSR laboratory in Wageningen, see Table 3 and Table 4. The samples were collected across

[3] EC, 2009. Council Regulation on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station. EC Brussels, No. 1048/2009.
[4] EC, 2008. Council Regulation on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station. EC Brussels, No. 733/2008.
[5] EC, 2020. Council Regulation on the conditions governing imports of food and feed originating in third countries following the accident at the Chernobyl nuclear power station. EC Brussels, No. 2020/1158.

the Netherlands. None of the samples showed any anthropogenic gamma activity above the minimal detectable activity (<1 Bq·kg^{-1} for ^{137}Cs in 0.5 L Marinelli beakers). The average concentration found for the natural radionuclide ^{40}K in the 44 cow's milk samples in 2020 was 42.6 ± 7.9 Bq·kg^{-1} and in the 43 cow's milk samples in 2021 was 40.4 ± 6.7 Bq·kg^{-1}; for the 6 goat's milk samples in 2020 the average was 58.4 ± 5.8 Bq·kg^{-1} and for the 6 goat's milk samples in 2021 the average was 50.6 ± 14.0 Bq·kg^{-1}, see Table 3 and Table 4.

The same 50 raw milk samples in 2020 and the same 49 raw milk samples in 2021 were analysed for the presence of the β-emitter ^{90}Sr using low-level liquid scintillation counting (LSC). The ^{90}Sr activity concentration was below the minimal detectable activity (0.2 Bq·kg^{-1}) in all samples taken, so none of the samples exceeded the set limit of 125 Bq·kg^{-1} used in new emergency exposure situations [6]. No limit for ^{90}Sr has been set for existing exposure situations as defined in [7].

Table 3 Measurements of activity concentrations (Bq·kg^{-1}) in additional milk samples in 2020 (source: WFSR).

Type of milk	No. of additional samples	^{40}K (1)	^{90}Sr	^{137}Cs
goat (from LMRV)	15	65.2 ± 13.0	not measured	< D.L.
cow	44	42.6 ± 7.9 (3)	< 0.2(2)	< 1.0(3,4)
goat	6	58.4 ± 5.8 (3)	< 0.2(2)	< 1.0(3,4)

(1) Standard deviation is given as 1σ.
(2) Measured using low-level liquid scintillation counting (LSC)
(3) Measured with a high resolution γ spectrometer.
(4) The calculated minimal detectable activity concentrations for ^{137}Cs, based on 0.5 litre Marinelli beaker measurements on the Food Monitor System.

Table 4 Measurements of activity concentrations (Bq·kg^{-1}) in additional milk samples in 2021 (source: WFSR).

Type of milk	No. of additional samples	^{40}K(1)	^{90}Sr (2)	^{137}Cs
goat (from LMRV)	28	60.5 ± 12.3	not measured	< D.L.
cow	43	40.4 ± 6.7 (3)	< 0.2	< 1.0(3,4)
goat	6	50.6 ± 14.0(3)	< 0.2	< 1.0(3,4)

(1) Standard deviation is given as 1σ.
(2) Measured using low-level liquid scintillation counting (LSC)
(3) Measured with a high resolution γ spectrometer.
(4) The calculated minimal detectable activity concentrations for ^{137}Cs, based on 0.5 litre Marinelli beaker measurements on the Food Monitor System.

WFSR also monitors raw milk specifically for export certification. For this, samples were analysed for ^{137}Cs and ^{90}Sr. All these measurements were also below minimum detectable activities.

[6] Council Regulation (Euratom) 2016/52 of 15 January 2016 laying down maximum permitted levels of radioactive contamination of food and feed following a nuclear accident or any other case of radiological emergency, and repealing Regulation (Euratom) No 3954/87 and Commission Regulations (Euratom) No 944/89 and (Euratom) No 770/90.
[7] Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

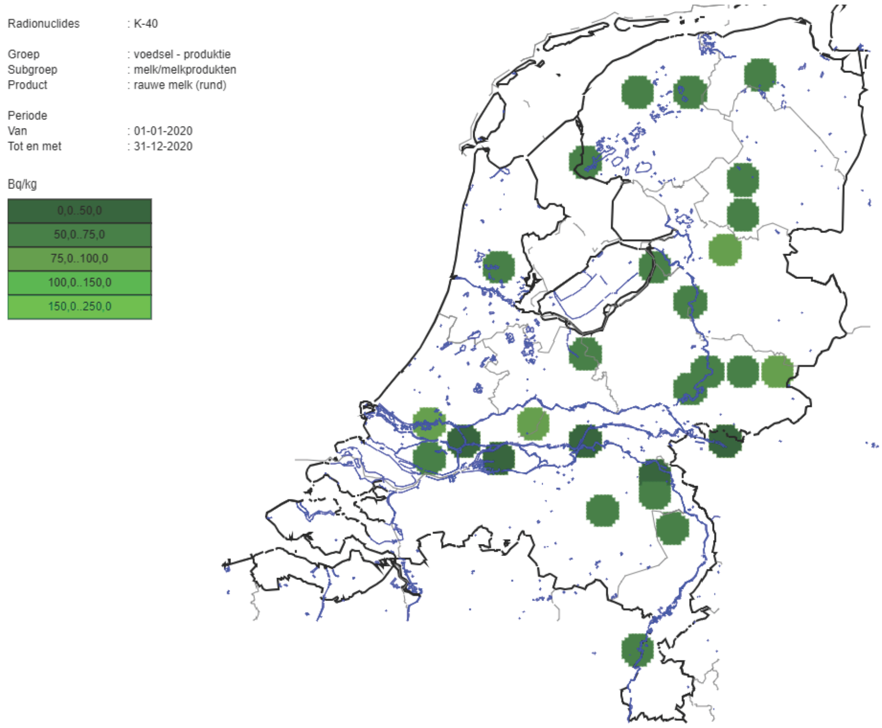

Figure 1 Impression of the spatial variation of ^{40}K activity concentrations ($Bq \cdot kg^{-1}$) in cow's milk in 2020. Based on data provided by dairy factories (source: WFSR)*.*

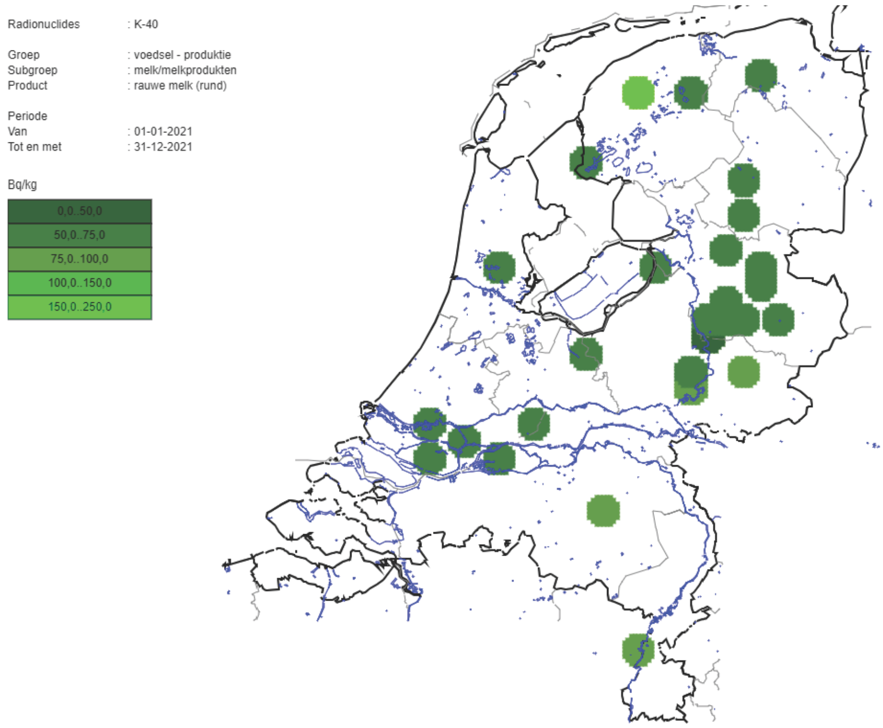

Figure 2 Impression of the spatial variation of ^{40}K activity concentrations ($Bq \cdot kg^{-1}$) in cow's milk in 2021. Based on data provided by dairy factories (source: WFSR).

3 Food

3.1 Introduction

On behalf of The Netherlands Food and Consumer Product Safety Authority (NVWA) and the Ministry of Agriculture, Nature and Food Quality (LNV), WFSR performs measurements on foodstuffs.

For the NVWA, measurements are performed on finished products from retail shops, wholesale produce auctions and distribution centres. For the LNV, measurements are performed on samples from earlier stages in the food production chain. In total about 2400 samples were analysed in 2020 and 2350 samples in 2021.

For the NVWA, activity concentrations in a ‘mixed diet’ are determined every year by sampling and measuring separate ingredients. In 2020, 212 samples were taken from retail shops, wholesale produce auctions and distribution centres, including 31 samples of honey [8]. Due to the Covid-19 pandemic the amount of samples taken by inspectors of the NVWA in 2020 was considerably lower than in 2019, when 344 samples were analysed. In 2021 the amount of collected samples were increased to match the level of earlier years: 365 samples were taken from retail shops, wholesale produce auctions and distribution centres, including 56 samples of honey. Though honey is not considered to be part of the mixed diet, samples are taken each year because it regularly contains higher levels of radioactivity (mainly ^{137}Cs). Previously deposited ^{137}Cs can end up in honey via vegetation and bees.

The separate ingredients were categorized into the following product groups: milk and dairy products, grain and grain products, vegetables and fruit products, poultry and game, salads, mushrooms, fish, oil and butter, mineral water, tea and honey. The results in 2020 and 2021 are presented in Table 5 and Table 6 respectively. All samples were measured on the food monitoring systems of the LMRV, of which 7 systems are situated in Wageningen. Measurements were performed according to SOP CHE01-WV143. None of the samples contained ^{137}Cs activity levels above the minimum detectable activity of 5 $Bq \cdot kg^{-1}$. None of the samples exceeded the set limit for the total cesium activity (sum of ^{134}Cs and ^{137}Cs) of 600 $Bq \cdot kg^{-1}$ for food or 370 $Bq \cdot kg^{-1}$ for milk and dairy products [3, 5].

[8] Jaarverslag NPK 2020. Nederlandse Voedsel en Waren Autoriteit (NVWA).

Table 5 Results of the analysis of market product for ^{134}Cs and ^{137}Cs, in 212 samples in the year 2020. The samples are supplied by Dutch Food and Consumer Product Safety Authority (source: WFSR).

Market product	Number of samples	^{134}Cs (1) Bq·kg^{-1}	^{137}Cs (1) Bq·kg^{-1}
Milk and dairy products	29	< 5 (0)	< 5 (0)
Grain and grain products	37	< 5 (0)	< 5 (0)
Vegetables and fruit products	47	< 5 (0)	< 5 (0)
Poultry and game	-	-	-
Salads	12	< 5 (0)	< 5 (0)
Mushrooms	1	< 5 (0)	< 5 (0)
Fish	15	< 5 (0)	< 5 (0)
Oil and butter	18	< 5 (0)	< 5 (0)
Mineral water	12	< 5 (0)	< 5 (0)
Tea	10	< 5 (0)	< 5 (0)
Honey	31	< 5 (0)	< 5 (0)

(1) Number of samples above the given detection limit is shown in brackets.

Table 6 Results of the analysis of market product for ^{134}Cs and ^{137}Cs, in 365 samples in the year 2021. The samples are supplied by Dutch Food and Consumer Product Safety Authority (source: WFSR).

Market product	Number of samples	^{134}Cs (1) Bq·kg^{-1}	^{137}Cs (1) Bq·kg^{-1}
Milk and dairy products	55	< 5 (0)	< 5 (0)
Grain and grain products	67	< 5 (0)	< 5 (0)
Vegetables and fruit products	75	< 5 (0)	< 5 (0)
Poultry and game	2	< 5 (0)	< 5 (0)
Salads	19	< 5 (0)	< 5 (0)
Mushrooms	3	< 5 (0)	< 5 (0)
Fish	14	< 5 (0)	< 5 (0)
Oil and butter	29	< 5 (0)	< 5 (0)
Mineral water	31	< 5 (0)	< 5 (0)
Tea	14	< 5 (0)	< 5 (0)
Honey	56	< 5 (0)	< 5 (0)

(1) Number of samples above the given detection limit is shown in brackets.

Table 7 Results of the analysis of food samples in different product categories for ^{134}Cs and ^{137}Cs as measured in 1552 samples in 2020 supplied by several food monitoring projects of WFSR (source: WFSR).

Product category	Number of samples	^{134}Cs (1) $Bq \cdot kg^{-1}$	^{137}Cs (1) $Bq \cdot kg^{-1}$
Raw milk	50	< 5 (0)	< 5 (0)
Vegetables	143	< 5 (0)	< 5 (0)
Fruits	79	< 5 (0)	< 5 (1)
Eggs	34	< 5 (0)	< 5 (0)
Poultry	179	< 5 (0)	< 5 (0)
Pork	409	< 5 (0)	< 5 (0)
Beef/veal	399	< 5 (0)	< 5 (2)
Sheep/lamb	11	< 5 (0)	< 5 (1)
Game	66	< 5 (0)	5–120 (16)
Other meat and meat products	37	< 5 (0)	< 5 (0)
Fish	45	< 5 (0)	< 5 (0)
Seafood	79	< 5 (0)	< 5 (0)
Ready meals	21	< 5 (0)	< 5 (0)

(1) Number of samples above the given detection limit is shown in brackets.

Table 8 Results of the analysis of food samples in different product categories for ^{134}Cs and ^{137}Cs as measured in 1745 samples in 2021 supplied by several food monitoring projects of WFSR (source: WFSR).

Product category	Number of samples	^{134}Cs (1) $Bq \cdot kg^{-1}$	^{137}Cs (1) $Bq \cdot kg^{-1}$
Raw milk	49	< 5 (0)	< 5 (0)
Vegetables	160	< 5 (0)	< 5 (0)
Fruits	57	< 5 (0)	< 5 (0)
Eggs	61	< 5 (0)	< 5 (0)
Poultry	198	< 5 (0)	< 5 (0)
Pork	396	< 5 (0)	< 5 (0)
Beef/veal	454	< 5 (0)	< 5 (0)
Sheep/lamb	12	< 5 (0)	< 5 (0)
Game	86	< 5 (0)	6–370 (36)
Other meat and meat products	13	< 5 (0)	< 5 (0)
Fish	155	< 5 (0)	< 5 (0)
Seafood	74	< 5 (0)	< 5 (0)
Ready meals	50	< 5 (0)	< 5 (0)

(1) Number of samples above the given detection limit is shown in brackets.

WFSR analysed the concentration of radionuclides in food products as part of the governmental monitoring programme for the Ministry of LNV. Samples were taken throughout the year and measurements were carried out according to standard procedures. In 2020, 1522 food samples, and in 2021, 1745 food samples were analysed for the presence of γ-emitters according to SOP-N-0132, which is based on NEN 5623. The results are presented in Table 7 for 2020 and Table 8 for 2021. None of the samples exceeded the set limit for radiocesium activity (sum of ^{134}Cs and ^{137}Cs) of 600 $Bq \cdot kg^{-1}$ (for food) or 370 $Bq \cdot kg^{-1}$ (for dairy products).

Of these food samples, 212 samples in 2020, and 234 in 2021, were additionally analysed for ^{90}Sr content according to SOP-A-1097. The results are presented in Table 9 and Table 10. These results are well below the set limit for new emergency exposure situations of 750 $Bq \cdot kg^{-1}$ for major food products [6]. No limit for ^{90}Sr has been set for existing exposure situations as defined in [9].

Table 9 Results of the analysis of food samples in different product categories for ^{90}Sr as measured in 212 samples in 2020 supplied by several food monitoring projects of WFSR (source: WFSR).

Product	**Number of samples**	**^{90}Sr (1) $Bq \cdot kg^{-1}$**
Raw milk	50	< 5 (0)
Vegetables	22	< 5 (0)
Fruits	23	< 5 (0)
Eggs	12	< 5 (0)
Poultry	13	< 5 (0)
Pork	11	< 5 (0)
Beef/veal	11	< 5 (0)
Sheep/lamb	1	< 5 (0)
Game	5	< 5 (0)
Other meat and meat products	2	< 5 (0)
Fish	14	< 5 (0)
Seafood	27	< 5 (0)
Ready meals	21	< 5 (0)

Table 10 Results of the analysis of food samples in different product categories for ^{90}Sr as measured in 234 samples in 2021 supplied by several food monitoring projects of WFSR (source: WFSR).

Product	**Number of samples**	**^{90}Sr (1) $Bq \cdot kg^{-1}$**
Raw milk	49	< 5 (0)
Vegetables	24	< 5 (0)
Fruits	19	< 5 (0)
Eggs	12	< 5 (0)
Poultry	5	< 5 (0)
Pork	6	< 5 (0)
Beef/veal	10	< 5 (0)
Sheep/lamb	1	< 5 (0)
Game	6	< 5 (0)
Other meat and meat products	0	-
Fish	30	< 5 (0)
Seafood	22	< 5 (0)
Ready meals	50	< 5 (0)

WFSR also monitors food specifically for export certification. For this purpose, samples were analysed for ^{137}Cs and ^{90}Sr. All results were below the limits set for ^{137}Cs and below minimal detectable activity for ^{90}Sr.

[9] EC, 2013. Council Directive laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom. EC Brussels, No. 2013/59/Euratom.

3.2 Analysis of results

Most of the samples analysed showed no activity concentration above the detection limit of 5 Bq·kg^{-1}. In the product group 'game' analysed by WFSR, 16 samples in 2020 and 36 samples in 2021 contained ^{137}Cs above the detection limit. The activity concentrations found in the product group 'game' varied from 5 to 120 Bq·kg^{-1} in 2020 and from 6 to 370 in 2021. Thus, no sample exceeded the limit of 600 Bq·kg^{-1} [5, 10].

3.3 Results for average daily intake

The measured concentrations of ^{90}Sr, ^{134}Cs and ^{137}Cs in food in Bq·kg^{-1} were used to calculate an average daily intake value per person per day (Bq·day^{-1}) using food consumption patterns [11], according to the method described in the Appendix. From these intake values, a contribution to the effective yearly dose was calculated using standard dose conversion coefficients for ingestion [9,12].

The average daily intake per person of ^{134}Cs, ^{137}Cs and ^{90}Sr is estimated at <5 Bq·day^{-1} for each of the three radionuclides. These estimates are mainly based on the minimal detectable activities for these radionuclides in the different food categories, as shown in Table 5 to Table 10.

The contribution to the effective yearly dose calculated from these average daily intake values is < 0.12 mSv. Because the dose is calculated predominantly based on the minimum detectable levels, the actual daily intake, and therefore the calculated dose, is most likely much lower.

[10] Dutch Government, 2022, Commodities Act Contaminants in foodstuffs (in Dutch: Warenwetregeling Verontreinigingen in levensmiddelen), Article 3, https://wetten.overheid.nl/BWBR0010269/2022-04-23.
RIVM, Food consumption survey 2012-2106 (in Dutch), https://www.wateetnederland.nl
[11] CTM van Rossum et al., 2020. The diet of the Dutch - Results of the Dutch National Food Consumption Survey 2012-2016, RIVM report 2020-0083.
[12] Dutch government, 2018, Basic Safety Standards of radiation protection (in Dutch: Besluit Basisveiligheidsnormen stralingsbescherming), https://wetten.overheid.nl/BWBR0040179/2021-07-01

4 Grass and feed

The National Monitoring Network of Radioactivity in Food (Landelijk Meetnet Radioactiviteit in Voedsel, LMRV), referred to in the previous section over milk, was set up as an emergency network for monitoring relatively high contamination levels in case of an incident. It is an important monitoring network used in cases of a nuclear or radiological emergency, as described in the National Crisis Plan for Radiation Incidents (Landelijk Crisisplan Straling, LCP-S)[13]. In addition to measuring radioactivity levels in milk and food samples, the network is used to measure radioactivity levels in grass samples. For this purpose, reference pastures and fields have been designated across the Netherlands in proximity to the companies and organisations that participate in the LMRV. In this way, the extent of radioactive deposition can be assessed rapidly by the LMRV in the event of a nuclear or radiological incident.
It is important to have accurate and recent information on the natural background levels of radioactivity in grass to compare with samples analysed during a nuclear or radiological incident. For this reason, all LMRV locations are requested to take a grass sample every year from their reference pasture or field according to a standardised protocol, and to measure this sample using the food monitoring system.

In 2020, 38 grass samples were taken at 28 locations, and in 2021, 32 grass samples were taken at 21 locations, and measured on the food monitoring system. None of the grass samples taken contained artificial radionuclides above the minimal detectable activities. The minimal detectable activities were approximately 20 $Bq \cdot m^{-2}$ (assuming a yield of 250 grams of grass per m^2) for the artificial radionuclides ^{60}Co, ^{131}I, ^{134}Cs and ^{137}Cs. Natural ^{40}K was found in all 38 samples in 2020, and in 28 out of the 32 samples in 2021. In some samples, natural radionuclides from the uranium and thorium decay chains deposited during rainfall were detected as well. Figure 3 and Figure 4 show the spatial variation of the yearly average ^{40}K concentrations per region and the distribution of the sampling locations across the Netherlands.

In addition, 775 feed samples in 2020 and 230 feed samples in 2021 were analysed for γ-emitters as part of the monitoring programme of WFSR. The results for ^{134}Cs were all lower than the minimal detectable activity of 5 $Bq \cdot kg^{-1}$. In 2020, 7 samples for ^{137}Cs were found with an activity above the minimum detectable activity of 5 $Bq \cdot kg^{-1}$, with a maximum of 17 $Bq \cdot kg^{-1}$. In 2021, 5 samples for ^{137}Cs were found with an activity above the minimum detectable activity, with a maximum of 17 $Bq \cdot kg^{1}$.

[13] Until 30 April 2021 the National Crisis Management Plan for Radiation Incidents (Nationaal Crisisplan Stralingsincidenten, NCS), and from 30 April 2021 onwards for the National Crisis Plan for Radiation Incidents (Landelijk Crisisplan Straling, LCP-S).

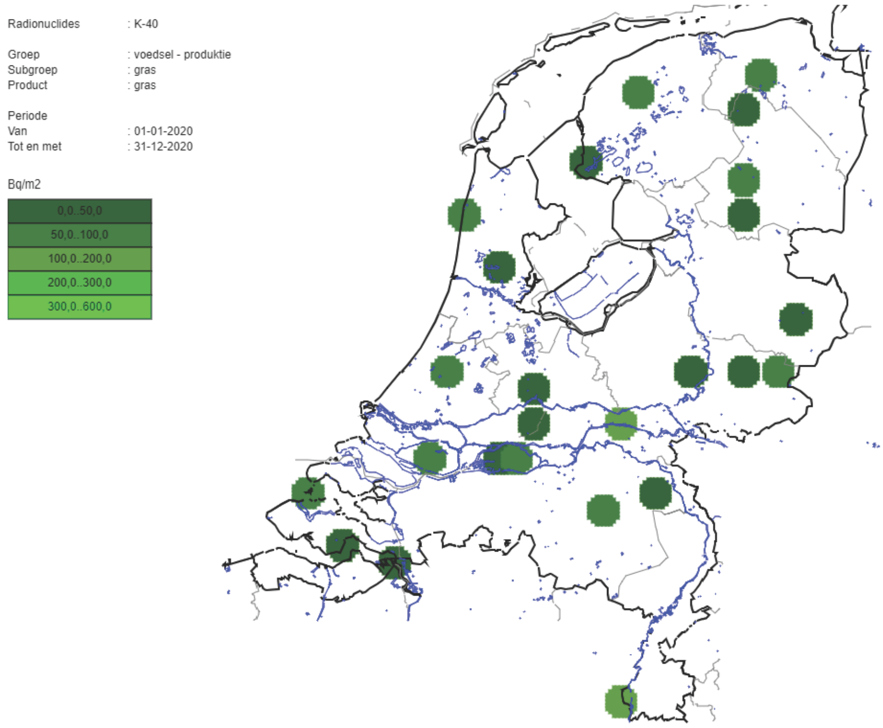

Figure 3 Impression of the spatial variation of ^{40}K activity in grass in Bq·m^{-2}, measured in 2020 (source: WFSR).

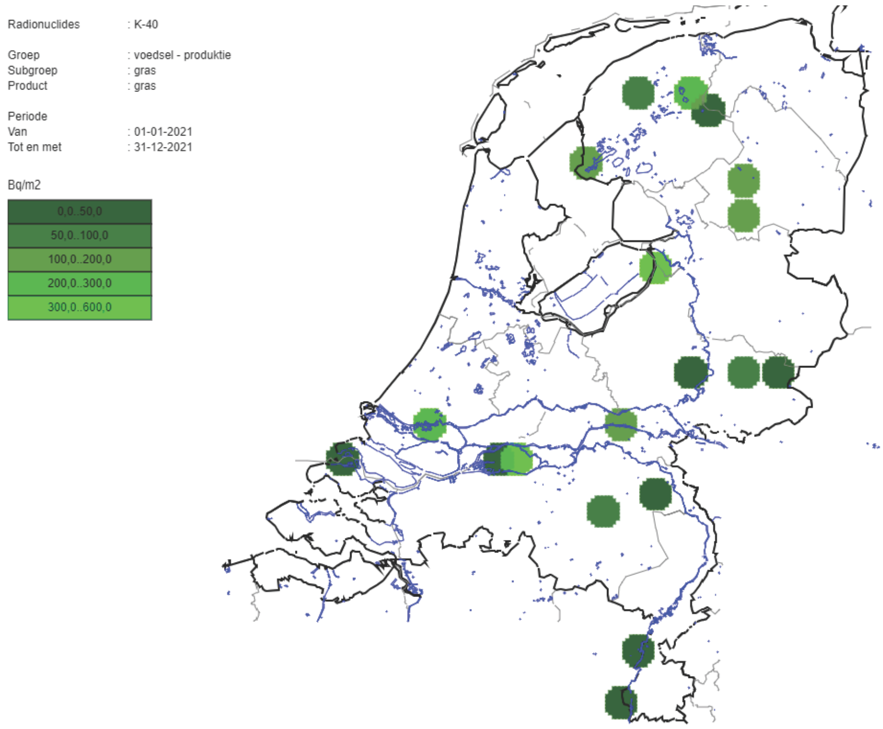

Figure 4 Impression of the spatial variation of ^{40}K activity in grass in Bq·m^{-2}, measured in 2021 (source: WFSR).

Appendix: Mixed diet, conversion from Bq.kg^{-1} to intake in Bq.day^{-1}

With respect to the results presented for mixed diets, WFSR used food consumption patterns to convert the measured concentrations of ^{90}Sr, ^{134}Cs and ^{137}Cs in food (Bq·kg^{-1}) to an average daily intake value per person per day (Bq·day^{-1}). For the Netherlands, the food consumption patterns were investigated by the RIVM and the results can be found in the report 'The diet of the Dutch - Results of the Dutch National Food Consumption Survey 2012-2016' [11]. In this report, the consumption patterns are presented by food category, sex and age group in grams per consumption day, as well as the percentage of consumption days. For the calculations in the current report, these values were combined to produce an average consumption amount in g·day^{-1} for each food category, sex and age group.

For each sex and age group and specific radionuclide, the daily intake ($DI_{a,s,n}$) is then calculated as follows:

$$\mathrm{DI}_{\mathrm{a,s,n}} = \sum_{\mathrm{i}} \frac{\mathrm{DI}_{\mathrm{a,s,i}}}{1000} \times \mathrm{AC}_{\mathrm{i,n}}$$

where

$DI_{a,s,n}$ = daily intake per age group, sex and radionuclide (Bq·day^{-1});
i = food category;
$DI_{a,s,i}$ = daily intake per age group, sex and food category (g·day^{-1});
$AC_{i,n}$ = activity concentration per food category and radionuclide (Bq·kg^{-1}).

These daily intakes were then averaged over the different age groups and sexes to obtain the total daily intake per person for each radionuclide. To include the monitoring results of ready meals in the final result, the assumption was made that ready meals make up 10% of the consumption of the categories meat, fish and vegetables.

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