Radioactive Substances in Food, Milk and Feed in the Netherlands: yearly bulletin 2021

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Summary

Within the Netherlands Wageningen Food Safety Research performs a monitoring program on the presence of natural and artificial radioactivity in the food and feed production chain. This monitoring program is based on several European and Dutch rules and regulations.

In 2021 the results of about 2750 gamma analyses and about 250 beta analyses in food and feed products showed no exceedings of the maximal allowed levels. Most samples did not show results above the minimal detectable levels, which indicated the radioactivity concentrations in food and feed products are generally very low.

With the analysis results a calculation of the annual yearly ingestion dose as a result of artificial radionuclides present in food products is performed. To be able to perform a more accurate calculation on the total yearly ingestion dose for the Dutch population also the contribution of the alpha-emitters which are naturally present in food and feed products should be analysed more intensively.

1 Introduction

As a member state of the European Union, the Netherlands must comply with the obligations imposed by Euratom and the European Commission with regard to the control of radioactivity in food and feed [1]. In the Netherlands, this has been implemented by two monitoring programs, which are the responsibility of the Ministry of Agriculture, Nature and Food Quality (LNV) and the Ministry of Health, Welfare and Sport (VWS). The operational implementation of the monitoring program of both ministries is formally assigned to the Netherlands Food and Consumer Product Safety Authority (NVWA). The monitoring program of LNV is directly assigned to Wageningen Food Safety Research (WFSR). All samples taken in the two separate monitoring programs are analyzed by WFSR. Additional analytical results are obtained through measurements carried out with the National Monitoring Network for Radioactivity in Food and Feed (LMRV).

This report provides an overview of the measurements carried out in 2021 within the two monitoring programs and with the LMRV. Successively, the data from the monitoring program in the field of food, milk, grass and animal feed are presented, with which the ingestion dose for the Dutch population is calculated.

2 Radiation ingestion dose of the Dutch population

The average radiation dose of the Dutch population consists of several natural and artificial contributions. Natural sources of radiation are for example the presence of radionuclides originating from the ^{238}U and ^{228}Th decay series and ^{40}K in the cosmos, the earth crust, building materials, food and water. Additionally the population obtains a radiation dose from artificial radioactive sources as a result of medical treatments, and regular or incidental emissions of companies handling radioactive sources, like nuclear power plants and medical facilities.

This results in an average calculated radiation dose for the Dutch population of about 2.5 mSv a year [2]. On average, about 15% of this yearly total radiation dose is caused by ingestion of food [3]. In this calculation, both the effect of natural and artificial radionuclides is taken into account for, where the contribution of the radionuclides of natural origin of ^{40}K, ^{210}Pb and ^{210}Po is assumed to be about 90% of the total ingestion dose.

Based on Euratom 2000/473 [1], which focuses on the contribution of radiation sources from artificial or industrial origin, for monitoring purposes, ^{137}Cs and ^{90}Sr are of special interest in determining the long term radiation dose effects because these nuclides have a half-life of approximately 30 years. Cesium is chemically and biologically very similar to potassium and has a biological half-life of around three months. This means that if someone has ingested cesium through food, for example, half of it has disappeared after three months. Strontium accumulates in bone tissue because it behaves chemically and biologically the same as calcium. When strontium is incorporated into bone tissue, release from bone is marginal and strontium causes somatic and stochastic effects. This makes it important to monitor foods for the presence of these radionuclides.

Consequently, this report focuses on the radiation levels of the ^{90}Sr, ^{134}Cs and ^{137}Cs in the several food and feed products. It should be noted the contribution of the natural radionuclides in the total radiation dose as a result of ingestion is not included in this research.

With the analysis results obtained the ingestion dose as a result of the radionuclides measured can be calculated. This calculation is performed according to Euratom 2000/473 [1], which requires that dose estimations of the population of EU member states should be estimated on a yearly basis.

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 2350 samples were analysed.

For the NVWA, activity concentrations in a 'mixed diet' are determined every year by sampling and measuring separate ingredients. In 2021, 365 samples were taken from retail shops, wholesale produce auctions and distribution centres, including 56 samples of honey. Due to the Covid-19 pandemic the amount of samples (212) taken in 2020 by inspectors of the NVWA had been considerably lower than before. In 2021 this has been restored. 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).

The separate ingredients were categorized into the following product groups: grain and grain products, vegetables and fruit products, milk and dairy products, salads, mushrooms, poultry and game, oil and butter, honey, tea, mineral water, and fish. The results in 2021 are presented in Table 1. 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 above the minimum detectable activity of 5 Bq·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·kg^{-1} for food or 370 Bq·kg^{-1} for milk and dairy products [4,5].

Table 1 *Results of the analysis of market products in 2021 for ^{134}Cs and ^{137}Cs as measured in 365 samples supplied by Dutch Food and Consumer Product Safety Authority.*

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 reporting limit is shown in brackets.

For the Ministry of LNV concentrations of radionuclides in food products were measured as part of the governmental monitoring programme. As a member state of the European Union, the Netherlands must comply with the obligations imposed by Euratom [1] and the European Commission with regard to the control of radioactivity in food and feed [4].

Samples were taken throughout the year and measurements were carried out according to standard procedures. 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 2. None of the samples exceeded the set limit for the total caesium activity (the sum of ^{134}Cs and ^{137}Cs) of 600 Bq·kg^{-1} (for food) or 370 Bq·kg^{-1} (for dairy products) [4,5].

Table 2 *Results of the analysis of food samples in different product categories for ^{134}Cs and ^{137}Cs as measured in 1745 samples supplied by several food monitoring projects of WFSR.*

Product category	**Number of samples**	**^{134}Cs (1) Bq·kg^{-1}**	**^{137}Cs (1) Bq·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.

Of these food samples, 234 samples were additionally analysed for ^{90}Sr content according to SOP-A-1097. The results are presented in Table 3. These results are well below the set limit for new emergency exposure situations of 750 Bq·kg^{-1} for major food products [12]. No limit for ^{90}Sr has been set for existing exposure situations as defined in [4]. 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.

Table 3 *Results of the analysis of food samples in different product categories for ^{90}Sr as measured in 234 samples supplied by several food monitoring projects of WFSR.*

Product	**Number of samples**	**^{90}Sr (1) Bq·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	< 5 (0)
Fish	30	< 5 (0)
Seafood	22	< 5 (0)
Ready meals	50	< 5 (0)

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

3.2 Analysis results

Most of the samples analysed showed no activity concentration above the detection limit of 5 $Bq \cdot kg^{-1}$. Only in the product group 'game' 36 analysed samples of game contained ^{137}Cs above the detection limit. The activity concentrations found in the product group 'game' varied from 6 to 370 $Bq \cdot kg^{-1}$. Thus, no sample exceeded the limit of 600 Bq·kg-1 [4,5].

3.3 Results for average daily intake

The measured concentrations of ^{90}Sr, ^{134}Cs and ^{137}Cs in food in $Bq \cdot kg^{-1}$ were used to calculate an average daily intake value per person per day (in $Bq \cdot day^{-1}$). For this the average consumption pattern was used as determined by the National Institute for Public Health and the Environment [6]. From these intake values, a contribution to the effective yearly dose was calculated using the dose conversion coefficients for ingestion for adults [7,8].

Based on an average amount of food consumed of about 1 kg per day per person of the Dutch population, the average daily intake per person of ^{134}Cs, ^{137}Cs and ^{90}Sr can be calculated at <5 $Bq \cdot day^{-1}$ for each of these three radionuclides. These estimates are mainly based on the minimal detectable activities for these radionuclides in the different food categories, as shown in Table 1 to Table 3.

The contribution to the effective yearly dose calculated from these average daily intake values is calculated at < 0.12 mSv for these three radionuclides. The actual daily intake (and therefore the calculated dose) in practice will be much lower. This is because the dose is calculated with the minimum detectable level as an input for this calculation.

4 Milk

The National Monitoring Network for Radioactivity in Food and Feed (in Dutch: Landelijk Meetnet voor Radioactiviteit in Voeding, abbreviated as LMRV) is a monitoring network consisting of approximately 50 measurement setups for gamma spectrometry analysis.

The LMRV consists of 50 low-resolution gamma spectrometers (NaI-detectors) located throughout the Netherlands, 22 of which are located at dairy factories. These so-called 'food monitoring stations' are set up at various companies and institutions and are optimized for the analysis of food and feed products.

The LMRV has been set up as an emergency network for monitoring radiation contamination levels in the Netherlands in case of a nuclear accident, and is a critical infrastructural information system of the National Crisis Plan for Radiation Incidents (Landelijk CrisisPlan Stralingsincidenten, LCP-S [9]).

In this way, besides offering additional measuring capacity and national availability of measuring locations in the event of a nuclear or radiological disaster, the LMRV is used in the national monitoring program aimed at consumer protection, to support export certification (especially for the dairy industry).

Wageningen Food Safety Research monitors radioactivity in milk on a weekly basis, mainly via the food monitoring stations the LMRV. Milk and milk products are an important part of the Dutch consumption package. Dairy is the second product group consumed by weight, on average in the period 2012-2016: 352 g per day [6]. Milk production in the Netherlands has been monitored for artificial and natural radionuclides since 1965 because iodine and cesium isotopes are quickly absorbed into milk via feed (grass) after a nuclear incident.

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 2021 are presented in Table 4. Figure 1 shows as an example the spatial variation of the yearly average ^{40}K concentrations per region and the distribution of the sampling locations across the Netherlands [10]. It should be noted Figure 1 provides just an impression of the actual situation at that moment, and that ^{40}K concentrations can vary, for example as a result of varying concentration of ^{40}K in animal feed.

Table 4 *Monthly average activity concentrations in cow's milk in 2021.*

Month	Number of samples	^{40}K Bq·kg^{-1}	^{40}K st dev (1) Bq·kg^{-1}	^{60}Co (2) Bq·kg^{-1}	^{131}I (2) Bq·kg^{-1}	^{134}Cs (2) Bq·kg^{-1}	^{137}Cs (2) Bq·kg^{-1}
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) Uncertainty 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.

In none of the samples anthropogenic γ-emitters were measured above the minimal detectable activity, as is shown in Table 4, so the limit of 370 $Bq \cdot kg^{-1}$ for the cesium activity (sum of ^{134}Cs and ^{137}Cs) set by the European Union [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 51.2 ± 10.4 $Bq \cdot kg^{-1}$. This value is within the range of those found in previous years [11].

Additionally, 28 goat's milk samples were analyzed. As in cow's milk, anthropogenic γ-emitters were not measured above the minimal detectable activity. The yearly average ^{40}K concentration in these samples was 60.5 ± 12.3 $Bq \cdot kg^{-1}$. This value corresponds well with the results found from 2014 to 2020.

In addition to the LMRV samples, 49 milk samples (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. The samples were collected across the Netherlands. None of the samples showed any anthropogenic gamma activity above the minimal detectable activity (<1 $Bq \cdot kg^{-1}$ 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 was 40.4 ± 6.7 $Bq \cdot kg^{-1}$; for the 6 goat's milk samples the average was 50.6 ± 14.0 $Bq \cdot kg^{-1}$ [10]. The same 49 raw milk samples 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 [12]. No limit for ^{90}Sr has been set for existing exposure situations as defined in [4].

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

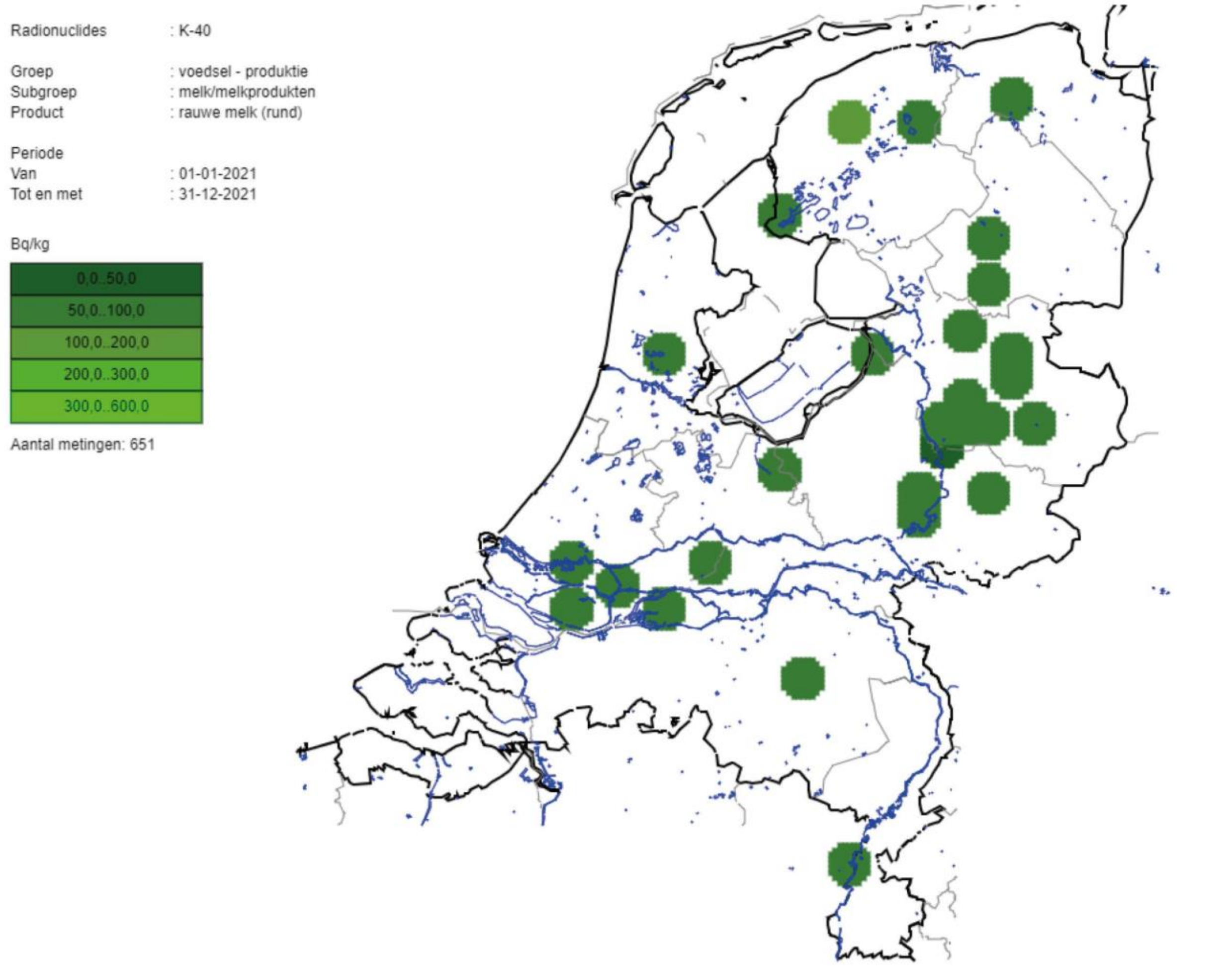

Figure 1 *Impression of the spatial variation of ^{40}K activity concentrations (Bq·kg^{-1}) in cow's milk in 2021.*

5 Grass and feed

Besides the monitoring of the activity concentration in milk, which is performed with the LMRV, also feed matrices can be analyzed with this radioactivity monitoring network.

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 organizations 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 [9].

It is important to have recent information on the natural background levels of radioactivity in grass to compare with samples analyzed 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 standardized protocol, and to measure this sample using the food monitoring system.

Figure 2 shows as an example the spatial variation of the yearly average ^{40}K concentrations per region and the distribution of the sampling locations across the Netherlands [10]. It should be noted Figure 2 provides just an impression of the situation at that moment, and that ^{40}K concentrations can vary, for example as a result of treating the agricultural areas with fertilizers.

In 2021, 32 grass samples were taken at 21 locations and measured on the food monitoring systems of the LMRV. None of the grass samples taken contained artificial radionuclides above the minimal detectable activities. The minimal detectable activities were approximately 20 $Bq.m^{-2}$ (i.e. with 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 28 of the 32 samples. In some samples, natural radionuclides from the uranium and thorium decay chains deposited during rainfall were detected as well.

In addition, 230 feed samples were analyzed for γ-emitters as part of the monitoring program of WFSR. The results for ^{134}Cs were all lower than the minimal detectable activity (of 5 $Bq \cdot kg^{-1}$). For ^{137}Cs 5 samples were found with an activity above the MDA, with a maximum of 17 Bq/kg.

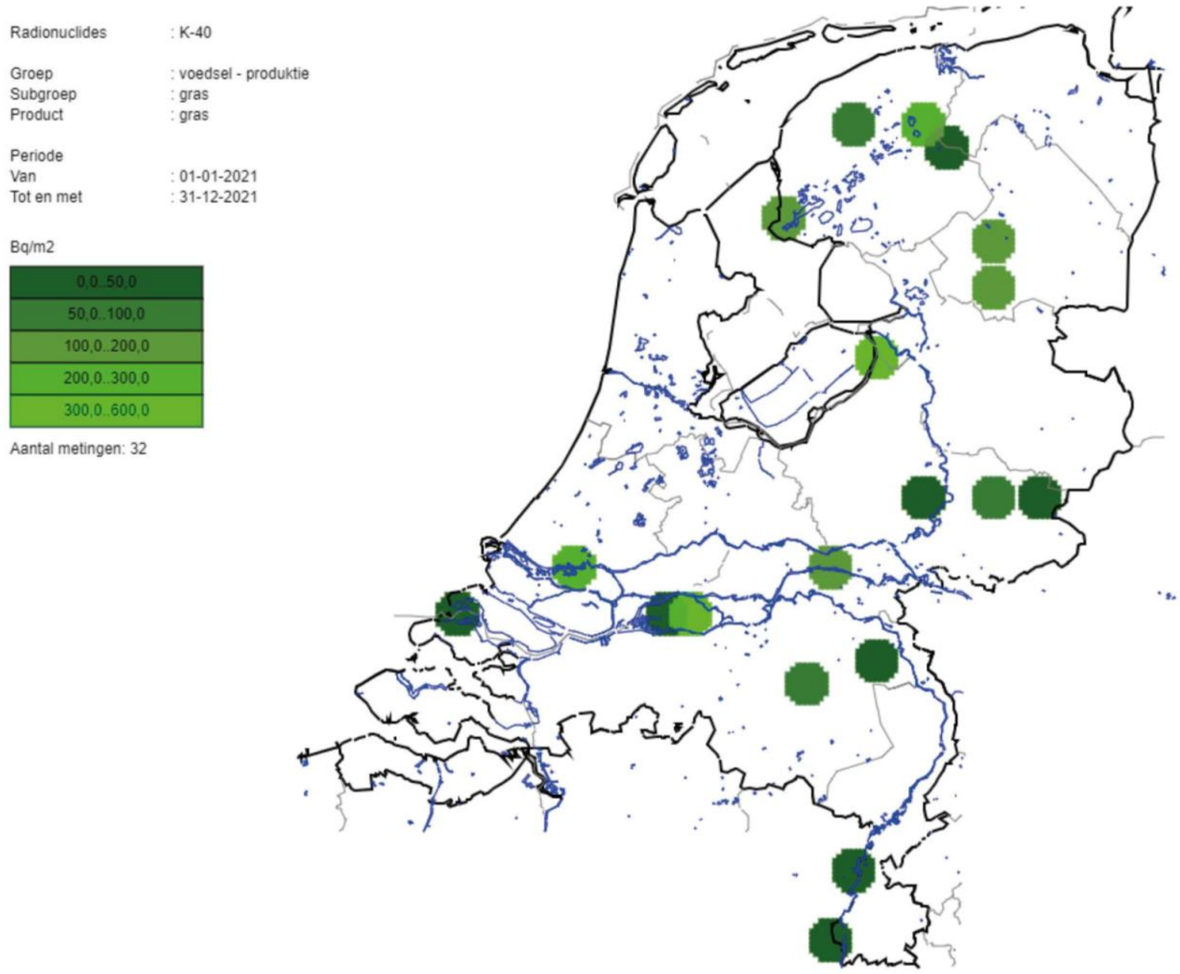

Figure 2 *Impression of spatial variation of ^{40}K activity in grass in Bq·m^{-2}, measured in 2021.*

6 Conclusions

Within the Netherlands Wageningen Food Safety Research performs a comprehensive monitoring program on the presence of natural and artificial radioactivity in the food and feed production chain. This monitoring program is based on several European and Dutch rules and regulations.

Different sample taking programs on food and feed products, coordinated as well by the NVWA as well as by WFSR, resulted in about 2750 gamma radiation measurements and about 250 beta radiation measurements.

In 2021 no results exceeded the maximal allowed radiation levels. Most samples did not show results above the Minimal Detectable Activity for the specific analyses for beta and gamma radiation.

With the analysis results the annual yearly ingestion dose as a result of for ^{134}Cs, ^{137}Cs and ^{90}Sr is calculated on < 0.12 mSv. Since most of the analyses report an analysis result below the minimal detectable activity, this value should be considered as an overestimation as the ingestion dose as a result of these three radionuclides.

At the moment the ingestion dose as a result of alpha radiating emitters, which are mostly present in food and feed products as a result of natural radioactivity, is not included in the calculation of the total ingestion dose.

To be able to perform a more accurate calculation on the total yearly ingestion dose for the Dutch population also the contribution of the alpha-emitters which are naturally present in food and feed product should be analysed more intensively.

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