Environmental radioactivity in the Netherlands
Results in 2016

This report contains an erratum
d.d. 24-09-2019 on page 118

RIVM Report 2018-0160
Colophon

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DOI 10.21945/RIVM-2018-0160

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This investigation has been performed by order and for the account of the Authority for Nuclear Safety and Radiation Protection, within the framework of Project 390010: environmental monitoring of radioactivity and radiation.

This is a publication of:
National Institute for Public Health and the Environment
P.O. Box 1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl/en
Synopsis

Environmental radioactivity in the Netherlands
Results in 2016

In 2016 the Netherlands met its annual European obligation to measure radioactivity in the environment and in food. All Member States of the European Union are required to perform these measurements each year under the terms of the Euratom Treaty of 1957. The Netherlands complied with the recommendations, as established in 2000, to perform these measurements in a uniform manner. 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.

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.

Radioactivity in air, food, milk, grass and feed
Radioactivity levels in the air were normal, i.e. within the range of previous years. Radioactivity levels in food and milk were well below the export and consumption limits set by European legislation. Radioactivity levels in grass and feed were normal, i.e. within the range of previous years.

Radioactivity in surface water, seawater and drinking water
Radioactivity levels in surface water and seawater were within the range of previous years. Radioactivity levels in untreated water for drinking water production were well below the screening levels above which further investigation should be carried out, with the exception of 19 samples of untreated water (5% of the total number of samples), which were slightly elevated. These measured radioactivity levels do not pose a threat to public health. Further investigation revealed that radioactivity levels in associated finished drinking water were well below the screening levels.

Keywords: radioactivity, environment, airborne particles, water, food, milk
Publiekssamenvatting

Radioactiviteit in het Nederlandse milieu
Resultaten in 2016


Radioactiviteit in lucht, voedsel, melk, gras en veevoer
De radioactiviteitsniveaus in lucht laten een normaal beeld zien dat niet verschilt van voorgaande jaren. De niveaus in voedsel en melk liggen net als in voorgaande jaren duidelijk onder de Europese limieten die zijn opgesteld voor consumptie en export. Ook de radioactiviteitsniveaus in gras en veevoer laten een normaal beeld zien dat niet verschilt van voorgaande jaren.

Radioactiviteit in oppervlaktewater, zeewater en drinkwater
De radioactiviteitsniveaus in oppervlaktewater en zeewater verschillen niet van voorgaande jaren. In ongezuiverd water voor de drinkwaterproductie liggen de niveaus meestal onder de zogeheten screeningswaarden (boven deze waarden moet nader onderzoek worden uitgevoerd). Een uitzondering daarop zijn 19 monsters ongezuiverd water (5 procent van het totale aantal monsters) waarbij licht verhoogde niveaus zijn gemeten. Deze verhogingen zijn zodanig laag dat ze niet schadelijk zijn voor de gezondheid. Aanvullend onderzoek toonde aan dat de niveaus in het gezuiverde drinkwater ruim onder de screeningswaarden lagen.

Trefwoorden: radioactiviteit, milieu, luchtstof, water, voedsel, melk
Acknowledgements

The following institutions contributed to this report:

**The National Institute for Public Health and the Environment**  
*Rijksinstituut voor Volksgezondheid en Milieu (RIVM)*  
Data on air dust, deposition, ambient dose rates and drinking water.  
Dr. C.P. Tanzi (editor), ing. G.J. Knetsch, ing. R.B. Tax, ing. M. Boshuis,  
ir. J.F.M. Versteegh

**Rijkswaterstaat (RWS)**  
Data on seawater and surface water from the main inland water bodies.  
C. Engeler, A. Baak

**The Netherlands Food and Consumer Product Safety Authority**  
*Nederlandse Voedsel en Waren Autoriteit (NVWA)*  
Data on foodstuffs.  
E. Laurensse

**RIKILT Wageningen UR**  
Data on milk and foodstuffs.  
ir. S.T. van Tuinen, ing. C. Onstenk, ing. A. Vos van Avezathe

**N.V. Elektriciteits-Produktiemaatschappij Zuid-Nederland (EPZ)**  
Data on environmental samples taken near the Borssele nuclear power  
plant, measured by the Nuclear Research & Consultancy Group (NRG).  
G.J.L. Goulooze
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Summary

The Dutch government is obliged to establish the necessary arrangements to carry out continuous monitoring of the level of radioactivity in air, water and soil under the terms of the Euratom Treaty of 1957. In 2000, the European Commission issued recommendations stipulating the matrices to be measured (air dust, ambient dose, surface water, drinking water, milk and food) and stipulating the frequency of the measurements. The results shall be reported to the European Commission annually.

In 2016, the Netherlands complied with the Euratom recommendations on annually measuring radioactivity in the environment and in food. The measurements were carried out by RIVM, RWS, RIKILT, NVWA and (commissioned by N.V. EPZ) NRG. This report presents the results of radioactivity measurements performed in the Dutch environment in 2016.

Yearly average activity concentrations in air dust were determined for gross $\alpha$, gross $\beta$, $^{7}$Be, $^{137}$Cs and $^{210}$Pb. The yearly total activity in deposition was determined for gross $\alpha$, gross $\beta$, $^{3}$H, $^{7}$Be, $^{137}$Cs, $^{210}$Pb and $^{210}$Po. Gross $\alpha$ and gross $\beta$ are the total activity of radionuclides emitting $\alpha$ and $\beta$ radiation, respectively. The results, which are presented in Table S1 below, are within the range of those presented in previous years.

The National Radioactivity Monitoring Network (NMR) was also used to determine the activity concentrations of gross $\alpha$ and artificial $\beta$ ($\beta$ radiation emitted by man-made radionuclides) in air dust. There is a difference between the NMR data and the gross $\alpha$ and gross $\beta$ data mentioned above, which is due to the contribution of short-lived natural radionuclides (radon daughters) to the NMR data. The yearly average gross $\alpha$ activity concentration in air dust was 3.7 Bq·m$^{-3}$. The yearly average of the $\beta$ activity concentration did not deviate significantly from zero. The NMR was also used to determine the ambient dose equivalent rate: the yearly average was 81 nSv·h$^{-1}$.

In surface water, the yearly average activity concentrations of gross $\alpha$, residual $\beta$ (gross $\beta$ minus naturally occurring $^{40}$K), $^{3}$H, $^{90}$Sr and $^{226}$Ra were determined. The yearly average activity concentrations of $^{60}$Co, $^{131}$I, $^{137}$Cs and $^{210}$Pb in suspended solids in surface water were also determined. In seawater, the yearly average activity concentrations were determined for gross $\alpha$, residual $\beta$, $^{3}$H and $^{90}$Sr. The yearly average activity concentrations of $^{137}$Cs and $^{210}$Pb in suspended solids in seawater were also determined. The results are presented in Table S1.

The yearly average gross $\alpha$, residual $\beta$, $^{3}$H, $^{90}$Sr and $^{226}$Ra activity concentrations in surface water were within the range of those found in previous years, with the exception of an elevated concentration of Ra-226 in the Scheldt. The yearly average $^{60}$Co, $^{131}$I, $^{137}$Cs and $^{210}$Pb activity concentrations in suspended solids in surface water were within the range of those found in previous years.
The yearly average gross \(\alpha\), residual \(\beta\), \(3^\text{H}\) and \(90\text{Sr}\) activity concentrations in seawater were within the range of those found in previous years. The yearly average \(137\text{Cs}\) and \(210\text{Pb}\) activity concentrations in suspended solids in seawater were within the range of those found in previous years.

Typical activities found in untreated and treated water used for drinking water production are presented in Table S1. There is little potassium (and thus \(40\text{K}\)) present in this water. The gross \(\alpha\) activity concentration in untreated water used to produce drinking water averaged per production station exceeded the screening level (0.1 Bq·L\(^{-1}\)) at 6 of the 183 production stations (in 19 of the 388 analyses). Further investigation into these slightly elevated levels in untreated water revealed that the gross \(\alpha\) activity concentration in associated finished drinking water was well below the screening level. The gross \(\beta\) activity concentrations were below the screening level (1.0 Bq·L\(^{-1}\)) and the \(3^\text{H}\) activity concentrations were below the parametric value of 100 Bq·L\(^{-1}\).

The results of the monitoring programme for milk and food are presented in Table S1. Radioactivity was measured in over 600 milk samples and over 2,000 food products. Of these food products, 24 samples of game and poultry and three samples of dried mushrooms contained \(137\text{Cs}\). The set limit of 600 Bq·kg\(^{-1}\) (or 370 Bq·kg\(^{-1}\) for milk and dairy products) for the activity of radiocesium (sum of \(134\text{Cs}\) and \(137\text{Cs}\)) was not exceeded.

The measured concentrations of \(90\text{Sr}\), \(134\text{Cs}\) and \(137\text{Cs}\) in food in Bq·kg\(^{-1}\) were converted to an average daily intake value per person per day (Bq·day\(^{-1}\)) using food consumption patterns. The average daily intake per person of \(134\text{Cs}\), \(137\text{Cs}\) and \(90\text{Sr}\) is \(< 5\), \(< 7\), \(< 5\) Bq·day\(^{-1}\), respectively. The contribution to the effective yearly dose calculated from these average daily intake values is \(< 0.1\) mSv. The actual daily intake (and following dose contribution) is most likely much lower.

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

Data on environmental samples taken near the Borssele nuclear power plant are presented in Table S2.
Samenvatting

In het kader van het Euratom Verdrag uit 1957 is de Nederlandse overheid verplicht om voorzieningen te treffen om radioactiviteitsgehalten te monitoren in de compartimenten lucht, water en bodem. In 2000 heeft de Europese Commissie aanbevelingen uitgegeven waarin in detail is beschreven wat moet worden gemeten (luchtstof, het omgevingsdosisequivalenttempo, oppervlaktewater, drinkwater, melk en voedsel) en met welke frequentie. De resultaten dienen jaarlijks te worden gerapporteerd aan de Europese Commissie.


In luchtstof werd de jaargemiddelde activiteitsconcentratie bepaald van totaal-α, totaal-β, 7Be, 137Cs en 210Pb. In depositie werd de totale jaarlijkse activiteit bepaald van totaal-α, totaal-β, 3H, 7Be, 137Cs, 210Pb en 210Po. Totaal-α respectievelijk totaal-β is de totale activiteit aan α- dan wel β-straling uitzendende radionucliden. De resultaten zijn weergegeven in Tabel S1 en vallen binnen de spreiding van de resultaten van voorgaande jaren.

Met het Nationaal Meetnet Radioactiviteit (NMR) werden activiteitsconcentraties bepaald in luchtstof voor totaal-α en kunstmatige β (β-straling uitgezonden door radionucliden, ontstaan door menselijk handelen). Er is een verschil tussen de NMR-metingen en bovenstaande totaal-α- en totaal-β-metingen, wat wordt veroorzaakt door de bijdrage van kortlevende natuurlijke radionucliden (radondochters).

Het jaargemiddelde voor de totaal-α-activiteitsconcentratie in luchtstof was 3,7 Bq·m⁻³. Het jaargemiddelde voor de kunstmatige β-activiteitsconcentratie in luchtstof week niet significant af van nul. Met het NMR werd daarnaast het omgevingsdosisequivalenttempo bepaald; het jaargemiddelde was 81 nSv·h⁻¹.

In oppervlaktewater werd de jaargemiddelde activiteitsconcentratie bepaald van totaal-α, rest-β (totaal-β minus het van nature aanwezige 40K), 3H, 90Sr en 226Ra en de jaargemiddelde activiteitsconcentratie van 60Co, 131I, 137Cs en 210Pb in zwevend stof.

In zeewater werd de jaargemiddelde activiteitsconcentratie bepaald van totaal-α, rest-β, 3H en 90Sr. In zwevend stof in zeewater werd de jaargemiddelde activiteitsconcentratie bepaald van 137Cs en 210Pb. De resultaten zijn weergegeven in Tabel S1.

De jaargemiddelde activiteitsconcentraties van totaal-α, rest-β (totaal-β minus het van nature aanwezige 40K), 3H, 90Sr en 226Ra in oppervlaktewater vallen binnen de spreiding van de resultaten van voorgaande jaren, met de uitzondering van verhoogde concentratie 226Ra in de Schelde. De jaargemiddelde activiteitsconcentraties van 60Co,
$^{131}$I, $^{137}$Cs en $^{210}$Pb in zwevend stof in oppervlaktewater vallen binnen de spreiding van de resultaten van voorgaande jaren.

De jaar gemiddelde totaal $\alpha$-, rest $\beta$-, $^3$H- en $^{90}$Sr-activiteits concentraties in zeewater vallen binnen de spreiding van de resultaten van voorgaande jaren. De jaar gemiddelde $^{137}$Cs- en $^{210}$Pb-activiteits concentraties in zwevend stof in zeewater vallen binnen de spreiding van de resultaten van voorgaande jaren.

Gangbare activiteits concentraties die in ongezuiverd en gezuiverd water voor de drinkwaterproductie gevonden worden, zijn weergegeven in Tabel S1. In dit water is er een geringe hoeveelheid kalium, en dus $^{40}$K, aanwezig. In 2016 overschrijdt de totaal $\alpha$-activiteitsconcentratie in ongezuiverd water voor drinkwaterproductie per productiestation de screeningswaarde van 0,1 Bq L$^{-1}$ bij 6 van de 183 productiestations (in 19 van de 388 uitgevoerde analyses). Deze verhogingen zijn zodanig laag dat ze niet schadelijk zijn voor de gezondheid. Additioneel onderzoek naar aanleiding van de licht verhoogde niveaus in ongezuiverd water toonde aan dat de niveaus in het gezuiverde drinkwater ruim onder de screeningswaarden lagen. De totaal $\beta$-activiteits concentraties waren lager dan 1,0 Bq L$^{-1}$ en de $^3$H-activiteits concentraties waren lager dan 100 Bq L$^{-1}$.

De resultaten van het meetprogramma voor melk en voedsel zijn weergegeven in Tabel S1. Radioactiviteit werd geanalyseerd in ruim 600 melk monsters en meer dan 2000 voedselproducten, waarvan 24 monsters pluimvee en wild en drie monsters gedroogde paddenstoelen $^{137}$Cs bevatten. De limiet van 600 Bq kg$^{-1}$ (respectievelijk 370 Bq kg$^{-1}$ voor melk en melkproducten) van radiocesium (som van $^{134}$Cs en $^{137}$Cs) wordt niet overschreden.

De gemeten concentraties $^{90}$Sr, $^{134}$Cs en $^{137}$Cs (Bq kg$^{-1}$) in voedsel worden omgerekend naar een gemiddelde dagelijkse opname per persoon per dag (Bq dag$^{-1}$) door gebruik te maken van voedselconsumptie patronen. De gemiddelde dagelijkse opname per persoon is $< 5$, $< 7$, $< 5$ Bq dag$^{-1}$ voor respectievelijk $^{134}$Cs, $^{137}$Cs en $^{90}$Sr. De bijdrage aan de effectieve jaardosis berekend uit deze waarden is $< 0,1$ mSv. De werkelijke dagelijkse opname (en daaruit volgende bijdrage aan de jaardosis) is vermoedelijk veel lager.

Geen van de geanalyseerde monsters gras en veevoer bevatten meetbare hoeveelheden van kunstmatige radionucliden ($^{60}$Co, $^{131}$I, $^{132}$Te, $^{134}$Cs en $^{137}$Cs).

Gegevens betreffende milieu monsters genomen rondom de kerncentrale Borssele zijn weergegeven in Tabel S2.
Table S1: Summary of the results from the Dutch monitoring programme in 2016

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Parameter</th>
<th>Locations</th>
<th>Values</th>
<th>Frequency (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air dust (1)</td>
<td>Gross α</td>
<td>1</td>
<td>0.019 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Gross β</td>
<td>1</td>
<td>0.362 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>⁷Be</td>
<td>1</td>
<td>2.910 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>1</td>
<td>0.000208 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>²¹⁰Pb</td>
<td>1</td>
<td>0.312 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td>Deposition (2)</td>
<td>Gross α</td>
<td>1</td>
<td>66 Bq·m⁻²</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Gross β</td>
<td>1</td>
<td>88 Bq·m⁻²</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>³H (3)</td>
<td>1</td>
<td>22–1,510 Bq·m⁻²</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>⁷Be</td>
<td>1</td>
<td>1,375 Bq·m⁻²</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs (3)</td>
<td>1</td>
<td>0.04–1.15 Bq·m⁻²</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>²¹⁰Pb</td>
<td>1</td>
<td>95–98 Bq·m⁻²</td>
<td>52</td>
</tr>
<tr>
<td>Surface water (1)</td>
<td>Gross α</td>
<td>8</td>
<td>29–249 mBq·L⁻¹</td>
<td>12–13 (4)</td>
</tr>
<tr>
<td></td>
<td>Residual β</td>
<td>8</td>
<td>13–112 mBq·L⁻¹</td>
<td>12–13 (4)</td>
</tr>
<tr>
<td></td>
<td>³H</td>
<td>8</td>
<td>1,550–14,600 mBq·L⁻¹</td>
<td>6–13 (4)</td>
</tr>
<tr>
<td></td>
<td>⁹⁰Sr</td>
<td>3</td>
<td>&lt; 1–3.1 mBq·L⁻¹</td>
<td>6–7 (4)</td>
</tr>
<tr>
<td></td>
<td>²²⁶Ra</td>
<td>4</td>
<td>4.0–33.1 mBq·L⁻¹</td>
<td>6–7 (4)</td>
</tr>
<tr>
<td>Suspended solids in surface water (1)</td>
<td>⁶⁰Co</td>
<td>8</td>
<td>&lt; 1–10.4 Bq·kg⁻¹</td>
<td>4–51 (4)</td>
</tr>
<tr>
<td></td>
<td>¹³¹I</td>
<td>8</td>
<td>&lt; 1–36.0 Bq·kg⁻¹</td>
<td>4–51 (4)</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>8</td>
<td>3.0–12.4 Bq·kg⁻¹</td>
<td>4–51 (4)</td>
</tr>
<tr>
<td></td>
<td>²¹⁰Pb</td>
<td>4</td>
<td>80–140 Bq·kg⁻¹</td>
<td>6–7 (4)</td>
</tr>
<tr>
<td>Seawater (1)</td>
<td>Gross α</td>
<td>8</td>
<td>190–420 mBq·L⁻¹</td>
<td>4–13 (4)</td>
</tr>
<tr>
<td></td>
<td>Residual β</td>
<td>8</td>
<td>34–140 mBq·L⁻¹</td>
<td>4–13 (4)</td>
</tr>
<tr>
<td></td>
<td>³H</td>
<td>8</td>
<td>350–5,200 mBq·L⁻¹</td>
<td>4–13 (4)</td>
</tr>
<tr>
<td></td>
<td>⁹⁰Sr</td>
<td>4</td>
<td>&lt; 1.4–1.9 mBq·L⁻¹</td>
<td>4–13 (4)</td>
</tr>
<tr>
<td>Suspended solids in seawater (1)</td>
<td>¹³⁷Cs</td>
<td>1</td>
<td>3.3 Bq·kg⁻¹</td>
<td>4 (4)</td>
</tr>
<tr>
<td></td>
<td>²¹⁰Pb</td>
<td>1</td>
<td>62 Bq·kg⁻¹</td>
<td>4 (4)</td>
</tr>
<tr>
<td>Drinking water (1)</td>
<td>Gross α</td>
<td>183</td>
<td>&lt; 0.06 Bq·L⁻¹</td>
<td>388 (5)</td>
</tr>
<tr>
<td></td>
<td>Gross β</td>
<td>186</td>
<td>&lt; 0.1 Bq·L⁻¹</td>
<td>428 (5)</td>
</tr>
<tr>
<td></td>
<td>Residual β</td>
<td>168</td>
<td>&lt; 0.1 Bq·L⁻¹</td>
<td>390 (5)</td>
</tr>
<tr>
<td></td>
<td>³H</td>
<td>88</td>
<td>&lt; 4.0 Bq·L⁻¹</td>
<td>448 (5)</td>
</tr>
<tr>
<td>Milk (1)</td>
<td>⁴⁰K</td>
<td>22</td>
<td>51.2 Bq·kg⁻¹</td>
<td>581 (5)</td>
</tr>
<tr>
<td></td>
<td>⁶⁰Co</td>
<td>22</td>
<td>50.1 Bq·kg⁻¹</td>
<td>581 (5)</td>
</tr>
<tr>
<td></td>
<td>⁹⁰Sr</td>
<td>22</td>
<td>5.1 Bq·kg⁻¹</td>
<td>47 (5)</td>
</tr>
<tr>
<td></td>
<td>¹³¹I</td>
<td>22</td>
<td>6.0 Bq·kg⁻¹</td>
<td>581 (5)</td>
</tr>
<tr>
<td></td>
<td>¹³⁴Cs</td>
<td>22</td>
<td>6.0 Bq·kg⁻¹</td>
<td>581 (5)</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>22</td>
<td>0.5 Bq·kg⁻¹</td>
<td>581 (5)</td>
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<table>
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<tr>
<th>Matrix</th>
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<th>Locations</th>
<th>Values</th>
<th>Frequency (per year)</th>
</tr>
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<tr>
<td><strong>Food</strong> (8, 9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain and grain products</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>31 (0) (11)</td>
</tr>
<tr>
<td>Vegetables and mushrooms</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>22–1019 Bq·kg$^{-1}$</td>
<td>84 (3) (11, 12)</td>
</tr>
<tr>
<td>Fruit and fruit products</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>10 (0) (11)</td>
</tr>
<tr>
<td>Milk and dairy products</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>50 (0) (11)</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>32 (0) (11)</td>
</tr>
<tr>
<td>Game and poultry</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>26 (0) (11)</td>
</tr>
<tr>
<td>Salads</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>17 (0) (11)</td>
</tr>
<tr>
<td>Oil and butter</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>30 (0) (11)</td>
</tr>
<tr>
<td>Honey</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>49 (1) (11)</td>
</tr>
<tr>
<td>Tea</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>3 (0) (11)</td>
</tr>
<tr>
<td>Mineral water</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>18 (0) (11)</td>
</tr>
<tr>
<td>Fish</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>21 (0) (11)</td>
</tr>
<tr>
<td>Vegetables and fruits</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>287 (0) (11)</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>$^{90}$Sr</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>23 (0) (11)</td>
</tr>
<tr>
<td>Game and poultry</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>568 (0) (11)</td>
</tr>
<tr>
<td>Eggs</td>
<td>$^{90}$Sr</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>15 (0) (11)</td>
</tr>
<tr>
<td>Fish and seafood products</td>
<td>$^{90}$Sr</td>
<td>-</td>
<td>5–43 Bq·kg$^{-1}$</td>
<td>398 (24) (11)</td>
</tr>
<tr>
<td>Ready meals</td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>19 (0) (11)</td>
</tr>
<tr>
<td></td>
<td>$^{90}$Sr</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>156 (0) (11)</td>
</tr>
<tr>
<td></td>
<td>$^{90}$Sr</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>6 (0) (11)</td>
</tr>
<tr>
<td></td>
<td>$^{137}$Cs (10)</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>201 (0) (11)</td>
</tr>
<tr>
<td></td>
<td>$^{90}$Sr</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>24 (0) (11)</td>
</tr>
<tr>
<td></td>
<td>$^{90}$Sr</td>
<td>-</td>
<td>$&lt; 5$ Bq·kg$^{-1}$</td>
<td>45 (0) (11)</td>
</tr>
</tbody>
</table>

(1) Yearly average.
(2) Yearly total.
(3) A 68% confidence interval.
(4) Frequency depends on location.
(5) Total number of samples taken combined over all locations.
(6) Yearly average in cow’s milk.
(7) Yearly average in goat’s milk.
(8) Given range represents values of individual (positive) samples.
(9) As measured by the Netherlands Food and Consumer Product Safety Authority.
(10) Samples were analysed for $^{134}$Cs as well, but measurements were below the detection limit of 5 Bq·kg$^{-1}$.
(11) Total number of samples taken (number of samples where the minimum detectable activity is exceeded in brackets).
(12) Activity concentrations above 1,000 Bq·kg$^{-1}$ were measured in dried mushrooms. As mushrooms are not consumed in their dry form, the activity concentration in their consumable form is compared to the set limit of 600 Bq·kg$^{-1}$.
(13) As measured by RIKILT Wageningen UR.
### Table S2 Summary of the results of the monitoring programme in the vicinity of the Borssele nuclear power plant in 2016

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Parameter</th>
<th>Locations</th>
<th>Values (1)</th>
<th>Frequency (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air (dust)</td>
<td>Gross α</td>
<td>5</td>
<td>0.002–0.153 mBq·m⁻³</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Gross β</td>
<td>5</td>
<td>0.03–1.27 mBq·m⁻³</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>⁶⁰Co</td>
<td>5 (2)</td>
<td>&lt; 0.04–&lt; 0.08 mBq·m⁻³</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>¹³¹Iₑₑ (3)</td>
<td>5 (2)</td>
<td>&lt; 0.1–&lt; 0.3 mBq·m⁻³</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>¹³¹Iₑᵣ (4)</td>
<td>5 (2)</td>
<td>&lt; 0.4–&lt; 1 mBq·m⁻³</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>5 (2)</td>
<td>&lt; 0.03–&lt; 0.06 mBq·m⁻³</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Nat. (5)</td>
<td>5 (2)</td>
<td>&lt; 1.3–3 mBq·m⁻³</td>
<td>12</td>
</tr>
<tr>
<td>Grass</td>
<td>⁶⁰Co</td>
<td>5 (2)</td>
<td>&lt; 0.8–&lt; 3 Bq·kg⁻¹</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>¹³¹I</td>
<td>5 (2)</td>
<td>&lt; 0.9–&lt; 2 Bq·kg⁻¹</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>5 (2)</td>
<td>&lt; 0.7–&lt; 2 Bq·kg⁻¹</td>
<td>12</td>
</tr>
<tr>
<td>Soil</td>
<td>⁵⁴Mn</td>
<td>4</td>
<td>&lt; 0.3–&lt; 0.4 Bq·kg⁻¹</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>⁶⁰Co</td>
<td>4</td>
<td>&lt; 0.3–&lt; 0.4 Bq·kg⁻¹</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>¹³⁴Cs</td>
<td>4</td>
<td>&lt; 0.2–&lt; 0.4 Bq·kg⁻¹</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>4</td>
<td>1.27–1.48 Bq·kg⁻¹</td>
<td>1</td>
</tr>
<tr>
<td>Water</td>
<td>Residual β</td>
<td>4</td>
<td>&lt; 0.011–0.132 Bq·L⁻¹</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>³H</td>
<td>4</td>
<td>1.4–7.3 Bq·L⁻¹</td>
<td>12</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>Gross β</td>
<td>4</td>
<td>0.20–3.10 kBq·kg⁻¹</td>
<td>12</td>
</tr>
<tr>
<td>Seaweed</td>
<td>⁶⁰Co</td>
<td>4 (2)</td>
<td>&lt; 0.6–&lt; 2 Bq·kg⁻¹</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>¹³¹I</td>
<td>4 (2)</td>
<td>&lt; 0.5–&lt; 2 Bq·kg⁻¹</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>4 (2)</td>
<td>&lt; 0.5–&lt; 2 Bq·kg⁻¹</td>
<td>12</td>
</tr>
<tr>
<td>Sediment</td>
<td>⁶⁰Co</td>
<td>4 (2)</td>
<td>&lt; 0.2–&lt; 0.3 Bq·kg⁻¹</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>¹³¹I</td>
<td>4 (2)</td>
<td>&lt; 0.2–&lt; 0.3 Bq·kg⁻¹</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>4 (2)</td>
<td>&lt; 0.2–0.99 Bq·kg⁻¹</td>
<td>12</td>
</tr>
</tbody>
</table>

(1) Given range represents the range of values of individual samples.
(2) Analysis was performed on a combined sample of the monthly samples collected in different locations.
(3) Elemental ¹³¹I.
(4) Organically bound ¹³¹I.
(5) Naturally occurring γ-emitters.
1 Introduction

Radioactivity of natural and artificial origin can be found in low concentration levels all around the globe. So-called naturally occurring radionuclides can be found in soil, water and air, and have existed since the creation of the universe or are continually generated, either from the decay of primordial isotopes or as a result of cosmic radiation. Concentration levels of naturally occurring radionuclides, such as $^{40}$K and daughters from the uranium and thorium series, may be enhanced as a result of human activities within or outside national borders (e.g. discharges from the ore-processing industry).

Man-made radionuclides are found in the environment as a result of events such as nuclear weapons tests and discharges from medical facilities and nuclear installations.

It is important to monitor radioactivity levels in the environment, as the intake of radioactivity and exposure to ionising radiation can lead to an effective dose that may eventually result in adverse health effects. Monitoring radioactivity levels in the environment provides background radioactivity levels under normal circumstances that enable the detection and confirmation of abnormal levels.

This report presents the results of radioactivity measurements performed in the environment in the Netherlands in 2016.

The aim of this report is threefold:
   i) to present a survey of radioactivity measurements performed in the Dutch environment, providing information on the exposure of the population to ionising radiation;
   ii) to provide information on typical environmental radioactivity levels, which can be used as a reference in the event of a radiological or nuclear incident or emergency;
   iii) to show the compliance of monitoring programmes in the Netherlands with the corresponding European obligations and recommendations and to report possible omissions.

In the following chapters, the results of the measurements will be presented in graphs and tables. More detailed information is presented in Appendix A. Chapters 2 to 8 are subdivided according to the structure of the Commission Recommendation on the Application of Article 36 of the Euratom Treaty [1] and present the results of measurements for various environmental compartments. Chapter 9 contains data on radioactivity levels in grass and feed. Chapter 10 contains data on environmental samples taken near the Borssele nuclear power plant. General conclusions are presented in Chapter 11.

Appendix B describes the methods used for the presentation of data. A glossary of frequently occurring terms is given in Appendix C.
2 Airborne particles

2.1 Introduction

Table 2.1 describes the monitoring programme for the determination of radionuclides in air dust. The sampling was performed at the RIVM premises in Bilthoven, the Netherlands. Air dust samples for the measurement of gross $\alpha$, gross $\beta$ and $\gamma$-emitters were collected weekly using a high-volume sampler. The high-volume sampler described in [2] was replaced by a Snow White high-volume sampler from Senya Ltd [3] in 2011.

The change in equipment coincided with a change in the filter type (polypropylene G-3 instead of glass fibre GF10), the volume sampled (125,000 m$^3$ instead of 50,000 m$^3$) and the sampling height (on top of a three-storey building instead of 1.8 m above ground level). Samples were collected weekly according to a standard procedure [4].

The collection efficiency of the filter type G-3 was determined to be 96 ± 1% with a flow rate of approximately 760 (normalized) m$^3$·h$^{-1}$ based on $^{7}$Be and $^{210}$Pb results [3]. The results presented in this chapter take this collection efficiency into account.

After sampling, the G-3 filters were dried and weighed to determine the dust load. Then a sub-sample was taken from the filter for the determination of gross $\alpha$ and gross $\beta$ according to a standard procedure [5]. The remainder of the filter was folded into a 250 ml container and measured on a coaxial detector (4 days delay time, 100,000 seconds counting time) to determine volatile $\gamma$-emitters according to standard procedures [5, 6].

Following this measurement, the filter was dry-ashed at 450 °C for 16 h. Calcium sulphate was added to the resulting residue to achieve a sample of 4 g, which was homogenized and transferred to a polyethylene vial. Measurements were carried out on a coaxial well-type detector (178,200 seconds counting time) according to standard procedures [5, 6].

The period between sampling and the gross $\alpha$ and gross $\beta$ analysis was five to ten days, which is long compared with the decay time of the short-lived decay products $^{222}$Rn and $^{220}$Rn. This is done to ensure that these naturally occurring short-lived decay products do not contribute to the measured $\alpha$ and $\beta$ activity concentrations.

In 2005 the data from 1991 to 2004 were re-analysed to determine the yearly averages following the method described in Appendix B [7]. This might have led to small differences between the data presented in this report and the data reported prior to 2005.
Table 2.1 Monitoring programme for the determination of radionuclides in air dust

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Location</th>
<th>Parameter</th>
<th>Sample period</th>
<th>Sample volume</th>
<th>Analysis frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air dust</td>
<td>Bilthoven</td>
<td>gross α, gross β</td>
<td>1 week</td>
<td>925 m$^3$</td>
<td>weekly</td>
</tr>
<tr>
<td>Air dust</td>
<td>Bilthoven</td>
<td>γ-emitters$^{(1)}$</td>
<td>1 week</td>
<td>125,000 m$^3$</td>
<td>weekly</td>
</tr>
</tbody>
</table>

$^{(1)}$ γ-spectroscopic analysis of specific γ-emitting radionuclides.

$^{(2)}$ A sub-sample of 0.74% from the total filter, through which approximately 125,000 m$^3$ of air was sampled.

2.2 Results for long-lived α and β activity

The weekly results of gross α and β activity concentrations in air dust are given in Figure 2.1 and Table A1 (see Appendix A). Due to large uncertainties caused by variations in the amount of dust on the filters, gross α activity concentrations in air dust should be regarded as indicative values [5]. The frequency distributions of gross α activity and gross β activity concentrations in air dust are given in Figures 2.2 and 2.3, respectively.

The yearly average activity concentrations in air dust were 0.019 mBq m$^{-3}$ for gross α and 0.362 ± 0.006 mBq m$^{-3}$ for gross β. The yearly averages of the gross α and β activity concentrations of long-lived radionuclides in 2016 were within the range of the results from the period 1992–2015, as illustrated in Figure 2.4. Since 2007, a new (more realistic) calibration for gross α has been applied to the measurements. The current calibration factor is 1.4 times higher than the one used before 2007, resulting in lower reported gross α activities.

In 2011, a change in equipment, with a coinciding change in filter type, resulted in changes in the reported gross α (-24%) and gross β (-15%) results, for which no correction is applied [3]. A possible explanation for these changes is a deeper permeation of the air dust in the present filter type G-3 than in the previous filter type GF10. This results in a difference in the self-absorption of the α and β particles measured, i.e. lower gross α and gross β results in the present G-3 filter than in the previous GF10 filter.

Normally there is a good correlation between gross β and naturally occurring $^{210}$Pb (in equilibrium with its β-emitting daughter $^{210}$Bi) activity concentrations, which suggests that under normal conditions $^{210}$Pb/$^{210}$Bi is the main contributor to the gross β value (see Figure 2.8).
Figure 2.1 Weekly average gross $\alpha$ and $\beta$ activity concentrations of long-lived radionuclides in air dust sampled at RIVM.

Figure 2.2 Frequency distribution of gross $\alpha$ activity concentration of long-lived radionuclides in air dust collected weekly in 2016.
Figure 2.3  Frequency distribution of gross \( \beta \) activity concentration of long-lived radionuclides in air dust collected weekly in 2016

Figure 2.4  Yearly average gross \( \alpha \) and gross \( \beta \) activity concentrations of long-lived radionuclides in air dust at RIVM since 1992
2.3 Results for $\gamma$-emitting radionuclides

Several $\gamma$-emitting radionuclides were detected frequently in air dust: $^7$Be (52 times), $^{210}$Pb (52 times) and $^{137}$Cs (47 times). The results are presented in Table A3 and Figures 2.5, 2.6 and 2.7. The detection limits for radionuclides considered in the $\gamma$-spectroscopic analysis of the HVS samples are given in Table A2.

The yearly average activity concentrations of $^7$Be, $^{137}$Cs and $^{210}$Pb were $2,910 \pm 30$, $0.208 \pm 0.004$ and $312 \pm 4 \mu$Bq·m$^{-3}$, respectively.

The behaviour of $^7$Be in the atmosphere has been studied worldwide [8, 9, 10, 11, 12, 13, 14]. Natural $^7$Be (half-life of 53.3 days) is formed by spallation reactions of cosmogenic radiation with atmospheric nuclei such as nitrogen and oxygen, resulting in the formation of BeO or Be(OH)$_2$ molecules. Approximately 70% of $^7$Be is produced in the stratosphere and the remainder is produced in the troposphere. It has an estimated residence time of one to two years in the stratosphere and approximately six weeks in the troposphere. Most of the $^7$Be produced in the stratosphere does not reach the troposphere, except during spring, when seasonal thinning of the tropopause takes place at mid-latitudes, resulting in air exchange between the stratosphere and the troposphere. In the troposphere, $^7$Be rapidly associates mainly with submicron-sized aerosol particles. Gravitational settling and precipitation processes accomplish transfer to the earth’s surface. Seasonal variations in the concentration of $^7$Be in surface air are influenced by the following main atmospheric processes: wet and dry deposition, mass exchange between stratosphere and troposphere, vertical transport in the troposphere, and horizontal transport of air masses from the subtropics and mid-latitudes to the tropics and polar regions.

The red line in Figure 2.5 shows the seasonal variation of the $^7$Be activity concentration, with peaks during the spring and summer periods, reflecting the seasonal variations in the transport rate of air from the stratosphere to the troposphere. Figure 2.5 further shows the influence of the solar cycle. The maxima of 1997 and 2007–2009, and the minimum at 2000–2002 are consistent with the solar minima (measured by radio flux and sunspot count) of 1996–1997 and 2008–2009, and the solar maximum of 2000–2002, respectively [15]. In the summer of 1991, two severe geomagnetic storms caused a significant worldwide disturbance of the earth’s geomagnetic field. This resulted in a considerable decrease in cosmogenic radiation, which was unprecedented in at least the previous four decades [16]. The absence of a 1991 summer peak in the $^7$Be activity concentration can be explained by the decrease in cosmogenic radiation. The concentrations found for $^7$Be in 2016 fit into the pattern described above.
Figure 2.5 Weekly average $^7$Be activity concentrations (blue) in air dust at RIVM since 1991. The red line is a moving average of 13 weeks.

The nuclide $^{137}$Cs (half-life of 30.2 years) is of anthropogenic origin. The two main sources of $^{137}$Cs in the environment are atmospheric nuclear weapons tests and some nuclear accidents, most notably the Chernobyl accident of 1986 and the Fukushima Daiichi accident of 2011. Resuspension of previously deposited activity has been the main source of airborne $^{137}$Cs activity in the Netherlands since 1986.

Figure 2.6 shows a peak during May 1992. During that month, several wildfires occurred near the Chernobyl area [17], and the level of airborne $^{137}$Cs activity increased ten times in the 30 km exclusion zone around Chernobyl. It is possible that the airborne $^{137}$Cs was transported to Western Europe by a strong easterly wind in the same period [18]. On 29 May 1998, an incident occurred at Algeciras (Spain): an iron foundry melted a $^{137}$Cs source concealed in scrap metal [19]. As a result, elevated levels of airborne $^{137}$Cs activity were measured in France, Germany, Italy and Switzerland during late May and early June. Figure 2.6 shows a slightly elevated level of $^{137}$Cs activity (second peak) around the same period (29 May to 5 June 1998). Such slightly elevated levels are not uncommon, as can be seen in Figure 2.6. These elevations may be related to the resuspension of previously deposited dust, especially during a period of strong winds from the continent [19]. From 18 March to 10 June 2011, elevated levels of $^{137}$Cs activity were measured as a result of the incident at Fukushima (Japan). More detailed results on $^{137}$Cs and other radionuclides during that period are presented in [20].

Figure 2.6 shows a lack of data between 2000 and the middle of 2009. During that period the detection limit was higher than it had been during 1991–1999 due to a different detector set-up. Since July 2009, a new detector set-up has been used, which results in lower detection limits (similar to those used before 2000).
Figure 2.6 Weekly average $^{137}$Cs activity concentrations in air dust at RIVM since 1991

The primary source of atmospheric $^{210}$Pb (half-life of 22.3 years) is the decay of $^{222}$Rn exhaled from continental surfaces. Therefore, the atmospheric concentration of $^{210}$Pb over continental areas is generally higher than it is over oceanic areas ($^{222}$Rn exhalation from the ocean is 1,000 times less than it is from the continents). The reported UNSCEAR reference level of $^{210}$Pb in air dust is 500 $\mu$Bq m$^{-3}$ [21]. In the atmosphere, this radionuclide is predominantly associated with submicron-sized aerosol particles [22, 23]. The mean aerosol (carrying $^{210}$Pb) residence time in the troposphere is approximately 5 days [24].

Other sources of $^{210}$Pb in air dust are volcanic activity and industrial emissions [25, 26, 27, 28, 29, 30]. Examples of industrial emissions are discharges from power plants that use fossil fuels, discharges from the fertilizer and phosphorus industries, and exhaust gases from traffic. In the Netherlands, emissions by power plants are only of local importance with respect to $^{210}$Pb deposition. Emissions by the phosphorus industry contribute a negligible part of the yearly total $^{210}$Pb deposition [30]. Furthermore, the phosphorus industry ceased to be operational in the Netherlands in 2012. Volcanic eruptions bring uranium decay products into the atmosphere, such as $^{226}$Ra, $^{222}$Rn, $^{210}$Pb and $^{210}$Po. Beks et al. [27] estimate that volcanoes contribute 60 TBq year$^{-1}$ to the atmospheric $^{210}$Pb stock. Unusual (high) $^{210}$Pb values might be explained by natural phenomena such as an explosive volcanic eruption, Saharan dust [31, 32, 33] or the resuspension of (local) dust. Normally there is a good correlation between $^{210}$Pb (in equilibrium with its $\beta$-emitting daughter $^{210}$Bi) and gross $\beta$ activity concentrations, as was the case in 2016 (Figure 2.8). This suggests that, under normal conditions, $^{210}$Pb/$^{210}$Bi is the main contributor to the gross $\beta$ value. The weekly average $^{210}$Pb activity concentrations in 2016 were within the range of those found in previous years (Figure 2.7).
Figure 2.7 Weekly average $^{210}\text{Pb}$ activity concentrations in air dust at RIVM since 1991

Figure 2.8 The weekly average gross $\beta$ and $^{210}\text{Pb}$ activity concentrations in air dust at RIVM show a good correlation.
3 Deposition

3.1 Introduction
Table 3.1 describes the monitoring programme for determining radionuclides in deposition. Sampling was done on the RIVM premises in Bilthoven. Samples were collected weekly for γ-emitters and monthly for gross α, gross β, 3H and 210Po according to a standard procedure [34].

The samples – weekly for γ-emitters and monthly for gross α and gross β – were acidified with sulphuric acid and evaporated. The resulting sulphate residue was analysed according to standard procedures [6, 35, 36].

The monthly samples for 3H were made alkaline by the addition of sodium carbonate and then distilled. A 10 ml aliquot of the distillate was mixed with an equal amount of scintillation solution (Ultima Gold LLT) in a plastic counting vial and then counted on a liquid scintillation counter for 1,000 minutes per sample.

The monthly samples for 210Po were reduced in volume by evaporation. The resulting solution was analysed according to a standard procedure [37] with a minor difference: the ingrowth of 210Po from 210Pb was derived from the 210Pb results from the weekly samples for γ-emitters, rather than by using the procedure described in [37].

In 2005 the data from 1993 to 2004 were re-analysed to determine the yearly totals by the method described in Appendix B [7]. This can lead to small differences between the data presented in this report and the data reported prior to 2005.

Table 3.1 Monitoring programme for the determination of radionuclides in deposition

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Location</th>
<th>Parameter</th>
<th>Sample period</th>
<th>Sample volume</th>
<th>Analysis frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposition Bilthoven</td>
<td>γ-emitters (1)</td>
<td>1 week</td>
<td>variable</td>
<td>weekly</td>
<td></td>
</tr>
<tr>
<td>Deposition Bilthoven</td>
<td>gross α, gross β, 210Po</td>
<td>1 month</td>
<td>variable</td>
<td>monthly</td>
<td></td>
</tr>
<tr>
<td>Deposition Bilthoven</td>
<td>3H</td>
<td>1 month</td>
<td>variable</td>
<td>quarterly</td>
<td></td>
</tr>
</tbody>
</table>

(1) γ spectroscopic analysis of specific γ emitting radionuclides.

3.2 Results for long-lived α and β activity
The monthly deposited gross α and gross β activities of long-lived radionuclides are given in Figure 3.1, Figure 3.3 and Table A4. The yearly total depositions of gross α and gross β were 66 ± 2 and 88 ± 2 Bq·m⁻², respectively. The yearly total depositions of gross α and gross β are within the range of those from previous years, as illustrated in Figure 3.2, Figure 3.4 and Table A6.
The monthly deposition of $^3$H is given in Table A4. In 2016 the yearly total deposition of $^3$H ranged between 22 and 1,510 Bq·m$^{-2}$ (68% confidence interval). The yearly total consisted of 12 samples and 11 out of 12 measurements were below the detection limit. These detection limits were used for the contribution to the yearly total, as described in Appendix B. The range in 2016 did not differ significantly from those measured since 1993, as illustrated in Figure 3.5 and Table A6. Up to 1998, samples were electrolytically enriched before counting, which resulted in a much lower detection limit than the one used from 1998 onwards.

Monthly totals (black dots) are shown with a 68% confidence interval (coloured bars).

*Figure 3.1 Monthly deposition of gross α activity of long-lived radionuclides at RIVM*
Yearly totals (black dots) are shown with a 68% confidence interval (coloured bars). Only the 68% confidence interval is shown if the sum leading to the yearly total contains at least one detection limit.

**Figure 3.2** Yearly deposition of gross α activity of long-lived radionuclides at RIVM since 1993

Monthly totals (black dots) are shown with a 68% confidence interval (coloured bars).

**Figure 3.3** Monthly deposition of gross β activity of long-lived radionuclides at RIVM
Yearly totals (black dots) are shown with a 68% confidence interval (coloured bars).

**Figure 3.4** Yearly deposition of gross β activity of long-lived radionuclides at RIVM since 1993

Yearly totals (black dots) are shown with a 68% confidence interval (coloured bars). Only the 68% confidence interval is shown if the sum leading to the yearly total contains at least one detection limit.

**Figure 3.5** Yearly deposition of $^3$H at RIVM since 1993
Monthly totals (black dots) are shown with a 68% confidence interval (coloured bars). The result for November was rejected.

*Figure 3.6* Monthly deposition of $^{210}$Po activity at RIVM

Yearly totals (black dots) are shown with a 68% confidence interval (coloured bars). Only the 68% confidence interval is shown if the sum leading to the yearly total contains at least one detection limit.

*Figure 3.7* Yearly deposition of $^{210}$Po activity at RIVM since 1993
The monthly α spectroscopy results for \(^{210}\text{Po}\) are given in Figure 3.6 and Table A5. The results for previous years are given in Figure 3.7 and Table A7. The yearly total deposition of \(^{210}\text{Po}\) in 2016 was \(40.6 \pm 1.0\) Bq∙m\(^{-2}\) (68% confidence interval) and is based on 11 monthly results. This value is within the range of the values from previous years, as illustrated in Figure 3.7 and Table A7.

### 3.3 Results for γ-emitting radionuclides

The naturally occurring radionuclides \(^{7}\text{Be}\) and \(^{210}\text{Pb}\) were found in all 52 and in 51 of the 52 weekly deposition samples, respectively. The yearly total deposition of \(^{7}\text{Be}\) was \(1,375 \pm 18\) Bq∙m\(^{-2}\) and the yearly total deposition of \(^{210}\text{Pb}\) ranged between 95 and 98 Bq∙m\(^{-2}\). The nuclide \(^{137}\text{Cs}\) was detected in two of the 52 weekly samples (the detection limit for \(^{137}\text{Cs}\) is 0.02 Bq∙m\(^{-2}\)). The yearly total deposition of \(^{137}\text{Cs}\) ranged between 0.04 and 1.15 Bq∙m\(^{-2}\) (68% confidence interval). The weekly results for deposition of \(^{7}\text{Be}\), \(^{137}\text{Cs}\) and \(^{210}\text{Pb}\) are given in Table A8 and Figures 3.9 and 3.12. The results for previous years are given in Table A7 and Figures 3.10, 3.11 and 3.13.

Figure 3.11 shows a change in trend for \(^{137}\text{Cs}\) between 2000 and the middle of 2009. During that period the detection limit was higher than it had been during 1993–1999 due to a different detector set-up. Since July 2009, a new detector set-up has been used, which results in lower detection limits. Since the \(^{137}\text{Cs}\) deposition values are mostly below the detection limit, no conclusion can be drawn concerning the correlation between the measured \(^{137}\text{Cs}\) values in air dust and the measured \(^{137}\text{Cs}\) deposition values.
Yearly totals (black dots) are shown with a 68% confidence interval (coloured bars). Only the 68% confidence interval is shown if the sum leading to the yearly total contains at least one detection limit.

*Figure 3.10*  Yearly $^7$Be activity deposited at RIVM since 1993

Yearly averages are shown solely as a 68% confidence interval since the sum leading to the yearly total contains at least one detection limit.

*Figure 3.11*  Yearly $^{137}$Cs activity deposited at RIVM since 1993
Weekly averages (black dots) are shown with a 68% confidence interval (coloured bars). In week 49 the measurement was below the detection limit of 0.2 Bq·m⁻² (not shown).

**Figure 3.12  Weekly deposited ²¹⁰Pb activity at RIVM**

Yearly averages (black dots) are shown with a 68% confidence interval (coloured bars). Only the 68% confidence interval is shown if the sum leading to the yearly total contains at least one detection limit.

**Figure 3.13  Yearly ²¹⁰Pb activity deposited at RIVM since 1993**
4 National Radioactivity Monitoring Network

4.1 Introduction
This chapter presents data on gross α and artificial β activity concentrations in air dust and ambient dose equivalent rates, as measured by the National Radioactivity Monitoring Network (Nationaal Meetnet Radioactiviteit, NMR). The data on gross α and artificial β differ in sample size, sampling frequency and analytical procedures (including a different approach to the contribution of short-lived natural radionuclides, i.e. radon daughters) from those given in Chapter 2.

The NMR consists of 167 sites, at which the ambient dose equivalent rate is determined. At 14 measuring sites, gross α and artificial β activity concentrations are determined, as well as the ambient dose equivalent rate (at a height of 3.5 m above ground level) [38]. At the other 153 measuring sites, only the ambient dose equivalent rate is determined (at 1 m above ground level).

Since the dose equivalent rate monitors are placed differently at 14 of the 167 sites with regard to height and surface covering, results can differ between the two types of measuring site [39]. For this reason, the 14 dose equivalent rate monitors are not taken into account when calculating the yearly average ambient dose equivalent. The reported artificial β activity concentrations are calculated from the difference between the measured gross β activity concentration and the natural gross β activity derived from the measured gross α activity concentration.

During the second half of 2002, the 14 aerosol FAG FHT59S monitors were gradually replaced by 14 new Berthold BAI 9128 monitors. Due to differences in detection method, filter transport, calibration radionuclides and algorithms, the results for the activity concentrations from the two types of monitor are not exactly the same. By running both monitors simultaneously at the same location, the measured gross α activity concentration was compared. On average, the Berthold monitor systematically reported about 20% higher values than the FAG monitor [40]. The estimated random uncertainty for both types of monitor is about 20%. No correction was applied for the difference in the gross α activity concentration between the Berthold and FAG monitors.

From November 2014 until the end of 2015 most of the ambient dose equivalent monitors were replaced. The Bitt RS03 monitors (proportional counters) were replaced by new Saphymo XL-2-3 monitors (Geiger-Müller). The energy response, cosmic response and self-effect of the two types of monitor differ slightly. Compared with the Bitt monitor, the Saphymo monitor reports on average 8 nSv/h higher at the natural background radiation level in the Netherlands. No correction for this difference is applied.

The data presented in this chapter are based on 10-minute measurements. Averages over the year are calculated for each location,
using daily averages derived from the 10-minute measurements (Tables A9 and A10). The data on external radiation, expressed in ambient dose equivalents, contain a systematic uncertainty because of an overestimation of the cosmogenic dose rate. NMR data are not corrected for these response uncertainties.

4.2 Results

An impression of the spatial variation in the yearly averages of the NMR data, constructed by using the RIVM’s Geographical Information System (GIS), is shown in Figures 4.1 and 4.3. An inverse distance weight interpolation algorithm was applied to calculate values between the NMR stations.

Figure 4.2 presents the yearly averages of gross α activity concentration since 1990, while Figure 4.4 presents the yearly averages of ambient dose equivalent rate since 1996.

In 2016 the yearly average gross α activity concentration in air dust was 3.7 Bq·m⁻³ (based on the yearly averages of the 14 measurement locations). The yearly average gross α activity concentration in air dust is within the range of those from previous years, as illustrated in Figure 4.2. When comparing this value (yearly average of 3.7 Bq·m⁻³) with data collected before 2002, it should be noted that the Berthold measurements are 20% higher than the FAG measurements. The yearly average of the artificial β activity concentration does not deviate significantly from zero.

Since 2004, the analysis of the ambient dose equivalent rate has been based on a set of 153 stations. The yearly average ambient dose equivalent rate in 2016 was calculated using all 153 stations.

In 2016, the yearly average for the ambient dose equivalent rate was 81.1 nSv h⁻¹. This value, similar to the value of 2015, is significantly higher than the values measured before 2014, as can be seen in Figure 4.4. This increase of the ambient dose equivalent rate coincides with, and is attributable to, the replacement of the old Bitt RS03 proportional counter monitors with the new Saphymo XL 2-3 Geiger-Müller monitors.
Dots represent the locations of the aerosol monitors.

*Figure 4.1* An impression of spatial variation in the average gross α activity concentration of (mainly) short-lived radionuclides in air dust

During the second half of 2002, the FAG monitors were replaced by Berthold monitors.

*Figure 4.2* Yearly average gross α activity concentration of (mainly) short-lived radionuclides in air dust.
Dots represent the locations of the dose equivalent rate monitors.

**Figure 4.3** An impression of spatial variation in the average ambient dose equivalent rate

During the course of 2015, most of the proportional counter monitors were replaced by Geiger-Müller monitors.

**Figure 4.4** The yearly average ambient dose equivalent rate
Figure 4.5 shows the cosmogenic contribution to the effective dose rate, which is related to the ambient dose equivalent rate. Figure 4.5 also shows the influence of the 11-year solar cycle on the cosmogenic contribution.

Figure derived from data supplied by the Federal Aviation Administration [41].

*Figure 4.5  Cosmogenic contribution to the effective dose rate (at sea level), influenced by the solar cycle: location 51° 26’ north and 3° 43’ east (in the southwestern part of the Netherlands), air pressure 1019 hPa*
5 Surface water and seawater

5.1 Introduction

The Rijkswaterstaat (RWS) regularly monitors the concentration of a large number of radionuclides in surface water and seawater. A representative part of the RWS’s monitoring programme is presented here. A more detailed description of the monitoring programme, its underlying strategy and the results of radioactivity measurements in Dutch waters are reported elsewhere [42, 43, 44, 45].

The general monitoring strategy used for surface water is to monitor the inland and border-crossing water bodies of the Netherlands. Therefore, the locations mentioned in Table 5.1 are used for monitoring as they represent the major inland, incoming and outgoing waters of the Netherlands. The locations for seawater presented in this report have been chosen to represent the major areas of seawater.

The monitoring programme used for determining radionuclides in surface water and seawater is shown in Tables 5.1 and 5.2 and in Figure 5.1. Radionuclides were measured in water and in suspended solids. The samples were collected at equidistant times.

Since 2010, measurements in sediment have been added to the RWS monitoring programme, but the results are not presented in this report. These results are presented elsewhere [45]. The radionuclides were measured according to standard procedures [46, 47].

Table 5.1 Monitoring programme for the determination of radionuclides in surface water

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<tr>
<th>Location</th>
<th>Parameter</th>
<th>Matrix</th>
<th>Monitoring frequency (per year)</th>
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<tr>
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<td>Residual β</td>
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<tr>
<td></td>
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<tr>
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<td>Terneuzen (Sas van Gent)</td>
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Table 5.2 Monitoring programme for the determination of radionuclides in seawater

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<td></td>
<td>³H</td>
<td>Water</td>
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<td></td>
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<td>Residual β</td>
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</tr>
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<td></td>
<td>³H</td>
<td>Water</td>
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</tr>
<tr>
<td></td>
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<td>⁹⁰Sr</td>
<td>Water</td>
<td>4</td>
</tr>
<tr>
<td>Central North Sea</td>
<td>Terschelling 235(1)</td>
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</tr>
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<td></td>
<td></td>
<td>³H</td>
<td>Water</td>
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<td>Water</td>
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<td>Marsdiep Noord</td>
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<td>Dantzigat</td>
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<tr>
<td></td>
<td></td>
<td>³H</td>
<td>Water</td>
<td>4</td>
</tr>
</tbody>
</table>

(1) Number indicates distance from shore. For example, 'Noordwijk 2' means Noordwijk 2 km offshore.
Figure 5.1 Overview of monitoring locations for the entire monitoring programme for surface water and seawater, as given by the Rijkswaterstaat
5.2 The results for surface water

The results of measurements of radioactivity in surface water are presented in Tables A11 and A12 and in Figures 5.2 to 5.19.

Gross α and residual β are indicative parameters. In general, gross alpha and beta analysis is used as a screening method to determine the total radioactivity present in the form of alpha and beta radiation, without regard to the identity of specific radionuclides.

The yearly average activity concentrations of gross α for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet were 33, 109, 96, 49, 249, 34, 75 and 29 mBq L⁻¹, respectively. The yearly average activity concentrations of residual β for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet were 14, 21, 46, 29, 112, 24, 28 and 13 mBq L⁻¹, respectively. The yearly average activity concentrations of gross α and residual β in 2016 were within the range of those in previous years.

Residual β in Noordzeekanaal, Nieuwe Waterweg and Scheldt has shown a change in trend since 1994, which was caused by a change in measuring technique that applies only to salt and brackish water [42]. This change in trend was therefore not seen for residual β in IJsselmeer, Rhine or Meuse.

The yearly average ³H activity concentrations for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet were 2.4, 2.6, 3.2, 3.5, 10.8, 14.6, 1.6 and 5.0 Bq L⁻¹, respectively. The yearly average ³H activity concentrations in 2016 were within the range of those in previous years. Elevated levels of ³H in the Rhine could have originated from several nuclear power plants or research reactors in Germany, France or Switzerland. Elevated levels of ³H in the Meuse could have originated from the nuclear power plants at Tihange (Belgium) or Chooz (France). Elevated levels of ³H in the Scheldt could have originated from the nuclear power plant at Doel (Belgium).

The nuclide ⁹⁰Sr is released into the environment by nuclear power plants and nuclear reprocessing plants. The yearly average ⁹⁰Sr activity concentrations for Nieuwe Waterweg, Rhine and Meuse were < 1.0, 3.1 and < 1.3 mBq L⁻¹, respectively. The yearly average ⁹⁰Sr activity concentrations in 2016 were within the range of those in previous years.

The nuclide ²²⁶Ra is released into the environment by the ore-processing industry and transshipment. ²²⁶Ra in Nieuwe Waterweg and Scheldt might originate from these industries in the port areas of Rotterdam-Rijnmond and Antwerp, respectively. The yearly average ²²⁶Ra activity concentrations for Nieuwe Waterweg, Rhine, Scheldt and Meuse were 4.0, 8.6, 33.1 and 5.5 mBq L⁻¹, respectively. The yearly average ²²⁶Ra activity concentrations in 2016 were within the range of those in previous years, with the exception of elevated ²²⁶Ra activity concentration in the Scheldt.
Average values are shown in cases of multiple measurements per month.

Figure 5.2 Gross α activity concentrations for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet

Figure 5.3 Yearly average gross α activity concentrations
Average values are shown in cases of multiple measurements per month.

**Figure 5.4** Residual $\beta$ activity concentrations for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet

**Figure 5.5** Yearly average residual $\beta$ activity concentrations
Average values are shown in cases of multiple measurements per month.

Figure 5.6  $^3$H activity concentrations for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet

Figure 5.7 Yearly average $^3$H activity concentrations
Average values are shown in cases of multiple measurements per month.

Figure 5.8  $^{90}$Sr activity concentrations for Nieuwe Waterweg, Rhine and Meuse


Figure 5.9  Yearly average $^{90}$Sr activity concentrations
Average values are shown in cases of multiple measurements per month.

Figure 5.10  $^{226}$Ra activity concentrations for Nieuwe Waterweg, Rhine, Scheldt and Meuse

Figure 5.11  Yearly average $^{226}$Ra activity concentrations
Nuclear power plants discharge radionuclides, including $^{60}$Co and $^{137}$Cs. $^{60}$Co activity concentrations are higher in Meuse than elsewhere. $^{60}$Co (and $^{137}$Cs) in Meuse could have originated from the nuclear power plants at Tihange (Belgium) or Chooz (France).

The yearly average $^{60}$Co activity concentrations in suspended solids for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet were all < 1 Bq kg$^{-1}$ except for Meuse (10.4 Bq kg$^{-1}$).

The yearly average $^{137}$Cs activity concentrations in suspended solids for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet were 3.0, 6.2, 7.3, 10.3, 5.7, 10.1, 5.3 and 12.4 Bq kg$^{-1}$, respectively. In 2016, the yearly average $^{60}$Co and $^{137}$Cs activity concentrations in suspended solids were within the range of those in previous years.

The nuclide $^{131}$I is released into the environment primarily by medical facilities. $^{131}$I activity concentrations are higher in Noordzeekanaal and Meuse than elsewhere. $^{131}$I in Noordzeekanaal and Meuse might originate from a sewage treatment plant in the port area of Westpoort and medical facilities in Belgium, respectively.

The yearly average $^{131}$I activity concentrations in suspended solids for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet were < 1, 36, < 2, < 2, < 1, 6.2, 6.5 and < 1.2 Bq kg$^{-1}$, respectively. In 2016, the yearly average $^{131}$I activity concentrations in suspended solids were within the range of those in previous years.

The radionuclides $^{210}$Po and $^{210}$Pb originate from the uranium decay chain and are released by the ore-processing industry [42]. Since $^{210}$Po is usually in equilibrium with $^{210}$Pb in suspended solids, RWS reports only $^{210}$Pb. $^{210}$Pb in Nieuwe Waterweg and Scheldt might originate from these types of industries in the port areas of Rijnmond and Antwerp, respectively. The yearly average $^{210}$Pb activity concentrations in suspended solids for Nieuwe Waterweg, Rhine, Scheldt and Meuse, were 97, 121, 80 and 140 Bq kg$^{-1}$, respectively. In 2016, the yearly average $^{210}$Pb activity concentrations in suspended solids were within the range of those in previous years. For the Noordzeekanaal (at location IJmuiden), the presence of $^{131}$I most likely originates from a sewage treatment facility. One of the contributions to the sewage waters is discharge from medical facilities. It has not been determined which changes over time might be related to the observed changes of activity concentrations over the years.
Average values are shown in cases of multiple measurements per month.

**Figure 5.12** $^{60}$Co activity concentrations in suspended solids for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet.

**Figure 5.13** Yearly average $^{60}$Co activity concentrations in suspended solids.
Average values are shown in cases of multiple measurements per month.

**Figure 5.14** $^{131}$I activity concentrations in suspended solids for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet

**Figure 5.15** Yearly average $^{131}$I activity concentrations in suspended solids
Average values are shown in cases of multiple measurements per month.

Figure 5.16 $^{137}$Cs activity concentrations in suspended solids for IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt, Meuse, Kanaal Gent Terneuzen and Haringvliet

Figure 5.17 Yearly average $^{137}$Cs activity concentrations in suspended solids
Average values are shown in cases of multiple measurements per month.

Figure 5.18  $^{210}$Pb activity concentrations in suspended solids

Figure 5.19  Yearly average $^{210}$Pb activity concentrations in suspended solids
5.3 The results for seawater

The results of measurements of radioactivity in seawater are presented in Tables A13 and A14 and in Figures 5.20 to 5.31. Gross α and residual β are indicative parameters [42]. In the first half of 2000, the background of the measuring equipment was unstable and higher than usual, which resulted in lower results. Therefore, yearly average concentrations of gross α in 2000 were based on data starting from the end of July 2000. Changes in the trend of gross α in the period 1985–1997 are explained elsewhere [42].

The yearly average activity concentrations of gross α in seawater for the Coastal Area, Southern North Sea, Central North Sea, Delta Coastal Waters, Western Scheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East were 410, 350, 190, 340, 350, 210, 390 and 420 mBq·L⁻¹, respectively. The yearly average gross α activity concentrations in 2016 were within the range of those in previous years (Figure 5.21).

Residual β shows an apparent change in trend since 1994 (Figure 5.23). This was caused by a change in measuring technique that applies only to salt and brackish water [42]. The yearly average activity concentrations of residual β in seawater for the Coastal Area, Southern North Sea, Central North Sea, Delta Coastal Waters, Western Scheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East were 59, 43, 34, 44, 110, 43, 68 and 140 mBq·L⁻¹, respectively. The yearly average residual β activity concentrations in 2016 were within the range of those in previous years (Figure 5.23).

Nuclear power plants discharge the radionuclides ³H and ¹³⁷Cs, among others. Nuclear fuel reprocessing plants discharge the radionuclides ³H and ⁹⁰Sr, among others. Discharges from the nuclear power plants at Doel (Belgium) and Borssele (Netherlands) are monitored in the Western Scheldt (WS) area. The impact of reprocessing plants at Sellafield (England) and Le Havre (France) is monitored in the Central North Sea (CN) and Southern North Sea (ZN) areas, respectively [42]. The impact of both sources (nuclear power and reprocessing plants) is monitored indirectly in the Delta Coastal Waters (VD) area.

The yearly average ³H activity concentrations in seawater for the Coastal Area, Southern North Sea, Central North Sea, Delta Coastal Waters, Western Scheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East were 4.3, 2.6, 0.4, 4.7, 5.2, 3.8, 4.1 and 3.8 Bq·L⁻¹, respectively.

The yearly average ⁹⁰Sr activity concentrations in seawater for the Southern North Sea, Central North Sea, Delta Coastal Waters and Western Scheldt were 1.9, < 1.4, < 1.9 and <1.8 mBq·L⁻¹, respectively. The yearly average ³H and ⁹⁰Sr concentrations in 2016 were within the range of those in previous years (Figures 5.25 and 5.27).
Figure 5.20  Gross α activity concentrations in seawater for the Coastal Area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Western Scheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO)

Figure 5.21  Yearly average gross α activity concentrations
Figure 5.22  Residual β activity concentrations in seawater for the Coastal Area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Western Scheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO)

Figure 5.23  Yearly average residual β activity concentrations
Figure 5.24 $^3$H activity concentrations in seawater for the Coastal Area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Western Scheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO).

Figure 5.25 Yearly average $^3$H activity concentrations.
Figure 5.26  $^{90}$Sr activity concentrations in seawater for the Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD) and Western Scheldt (WS)

Figure 5.27  Yearly average $^{90}$Sr activity concentrations
The radionuclides $^{210}\text{Pb}$ and $^{210}\text{Po}$ originate from the uranium decay chain and are released, for example, by the phosphate-processing industry and production platforms for oil and gas [42]. The phosphate-processing industry has not been operational in the Netherlands since 2012. Since $^{210}\text{Po}$ is usually in equilibrium with $^{210}\text{Pb}$ in suspended solids, RWS reports only $^{210}\text{Pb}$ (as in surface water). In cases in which a strong increase in the gross α value is noticed, however, $^{210}\text{Po}$ is determined as well. Discharges via the main rivers are monitored in the Coastal Area (KZ). Discharges from the ore- and phosphate-processing industries in Belgium and the Netherlands are monitored in the Western Scheldt (WS) area. Discharges from Delfzijl, Eemshaven and plants in Germany are monitored in the Eems-Dollard (ED) area. The impact of these discharges, together with activity originating from the North Sea, is monitored indirectly in the Wadden Sea (WW and WO) area.

Since 2009, Wadden Sea West has replaced Wadden Sea East as a monitoring location. Since 2014, the monitoring of suspended solids has been discontinued in the Coastal Area, Eems-Dollard and Wadden Sea West.

The yearly average $^{137}\text{Cs}$ and $^{210}\text{Pb}$ activity concentrations in suspended solids for Western Scheldt were 3.3 and 62 Bq·kg$^{-1}$, respectively. The yearly average $^{137}\text{Cs}$ and $^{210}\text{Pb}$ activity concentrations in 2016 were within the range of those in previous years (Figures 5.29 and 5.31).

![Figure 5.28](image)

*Figure 5.28  $^{137}\text{Cs}$ activity concentrations in suspended solids in seawater for the Western Scheldt (WS)*
Since 2009, Wadden Sea West (WW) has replaced Wadden Sea East (WO) as a monitoring location. Since 2014, the monitoring of suspended solids has been discontinued in the Coastal Area (KZ), Eems-Dollard (ED) and Wadden Sea West (WW).

Figure 5.29 Yearly average $^{137}$Cs activity concentrations in suspended solids

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Figure 5.30 $^{210}$Pb activity concentrations in suspended solids in seawater for the Western Scheldt (WS)
Since 2009, Wadden Sea West (WW) has replaced Wadden Sea East (WO) as a monitoring location. Since 2014, the monitoring of suspended solids has been discontinued in the Coastal Area (KZ), Eems-Dollard (ED) and Wadden Sea West (WW).

Figure 5.31  Yearly average $^{210}$Pb activity concentrations in suspended solids
6  Water for human consumption

6.1  Introduction

In addition to the Recommendation on the Application of Article 36 of the Euratom Treaty [1], requirements for the monitoring of drinking water are given in Council Directive 2013/51/EC [48]. According to this directive, the parameters $^3$H and the total indicative dose should be monitored. Screening methods for gross $\alpha$ and gross $\beta$ activity concentrations may be used to monitor the total indicative dose. If the gross $\alpha$ and gross $\beta$ activity concentrations are less than the screening levels of 0.1 and 1.0 Bq·L$^{-1}$, respectively, it can be assumed that the total indicative dose is less than the parametric value of 0.1 mSv·year$^{-1}$ [49, 50, 51].

In the Netherlands, drinking water production stations monitor untreated water and treated water for $^3$H, gross $\alpha$, gross $\beta$ and residual $\beta$ activity concentrations. The monitoring frequency per location ranges from 1 to 26 times per year, depending on the volume of water produced. The activity concentrations are averaged over a year for each production station.

6.2  Results

The results for 2016 are presented in Table 6.1. For gross $\alpha$, $^3$H, gross $\beta$ and residual $\beta$, several hundred analyses were performed at a number of production stations; the number of production stations varied between 168 and 186.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gross $\alpha$</th>
<th>$^3$H</th>
<th>Residual $\beta$</th>
<th>Gross $\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average value</td>
<td>$&lt; 0.06$ Bq·L$^{-1}$</td>
<td>$&lt; 4.0$ Bq·L$^{-1}$</td>
<td>$&lt; 0.1$ Bq·L$^{-1}$</td>
<td>$&lt; 0.1$ Bq·L$^{-1}$</td>
</tr>
<tr>
<td>No. of all production stations</td>
<td>183</td>
<td>180</td>
<td>168</td>
<td>186</td>
</tr>
<tr>
<td>No. of all analyses</td>
<td>388</td>
<td>448</td>
<td>390</td>
<td>428</td>
</tr>
<tr>
<td>Maximum value</td>
<td>0.44 Bq·L$^{-1}$</td>
<td>16.5 Bq·L$^{-1}$</td>
<td>$&lt; 0.2$ Bq·L$^{-1}$</td>
<td>0.6 Bq·L$^{-1}$</td>
</tr>
<tr>
<td>No. of production stations</td>
<td>1</td>
<td>1</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>No. of analyses</td>
<td>1</td>
<td>13</td>
<td>103</td>
<td>1</td>
</tr>
</tbody>
</table>

(1) Activity concentration averaged over all production stations.
(2) Maximum value of activity concentration averaged per production station.
(3) Number of production stations with maximum value.
(4) Number of analyses performed per production station that led to maximum value.

In 2016, the gross $\alpha$ activity concentration in untreated water used for drinking water production, averaged per production station, exceeded the screening level of 0.1 Bq·L$^{-1}$ at 6 of the 183 production stations (in 19 of the 388 analyses). The measured radioactivity levels do not, however, pose a threat to public health. Further investigation into these slightly elevated levels in untreated water revealed that the gross $\alpha$ activity concentration in associated finished drinking water was well below the screening level.

For $^3$H, gross $\beta$ and residual $\beta$, the results were within the range of those in previous years [7, 20, 52, 53, 54, 55, 56, 57, 58, 59, 20, 60, 61, 62,
63]. Since $^{40}$K was almost absent, for most stations there was no significant difference between average gross β and residual β activity concentrations. The gross β activity concentrations were below the screening level of 1.0 Bq·L$^{-1}$ and the $^3$H activity concentrations were below the parametric value of 100 Bq·L$^{-1}$ [48, 50, 51].

Following Council Directive 2013/51/EC [48] it is not necessary to incorporate $^{222}$Rn in the yearly Dutch drinking water monitoring programme if it is clearly demonstrated that all data are well below accepted levels. The routine determination of gross α, gross β and tritium covers most radioactivity parameters and gives an accurate estimation of the dose (indicative dose).

In 2015, a survey was carried out to determine radon activity in Dutch water [64]. The results of the 2015 survey have been summarised in [63]: the parametric value of 100 Bq·L$^{-1}$ of $^{222}$Rn was not exceeded. The highest concentration of $^{222}$Rn in groundwater was 16.7 Bq·L$^{-1}$, with consistently lower amounts of $^{222}$Rn in finished drinking water than in groundwater. All observed $^{222}$Rn activities originated from unsupported $^{222}$Rn, i.e. without any $^{226}$Ra present in the water phase.
7 Milk

7.1 Introduction
RIKILT Wageningen UR 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 has been set up as an emergency network for monitoring relatively high contamination levels in case of an accident. The LMRV consists of 48 low-resolution $\gamma$-spectrometers (NaI-detectors) located throughout the Netherlands, 22 of which are located at dairy factories.

7.2 Results
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 2016 are presented in Table 7.1. Figure 7.1 shows the spatial variation of the yearly average 40K concentrations per region and the distribution of the sampling locations across the Netherlands.

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of samples</th>
<th>$^{40}\text{K}$ $^{(1)}$ Bq kg$^{-1}$</th>
<th>$^{60}\text{Co}$ $^{(2)}$ Bq kg$^{-1}$</th>
<th>$^{131}\text{I}$ $^{(2)}$ Bq kg$^{-1}$</th>
<th>$^{134}\text{Cs}$ $^{(2)}$ Bq kg$^{-1}$</th>
<th>$^{137}\text{Cs}$ $^{(2)}$ Bq kg$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>45</td>
<td>51.9 ± 10.0</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>February</td>
<td>51</td>
<td>50.6 ± 13.9</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>March</td>
<td>51</td>
<td>50.7 ± 11.0</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>April</td>
<td>41</td>
<td>51.1 ± 12.3</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>May</td>
<td>55</td>
<td>50.9 ± 13.4</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>June</td>
<td>55</td>
<td>46.9 ± 9.1</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>July</td>
<td>45</td>
<td>52.1 ± 14.1</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>August</td>
<td>49</td>
<td>50.1 ± 13.1</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>September</td>
<td>43</td>
<td>53.1 ± 12.3</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>October</td>
<td>39</td>
<td>54.1 ± 14.7</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>November</td>
<td>48</td>
<td>51.3 ± 12.2</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>December</td>
<td>59</td>
<td>52.7 ± 11.3</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Average</td>
<td>581 $^{(3)}$</td>
<td>51.2 ± 12.3</td>
<td>&lt; 1.4</td>
<td>&lt; 0.6</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
</tr>
</tbody>
</table>

(1) Uncertainty is given as 1$\sigma$.
(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 were anthropogenic $\gamma$-emitters were measured above the minimal detectable activity, as is shown in Table 7.1, so the limit of 370 Bq kg$^{-1}$ for the radiocesium activity (sum of $^{134}\text{Cs}$ and $^{137}\text{Cs}$) set by the European Union [65, 66] was not exceeded. The activity concentration of the natural radionuclide $^{40}\text{K}$ is given as a reference value. The yearly average concentration was $51.2 \pm 12.3$ Bq kg$^{-1}$. This value is within the range of those found in previous years.

Additionally, 11 goat’s milk samples were analysed. As in cow’s milk, anthropogenic $\gamma$-emitters were not measured above the minimal detectable activity. The yearly average $^{40}\text{K}$ concentration in these samples was $50.1 \pm 7.6$ Bq kg$^{-1}$. This value is lower than those found in previous years.
In addition to the LMRV samples, 47 milk samples (45 cow’s milk and 2 goat’s milk samples) were analysed for a range of γ-emitters on a high-resolution gamma spectrometer in the RIKILT 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·kg⁻¹ for ¹³⁷Cs in 0.5 L Marinelli beakers). The average concentration found for the natural radionuclide ⁴⁰K in the 45 cow’s milk samples was 45.4 ± 9.7 Bq·kg⁻¹; for the 2 goat’s milk samples the average was 66.9 ± 7.4 Bq·kg⁻¹.

The same 47 raw milk samples were analysed for the presence of the β-emitter ⁹⁰Sr using low-level liquid scintillation counting (LSC). The ⁹⁰Sr 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 [67]. No limit for ⁹⁰Sr has been set for existing exposure situations as defined in [68].

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

Based on data provided by dairy factories.

Figure 7.1  Impression of the spatial variation of ⁴⁰K activity concentrations (Bq·kg⁻¹) in cow’s milk
8 Food

8.1 Introduction

The Netherlands Food and Consumer Product Safety Authority (NVWA) performs measurements on finished products from retail shops, wholesale produce auctions and distribution centres, while RIKILT Wageningen UR performs measurements on samples from earlier stages in the food production chain.

The measurements performed on food by the NVWA were carried out according to standard procedures [69, 70]. Since 2005, the NVWA has monitored activity concentrations in a ‘mixed diet’ every year by sampling and measuring separate ingredients. Over a period of four weeks in 2016, 372 samples were taken from retail shops, wholesale produce auctions and distribution centres, including 49 samples of honey [71]. 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 categorised into the following product groups: grain and grain products, vegetables and mushrooms, fruit and fruit products, milk and dairy products, meat and meat products, game and poultry, salads, oil and butter, honey, tea, mineral water, and fish. The 2016 results are presented in Table 8.1. All three samples containing $^{137}$Cs above the minimum detectable activity were dried mushrooms, with the highest measured value of 1,019 Bq/kg of $^{137}$Cs. As mushrooms are not consumed in their dry form, the activity concentration in its consumable form is compared to the set limit of 600 Bq/kg, according to EC regulation No. 73/2008 [66]. This is achieved by multiplying by a reduction factor that can vary between 0.1 and 0.25. None of the values exceeded the set limit of 600 Bq·kg$^{-1}$ (or 370 Bq·kg$^{-1}$ for milk and dairy products) [65, 66] so no further action was taken.

In 2016, RIKILT Wageningen UR analysed radioactivity in food products as part of the governmental monitoring programme. Samples were taken throughout the year and measurements were carried out according to standard procedures. A total of 1,702 food samples were analysed for the presence of $\gamma$-emitters. The results are presented in Table 8.2. None of the samples exceeded the set limit for radiocesium activity (sum of $^{134}$Cs and $^{137}$Cs) of 600 Bq·kg$^{-1}$ (for food) or 370 Bq·kg$^{-1}$ (for dairy products).

Of these food samples, 179 samples were additionally analysed for $^{90}$Sr content. The results are presented in Table 8.3. These results are well below the set limit for new emergency exposure situations of 750 Bq·kg$^{-1}$ for major food products [67]. No limit for $^{90}$Sr has been set for existing exposure situations as defined in [68].

RIKILT also monitors food specifically for export certification. For this, 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.
8.2 Results for honey
In total, 49 samples of honey were analysed by the NVWA [71]. No sample of honey contained $^{137}$Cs above the minimum detectable activity of 5 Bq kg$^{-1}$. Radiocesium activity was below the set limit of 600 Bq kg$^{-1}$ [65, 66].

8.3 Results for vegetables and mushrooms
In the product group 'vegetables and mushrooms' analysed by the NVWA, concentrations above the minimum detectable activity of 5 Bq kg$^{-1}$ of $^{137}$Cs were detected in three samples of dried mushrooms: 58, 222 and 1,019 Bq kg$^{-1}$ of $^{137}$Cs. As mushrooms are not consumed in their dry form, the activity concentration in its consumable form is compared to the set limit of 600 Bq kg$^{-1}$. None of the values exceeded the set limit of 600 Bq kg$^{-1}$ [65, 66].

8.4 Results for game and poultry
In the product group 'game and poultry' analysed by RIKILT Wageningen UR, 24 samples of game contained $^{137}$Cs. The activity varied from 5 up to 43 Bq kg$^{-1}$, all below the set limit of 600 Bq kg$^{-1}$ [65, 66].

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

The average daily intake per person of $^{134}$Cs, $^{137}$Cs and $^{90}$Sr is estimated at < 5, < 7, < 5 Bq day$^{-1}$, respectively. These estimates are mainly based on the minimal detectable activities for these radionuclides in the different food categories, as shown in Tables 8.1 to 8.3.

The contribution to the effective yearly dose calculated from these average daily intake values is < 0.1 mSv. The actual daily intake (and following dose contribution) is probably much lower.
Table 8.1 Results of 2016 analysis of food for $^{134}$Cs and $^{137}$Cs as measured by the Netherlands Food and Consumer Product Safety Authority

<table>
<thead>
<tr>
<th>Product</th>
<th>Number of samples</th>
<th>$^{134}$Cs (1) Bq.kg$^{-1}$</th>
<th>$^{137}$Cs (1) Bq.kg$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain and grain products</td>
<td>31</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Vegetables and mushrooms</td>
<td>84</td>
<td>&lt; 5 (0)</td>
<td>58, 222, 1019 (3)</td>
</tr>
<tr>
<td>Fruit and fruit products</td>
<td>10</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Milk and dairy products</td>
<td>50</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>32</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Game and poultry</td>
<td>26</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Salads</td>
<td>17</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Oil and butter</td>
<td>30</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Honey</td>
<td>49</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Tea</td>
<td>3</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Mineral water</td>
<td>18</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Fish</td>
<td>22</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
</tbody>
</table>

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

Table 8.2 Results of 2016 analysis of food for $^{134}$Cs and $^{137}$Cs as measured by RIKILT Wageningen UR

<table>
<thead>
<tr>
<th>Product</th>
<th>Number of samples</th>
<th>$^{134}$Cs (1) Bq.kg$^{-1}$</th>
<th>$^{137}$Cs (1) Bq.kg$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables and fruits</td>
<td>287</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>568</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Game and poultry</td>
<td>398</td>
<td>&lt; 5 (0)</td>
<td>5–43 (24)</td>
</tr>
<tr>
<td>Eggs</td>
<td>156</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Fish and seafood products</td>
<td>201</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Ready meals</td>
<td>45</td>
<td>&lt; 5 (0)</td>
<td>&lt; 5 (0)</td>
</tr>
</tbody>
</table>

(1) Number of samples above the given detection limit is shown in brackets.
(2) Range of activity concentrations above the minimum detectable activity level.

Table 8.3 Results of 2016 analysis of food for $^{90}$Sr as measured by RIKILT Wageningen UR

<table>
<thead>
<tr>
<th>Product</th>
<th>Number of samples</th>
<th>$^{90}$Sr (1) Bq.kg$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables and fruits</td>
<td>23</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>15</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Game and poultry</td>
<td>19</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Eggs</td>
<td>6</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Fish and seafood products</td>
<td>24</td>
<td>&lt; 5 (0)</td>
</tr>
<tr>
<td>Ready meals</td>
<td>45</td>
<td>&lt; 5 (0)</td>
</tr>
</tbody>
</table>

(1) Number of samples above the minimum detectable activity level is shown in brackets.
Grass & feed

The National Monitoring Network of Radioactivity in Food (Landelijk Meetnet Radioactiviteit in Voedsel, LMRV), referred to in Chapter 7, is an important monitoring network used in cases of a nuclear or radiological emergency, as described in the National Crisis Management Plan for Radiation Incidents (Nationaal Crisisplan Stralingsincidenten, NCS). 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 2016, 36 grass samples were taken at 19 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 m\(^{-2}\) (i.e. with a yield of 250 gram grass per m\(^{2}\)) for the artificial radionuclides \(^{60}\)Co, \(^{131}\)I, \(^{132}\)Te, \(^{134}\)Cs and \(^{137}\)Cs. Natural \(^{40}\)K was found in all samples. In some samples, natural radionuclides from the uranium and thorium decay chains deposited during rainfall were measured as well.

The results of the grass measurements can be plotted on a map of the Netherlands, resulting in a deposition map that can be used in the event of contamination in an emergency situation. The spatial variation of the natural \(^{40}\)K activity in grass is shown in Figure 9.1. This variation in \(^{40}\)K activity can be attributed to factors such as fertilisation, grass species, length of stalk and soil type.

In addition, 462 feed samples were analysed for \(\gamma\)-emitters as part of the monitoring programme of RIKILT Wageningen UR. No artificial radioactivity was found in these samples; the results for \(^{134}\)Cs and \(^{137}\)Cs were all lower than the minimal detectable activity (2 Bq kg\(^{-1}\)).
Figure 9.1  Impression of spatial variation of $^{40}$K activity in grass in Bq·m$^{-2}$, as measured in 2016
The Borssele nuclear power plant

The Nuclear Research & Consultancy Group (NRG) is commissioned by Elektriciteits-Produktiemaatschappij Zuid-Nederland (N.V. EPZ) to perform monthly measurements on environmental samples taken in the vicinity of the Borssele nuclear power plant (owned by N.V. EPZ). Samples are taken to monitor the compartments of air, water and soil [72]. A more detailed description of the monitoring programme and underlying strategy can be found elsewhere [73]. The 2016 monitoring programme for environmental samples is outlined in Table 10.1 and Figure 10.1. Radionuclides were determined in air dust, grass, soil, water, suspended solids, seaweed and sediment.

Table 10.1 Monitoring programme for environmental samples taken near the Borssele nuclear power plant in 2016

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Location</th>
<th>Parameter</th>
<th>Monitoring frequency (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air dust</td>
<td>21, 22, 23, 27 and 29</td>
<td>gross α, gross β γ-emitters (1)</td>
<td>12 (11 for location 29)</td>
</tr>
<tr>
<td>Grass</td>
<td>21, 22, 23, 27 and 29</td>
<td>γ-emitters (3)</td>
<td>12 (2)</td>
</tr>
<tr>
<td>Soil</td>
<td>O1, O2, O3 and O4 (4)</td>
<td>γ-emitters (5)</td>
<td>1</td>
</tr>
<tr>
<td>Water</td>
<td>1, 2, 3 and 4</td>
<td>residual β, 3H</td>
<td>12</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>1, 2, 3 and 4</td>
<td>gross β</td>
<td>12</td>
</tr>
<tr>
<td>Seaweed</td>
<td>1, 2, 3 and 4</td>
<td>γ-emitters (3)</td>
<td>12 (2)</td>
</tr>
<tr>
<td>Sediment</td>
<td>1, 2, 3 and 4</td>
<td>γ-emitters (3)</td>
<td>12 (2)</td>
</tr>
</tbody>
</table>

The location numbers correspond to the location numbers given in Figure 10.1.

(1) γ-spectroscopic analysis of specific γ-emitting radionuclides: 60Co, 137Cs, naturally occurring radionuclides and elemental and organically bound 131I.

(2) Analysis was performed on a combined sample of monthly samples taken from all four or five locations.

(3) γ-spectroscopic analysis of specific γ-emitting radionuclides: 60Co, 131I and 137Cs.

(4) The four locations where samples were taken near the outlet are not shown in Figure 10.1.

(5) γ-spectroscopic analysis of specific γ-emitting radionuclides: 54Mn, 60Co, 134Cs and 137Cs.
The numbers given in Table 10.1 correspond with the locations on the map. Figure 10.1 Overview of monitoring locations for the monitoring programme conducted by NRG near the Borssele nuclear power plant.

10.2 Air

The results for gross α and β activity concentrations in air dust are presented in Tables A15 and A16. Due to large uncertainties caused by variations in the amount of dust on the filters, gross α activity concentrations in air dust should be regarded as indicative values [5]. The period between sampling and analysis was at least 5 days, which is long relative to the decay time of the short-lived decay products of $^{222}$Rn and $^{220}$Rn. This is to ensure that these naturally occurring decay products do not contribute to the measured α and β activity concentrations.

The 2016 yearly averages of the gross α and β activity concentrations of long-lived radionuclides were within the range of the results from previous years, as illustrated in Figures 10.2 and 10.3.

The results for the radionuclides considered in the γ-spectroscopic analysis are given in Table A17.
Figure 10.2: Yearly average gross α activity concentrations in air dust at five locations near the Borssele nuclear power plant (see Figure 10.1)

Figure 10.3: Yearly average gross β activity concentrations in air dust at five locations near the Borssele nuclear power plant (see Figure 10.1)

### 10.3 Soil and grass

The results for the radionuclides considered in the γ-spectroscopic analysis of grass and soil are given in Tables A18 and A19. The four soil samples were taken near the outlet of the nuclear power plant. In 2016,
the yearly average concentrations (in grass) and the yearly concentrations (in soil) of \(^{54}\text{Mn}, \quad ^{60}\text{Co}, \quad ^{134}\text{Cs}\) and \(^{137}\text{Cs}\) were within the range of those in previous years \([20, \, 56, \, 57, \, 58, \, 59, \, 60, \, 61, \, 62, \, 63]\). Except for \(^{137}\text{Cs}\) in soil all results were below the minimum detectable activities. The yearly concentrations of \(^{137}\text{Cs}\) in soil are shown in Figure 10.4.

![Figure 10.4](image)

**Figure 10.4** \(^{137}\text{Cs}\) activity concentrations of yearly soil sample at four locations near the outlet of the Borssele nuclear power plant (see Figure 10.1)

### 10.4 Water

The results for residual β and \(^{3}\text{H}\) activity concentrations in surface water and gross β activity concentrations in suspended solids in the Western Scheldt area are presented in Tables A20, A21 and A22.

In 2016, the yearly averages of the residual β concentrations in surface water were within the range of the results from previous years, as illustrated in Figure 10.5. Since 2012, the \(^{3}\text{H}\) activity concentrations in water have been significantly lower than those in previous years, as illustrated in Figure 10.6. Since 2012, the gross β activity concentrations in suspended solids have been somewhat higher than those in previous years, as illustrated in Figure 10.7. The changes in trends of \(^{3}\text{H}\) and gross β activity concentrations were investigated. For gross β there has been a change in the counting efficiency used, which is a plausible explanation for the change in trend of the gross β activity concentration. For \(^{3}\text{H}\) no significant changes in analysis procedures have been found.
Figure 10.5 Yearly average residual $\beta$ activity concentrations in surface water in the Western Scheldt area at four locations near the Borssele nuclear power plant (see Figure 10.1)

Figure 10.6 Yearly average $^3$H activity concentrations in surface water in the Western Scheldt area at four locations near the Borssele nuclear power plant (see Figure 10.1)
Figure 10.7 Yearly average gross $\beta$ activity concentrations in suspended solids in the Western Scheldt area at four locations near the Borssele nuclear power plant (see Figure 10.1)

Figure 10.8 Yearly average $^{137}$Cs activity concentrations in sediment based on combined samples at four locations near the Borssele nuclear power plant.

The results for the radionuclides considered in the $\gamma$-spectroscopic analysis of seaweed and sediment are given in Tables A23 and A24. Except for $^{137}$Cs in sediment, all results were below the minimum detectable activities. The yearly concentrations of $^{137}$Cs in sediment are shown in Figure 10.8.
11 Conclusions

In 2016, the Netherlands were in compliance with the Euratom recommendations on annual measurement of radioactivity in the environment and in food.

The gross α activity concentration in untreated water used for drinking water production, averaged per production station, exceeded the screening level (0.1 Bq·L⁻¹) at 6 of the 183 production stations (in 19 of the 388 analyses). The measured radioactivity levels do not, however, pose a threat to public health. Further investigation into these slightly elevated levels in untreated water revealed that the gross α activity concentration in associated finished drinking water was well below the screening level.

Radioactivity was measured in over 2,000 food products, 27 samples of which contained ¹³⁷Cs. Three samples of dried mushrooms contained ¹³⁷Cs (58, 222 and 1,109 Bq·kg⁻¹). As mushrooms are not consumed in their dry form, the activity concentration in its consumable form is compared to the set limit of 600 Bq·kg⁻¹. Twenty-four samples of game and poultry contained ¹³⁷Cs and the activity varied from 5 to 43 Bq·kg⁻¹. Radioactivity levels in none of the samples were above the set limit of 600 Bq·kg⁻¹ (or 370 Bq·kg⁻¹ for milk and dairy products) for the activity of radiocesium (sum of ¹³⁴Cs and ¹³⁷Cs).

The measured concentrations of ⁹⁰Sr, ¹³⁴Cs and ¹³⁷Cs in food in Bq·kg⁻¹ were converted to an average daily intake value per person per day (Bq·day⁻¹) using food consumption patterns. The average daily intake per person of ¹³⁴Cs, ¹³⁷Cs and ⁹⁰Sr is < 5, < 7, < 5 Bq·day⁻¹, respectively. The contribution to the effective yearly dose calculated from these values is < 0.1 mSv. The actual daily intake (and following dose contribution) is probably much lower.

All other radioactivity measurements were within the range of those in previous years.
### Table A1  Weekly average gross α and gross β activity concentrations in air dust sampled with the Snow White high-volume sampler at RIVM in 2016

<table>
<thead>
<tr>
<th>Week number</th>
<th>Gross α (2) mBq·m⁻³</th>
<th>Gross β (2) mBq·m⁻³</th>
<th>Week number</th>
<th>Gross α (2) mBq·m⁻³</th>
<th>Gross β (2) mBq·m⁻³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.020</td>
<td>0.40 ± 0.04</td>
<td>27</td>
<td>0.011</td>
<td>0.167 ± 0.018</td>
</tr>
<tr>
<td>2</td>
<td>0.008</td>
<td>0.159 ± 0.017</td>
<td>28</td>
<td>0.017</td>
<td>0.27 ± 0.03</td>
</tr>
<tr>
<td>3</td>
<td>0.017</td>
<td>0.27 ± 0.03</td>
<td>29</td>
<td>0.022</td>
<td>0.38 ± 0.04</td>
</tr>
<tr>
<td>4</td>
<td>0.021</td>
<td>0.30 ± 0.03</td>
<td>30</td>
<td>0.029</td>
<td>0.52 ± 0.05</td>
</tr>
<tr>
<td>5</td>
<td>0.009</td>
<td>0.131 ± 0.014</td>
<td>31</td>
<td>0.011</td>
<td>0.144 ± 0.015</td>
</tr>
<tr>
<td>6</td>
<td>0.010</td>
<td>0.20 ± 0.02</td>
<td>32</td>
<td>0.015</td>
<td>0.25 ± 0.03</td>
</tr>
<tr>
<td>7</td>
<td>0.018</td>
<td>0.34 ± 0.04</td>
<td>33</td>
<td>0.012</td>
<td>0.23 ± 0.02</td>
</tr>
<tr>
<td>8</td>
<td>0.015</td>
<td>0.20 ± 0.02</td>
<td>34</td>
<td>0.025</td>
<td>0.39 ± 0.04</td>
</tr>
<tr>
<td>9</td>
<td>0.014</td>
<td>0.21 ± 0.02</td>
<td>35</td>
<td>0.023</td>
<td>0.48 ± 0.05</td>
</tr>
<tr>
<td>10</td>
<td>0.014</td>
<td>0.19 ± 0.02</td>
<td>36</td>
<td>0.014</td>
<td>0.23 ± 0.02</td>
</tr>
<tr>
<td>11</td>
<td>0.020</td>
<td>0.44 ± 0.05</td>
<td>37</td>
<td>0.040</td>
<td>0.97 ± 0.10</td>
</tr>
<tr>
<td>12</td>
<td>0.016</td>
<td>0.27 ± 0.03</td>
<td>38</td>
<td>0.031</td>
<td>0.79 ± 0.08</td>
</tr>
<tr>
<td>13</td>
<td>0.023</td>
<td>0.21 ± 0.02</td>
<td>39</td>
<td>0.022</td>
<td>0.61 ± 0.06</td>
</tr>
<tr>
<td>14</td>
<td>0.029</td>
<td>0.38 ± 0.04</td>
<td>40</td>
<td>0.011</td>
<td>0.24 ± 0.03</td>
</tr>
<tr>
<td>15</td>
<td>0.015</td>
<td>0.24 ± 0.03</td>
<td>41</td>
<td>0.011</td>
<td>0.28 ± 0.03</td>
</tr>
<tr>
<td>16</td>
<td>0.017</td>
<td>0.20 ± 0.02</td>
<td>42</td>
<td>0.038</td>
<td>0.77 ± 0.08</td>
</tr>
<tr>
<td>17</td>
<td>0.010</td>
<td>0.161 ± 0.017</td>
<td>43</td>
<td>0.030</td>
<td>0.60 ± 0.06</td>
</tr>
<tr>
<td>18 (3)</td>
<td>0.012</td>
<td>0.23 ± 0.02</td>
<td>44</td>
<td>0.023</td>
<td>0.42 ± 0.04</td>
</tr>
<tr>
<td>19 (3)</td>
<td>0.0075</td>
<td>0.50 ± 0.05</td>
<td>45</td>
<td>0.023</td>
<td>0.33 ± 0.03</td>
</tr>
<tr>
<td>20</td>
<td>0.010</td>
<td>0.42 ± 0.04</td>
<td>46</td>
<td>0.028</td>
<td>0.46 ± 0.05</td>
</tr>
<tr>
<td>21</td>
<td>0.010</td>
<td>0.21 ± 0.02</td>
<td>47</td>
<td>0.011</td>
<td>0.25 ± 0.03</td>
</tr>
<tr>
<td>22</td>
<td>0.010</td>
<td>0.47 ± 0.05</td>
<td>48 (3)</td>
<td>0.015</td>
<td>0.24 ± 0.03</td>
</tr>
<tr>
<td>23</td>
<td>0.014</td>
<td>0.45 ± 0.05</td>
<td>49 (3)</td>
<td>0.034</td>
<td>0.65 ± 0.05</td>
</tr>
<tr>
<td>24</td>
<td>0.029</td>
<td>0.42 ± 0.04</td>
<td>50</td>
<td>0.038</td>
<td>0.80 ± 0.08</td>
</tr>
<tr>
<td>25</td>
<td>0.018</td>
<td>0.23 ± 0.02</td>
<td>51</td>
<td>0.032</td>
<td>0.70 ± 0.07</td>
</tr>
<tr>
<td>26</td>
<td>0.014</td>
<td>0.25 ± 0.03</td>
<td>52</td>
<td>0.017</td>
<td>0.174 ± 0.018</td>
</tr>
</tbody>
</table>

Average Gross α 0.019 Gross β 0.362 ± 0.006

Average SD 0.009

(1) The precise sampling period is given in Table A3.
(2) Values are indicative due to large uncertainties caused by variations in the amount of dust on the filters [5].
(3) The sampling period deviated from the regular 7-day sampling period.
(4) The uncertainty in the yearly average is equal to the square root of the sum of the squared weekly uncertainties divided by the number of weeks. Uncertainties are given as 1σ.
(5) SD is the standard deviation of the weekly results.
Table A2  Detection limits (µBq/m³) in the residue measurement of air dust sampled during a 7-day sampling period with the Snow White high-volume sampler at RIVM in 2016

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Detection limit µBq·m⁻³</th>
</tr>
</thead>
<tbody>
<tr>
<td>⁷Be</td>
<td>2.0</td>
</tr>
<tr>
<td>²²Na</td>
<td>0.2</td>
</tr>
<tr>
<td>⁶⁰Co</td>
<td>0.1</td>
</tr>
<tr>
<td>¹³¹I</td>
<td>1.7 (¹)</td>
</tr>
<tr>
<td>¹³⁷Cs</td>
<td>0.1</td>
</tr>
<tr>
<td>²¹⁰Pb</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Measurements were carried out on ash residue using a well-type detector, with a 7-day delay between sampling and the start of measurement. The sample volume was about 125,000 m³. Between January 2000 and July 2009, the detection limits were higher than they had been before 2000 [74] due to a different detector set-up. The detector set-up was changed again in the second half of 2009, including a change in counting time from 100,000 seconds to 178,200 seconds. Detection limits were therefore lower from July 2009 until January 2011, when a change in the high-volume sampler (and consequently the sample volume) resulted in a further reduction of the detection limits.

(¹) The detection limit is given for the filter measurement on the coaxial detector (4-day delay time, 100,000 seconds counting time). Due to the sample preparation procedure, the volatile radionuclide ¹³¹I cannot be determined in the residue measurement on the well-type detector.

Table A3  Weekly average ⁷Be, ¹³⁷Cs and ²¹⁰Pb activity concentrations in air dust sampled with the Snow White high-volume sampler at RIVM in 2016

<table>
<thead>
<tr>
<th>Week number</th>
<th>Period</th>
<th>⁷Be µBq·m⁻³</th>
<th>¹³⁷Cs µBq·m⁻³</th>
<th>²¹⁰Pb µBq·m⁻³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31/12–07/01</td>
<td>2,030 ± 150</td>
<td>0.35 ± 0.04</td>
<td>450 ± 30</td>
</tr>
<tr>
<td>2</td>
<td>07/01–14/01</td>
<td>2,300 ± 170</td>
<td>0.08 ± 0.02</td>
<td>117 ± 9</td>
</tr>
<tr>
<td>3</td>
<td>14/01–21/01</td>
<td>2,520 ± 180</td>
<td>0.27 ± 0.03</td>
<td>226 ± 17</td>
</tr>
<tr>
<td>4</td>
<td>21/01–28/01</td>
<td>2,130 ± 160</td>
<td>0.17 ± 0.03</td>
<td>280 ± 20</td>
</tr>
<tr>
<td>5</td>
<td>28/01–04/02</td>
<td>2,210 ± 160</td>
<td>&lt; 0.09</td>
<td>81 ± 6</td>
</tr>
<tr>
<td>6</td>
<td>04/02–11/02</td>
<td>2,250 ± 160</td>
<td>0.04 ± 0.02</td>
<td>130 ± 10</td>
</tr>
<tr>
<td>7</td>
<td>11/02–18/02</td>
<td>1,930 ± 140</td>
<td>0.35 ± 0.04</td>
<td>320 ± 20</td>
</tr>
<tr>
<td>8</td>
<td>18/02–25/02</td>
<td>1,510 ± 110</td>
<td>0.06 ± 0.02</td>
<td>131 ± 10</td>
</tr>
<tr>
<td>9</td>
<td>25/02–03/03</td>
<td>1,980 ± 150</td>
<td>0.19 ± 0.03</td>
<td>128 ± 9</td>
</tr>
<tr>
<td>10</td>
<td>03/03–10/03</td>
<td>1,940 ± 140</td>
<td>0.19 ± 0.03</td>
<td>140 ± 10</td>
</tr>
<tr>
<td>11</td>
<td>10/03–17/03</td>
<td>2,430 ± 180</td>
<td>0.53 ± 0.05</td>
<td>470 ± 40</td>
</tr>
<tr>
<td>12</td>
<td>17/03–24/03</td>
<td>2,800 ± 200</td>
<td>0.36 ± 0.04</td>
<td>248 ± 18</td>
</tr>
<tr>
<td>13</td>
<td>24/03–31/03</td>
<td>3,100 ± 200</td>
<td>0.079 ± 0.018</td>
<td>122 ± 9</td>
</tr>
<tr>
<td>14</td>
<td>31/03–07/04</td>
<td>3,800 ± 300</td>
<td>0.16 ± 0.03</td>
<td>290 ± 20</td>
</tr>
<tr>
<td>15</td>
<td>07/04–14/04</td>
<td>3,100 ± 200</td>
<td>0.13 ± 0.02</td>
<td>181 ± 13</td>
</tr>
<tr>
<td>16</td>
<td>14/04–21/04</td>
<td>2,370 ± 170</td>
<td>0.08 ± 0.03</td>
<td>128 ± 9</td>
</tr>
<tr>
<td>17</td>
<td>21/04–28/04</td>
<td>2,540 ± 190</td>
<td>0.13 ± 0.03</td>
<td>116 ± 9</td>
</tr>
<tr>
<td>18 (¹)</td>
<td>28/04–04/05</td>
<td>3,200 ± 200</td>
<td>0.08 ± 0.02</td>
<td>157 ± 12</td>
</tr>
<tr>
<td>19 (¹)</td>
<td>04/05–12/05</td>
<td>5,000 ± 400</td>
<td>0.67 ± 0.06</td>
<td>530 ± 40</td>
</tr>
<tr>
<td>20</td>
<td>12/05–19/05</td>
<td>5,600 ± 400</td>
<td>0.47 ± 0.04</td>
<td>330 ± 20</td>
</tr>
<tr>
<td>21</td>
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<td>2,480 ± 180</td>
<td>0.11 ± 0.03</td>
<td>175 ± 13</td>
</tr>
<tr>
<td>22</td>
<td>26/05–02/06</td>
<td>3,300 ± 200</td>
<td>0.20 ± 0.03</td>
<td>480 ± 40</td>
</tr>
<tr>
<td>23</td>
<td>02/06–09/06</td>
<td>5,800 ± 400</td>
<td>0.25 ± 0.03</td>
<td>430 ± 30</td>
</tr>
<tr>
<td>24</td>
<td>09/06–16/06</td>
<td>5,100 ± 400</td>
<td>0.12 ± 0.03</td>
<td>250 ± 18</td>
</tr>
<tr>
<td>25</td>
<td>16/06–23/06</td>
<td>2,230 ± 160</td>
<td>&lt; 0.10</td>
<td>141 ± 10</td>
</tr>
</tbody>
</table>

Continued on next page
Table A3  Continued

<table>
<thead>
<tr>
<th>Week number</th>
<th>Period</th>
<th>(^{7}\text{Be}) μBq·m(^{-3})</th>
<th>(^{137}\text{Cs}) μBq·m(^{-3})</th>
<th>(^{210}\text{Pb}) μBq·m(^{-3})</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>23/06–30/06</td>
<td>2,900 ± 200</td>
<td>0.07 ± 0.02</td>
<td>209 ± 15</td>
</tr>
<tr>
<td>27</td>
<td>30/06–07/07</td>
<td>1,680 ± 120</td>
<td>&lt; 0.11</td>
<td>112 ± 8</td>
</tr>
<tr>
<td>28</td>
<td>07/07–14/07</td>
<td>2,700 ± 200</td>
<td>0.06 ± 0.02</td>
<td>191 ± 14</td>
</tr>
<tr>
<td>29</td>
<td>14/07–21/07</td>
<td>3,900 ± 300</td>
<td>0.12 ± 0.02</td>
<td>320 ± 20</td>
</tr>
<tr>
<td>30</td>
<td>21/07–28/07</td>
<td>3,200 ± 200</td>
<td>0.09 ± 0.02</td>
<td>450 ± 30</td>
</tr>
<tr>
<td>31</td>
<td>28/07–04/08</td>
<td>1,940 ± 140</td>
<td>&lt; 0.09</td>
<td>130 ± 10</td>
</tr>
<tr>
<td>32</td>
<td>04/08–11/08</td>
<td>2,900 ± 200</td>
<td>&lt; 0.09</td>
<td>147 ± 11</td>
</tr>
<tr>
<td>33</td>
<td>11/08–18/08</td>
<td>2,900 ± 200</td>
<td>0.10 ± 0.02</td>
<td>168 ± 12</td>
</tr>
<tr>
<td>34</td>
<td>18/08–25/08</td>
<td>4,800 ± 400</td>
<td>0.17 ± 0.03</td>
<td>350 ± 30</td>
</tr>
<tr>
<td>35</td>
<td>25/08–01/09</td>
<td>4,800 ± 400</td>
<td>0.24 ± 0.03</td>
<td>440 ± 30</td>
</tr>
<tr>
<td>36</td>
<td>01/09–08/09</td>
<td>2,900 ± 200</td>
<td>0.08 ± 0.02</td>
<td>224 ± 17</td>
</tr>
<tr>
<td>37</td>
<td>08/09–15/09</td>
<td>4,500 ± 300</td>
<td>0.23 ± 0.03</td>
<td>920 ± 70</td>
</tr>
<tr>
<td>38</td>
<td>15/09–22/09</td>
<td>5,100 ± 400</td>
<td>0.32 ± 0.03</td>
<td>620 ± 50</td>
</tr>
<tr>
<td>39</td>
<td>22/09–29/09</td>
<td>3,900 ± 300</td>
<td>0.21 ± 0.03</td>
<td>520 ± 40</td>
</tr>
<tr>
<td>40</td>
<td>29/09–06/10</td>
<td>3,000 ± 200</td>
<td>0.11 ± 0.03</td>
<td>194 ± 14</td>
</tr>
<tr>
<td>41</td>
<td>06/10–13/10</td>
<td>1,650 ± 120</td>
<td>0.23 ± 0.03</td>
<td>310 ± 20</td>
</tr>
<tr>
<td>42</td>
<td>13/10–20/10</td>
<td>2,610 ± 190</td>
<td>0.22 ± 0.03</td>
<td>680 ± 50</td>
</tr>
<tr>
<td>43</td>
<td>20/10–27/10</td>
<td>1,350 ± 100</td>
<td>0.26 ± 0.03</td>
<td>610 ± 40</td>
</tr>
<tr>
<td>44</td>
<td>27/10–03/11</td>
<td>3,300 ± 200</td>
<td>0.27 ± 0.03</td>
<td>280 ± 20</td>
</tr>
<tr>
<td>45</td>
<td>03/11–10/11</td>
<td>1,470 ± 110</td>
<td>0.18 ± 0.03</td>
<td>270 ± 20</td>
</tr>
<tr>
<td>46</td>
<td>10/11–17/11</td>
<td>1,720 ± 130</td>
<td>0.19 ± 0.03</td>
<td>430 ± 30</td>
</tr>
<tr>
<td>47</td>
<td>17/11–24/11</td>
<td>3,300 ± 200</td>
<td>0.12 ± 0.02</td>
<td>186 ± 14</td>
</tr>
<tr>
<td>48 (1)</td>
<td>24/11–30/11</td>
<td>2,250 ± 170</td>
<td>0.31 ± 0.04</td>
<td>220 ± 16</td>
</tr>
<tr>
<td>49 (1)</td>
<td>30/11–08/12</td>
<td>3,010 ± 170</td>
<td>0.54 ± 0.04</td>
<td>590 ± 30</td>
</tr>
<tr>
<td>50</td>
<td>08/12–15/12</td>
<td>2,310 ± 170</td>
<td>0.17 ± 0.03</td>
<td>830 ± 60</td>
</tr>
<tr>
<td>51</td>
<td>15/12–22/12</td>
<td>2,290 ± 170</td>
<td>0.36 ± 0.04</td>
<td>690 ± 50</td>
</tr>
<tr>
<td>52</td>
<td>22/12–29/12</td>
<td>1,290 ± 90</td>
<td>0.064 ± 0.019</td>
<td>97 ± 7</td>
</tr>
</tbody>
</table>

Average 2,910 ± 30 (2) 0.208 ± 0.004 (2, 3) 312 ± 4 (2)
SD (4) 1,100 0.14 200

(1) The sampling period deviated from the regular 7-day sampling period.
(2) The uncertainty in the yearly average is equal to the square root of the sum of the squared weekly uncertainties divided by the number of weeks. Uncertainties are given as 1σ.
(3) The detection limits are omitted in the calculation of the averages.
(4) SD is the standard deviation of the weekly results.
Table A4  Precipitation per month and monthly deposited $^3$H, long-lived gross α and gross β activity sampled at RIVM in 2016

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation (mm)</th>
<th>$^3$H (Bq·m$^{-2}$)</th>
<th>Gross α (Bq·m$^{-2}$)</th>
<th>Gross β (Bq·m$^{-2}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>129.5</td>
<td>&lt; 200</td>
<td>3.6 ± 0.4</td>
<td>7.6 ± 0.6</td>
</tr>
<tr>
<td>February</td>
<td>91.0</td>
<td>&lt; 160</td>
<td>2.3 ± 0.3</td>
<td>2.8 ± 0.2</td>
</tr>
<tr>
<td>March</td>
<td>44.8</td>
<td>&lt; 80</td>
<td>3.9 ± 0.4</td>
<td>6.7 ± 0.5</td>
</tr>
<tr>
<td>April</td>
<td>71.5</td>
<td>&lt; 110</td>
<td>7.6 ± 0.7</td>
<td>9.7 ± 0.7</td>
</tr>
<tr>
<td>May</td>
<td>59.5</td>
<td>&lt; 90</td>
<td>7.0 ± 0.7</td>
<td>8.8 ± 0.7</td>
</tr>
<tr>
<td>June</td>
<td>141.7</td>
<td>&lt; 200</td>
<td>7.8 ± 0.7</td>
<td>11.8 ± 0.9</td>
</tr>
<tr>
<td>July</td>
<td>93.0</td>
<td>&lt; 170</td>
<td>7.3 ± 0.7</td>
<td>8.1 ± 0.6</td>
</tr>
<tr>
<td>August</td>
<td>56.1</td>
<td>&lt; 100</td>
<td>6.4 ± 0.6</td>
<td>7.9 ± 0.6</td>
</tr>
<tr>
<td>September</td>
<td>16.2</td>
<td>32 ± 9</td>
<td>8.4 ± 0.8</td>
<td>9.6 ± 0.7</td>
</tr>
<tr>
<td>October</td>
<td>50.1</td>
<td>&lt; 100</td>
<td>4.7 ± 0.5</td>
<td>5.1 ± 0.4</td>
</tr>
<tr>
<td>November</td>
<td>81.3</td>
<td>&lt; 170</td>
<td>3.2 ± 0.4</td>
<td>5.2 ± 0.4</td>
</tr>
<tr>
<td>December</td>
<td>18.4</td>
<td>&lt; 40</td>
<td>3.4 ± 0.4</td>
<td>4.8 ± 0.4</td>
</tr>
<tr>
<td>Total</td>
<td>852.8</td>
<td></td>
<td>66 ± 2 (2)</td>
<td>88 ± 2 (2)</td>
</tr>
</tbody>
</table>

Lower limit (3) - 22

Upper limit (3) - 1,510

(1) The detection limit in Bq·m$^{-2}$ is mainly dependent on the amount of precipitation, as the detection limit of the counting sample itself is more or less constant (1.6–2.0 Bq·L$^{-1}$).
(2) The uncertainty in the sum is equal to the square root of the sum of the squared monthly uncertainties. Uncertainties are given as 1σ.
(3) The result for November has been rejected.
(4) The lower and upper limits are defined in Appendix B.

Table A5  Monthly deposited $^{210}$Po activity (1) sampled at RIVM in 2016

<table>
<thead>
<tr>
<th>Month</th>
<th>$^{210}$Po (Bq·m$^{-2}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>3.8 ± 0.3</td>
</tr>
<tr>
<td>February</td>
<td>1.08 ± 0.13</td>
</tr>
<tr>
<td>March</td>
<td>2.81 ± 0.16</td>
</tr>
<tr>
<td>April</td>
<td>5.9 ± 0.4</td>
</tr>
<tr>
<td>May</td>
<td>2.1 ± 0.3</td>
</tr>
<tr>
<td>June</td>
<td>3.5 ± 0.3</td>
</tr>
<tr>
<td>July</td>
<td>5.6 ± 0.4</td>
</tr>
<tr>
<td>August</td>
<td>4.7 ± 0.3</td>
</tr>
<tr>
<td>September</td>
<td>6.0 ± 0.3</td>
</tr>
<tr>
<td>October</td>
<td>2.8 ± 0.2</td>
</tr>
<tr>
<td>November</td>
<td>-</td>
</tr>
<tr>
<td>December</td>
<td>2.36 ± 0.13</td>
</tr>
<tr>
<td>Total</td>
<td>40.6 ± 1.0 (2)</td>
</tr>
</tbody>
</table>

Lower limit (4) -

Upper limit (4) -

(1) Measurements were carried out using α-spectroscopy. Uncertainties are given as 1σ.
(2) The uncertainty in the sum is equal to the square root of the sum of the squared monthly uncertainties. Uncertainties are given as 1σ.
(3) The result for November has been rejected.
(4) The lower and upper limits are defined in Appendix B.
Table A6  Yearly totals for long-lived gross α, gross β and 3H activity in deposition since 1993

<table>
<thead>
<tr>
<th>Year</th>
<th>Precipitation mm</th>
<th>3H Bq·m⁻²</th>
<th>Gross α Bq·m⁻²</th>
<th>Gross β Bq·m⁻²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>886</td>
<td>1,310 ± 30</td>
<td>54.3 ± 0.7</td>
<td>87.8 ± 0.8</td>
</tr>
<tr>
<td>1994</td>
<td>1,039</td>
<td>1,210 ± 30</td>
<td>52 ± 2</td>
<td>91 ± 3</td>
</tr>
<tr>
<td>1995</td>
<td>724</td>
<td>970 ± 40</td>
<td>33.6–44.6</td>
<td>95 ± 8</td>
</tr>
<tr>
<td>1996</td>
<td>626</td>
<td>970 ± 50</td>
<td>16.4 ± 1.5</td>
<td>67 ± 5</td>
</tr>
<tr>
<td>1997</td>
<td>760</td>
<td>1,160 ± 60</td>
<td>22.0–25.0</td>
<td>87 ± 3</td>
</tr>
<tr>
<td>1998</td>
<td>1,238</td>
<td>1,090–2,190</td>
<td>31.1 ± 1.3</td>
<td>106 ± 3</td>
</tr>
<tr>
<td>1999</td>
<td>916</td>
<td>1,420–1,900</td>
<td>25.5 ± 1.1</td>
<td>84 ± 2</td>
</tr>
<tr>
<td>2000</td>
<td>935</td>
<td>260–1,440</td>
<td>35.2 ± 1.3</td>
<td>104 ± 3</td>
</tr>
<tr>
<td>2001</td>
<td>1,053</td>
<td>0–2,420</td>
<td>23.9 ± 1</td>
<td>97 ± 3</td>
</tr>
<tr>
<td>2002</td>
<td>965</td>
<td>300–1,710</td>
<td>20.6 ± 0.9</td>
<td>97 ± 2</td>
</tr>
<tr>
<td>2003</td>
<td>605</td>
<td>260–1,080</td>
<td>13.6–16.7</td>
<td>70.0 ± 1.8</td>
</tr>
<tr>
<td>2004</td>
<td>875</td>
<td>0–1,600</td>
<td>14.3–17.1</td>
<td>73.5 ± 1.8</td>
</tr>
<tr>
<td>2005</td>
<td>856</td>
<td>0–1,530</td>
<td>17.6 ± 1.0</td>
<td>88 ± 2</td>
</tr>
<tr>
<td>2006</td>
<td>854</td>
<td>280–1,820</td>
<td>25.7 ± 1.5</td>
<td>98 ± 3</td>
</tr>
<tr>
<td>2007</td>
<td>984</td>
<td>335–1,600</td>
<td>24.4 ± 1.2</td>
<td>85 ± 2</td>
</tr>
<tr>
<td>2008</td>
<td>908</td>
<td>102–1,550</td>
<td>39.4 ± 1.5</td>
<td>106 ± 3</td>
</tr>
<tr>
<td>2009</td>
<td>794</td>
<td>0–1,330</td>
<td>36.9 ± 1.3</td>
<td>95 ± 2</td>
</tr>
<tr>
<td>2010</td>
<td>868</td>
<td>180–1,400</td>
<td>36.7 ± 1.3</td>
<td>90 ± 2</td>
</tr>
<tr>
<td>2011</td>
<td>895</td>
<td>332–1,540</td>
<td>45.0 ± 1.5</td>
<td>123 ± 3</td>
</tr>
<tr>
<td>2012</td>
<td>922</td>
<td>316–1,650</td>
<td>32.7 ± 1.1</td>
<td>88 ± 2</td>
</tr>
<tr>
<td>2013</td>
<td>851</td>
<td>0–1,580</td>
<td>48.1 ± 1.6</td>
<td>95 ± 2</td>
</tr>
<tr>
<td>2014</td>
<td>878</td>
<td>117–1,630</td>
<td>62 ± 2</td>
<td>106 ± 3</td>
</tr>
<tr>
<td>2015</td>
<td>878</td>
<td>210–1,650</td>
<td>53.9 ± 1.8</td>
<td>90 ± 2</td>
</tr>
<tr>
<td>2016</td>
<td>853</td>
<td>22–1,510</td>
<td>66 ± 2</td>
<td>88 ± 2</td>
</tr>
</tbody>
</table>

Either the yearly total with uncertainty (1) or the lower and upper limits (2) of the 68% confidence interval are given.

(1) Uncertainties are given as 1σ.

(2) Lower and upper limits are given as defined in Appendix B.
Table A7  Yearly totals for $^7$Be, $^{137}$Cs, $^{210}$Pb and $^{210}$Po activity in deposition since 1993

<table>
<thead>
<tr>
<th>Year</th>
<th>$^7$Be (3) Bq·m$^{-2}$</th>
<th>$^{137}$Cs (3) Bq·m$^{-2}$</th>
<th>$^{210}$Pb (3) Bq·m$^{-2}$</th>
<th>$^{210}$Po (4) Bq·m$^{-2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>1,090 ± 20</td>
<td>0.50–0.76</td>
<td>105 ± 2</td>
<td>78 ± 3</td>
</tr>
<tr>
<td>1994</td>
<td>1,320 ± 30</td>
<td>0.36–0.71</td>
<td>118 ± 3</td>
<td>82 ± 3</td>
</tr>
<tr>
<td>1995</td>
<td>990 ± 20</td>
<td>0.37–0.63</td>
<td>96 ± 2</td>
<td>n/a (5)</td>
</tr>
<tr>
<td>1996</td>
<td>920 ± 20</td>
<td>0.52–0.83</td>
<td>63–67</td>
<td>n/a (5)</td>
</tr>
<tr>
<td>1997</td>
<td>1,090 ± 30</td>
<td>0.11–0.69</td>
<td>65–69</td>
<td>80 ± 4</td>
</tr>
<tr>
<td>1998</td>
<td>1,840 ± 50</td>
<td>0.56–0.85</td>
<td>162 ± 4</td>
<td>91 ± 4</td>
</tr>
<tr>
<td>1999</td>
<td>1,580 ± 30</td>
<td>1.16–1.99</td>
<td>158 ± 4</td>
<td>- (6)</td>
</tr>
<tr>
<td>2000</td>
<td>1,490 ± 30</td>
<td>0–4.82</td>
<td>177 ± 6</td>
<td>-</td>
</tr>
<tr>
<td>2001</td>
<td>1,480 ± 30</td>
<td>0–4.50</td>
<td>83–104</td>
<td>-</td>
</tr>
<tr>
<td>2002</td>
<td>1,510 ± 30</td>
<td>0–5.22</td>
<td>119–142</td>
<td>-</td>
</tr>
<tr>
<td>2003</td>
<td>1,000–1,050</td>
<td>0–4.69</td>
<td>88–113</td>
<td>-</td>
</tr>
<tr>
<td>2004</td>
<td>1,330 ± 30</td>
<td>0.22–5.53</td>
<td>64–102</td>
<td>-</td>
</tr>
<tr>
<td>2005</td>
<td>1,320 ± 30</td>
<td>0–6.09</td>
<td>87–117</td>
<td>-</td>
</tr>
<tr>
<td>2006</td>
<td>1,400 ± 30</td>
<td>0.06–7.47</td>
<td>66–103</td>
<td>-</td>
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<tr>
<td>2007</td>
<td>1,760 ± 40</td>
<td>0.11–7.37</td>
<td>72–132</td>
<td>-</td>
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<tr>
<td>2008</td>
<td>1,990 ± 40</td>
<td>0–7.63</td>
<td>63–143</td>
<td>-</td>
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<tr>
<td>2009</td>
<td>1,410 ± 30</td>
<td>0–4.3</td>
<td>82–125</td>
<td>-</td>
</tr>
<tr>
<td>2010</td>
<td>1,240 ± 30</td>
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<td>93 ± 2</td>
<td>-</td>
</tr>
<tr>
<td>2011</td>
<td>1,320 ± 30</td>
<td>0.5–1.5</td>
<td>104 ± 2</td>
<td>-</td>
</tr>
<tr>
<td>2012</td>
<td>1,330 ± 30</td>
<td>0–1.2</td>
<td>98 ± 2</td>
<td>-</td>
</tr>
<tr>
<td>2013</td>
<td>1,030 ± 30</td>
<td>0–1.1</td>
<td>82.9 ± 1.8</td>
<td>-</td>
</tr>
<tr>
<td>2014</td>
<td>1,341 ± 17</td>
<td>0–1.1</td>
<td>107 ± 2</td>
<td>-</td>
</tr>
<tr>
<td>2015</td>
<td>1,219 ± 16</td>
<td>0–1.1</td>
<td>102.8 ± 1.5</td>
<td>-</td>
</tr>
<tr>
<td>2016</td>
<td>1,375 ± 18</td>
<td>0.04–1.15</td>
<td>95–98</td>
<td>-</td>
</tr>
</tbody>
</table>

Either the yearly total with uncertainty (1) or the lower and upper limits (2) of the 68% confidence range are given.

(1) Uncertainties are given as 1σ.
(2) Lower and upper limits are given as defined in Appendix B.
(3) Data from γ-spectroscopy.
(4) Data from α-spectroscopy.
(5) Not available. Result rejected [75].
(6) α-spectroscopy analysis of $^{210}$Pb stopped in 1999.
(7) Results revised in RIVM Report 610791003.
(8) The yearly total deposition is based on 10 monthly results.
(9) The yearly total deposition is based on 11 monthly results.
<table>
<thead>
<tr>
<th>Week no.</th>
<th>Period</th>
<th>Precipitation mm</th>
<th>⁷Be Bq·m⁻²</th>
<th>¹³⁷Cs Bq·m⁻²</th>
<th>²¹⁰Pb Bq·m⁻²</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>31/12–07/01</td>
<td>27.5</td>
<td>8.7 ± 0.6</td>
<td>&lt; 0.01</td>
<td>0.61 ± 0.06</td>
</tr>
<tr>
<td>2</td>
<td>07/01–14/01</td>
<td>34.8</td>
<td>33 ± 2</td>
<td>&lt; 0.02</td>
<td>0.83 ± 0.10</td>
</tr>
<tr>
<td>3</td>
<td>14/01–21/01</td>
<td>14.3</td>
<td>20.8 ± 1.5</td>
<td>&lt; 0.02</td>
<td>0.56 ± 0.08</td>
</tr>
<tr>
<td>4</td>
<td>21/01–28/01</td>
<td>23.5</td>
<td>20.4 ± 1.5</td>
<td>&lt; 0.02</td>
<td>0.91 ± 0.10</td>
</tr>
<tr>
<td>5</td>
<td>28/01–04/02</td>
<td>29.5</td>
<td>50 ± 4</td>
<td>&lt; 0.02</td>
<td>1.73 ± 0.16</td>
</tr>
<tr>
<td>6</td>
<td>04/02–11/02</td>
<td>32.5</td>
<td>38 ± 3</td>
<td>&lt; 0.02</td>
<td>1.41 ± 0.13</td>
</tr>
<tr>
<td>7</td>
<td>11/02–18/02</td>
<td>18.0</td>
<td>12.1 ± 0.9</td>
<td>&lt; 0.02</td>
<td>2.03 ± 0.17</td>
</tr>
<tr>
<td>8</td>
<td>18/02–25/02</td>
<td>25.0</td>
<td>24.7 ± 1.8</td>
<td>&lt; 0.02</td>
<td>0.99 ± 0.11</td>
</tr>
<tr>
<td>9</td>
<td>25/02–03/03</td>
<td>15.5</td>
<td>19.4 ± 1.4</td>
<td>&lt; 0.02</td>
<td>0.71 ± 0.10</td>
</tr>
<tr>
<td>10</td>
<td>03/03–10/03</td>
<td>18.5</td>
<td>18.2 ± 1.3</td>
<td>&lt; 0.02</td>
<td>1.21 ± 0.13</td>
</tr>
<tr>
<td>11</td>
<td>10/03–17/03</td>
<td>0.0</td>
<td>1.52 ± 0.14</td>
<td>&lt; 0.02</td>
<td>0.24 ± 0.07</td>
</tr>
<tr>
<td>12</td>
<td>17/03–24/03</td>
<td>2.3</td>
<td>6.2 ± 0.5</td>
<td>&lt; 0.03</td>
<td>0.63 ± 0.10</td>
</tr>
<tr>
<td>13</td>
<td>24/03–31/03</td>
<td>24.0</td>
<td>38 ± 3</td>
<td>&lt; 0.02</td>
<td>1.41 ± 0.13</td>
</tr>
<tr>
<td>14</td>
<td>31/03–07/04</td>
<td>26.0</td>
<td>60 ± 4</td>
<td>&lt; 0.02</td>
<td>5.4 ± 0.4</td>
</tr>
<tr>
<td>15</td>
<td>07/04–14/04</td>
<td>9.5</td>
<td>22.2 ± 1.6</td>
<td>&lt; 0.02</td>
<td>0.67 ± 0.09</td>
</tr>
<tr>
<td>16</td>
<td>14/04–21/04</td>
<td>13.0</td>
<td>24.7 ± 1.8</td>
<td>&lt; 0.02</td>
<td>1.05 ± 0.11</td>
</tr>
<tr>
<td>17</td>
<td>21/04–28/04</td>
<td>23.0</td>
<td>49 ± 4</td>
<td>&lt; 0.02</td>
<td>2.6 ± 0.2</td>
</tr>
<tr>
<td>18</td>
<td>28/04–04/05</td>
<td>14.5</td>
<td>27 ± 2</td>
<td>&lt; 0.02</td>
<td>1.38 ± 0.11</td>
</tr>
<tr>
<td>19</td>
<td>04/05–12/05</td>
<td>0.0</td>
<td>6.8 ± 0.5</td>
<td>0.015 ± 0.005</td>
<td>3.1 ± 0.2</td>
</tr>
<tr>
<td>20</td>
<td>12/05–19/05</td>
<td>1.5</td>
<td>23.8 ± 1.7</td>
<td>0.031 ± 0.005</td>
<td>6.8 ± 0.5</td>
</tr>
<tr>
<td>21</td>
<td>19/05–26/05</td>
<td>35.5</td>
<td>46 ± 3</td>
<td>&lt; 0.02</td>
<td>3.3 ± 0.3</td>
</tr>
<tr>
<td>22</td>
<td>26/05–02/06</td>
<td>8.0</td>
<td>30 ± 2</td>
<td>&lt; 0.02</td>
<td>3.5 ± 0.3</td>
</tr>
<tr>
<td>23</td>
<td>02/06–09/06</td>
<td>1.7</td>
<td>20.9 ± 1.5</td>
<td>&lt; 0.02</td>
<td>2.04 ± 0.17</td>
</tr>
<tr>
<td>24</td>
<td>09/06–16/06</td>
<td>28.5</td>
<td>46 ± 3</td>
<td>&lt; 0.02</td>
<td>3.0 ± 0.2</td>
</tr>
<tr>
<td>25</td>
<td>16/06–23/06</td>
<td>72.5</td>
<td>93 ± 7</td>
<td>&lt; 0.03</td>
<td>4.7 ± 0.4</td>
</tr>
<tr>
<td>26</td>
<td>23/06–30/06</td>
<td>39.0</td>
<td>85 ± 6</td>
<td>&lt; 0.02</td>
<td>3.9 ± 0.3</td>
</tr>
</tbody>
</table>

Continued on next page
**Table A8 Continued**

<table>
<thead>
<tr>
<th>Week no.</th>
<th>Period</th>
<th>Precipitation mm</th>
<th>$^7\text{Be}$ Bq·m$^{-2}$</th>
<th>$^{137}\text{Cs}$ Bq·m$^{-2}$</th>
<th>$^{210}\text{Pb}$ Bq·m$^{-2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>30/06–07/07</td>
<td>27.5</td>
<td>42 ± 3</td>
<td>&lt; 0.02</td>
<td>1.73 ± 0.16</td>
</tr>
<tr>
<td>28</td>
<td>07/07–14/07</td>
<td>15.0</td>
<td>34 ± 2</td>
<td>&lt; 0.03</td>
<td>2.5 ± 0.2</td>
</tr>
<tr>
<td>29</td>
<td>14/07–21/07</td>
<td>0.0</td>
<td>10.9 ± 0.8</td>
<td>&lt; 0.02</td>
<td>3.2 ± 0.2</td>
</tr>
<tr>
<td>30</td>
<td>21/07–28/07</td>
<td>22.5</td>
<td>58 ± 4</td>
<td>&lt; 0.02</td>
<td>5.5 ± 0.4</td>
</tr>
<tr>
<td>31</td>
<td>28/07–04/08</td>
<td>28.0</td>
<td>37 ± 3</td>
<td>&lt; 0.02</td>
<td>1.32 ± 0.13</td>
</tr>
<tr>
<td>32</td>
<td>04/08–11/08</td>
<td>24.0</td>
<td>48 ± 4</td>
<td>&lt; 0.02</td>
<td>2.4 ± 0.2</td>
</tr>
<tr>
<td>33</td>
<td>11/08–18/08</td>
<td>10.0</td>
<td>11.7 ± 0.9</td>
<td>&lt; 0.02</td>
<td>0.43 ± 0.08</td>
</tr>
<tr>
<td>34</td>
<td>18/08–25/08</td>
<td>21.0</td>
<td>37 ± 3</td>
<td>&lt; 0.02</td>
<td>1.85 ± 0.16</td>
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<tr>
<td>35</td>
<td>25/08–01/09</td>
<td>1.1</td>
<td>28 ± 2</td>
<td>&lt; 0.02</td>
<td>4.2 ± 0.3</td>
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<tr>
<td>36</td>
<td>01/09–08/09</td>
<td>3.9</td>
<td>17.9 ± 1.4</td>
<td>&lt; 0.02</td>
<td>1.41 ± 0.14</td>
</tr>
<tr>
<td>37</td>
<td>08/09–15/09</td>
<td>1.5</td>
<td>13.5 ± 1.0</td>
<td>&lt; 0.02</td>
<td>1.60 ± 0.15</td>
</tr>
<tr>
<td>38</td>
<td>15/09–22/09</td>
<td>6.3</td>
<td>18.2 ± 1.4</td>
<td>&lt; 0.02</td>
<td>1.52 ± 0.14</td>
</tr>
<tr>
<td>39</td>
<td>22/09–29/09</td>
<td>4.5</td>
<td>16.9 ± 1.3</td>
<td>&lt; 0.02</td>
<td>2.23 ± 0.19</td>
</tr>
<tr>
<td>40</td>
<td>29/09–06/10</td>
<td>12.0</td>
<td>14.4 ± 1.1</td>
<td>&lt; 0.02</td>
<td>1.08 ± 0.11</td>
</tr>
<tr>
<td>41</td>
<td>06/10–13/10</td>
<td>0.0</td>
<td>3.7 ± 0.3</td>
<td>&lt; 0.02</td>
<td>0.60 ± 0.09</td>
</tr>
<tr>
<td>42</td>
<td>13/10–20/10</td>
<td>31.0</td>
<td>30 ± 2</td>
<td>&lt; 0.02</td>
<td>2.8 ± 0.2</td>
</tr>
<tr>
<td>43</td>
<td>20/10–27/10</td>
<td>1.7</td>
<td>4.4 ± 0.3</td>
<td>&lt; 0.02</td>
<td>0.18 ± 0.07</td>
</tr>
<tr>
<td>44</td>
<td>27/10–03/11</td>
<td>5.4</td>
<td>7.9 ± 0.6</td>
<td>&lt; 0.02</td>
<td>0.91 ± 0.11</td>
</tr>
<tr>
<td>45</td>
<td>03/11–10/11</td>
<td>24.5</td>
<td>23.6 ± 1.7</td>
<td>&lt; 0.02</td>
<td>0.77 ± 0.10</td>
</tr>
<tr>
<td>46</td>
<td>10/11–17/11</td>
<td>32.5</td>
<td>38 ± 3</td>
<td>&lt; 0.02</td>
<td>0.82 ± 0.11</td>
</tr>
<tr>
<td>47</td>
<td>17/11–24/11</td>
<td>23.8</td>
<td>23.4 ± 1.8</td>
<td>&lt; 0.018</td>
<td>1.25 ± 0.12</td>
</tr>
<tr>
<td>48</td>
<td>24/11–30/11</td>
<td>0.5</td>
<td>4.6 ± 0.4</td>
<td>&lt; 0.02</td>
<td>0.36 ± 0.07</td>
</tr>
<tr>
<td>49</td>
<td>30/11–08/12</td>
<td>1.9</td>
<td>2.7 ± 0.2</td>
<td>&lt; 0.02</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>50</td>
<td>08/12–15/12</td>
<td>8.0</td>
<td>9.3 ± 0.7</td>
<td>&lt; 0.02</td>
<td>1.30 ± 0.13</td>
</tr>
<tr>
<td>51</td>
<td>15/12–22/12</td>
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<td>7.1 ± 0.5</td>
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<td>0.79 ± 0.10</td>
</tr>
<tr>
<td>52</td>
<td>22/12–29/12</td>
<td>4.6</td>
<td>6.5 ± 0.5</td>
<td>&lt; 0.02</td>
<td>0.39 ± 0.09</td>
</tr>
</tbody>
</table>

Total (2) 852.8 1,375 ± 18 - -

Lower limit (3) - - 0.04 95

Upper limit (3) - - 1.15 98

(1) Measurements were carried out using γ-spectroscopy.
(2) The uncertainty in the sum is equal to the square root of the sum of the squared weekly uncertainties. Uncertainties are given as 1σ.
(3) The lower and upper limits are defined in Appendix B.
Table A9  Yearly average α activity concentration in air and ambient dose equivalent rate in 2016, as measured by the NMR stations equipped with aerosol monitors

<table>
<thead>
<tr>
<th>Station</th>
<th>No.</th>
<th>α activity concentration Bq.m⁻³</th>
<th>Ambient dose equivalent rate (1) nSv.h⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arnhem</td>
<td>970</td>
<td>4.1</td>
<td>77</td>
</tr>
<tr>
<td>Kollumerwaard</td>
<td>972</td>
<td>3.4</td>
<td>87</td>
</tr>
<tr>
<td>Valtermoed</td>
<td>974</td>
<td>3.0</td>
<td>68</td>
</tr>
<tr>
<td>Vlaardingen</td>
<td>976</td>
<td>3.2</td>
<td>79</td>
</tr>
<tr>
<td>Braakman</td>
<td>978</td>
<td>3.7</td>
<td>75</td>
</tr>
<tr>
<td>Huijbergen</td>
<td>980</td>
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<td>64</td>
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<td>Houtakker</td>
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<td>De Zilk</td>
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<td>990</td>
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<td>992</td>
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<td>Biddinghuizen</td>
<td>994</td>
<td>3.5</td>
<td>87</td>
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<tr>
<td>Bilthoven</td>
<td>998</td>
<td>3.2</td>
<td>68</td>
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(1) These dose equivalent rate monitors are placed differently from the dose equivalent rate monitors mentioned in Table A10 with regard to height and surface covering.
Table A10  Yearly average ambient dose equivalent rate for the NMR stations in 2017

<table>
<thead>
<tr>
<th>Station</th>
<th>No.</th>
<th>Ambient dose equivalent rate nSv.h⁻¹</th>
<th>Station</th>
<th>No.</th>
<th>Ambient dose equivalent rate nSv.h⁻¹</th>
</tr>
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<tbody>
<tr>
<td>Den Burg</td>
<td>1001</td>
<td>77</td>
<td>Lelystad</td>
<td>1103</td>
<td>82</td>
</tr>
<tr>
<td>Den Helder</td>
<td>1002</td>
<td>76</td>
<td>Urk</td>
<td>1105</td>
<td>82</td>
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<tr>
<td>Den Oever</td>
<td>1003</td>
<td>78</td>
<td>Eemshaven</td>
<td>1106</td>
<td>82</td>
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<tr>
<td>Petten</td>
<td>1006</td>
<td>70</td>
<td>Uithuizen</td>
<td>1107</td>
<td>87</td>
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<tr>
<td>Kolhorn</td>
<td>1007</td>
<td>92</td>
<td>Wagenborgen</td>
<td>1109</td>
<td>78</td>
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<tr>
<td>Egmond aan Zee</td>
<td>1009</td>
<td>70</td>
<td>Winschoten</td>
<td>1110</td>
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<td>Heerhugowaard</td>
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<td>84</td>
<td>Ter Apel</td>
<td>1111</td>
<td>74</td>
</tr>
<tr>
<td>Nederhorst Den Berg</td>
<td>1015</td>
<td>82</td>
<td>Stadskanaal</td>
<td>1112</td>
<td>72</td>
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<tr>
<td>Velsen</td>
<td>1016</td>
<td>75</td>
<td>Nieuweschans</td>
<td>1113</td>
<td>84</td>
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<td>Enkhuizen</td>
<td>1018</td>
<td>81</td>
<td>Bellingwolde</td>
<td>1114</td>
<td>66</td>
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<td>Groningen</td>
<td>1116</td>
<td>85</td>
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<td>Zaandam (1)</td>
<td>1021</td>
<td>111</td>
<td>Leens</td>
<td>1117</td>
<td>87</td>
</tr>
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(1) The Zaandam station showed a significantly higher value than most other stations. This is due to a higher background level of the surrounding surface at the site since the end of 2014.

(2) A few stations have been moved during 2018: Wekerom station was moved to Otterlo, Harlingen station to Witmarsum, Hengelo (Ov) station to Laren (Gld) and Den Ham station to Vroomshoop.

(3) As in previous years, the 's-Heerenhoek station showed a significantly higher value than all other stations. This is due to a higher background level of the ground surface at the site. Since September 2009, this background level has been reduced by covering the surrounding ground surface with a layer of shells.
Table A11 Gross α, residual β, ³H, ⁹⁰Sr and ²²⁶Ra activity concentrations (mBq·L⁻¹) in surface water in 2016 as measured by RWS

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<th>Location</th>
<th>$^{60}$Co Bq·kg$^{-1}$</th>
<th>$^{131}$I Bq·kg$^{-1}$</th>
<th>$^{137}$Cs Bq·kg$^{-1}$</th>
<th>$^{210}$Pb Bq·kg$^{-1}$</th>
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</thead>
<tbody>
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<td>25/02/16</td>
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</tr>
<tr>
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<td>Kanaal Gent Terneuzen</td>
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<td>&lt; 1</td>
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<td>&lt; 1</td>
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<tr>
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<td>Kanaal Gent Terneuzen</td>
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<tr>
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<td>&lt; 1</td>
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<td>Haringvliet</td>
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<td>&lt; 1</td>
<td>13.7</td>
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</tr>
<tr>
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<td>Haringvliet</td>
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<td>Haringvliet</td>
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<tr>
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<td>&lt; 1</td>
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<td>Haringvliet</td>
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<td>Haringvliet</td>
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Table A13  Gross α, residual β, $^3$H and $^{90}$Sr activity concentrations (mBq∙L$^{-1}$) in seawater in 2016 as measured by RWS

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Gross α mBq∙L$^{-1}$</th>
<th>Residual β mBq∙L$^{-1}$</th>
<th>$^3$H mBq∙L$^{-1}$</th>
<th>$^{90}$Sr mBq∙L$^{-1}$</th>
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<tr>
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<td>16</td>
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<td>43</td>
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<td>4,300</td>
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<td>19/05/16</td>
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<tr>
<td>15/08/16</td>
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<tr>
<td>10/11/16</td>
<td>349</td>
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<tr>
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<table>
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<th>Date</th>
<th>Location</th>
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</thead>
<tbody>
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<td>Wadden Sea West</td>
</tr>
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<td>18/02/16</td>
<td>210</td>
</tr>
<tr>
<td>19/05/16</td>
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<td>16/08/16</td>
<td>287</td>
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<tr>
<td>16/11/16</td>
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<th>Location</th>
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<td>11/08/16</td>
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<td>15/11/16</td>
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<td>Average</td>
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### Table A14  $^{137}$Cs and $^{210}$Pb activity concentrations in suspended solids (Bq·kg$^{-1}$) in seawater in 2016 as measured by RWS

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</tr>
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<td>25/08/16</td>
<td>3.1</td>
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<td>24/11/16</td>
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</tr>
<tr>
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### Table A15  Monthly average gross α activity concentrations in air dust near the Borssele nuclear power plant in 2016

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<th>Date (1)</th>
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<td>02/03/16</td>
<td>0.022</td>
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<tr>
<td>06/04/16</td>
<td>0.008</td>
</tr>
<tr>
<td>03/05/16</td>
<td>0.018</td>
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<tr>
<td>07/06/16</td>
<td>0.095</td>
</tr>
<tr>
<td>06/07/16</td>
<td>0.021</td>
</tr>
<tr>
<td>03/08/16</td>
<td>0.031</td>
</tr>
<tr>
<td>07/09/16</td>
<td>0.021</td>
</tr>
<tr>
<td>06/10/16</td>
<td>0.059</td>
</tr>
<tr>
<td>03/11/16</td>
<td>0.104</td>
</tr>
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<td>05/12/16</td>
<td>0.064</td>
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<tr>
<td>05/01/17</td>
<td>0.06</td>
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</table>

(1) End date of monthly sampling period.
(2) Gross α activity concentrations in air dust are given as indicative values.
Table A16  Monthly average gross β activity concentrations in air dust near the Borssele nuclear power plant in 2016

<table>
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<th>Date</th>
<th>Location</th>
<th>Gross β mBq∙m⁻³</th>
</tr>
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<tbody>
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<td></td>
<td>21</td>
<td>22</td>
</tr>
<tr>
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<td>0.03 ± 0.05</td>
<td>0.14 ± 0.03</td>
</tr>
<tr>
<td>02/03/16</td>
<td>0.17 ± 0.05</td>
<td>0.22 ± 0.03</td>
</tr>
<tr>
<td>06/04/16</td>
<td>0.31 ± 0.04</td>
<td>0.28 ± 0.02</td>
</tr>
<tr>
<td>03/05/16</td>
<td>0.13 ± 0.05</td>
<td>0.19 ± 0.03</td>
</tr>
<tr>
<td>07/06/16</td>
<td>0.65 ± 0.05</td>
<td>0.49 ± 0.02</td>
</tr>
<tr>
<td>06/07/16</td>
<td>0.15 ± 0.05</td>
<td>0.33 ± 0.03</td>
</tr>
<tr>
<td>03/08/16</td>
<td>0.33 ± 0.05</td>
<td>0.24 ± 0.03</td>
</tr>
<tr>
<td>07/09/16</td>
<td>0.45 ± 0.05</td>
<td>0.62 ± 0.04</td>
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<tr>
<td>06/10/16</td>
<td>1.01 ± 0.06</td>
<td>0.63 ± 0.03</td>
</tr>
<tr>
<td>03/11/16</td>
<td>0.76 ± 0.07</td>
<td>0.41 ± 0.04</td>
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</tbody>
</table>

(1) End date of monthly sampling period.

Table A17  Monthly average activity concentrations of γ-emitters in air (dust) near the Borssele nuclear power plant in 2016

<table>
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<th>Date</th>
<th>⁶⁰Co mBq∙m⁻³</th>
<th>¹³¹Iₑₓ (3) mBq∙m⁻³</th>
<th>¹³¹Iₒʳ (4) mBq∙m⁻³</th>
<th>¹³⁷Cs mBq∙m⁻³</th>
<th>Nat. (5) mBq∙m⁻³</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/02/16</td>
<td>&lt; 0.046</td>
<td>&lt; 0.2</td>
<td>&lt; 0.6</td>
<td>&lt; 0.035</td>
<td>&lt; 1.6</td>
</tr>
<tr>
<td>02/03/16</td>
<td>&lt; 0.053</td>
<td>&lt; 0.2</td>
<td>&lt; 0.6</td>
<td>&lt; 0.037</td>
<td>&lt; 1.5</td>
</tr>
<tr>
<td>06/04/16</td>
<td>&lt; 0.039</td>
<td>&lt; 0.1</td>
<td>&lt; 0.4</td>
<td>&lt; 0.029</td>
<td>&lt; 1.5</td>
</tr>
<tr>
<td>03/05/16</td>
<td>&lt; 0.050</td>
<td>&lt; 0.2</td>
<td>&lt; 0.7</td>
<td>&lt; 0.038</td>
<td>&lt; 1.8</td>
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<tr>
<td>07/06/16</td>
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<td>&lt; 0.6</td>
<td>&lt; 0.031</td>
<td>&lt; 1.6</td>
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<tr>
<td>06/07/16</td>
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<td>&lt; 0.5</td>
<td>&lt; 0.031</td>
<td>&lt; 1.3</td>
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<tr>
<td>03/08/16</td>
<td>&lt; 0.049</td>
<td>&lt; 0.2</td>
<td>&lt; 0.8</td>
<td>&lt; 0.038</td>
<td>&lt; 1.8</td>
</tr>
<tr>
<td>07/09/16</td>
<td>&lt; 0.052</td>
<td>&lt; 0.1</td>
<td>&lt; 0.7</td>
<td>&lt; 0.039</td>
<td>&lt; 1.9</td>
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<tr>
<td>06/10/16</td>
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<td>&lt; 1.0</td>
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<td>&lt; 0.4</td>
<td>&lt; 0.054</td>
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<td>05/01/17</td>
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<td>&lt; 0.1</td>
<td>&lt; 0.4</td>
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(1) Analysis was performed on a combined sample of the monthly samples taken from all five locations (21, 22, 23, 27 and 29).
(2) End date of monthly sampling period.
(3) Elemental ¹³¹I.
(4) Organically bound ¹³¹I.
(5) Naturally occurring γ-emitters.
### Table A18  Activity concentrations of γ-emitters in grass near the Borssele nuclear power plant in 2016 (1)

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<th>¹³⁷Cs Bq·kg⁻¹ (2)</th>
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<td>0.664</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>02/03/16</td>
<td>0.622</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>06/04/16</td>
<td>0.550</td>
<td>&lt; 1</td>
<td>&lt; 0.9</td>
<td>&lt; 0.9</td>
</tr>
<tr>
<td>03/05/16</td>
<td>0.711</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>07/06/16</td>
<td>0.880</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>06/07/16</td>
<td>0.733</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>03/08/16</td>
<td>0.835</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>07/09/16</td>
<td>1.21</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>06/10/16</td>
<td>1.15</td>
<td>&lt; 1</td>
<td>&lt; 0.9</td>
<td>&lt; 0.8</td>
</tr>
<tr>
<td>03/11/16</td>
<td>0.703</td>
<td>&lt; 3</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>05/12/16</td>
<td>1.28</td>
<td>&lt; 0.8</td>
<td>&lt; 1</td>
<td>&lt; 0.7</td>
</tr>
<tr>
<td>05/01/17</td>
<td>0.604</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

(1) Analysis was performed on a combined sample of the monthly samples taken from all five locations (21, 22, 23, 27 and 29).

(2) Dry weight.

### Table A19  Activity concentrations of γ-emitters in soil near the Borssele nuclear power plant in 2016 (1)

<table>
<thead>
<tr>
<th>Location</th>
<th>Mass kg·m⁻²</th>
<th>⁵⁴Mn Bq·kg⁻¹ (2)</th>
<th>⁶⁰Co Bq·kg⁻¹ (2)</th>
<th>¹³⁴Cs Bq·kg⁻¹ (2)</th>
<th>¹³⁷Cs Bq·kg⁻¹ (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1</td>
<td>76.8</td>
<td>&lt; 0.3</td>
<td>&lt; 0.4</td>
<td>&lt; 0.2</td>
<td>1.27 ± 0.06</td>
</tr>
<tr>
<td>O2</td>
<td>91.2</td>
<td>&lt; 0.4</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>1.48 ± 0.07</td>
</tr>
<tr>
<td>O3</td>
<td>73.8</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>&lt; 0.4</td>
<td>1.22 ± 0.06</td>
</tr>
<tr>
<td>O4</td>
<td>71.2</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>1.47 ± 0.06</td>
</tr>
</tbody>
</table>

(1) Analysis was performed on four samples taken near the outlet of the plant on 9 May 2016.

(2) Dry weight.

### Table A20  Residual β activity concentrations in water from the Western Scheldt in 2016

<table>
<thead>
<tr>
<th>Location</th>
<th>Residual β Bq·L⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/02/16</td>
<td>0.043 ± 0.008</td>
</tr>
<tr>
<td>02/03/16</td>
<td>0.060 ± 0.008</td>
</tr>
<tr>
<td>06/04/16</td>
<td>0.050 ± 0.007</td>
</tr>
<tr>
<td>03/05/16</td>
<td>0.033 ± 0.008</td>
</tr>
<tr>
<td>07/06/16</td>
<td>0.035 ± 0.008</td>
</tr>
<tr>
<td>06/07/16</td>
<td>0.035 ± 0.007</td>
</tr>
<tr>
<td>03/08/16</td>
<td>0.037 ± 0.008</td>
</tr>
<tr>
<td>07/09/16</td>
<td>0.030 ± 0.009</td>
</tr>
<tr>
<td>06/10/16</td>
<td>0.049 ± 0.009</td>
</tr>
<tr>
<td>03/11/16</td>
<td>0.036 ± 0.008</td>
</tr>
<tr>
<td>05/12/16</td>
<td>0.060 ± 0.009</td>
</tr>
<tr>
<td>05/01/17</td>
<td>0.085 ± 0.012</td>
</tr>
</tbody>
</table>
### Table A21  
*3H activity concentrations in water from the Western Scheldt in 2016*

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>1 Bq L⁻¹</th>
<th>2 Bq L⁻¹</th>
<th>3 Bq L⁻¹</th>
<th>4 Bq L⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/02/16</td>
<td>5.6 ± 1.2</td>
<td>5.1 ± 1.1</td>
<td>2.7 ± 1.1</td>
<td>7.0 ± 1.2</td>
<td></td>
</tr>
<tr>
<td>02/03/16</td>
<td>4.5 ± 1.1</td>
<td>5.0 ± 1.1</td>
<td>4.6 ± 1.1</td>
<td>6.1 ± 1.2</td>
<td></td>
</tr>
<tr>
<td>06/04/16</td>
<td>7.0 ± 1.2</td>
<td>5.6 ± 1.2</td>
<td>6.3 ± 1.2</td>
<td>5.6 ± 1.2</td>
<td></td>
</tr>
<tr>
<td>03/05/16</td>
<td>5.7 ± 1.1</td>
<td>6.9 ± 1.2</td>
<td>3.9 ± 1.1</td>
<td>3.5 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>07/06/16</td>
<td>1.8 ± 1.1</td>
<td>2.7 ± 1.1</td>
<td>4.3 ± 1.1</td>
<td>3.3 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>06/07/16</td>
<td>2.6 ± 1.1</td>
<td>4.7 ± 1.2</td>
<td>1.4 ± 1.1</td>
<td>2.5 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>03/08/16</td>
<td>5.6 ± 1.1</td>
<td>5.2 ± 1.1</td>
<td>3.0 ± 1.1</td>
<td>5.5 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>07/09/16</td>
<td>4.2 ± 1.2</td>
<td>2.9 ± 1.1</td>
<td>3.9 ± 1.2</td>
<td>2.7 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>06/10/16</td>
<td>5.7 ± 1.2</td>
<td>3.7 ± 1.1</td>
<td>3.6 ± 1.2</td>
<td>6.7 ± 1.2</td>
<td></td>
</tr>
<tr>
<td>03/11/16</td>
<td>3.3 ± 1.1</td>
<td>4.6 ± 1.1</td>
<td>4.7 ± 1.1</td>
<td>3.6 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>05/12/16</td>
<td>4.4 ± 1.1</td>
<td>7.3 ± 1.2</td>
<td>4.2 ± 1.1</td>
<td>4.3 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>05/01/17</td>
<td>5.1 ± 1.1</td>
<td>4.9 ± 1.1</td>
<td>2.3 ± 0.8</td>
<td>5.8 ± 1.2</td>
<td></td>
</tr>
</tbody>
</table>

### Table A22  
*Gross β activity concentrations in suspended solids from the Western Scheldt in 2016*

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>1 kBq kg⁻¹</th>
<th>2 kBq kg⁻¹</th>
<th>3 kBq kg⁻¹</th>
<th>4 kBq kg⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/02/16</td>
<td>1.8 ± 0.9</td>
<td>2.2 ± 0.4</td>
<td>1.13 ± 0.09</td>
<td>3.1 ± 0.9</td>
<td></td>
</tr>
<tr>
<td>02/03/16</td>
<td>1.6 ± 0.4</td>
<td>2.0 ± 0.3</td>
<td>1.6 ± 0.4</td>
<td>1.8 ± 0.3</td>
<td></td>
</tr>
<tr>
<td>06/04/16</td>
<td>1.5 ± 0.8</td>
<td>2.3 ± 0.5</td>
<td>1.50 ± 0.14</td>
<td>2.1 ± 0.3</td>
<td></td>
</tr>
<tr>
<td>03/05/16</td>
<td>2.3 ± 0.7</td>
<td>2.1 ± 0.7</td>
<td>1.0 ± 0.5</td>
<td>0.2 ± 1.2</td>
<td></td>
</tr>
<tr>
<td>07/06/16</td>
<td>1.51 ± 0.10</td>
<td>1.50 ± 0.13</td>
<td>2.6 ± 0.5</td>
<td>1.76 ± 0.16</td>
<td></td>
</tr>
<tr>
<td>06/07/16</td>
<td>2.4 ± 0.5</td>
<td>3.0 ± 0.6</td>
<td>2.7 ± 0.9</td>
<td>2.6 ± 0.5</td>
<td></td>
</tr>
<tr>
<td>03/08/16</td>
<td>1.0 ± 0.3</td>
<td>2.3 ± 0.5</td>
<td>1.2 ± 0.3</td>
<td>2.7 ± 0.6</td>
<td></td>
</tr>
<tr>
<td>07/09/16</td>
<td>1.4 ± 0.8</td>
<td>2.3 ± 0.9</td>
<td>2.4 ± 0.8</td>
<td>1.8 ± 0.6</td>
<td></td>
</tr>
<tr>
<td>06/10/16</td>
<td>1.2 ± 0.3</td>
<td>1.5 ± 0.2</td>
<td>0.7 ± 0.3</td>
<td>1.1 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>03/11/16</td>
<td>2.1 ± 0.5</td>
<td>1.7 ± 0.6</td>
<td>2.0 ± 0.3</td>
<td>1.4 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>05/12/16</td>
<td>1.7 ± 0.4</td>
<td>0.63 ± 0.19</td>
<td>0.3 ± 0.2</td>
<td>0.6 ± 0.4</td>
<td></td>
</tr>
<tr>
<td>05/01/17</td>
<td>1.3 ± 1.2</td>
<td>2.6 ± 1.2</td>
<td>1.2 ± 1.3</td>
<td>2.7 ± 1.0</td>
<td></td>
</tr>
</tbody>
</table>
Table A23  Activity concentrations of γ-emitters in seaweed from the Western Scheldt in 2016

<table>
<thead>
<tr>
<th>Date</th>
<th>Mass</th>
<th>(^{60}\text{Co}) Bq·kg(^{-1}) (2)</th>
<th>(^{131}\text{I}) Bq·kg(^{-1}) (2)</th>
<th>(^{137}\text{Cs}) Bq·kg(^{-1}) (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/02/16</td>
<td>0.253</td>
<td>&lt; 1</td>
<td>&lt; 0.8</td>
<td>&lt; 0.7</td>
</tr>
<tr>
<td>02/03/16</td>
<td>0.167</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>06/04/16</td>
<td>0.236</td>
<td>&lt; 0.6</td>
<td>&lt; 0.5</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>03/05/16</td>
<td>0.115</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>07/06/16</td>
<td>0.111</td>
<td>&lt; 1</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>06/07/16</td>
<td>0.119</td>
<td>&lt; 1</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>03/08/16</td>
<td>0.102</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>07/09/16</td>
<td>0.142</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>&lt; 0.7</td>
</tr>
<tr>
<td>06/10/16</td>
<td>0.15</td>
<td>&lt; 0.7</td>
<td>&lt; 0.8</td>
<td>&lt; 0.8</td>
</tr>
<tr>
<td>03/11/16</td>
<td>0.096</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>05/12/16</td>
<td>0.166</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>&lt; 0.9</td>
</tr>
<tr>
<td>05/01/17</td>
<td>0.117</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

(1) Analysis was performed on a combined sample of the monthly samples taken from all four locations (1, 2, 3 and 4).
(2) Dry weight.

Table A24  Activity concentrations of γ-emitters in sediment from the Western Scheldt in 2016

<table>
<thead>
<tr>
<th>Location</th>
<th>Mass kg·m(^{-2})</th>
<th>(^{60}\text{Co}) Bq·kg(^{-1}) (2)</th>
<th>(^{131}\text{I}) Bq·kg(^{-1}) (2)</th>
<th>(^{137}\text{Cs}) Bq·kg(^{-1}) (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/02/16</td>
<td>67.2</td>
<td>&lt; 0.2</td>
<td>&lt; 0.3</td>
<td>0.36 ± 0.03</td>
</tr>
<tr>
<td>02/03/16</td>
<td>79.9</td>
<td>&lt; 0.2</td>
<td>&lt; 0.3</td>
<td>0.27 ± 0.03</td>
</tr>
<tr>
<td>06/04/16</td>
<td>77.5</td>
<td>&lt; 0.2</td>
<td>&lt; 0.2</td>
<td>0.44 ± 0.07</td>
</tr>
<tr>
<td>03/05/16</td>
<td>74.4</td>
<td>&lt; 0.2</td>
<td>&lt; 0.2</td>
<td>0.29 ± 0.03</td>
</tr>
<tr>
<td>07/06/16</td>
<td>63.5</td>
<td>&lt; 0.3</td>
<td>&lt; 0.2</td>
<td>0.77 ± 0.05</td>
</tr>
<tr>
<td>06/07/16</td>
<td>76.7</td>
<td>&lt; 0.2</td>
<td>&lt; 0.3</td>
<td>0.39 ± 0.04</td>
</tr>
<tr>
<td>03/08/16</td>
<td>78.9</td>
<td>&lt; 0.2</td>
<td>&lt; 0.2</td>
<td>0.38 ± 0.03</td>
</tr>
<tr>
<td>07/09/16</td>
<td>59.7</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>0.99 ± 0.05</td>
</tr>
<tr>
<td>06/10/16</td>
<td>57.6</td>
<td>&lt; 0.2</td>
<td>&lt; 0.3</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>03/11/16</td>
<td>65.2</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>0.81 ± 0.05</td>
</tr>
<tr>
<td>05/12/16</td>
<td>69.8</td>
<td>&lt; 0.2</td>
<td>&lt; 0.2</td>
<td>0.25 ± 0.03</td>
</tr>
<tr>
<td>05/01/17</td>
<td>61.8</td>
<td>&lt; 0.2</td>
<td>&lt; 0.3</td>
<td>0.84 ± 0.04</td>
</tr>
</tbody>
</table>

(1) Analysis was performed on a combined sample of the monthly samples taken from all four locations (1, 2, 3 and 4).
(2) Dry weight.
Appendix B Presentation of data

The methods described below were applied to the data provided by the RIVM/VLH (e.g. air dust and deposition), unless otherwise stated. Data from the other institutions are reported as provided, unless otherwise stated.

B.1 Correction for radioactive decay
In general, the activities of specific radionuclides are corrected for radioactive decay. The activities measured in the sample are multiplied by a decay factor, combining the time from halfway through the sampling period to the time of analysis, the decay during the measurement and the half-life of the radionuclide. If the radionuclides are unknown, as with gross α and gross β, no correction for radioactive decay is made.

B.2 Calculation of sums and averages
In the calculation of weekly, monthly or yearly averages or sums, the original results before rounding-off are used. If a certain radionuclide cannot be measured, the detection limit is used in the calculation of the sums. In that case, only a range (lower and upper limit) is given instead of a total with an uncertainty. Both range and total with an uncertainty are presented with a 68% confidence interval.

The lower and upper limits are calculated as follows:

\[
\text{Lower limit} = \sum x_i - \sqrt{\sum s_i^2}
\]

\[
\text{Upper limit} = \sum x_i + \sqrt{\sum s_i^2 + \sum MDA_i}
\]

where

- \(x_i\) = weekly or monthly result that is not a detection limit;
- \(\sqrt{\sum s_i^2}\) = the uncertainty in the sum;
- \(s_i\) = uncertainty in the weekly or monthly result (1σ);
- \(MDA_i\) = weekly or monthly result that is a detection limit.

The detection limits are omitted in the calculation of the averages. If data are not reported (e.g. a sample was not analysed/available), the sampling period is not taken into account for the calculation of the sum or average.

B.3 Calculation of uncertainties
The uncertainties given in Tables A1–A8 are a combination of the statistical uncertainties and estimations of the experimental uncertainties. In the yearly total, the uncertainty is the square root of the sum of the squared weekly or monthly uncertainties. In the yearly
average, the uncertainty is the square root of the sum of the squared weekly uncertainties divided by the number of weeks.

**B.4 Mixed diets: conversion from Bq kg\(^{-1}\) to intake in Bq day\(^{-1}\)**

With respect to the results presented for mixed diets (Chapter 8), RIKILT Wageningen UR 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 ‘Dutch National Food Consumption Survey 2007–2010. Diet of children and adults aged 7 to 69 years’ [76]. In this report, the consumption patterns are presented by food category, sex and age group, in grams per consumption day, and 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:

\[
DI_{a,s,n} = \sum_i \frac{DI_{a,s,i}}{1000} \times AC_{i,n}
\]

where

- \(DI_{a,s,n}\) = daily intake per age group, sex and radionuclide (Bq\cdot day\(^{-1}\));
- \(i\) = food category;
- \(DI_{a,s,i}\) = daily intake per age group, sex and food category (g\cdot day\(^{-1}\));
- \(AC_{i,n}\) = activity concentration per food category and radionuclide (Bq\cdot 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.
### Appendix C Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient dose equivalent</td>
<td>An operational quantity used when monitoring radiation in the environment. The unit of ambient dose equivalent is the Sievert (Sv).</td>
</tr>
<tr>
<td>Becquerel (Bq)</td>
<td>One radioactive transformation per second.</td>
</tr>
<tr>
<td>Decay product</td>
<td>A decay product (also known as a daughter product, daughter isotope, or daughter nuclide) is a nuclide resulting from the radioactive decay of a parent isotope or precursor nuclide. The decay product may be stable or it may decay to form a daughter product of its own.</td>
</tr>
<tr>
<td>Dose rate</td>
<td>The radiation dose delivered per unit of time.</td>
</tr>
<tr>
<td>Effective dose</td>
<td>The sum of the equivalent doses from internal and external radiation in all tissue and organs of the body, having been weighted by their tissue weighting factors. The unit of effective dose is the Sievert (Sv).</td>
</tr>
<tr>
<td>Gross alpha activity</td>
<td>Gross α (or total α) activity is the total activity of radionuclides emitting α radiation.</td>
</tr>
<tr>
<td>Gross beta activity</td>
<td>Gross β (or total β) activity is the total activity of radionuclides emitting β radiation. Depending on the measurement methodology, it might exclude tritium and/or radon daughters.</td>
</tr>
<tr>
<td>Limit</td>
<td>Consumption limits in milk, foodstuffs and of feeding stuffs set in European legislation [65, 66, 67].</td>
</tr>
<tr>
<td>Parametric value</td>
<td>The value of radioactive substances in drinking water above which Member States shall assess whether the presence of radioactive substances in water intended for human consumption poses a risk to human health that requires action and, where necessary, shall take remedial action to improve the quality of water to a level which complies with the requirements for the protection of human health from a radiation protection point of view [48].</td>
</tr>
<tr>
<td>Radioactivity</td>
<td>The emission of α particles, β particles, neutrons and γ or X radiation from the disintegration of an atomic nucleus. The unit of radioactivity is the Becquerel (Bq).</td>
</tr>
<tr>
<td>Radiocesium activity</td>
<td>Sum of the activity of $^{134}$Cs and $^{137}$Cs.</td>
</tr>
<tr>
<td>Radionuclide</td>
<td>An unstable form of an element that undergoes radioactive decay.</td>
</tr>
</tbody>
</table>
Residual beta activity

The residual β activity is the gross β activity (total β activity) minus the β activity of naturally occurring $^{40}$K. For brackish and salt water, the RWS uses a direct method to determine residual β activity [43].

Screening level

Level for gross α or gross β activity in drinking water (Bq·L$^{-1}$) below which it can be assumed that the individual dose is less than the parametric value of 0.1 mSv and radiological investigation is not needed unless it is known from other sources of information that specific radionuclides are present in the water that are liable to cause an individual dose in excess of 0.1 mSv [48].
References


Erratum
Author C.P. Tanzi
Date 13 June 2019
Report number 2018-0160
Report title Environmental radioactivity in the Netherlands - Results in 2016

Errors
Two transcription errors have been identified in the Summary Table S.1 on page 15: for drinking water, the number of locations for $^3$H is 180 (instead of the reported 88), and for $^{90}$Sr in milk, the value is <0.2 Bq·kg$^{-1}$ (instead of the reported <5 Bq·kg$^{-1}$). The correct table is given below.

There is typographical error in the caption of table A10 on page 94, where the year 2017 is incorrectly mentioned, instead of the relevant year 2016. The correct caption is given below:
Table A10 Yearly average ambient dose equivalent rate for the NMR stations in 2016

There is typographical error in note (2) of table A10 on page 95, where the year 2018 is incorrectly mentioned, instead of the relevant year 2016. The correct note is given below:
(2) A few stations have been moved during 2016: Wekerom station was moved to Otterlo, Harlingen station to Witmarsum, Hengelo (Ov) station to Laren (Gld) and Den Ham station to Vroomshoop.

There is typographical error in the caption of table A12 on page 99, where the year 2015 is incorrectly mentioned, instead of the relevant year 2016. The correct caption is given below:
Table A12 $^{60}$Co, $^{131}$I, $^{137}$Cs and $^{210}$Pb activity concentrations in suspended solids (Bq·kg$^{-1}$) in surface water in 2016 as measured by RWS

These corrections have no consequence for the conclusions of the report.
Table S1 Summary of the results from the Dutch monitoring programme in 2016

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Parameter</th>
<th>Locations</th>
<th>Values</th>
<th>Frequency (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air dust</td>
<td>Gross α</td>
<td>1</td>
<td>0.019 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Gross β</td>
<td>1</td>
<td>0.362 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>⁷Be</td>
<td>1</td>
<td>2.910 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>1</td>
<td>0.000208 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>²¹⁰Pb</td>
<td>1</td>
<td>0.312 mBq·m⁻³</td>
<td>52</td>
</tr>
<tr>
<td>Deposition</td>
<td>Gross α</td>
<td>1</td>
<td>66 Bq·m⁻²</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Gross β</td>
<td>1</td>
<td>88 Bq·m⁻²</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>³H (³)</td>
<td>1</td>
<td>22–1,510 Bq·m⁻²</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>⁷Be</td>
<td>1</td>
<td>1,375 Bq·m⁻²</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs (³)</td>
<td>1</td>
<td>0.04–1.15 Bq·m⁻²</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>²¹⁰Pb</td>
<td>1</td>
<td>95–98 Bq·m⁻²</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>²¹⁰Po</td>
<td>1</td>
<td>40.6 Bq·m⁻²</td>
<td>12</td>
</tr>
<tr>
<td>Surface water</td>
<td>Gross α</td>
<td>8</td>
<td>29–249 mBq·L⁻¹</td>
<td>12–13 (⁴)</td>
</tr>
<tr>
<td></td>
<td>Residual β</td>
<td>8</td>
<td>13–112 mBq·L⁻¹</td>
<td>12–13 (⁴)</td>
</tr>
<tr>
<td></td>
<td>³H</td>
<td>8</td>
<td>1,550–14,600 mBq·L⁻¹</td>
<td>6–13 (⁴)</td>
</tr>
<tr>
<td></td>
<td>⁹⁰Sr</td>
<td>3</td>
<td>&lt; 1–3.1 mBq·L⁻¹</td>
<td>6–7 (⁴)</td>
</tr>
<tr>
<td></td>
<td>²²⁶Ra</td>
<td>4</td>
<td>4.0–33.1 mBq·L⁻¹</td>
<td>6–7 (⁴)</td>
</tr>
<tr>
<td>Suspended solids in surface water</td>
<td>⁶⁰Co</td>
<td>8</td>
<td>&lt; 1–10.4 Bq·kg⁻¹</td>
<td>4–51 (⁴)</td>
</tr>
<tr>
<td></td>
<td>¹³¹I</td>
<td>8</td>
<td>&lt; 1–36.0 Bq·kg⁻¹</td>
<td>4–51 (⁴)</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>8</td>
<td>3.0–12.4 Bq·kg⁻¹</td>
<td>4–51 (⁴)</td>
</tr>
<tr>
<td></td>
<td>²¹⁰Pb</td>
<td>4</td>
<td>80–140 Bq·kg⁻¹</td>
<td>6–7 (⁴)</td>
</tr>
<tr>
<td>Seawater</td>
<td>Gross α</td>
<td>8</td>
<td>190–420 mBq·L⁻¹</td>
<td>4–13 (⁴)</td>
</tr>
<tr>
<td></td>
<td>Residual β</td>
<td>8</td>
<td>34–140 mBq·L⁻¹</td>
<td>4–13 (⁴)</td>
</tr>
<tr>
<td></td>
<td>³H</td>
<td>8</td>
<td>350–5,200 mBq·L⁻¹</td>
<td>4–13 (⁴)</td>
</tr>
<tr>
<td></td>
<td>⁹⁰Sr</td>
<td>4</td>
<td>&lt; 1.4–1.9 mBq·L⁻¹</td>
<td>4–13 (⁴)</td>
</tr>
<tr>
<td>Suspended solids in seawater</td>
<td>¹³⁷Cs</td>
<td>1</td>
<td>3.3 Bq·kg⁻¹</td>
<td>4 (⁴)</td>
</tr>
<tr>
<td></td>
<td>²¹⁰Pb</td>
<td>1</td>
<td>62 Bq·kg⁻¹</td>
<td>4 (⁴)</td>
</tr>
<tr>
<td>Drinking water</td>
<td>Gross α</td>
<td>183</td>
<td>&lt; 0.06 Bq·L⁻¹</td>
<td>388 (⁵)</td>
</tr>
<tr>
<td></td>
<td>Gross β</td>
<td>186</td>
<td>&lt; 0.1 Bq·L⁻¹</td>
<td>428 (⁵)</td>
</tr>
<tr>
<td></td>
<td>Residual β</td>
<td>168</td>
<td>&lt; 0.1 Bq·L⁻¹</td>
<td>390 (⁵)</td>
</tr>
<tr>
<td></td>
<td>³H</td>
<td>180</td>
<td>&lt; 4.0 Bq·L⁻¹</td>
<td>448 (⁵)</td>
</tr>
<tr>
<td>Milk</td>
<td>⁴⁰K</td>
<td>22</td>
<td>51.2 Bq·kg⁻¹ (⁶)</td>
<td>581 (⁵)</td>
</tr>
<tr>
<td></td>
<td>⁶⁰Co</td>
<td>22</td>
<td>&lt; 1.4 Bq·kg⁻¹</td>
<td>581 (⁵)</td>
</tr>
<tr>
<td></td>
<td>⁹⁰Sr</td>
<td>22</td>
<td>&lt; 0.2 Bq·kg⁻¹</td>
<td>47 (⁵)</td>
</tr>
<tr>
<td></td>
<td>¹³¹I</td>
<td>22</td>
<td>&lt; 0.6 Bq·kg⁻¹</td>
<td>581 (⁵)</td>
</tr>
<tr>
<td></td>
<td>¹³⁴Cs</td>
<td>22</td>
<td>&lt; 0.6 Bq·kg⁻¹</td>
<td>581 (⁵)</td>
</tr>
<tr>
<td></td>
<td>¹³⁷Cs</td>
<td>22</td>
<td>&lt; 0.5 Bq·kg⁻¹</td>
<td>581 (⁵)</td>
</tr>
</tbody>
</table>

Paraaf projectleider/labhoofd
Voor akkoord, 28 juni 2019

GJ Knetsch
Programma coördinator “Uitvoering Wettelijke Taken”