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G.J. Knetsch et al.

Environmental radioactivity in the Netherlands

Results in 2007

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RIVM Report 610791002/2008

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Abstract

Environmental radioactivity in the Netherlands
Results in 2007

The Member States of the European Union have the obligation to measure radioactivity in the environment yearly, as stated in the Euratom Treaty of 1957. The Netherlands fulfilled this obligation also in 2007. In 2000 Euratom made recommendations to perform the measurements according to a certain outline, however Member States are not obliged to comply with these recommendations. In 2007 the Netherlands complied to the Euratom recommendations except for the determination of strontium-90 in mixed diet.

Measurements in air and environment show normal levels. Radioactivity levels in food and milk were below the export and consumption limits set by the European Union.

The target values in fresh water were exceeded for some radionuclides and locations, however these exceedings do not pose a threat to the public health. Target values are values that should preferably not be exceeded, however they are not limits. Since 2007 data on environmental samples taken around the nuclear power plant at Borssele has been added to this report.

Key words:
radioactivity, environment, airborne particles, water, food, milk

Rapport in het kort

Radioactiviteit in het Nederlandse milieu
Resultaten in 2007

Volgens het EURATOM-verdrag uit 1957 moeten alle lidstaten van de Europese Unie jaarlijks de hoeveelheid radioactiviteit in het milieu meten. Ook in 2007 heeft Nederland aan deze verplichting voldaan. Sinds 2000 kent EURATOM aanbevelingen om de metingen volgens een bepaald stramien uit te voeren, lidstaten zijn echter niet verplicht deze na te leven. Nederland voldeed in 2007 aan alle Europese aanbevelingen, met uitzondering van de bepaling van strontium-90 in voedsel.

De metingen in lucht en omgeving lieten een normaal beeld zien. In voedsel en melk zijn geen radioactiviteitniveaus aangetroffen boven de Europese limieten voor export en consumptie.

In het oppervlaktewater is op een aantal locaties voor sommige radioactieve stoffen de streefwaarde overschreden. Deze overschrijdingen zijn echter zodanig dat ze niet schadelijk zijn voor de volksgezondheid. Streefwaarden zijn waarden die bij voorkeur niet overschreden mogen worden, maar het zijn geen limieten. Met ingang van 2007 zijn gegevens betreffende milieumonsters rondom kerncentrale Borssele toegevoegd aan dit rapport.

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

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Preface

The following institutes have contributed to the report:

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Nuclear Research & consultancy Group (NRG)
Data on environmental samples around the nuclear power plant at Borssele.
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Summary

The Dutch government is obligated to measure radioactivity in air, water and soil under the terms of the Euratom Treaty of 1957. In 2000 the European Union specified this treaty by means of recommendations describing the matrices to be measured (air dust, ambient dose, surface water, drinking water, milk and food) and the frequency of the measurements. The results should be published yearly. This report presents the results of radioactivity measurements in the Dutch environment in 2007. The measurements were carried out by RIVM, Centre for Water Management, RIKILT, VWA and NRG.

The yearly averaged activity concentration in air dust was determined for gross α, gross β, ^{7}Be, ^{137}Cs and ^{210}Pb. The yearly total activity in deposition was determined for gross α, gross β, ^{3}H, ^{7}Be, ^{137}Cs, ^{210}Pb and ^{210}Po. Gross α respectively gross β is the total activity of nuclides emitting α- respectively β-radiation. The results are presented in Table S1 and are within the range of those in previous years. Since 2007 a new (more realistic) calibration for gross α has been implemented. This new calibration is 1.4 times higher than the one for previous years, which results in lower reported gross α-activities.

The National Radioactivity Monitoring Network (NMR) was used to determine the activity concentrations in air dust of gross α and artificial β (β-radiation emitted by man-made nuclides). The difference between the NMR data and those mentioned above is due to the contribution of short-lived natural radionuclides (radon daughters). The yearly averaged gross α-activity concentration in air dust was 2.9 Bq·m^{-3}. The yearly average of the calculated artificial β-activity concentration did not deviate significantly from zero. The NMR was also used to determine the ambient dose equivalent rate, the yearly averaged measured value was 73.4 nSv·h^{-1}. Based upon earlier research it is assumed that this value is an overestimate of 5 to 10 nSv·h^{-1}.

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

The gross α-activity concentration in the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg and Scheldt exceeds the target value (100 mBq·L^{-1}) in one out of thirteen, four out of six, five out of thirteen and thirteen out of thirteen samples taken, respectively. The yearly averaged gross α-activity concentrations in the Noordzeekanaal, Nieuwe Waterweg and Scheldt (121, 110 and 250 mBq·L^{-1}, respectively) are above the target value, but within the range of those in previous years.

The ^{3}H-activity concentration in the Scheldt and Meuse exceeds the target value (10 Bq·L^{-1}) in one out of seven and nine out of thirteen samples taken, respectively. The yearly averaged ^{3}H-activity concentration in the Meuse (17.0 Bq·L^{-1}) is above the target value, but within the range of those in previous years.

The ^{226}Ra-activity concentration in the Scheldt exceeds the target value (5 mBq·L^{-1}) in seven out of seven samples taken, respectively. The yearly averaged ^{226}Ra-activity concentration in the Scheldt (11.1 mBq·L^{-1}) is above the target value, but within the range of those in previous years.

The ^{60}Co-activity concentration in the Meuse exceeds the target value (10 Bq·kg^{-1}) in four out of fifty-two samples taken. However the yearly averaged ^{60}Co-activity concentration in the Meuse is below the target value.

The ^{131}I-activity concentration in the Noordzeekanaal and Meuse exceeds the target value (20 Bq·kg^{-1}) in one out of six and twenty-five out of fifty-two samples taken, respectively. The yearly averaged ^{131}I-activity concentration in the Meuse (22 Bq·kg^{-1}) is above the target value, but within the range of those in previous years.

The ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine and Meuse exceeds the target value (100 Bq·kg^{-1}) in one out of seven, five out of six and six out of six samples taken, respectively. The yearly averaged ^{210}Pb-activity concentration in the Rhine and Meuse (112 and 150 Bq·kg^{-1}, respectively) are above the target value, but within the range of those in previous years.

The yearly averaged gross α-, ^{3}H- ^{90}Sr, ^{137}Cs and ^{210}Po-activity concentrations in seawater are within the range of those in previous years.

Typical activities found in raw input water for drinking water production are presented in Table S1. There is little potassium, and thus ^{40}K, present in this water. In 2007 at 3 of the 148 pumping stations the gross α-activity concentration averaged per pumping station exceeds 0.1 Bq·L^{-1}. These values were not thoroughly investigated. Future values above 0.1 Bq·L^{-1} for the gross α-activity concentration will be investigated.

The results of the monitoring program in milk and mixed diet are presented in Table S1.
Since 2007 data on environmental samples taken around the nuclear power plant at Borssele has been added to this report, see Table S2. In 2007 the Netherlands complied to the Euratom recommendations except for the determination of strontium-90 in mixed diet.

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Samenvatting

In het kader van het Euratom Verdrag uit 1957 is de Nederlandse overheid verplicht om radioactiviteitsgehalten te meten in de compartimenten lucht, water en bodem. In 2000 heeft de Europese Unie dit nauwkeuriger gespecificeerd middels aanbevelingen. Hierin wordt in detail beschreven wat moet worden gemeten (luchtstof, de omgevingsdosis, oppervlaktewater, drinkwater, melk en voedsel) en met welke frequentie. De resultaten dienen jaarlijks te worden gerapporteerd. In dit rapport worden de resultaten gegeven van radioactiviteits-metingen in het Nederlandse milieu in 2007. De metingen zijn verricht door RIVM, RWS Waterdienst, RIKILT, VWA en NRG.

In luchtstof werd de jaargemiddelde activiteitsconcentratie bepaald van totaal-α, totaal-β, ^{7}Be, ^{137}Cs en ^{210}Pb. In depositie werd de totale jaarlijkse activiteit bepaald van totaal-α, totaal-β, ^{3}H, ^{7}Be, ^{137}Cs, ^{210}Pb en ^{210}Po. Totaal-α respectievelijk totaal-β is de totale activiteit aan α- dan wel β-straling uitzendende nucliden. De resultaten zijn weergegeven in Tabel S1 en vallen binnen het bereik van voorgaande jaren. Met ingang van 2007 is de kalibratie voor totaal-α in luchtstof gewijzigd. De nieuwe kalibratie benadert de realiteit beter, maar valt een factor 1,4 hoger uit dan in voorgaande jaren. Hierdoor vallen de gerapporteerde totaal-α activiteiten lager uit.

Met het Nationaal Meetnet Radioactiviteit (NMR) werden activiteitsconcentraties bepaald in luchtstof voor totaal-α en kunstmatige β (β-straling uitgezonden door nucliden ontstaan door menselijk handelen). Het verschil tussen de NMR-metingen en bovenstaande metingen wordt veroorzaakt door de bijdrage van kortlevende natuurlijke radionucliden (radondochters). Het jaargemiddelde voor de totaal-α-activiteitsconcentratie in luchtstof was 2,9 Bq·m^{-3}. Het jaargemiddelde voor de berekende kunstmatige β-activiteitsconcentratie in luchtstof week niet significant af van nul. Met het NMR werd daarnaast het omgevingsdosisequivalenttempo bepaald, de jaargemiddelde meetwaarde was 73,4 nSv·h^{-1}. Gebaseerd op eerder onderzoek wordt aangenomen dat deze waarde een overschatting is met 5 tot 10 nSv·h^{-1}.

In oppervlaktewater werd de jaargemiddelde activiteitsconcentratie bepaald van totaal-α, rest-β (totaal-β minus het van nature aanwezige ^{40}K), ^{3}H, ^{90}Sr en ^{226}Ra en de jaargemiddelde activiteitsconcentratie van ^{60}Co, ^{131}I, ^{137}Cs en ^{210}Pb in zwevend stof. In zeewater werd de jaargemiddelde activiteitsconcentratie bepaald van totaal-α, rest-β, ^{3}H en ^{90}Sr. In zwevend stof in zeewater werd de jaargemiddelde activiteitsconcentratie bepaald van ^{137}Cs en ^{210}Po. De resultaten zijn weergegeven in Tabel S1.

De totaal α-activiteitsconcentratie in het IJsselmeer, Noordzeekanaal, de Nieuwe Waterweg en de Schelde overschreed de streefwaarde (100 mBq·L^{-1}) in respectievelijk één van de dertien, vier van de zes, vijf van de dertien en dertien van de dertien genomen monsters.
De jaargemiddelde totaal α-activiteitsconcentraties in het Noordzeekanaal, de Nieuwe Waterweg en de Schelde (respectievelijk 121, 110 en 250 mBq·L^{-1}) zijn boven de streefwaarde, maar vallen binnen het bereik van voorgaande jaren.

De ^{3}H-activeitsconcentratie in de Schelde en de Maas overschreed de streefwaarde (10 Bq·L^{-1}) in respectievelijk één van de zeven en negen van de dertien genomen monsters. De jaargemiddelde ^{3}H-activiteitsconcentratie in de Maas (17,0 Bq·L^{-1}) is boven de streefwaarde, maar valt binnen het bereik van voorgaande jaren.

De ^{226}Ra-activiteitsconcentratie in de Schelde overschreed de streefwaarde (5 mBq·L^{-1}) in respectievelijk zeven van de zeven genomen monsters. De jaargemiddelde ^{226}Ra-activiteitsconcentratie in de Schelde (11,1 mBq·L^{-1}) is boven de streefwaarde, maar valt binnen het bereik van voorgaande jaren.

De ^{60}Co-activiteitsconcentratie in de Maas overschreed de streefwaarde (10 Bq·kg^{-1}) in vier van de tweeënvijftig genomen monsters. De jaargemiddelde ^{60}Co-activiteitsconcentratie in de Maas is echter beneden de streefwaarde.

De ^{131}I-activiteitsconcentratie in het Noordzeekanaal en de Maas overschreed de streefwaarde (20 Bq·kg^{-1}) in respectievelijk één van de zes en vijfentwintig van de tweeënvijftig genomen monsters.
De jaargemiddelde ^{131}I-activiteitsconcentratie in de Maas (22 Bq·kg^{-1}) is boven de streefwaarde, maar valt binnen het bereik van voorgaande jaren.

De ^{210}Pb-activiteitsconcentratie in de Nieuwe Waterweg, de Rijn en de Maas overschreed de streefwaarde (100 Bq·kg^{-1}) in respectievelijk één van de zeven, vijf van de zes en zes van de zes genomen monsters. De jaargemiddelde ^{210}Pb-activiteitsconcentraties in de Rijn en de Maas (respectievelijk 112 en 150 Bq·kg^{-1}) zijn boven de streefwaarde, maar vallen binnen het bereik van voorgaande jaren.

De jaargemiddelde totaal α-, ^{3}H-, ^{90}Sr-, ^{137}Cs- en ^{210}Po-activiteitsconcentraties in zeewater vallen binnen het bereik van voorgaande jaren.

Gangbare waarden die in ruw water voor de drinkwaterproductie gevonden worden, zijn weergegeven in Tabel S1. In dit water is weinig kalium, en dus ^{40}K, aanwezig. De totaal α-activiteitsconcentratie gemiddeld per pompstation overschreed de grenswaarde van 0,1 Bq·L^{-1} bij 3 van de 148 pompstations. Deze waarden zijn niet grondig onderzocht. Toekomstige waarden boven 0,1 Bq·L^{-1} worden nader onderzocht.

De resultaten van het meetprogramma voor melk en voedsel zijn weergegeven in Tabel S1.
Met ingang van 2007 zijn gegevens betreffende milieumonsters rondom de kerncentrale Borssele toegevoegd aan dit rapport, zie Tabel S2. Nederland voldeed in 2007 aan alle Europese aanbevelingen, met uitzondering van de bepaling van strontium-90 in voedsel.

Table S1: Summary of the results of the Dutch monitoring program in 2007.
Tabel S1: Overzicht van de resultaten van het Nederlandse monitoringsprogramma in 2007.

Matrix	Parameter	Locations	Values	Frequency (per year)
Air dust [1]	Gross α	1	0.04 $mBq \cdot m^{-3}$	52
	Gross β	1	0.411 $mBq \cdot m^{-3}$	52
	^{7}Be	1	3.790 $mBq \cdot m^{-3}$	52
	^{137}Cs	1	< 0.002 $mBq \cdot m^{-3}$	52
	^{210}Pb	1	0.372 $mBq \cdot m^{-3}$	52
Deposition [2]	Gross α	1	24.4 $Bq \cdot m^{-2}$	12
	Gross β	1	85 $Bq \cdot m^{-2}$	12
	^{3}H	1	335 - 1600 $Bq \cdot m^{-2}$ [3]	12
	^{7}Be	1	1760 $Bq \cdot m^{-2}$	52
	^{137}Cs	1	0.11 - 7.37 $Bq \cdot m^{-2}$ [3]	52
	^{210}Pb	1	72 - 132 $Bq \cdot m^{-2}$ [3]	52
	^{210}Po	1	12.0 $Bq \cdot m^{-2}$ [3]	12
Surface water [1]	Gross α	6	42 - 250 $mBq \cdot L^{-1}$	6 or 13 [4]
	Residual β	6	28 - 89 $mBq \cdot L^{-1}$	6 or 13 [4]
	^{3}H	6	2500 - 17000 $mBq \cdot L^{-1}$	6, 7 or 13 [4]
	^{90}Sr	3	< 1.1 - 3.2 $mBq \cdot L^{-1}$	6 or 7 [4]
	^{226}Ra	4	2.3 - 11.1 $mBq \cdot L^{-1}$	6 or 7 [4]
	^{60}Co	7	< 1 - 6.3 $Bq \cdot kg^{-1}$	6, 7, 13 or 52 [4]
	^{131}I	7	< 1 - 22 $Bq \cdot kg^{-1}$	6, 7, 13 or 52 [4]
	^{137}Cs	7	6.5 - 15.5 $Bq \cdot kg^{-1}$	6, 7, 13 or 52 [4]
	^{210}Pb	4	89 - 150 $Bq \cdot kg^{-1}$	6 or 7 [4]
Seawater [1]	Gross α	8	340 - 520 $mBq \cdot L^{-1}$	4, 12 or 13 [4]
	Residual β	8	48 - 131 $mBq \cdot L^{-1}$	4, 12 or 13 [4]
	^{3}H	8	280 - 4900 $mBq \cdot L^{-1}$	4 or 13 [4]
	^{90}Sr	4	< 1 – 1.9 $mBq \cdot L^{-1}$	4 or 13 [4]
	^{137}Cs	4	4.7 - 7.2 $Bq \cdot kg^{-1}$	2, 3 or 4 [4]
	^{210}Po	4	67 - 100 $Bq \cdot kg^{-1}$	2, 3 or 4 [4]

To be continued on the next page.

Tabel S1: Vervolg.
Table S1: Continued.

Matrix	Parameter	Locations	Values	Frequency (per year)
Drinking water [1]	Gross α	148	< 0.1 $Bq \cdot L^{-1}$	371 [5]
	Gross β	153	< 0.3 $Bq \cdot L^{-1}$	411 [5]
	Residual β	135	< 0.3 $Bq \cdot L^{-1}$	342 [5]
	^{3}H	147	< 3.1 $Bq \cdot L^{-1}$	401 [5]
Milk [1]	^{40}K	24	48 $Bq \cdot L^{-1}$	986 [5]
	^{60}Co	24	< 1.4 $Bq \cdot L^{-1}$	986 [5]
	^{90}Sr	27	< 5 $Bq \cdot L^{-1}$	27 [5]
	^{131}I	24	< 0.6 $Bq \cdot L^{-1}$	986 [5]
	^{134}Cs	24	< 0.6 $Bq \cdot L^{-1}$	986 [5]
	^{137}Cs	24	< 0.5 $Bq \cdot L^{-1}$	986 [5]
Food [6, 7]				
Grain	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	113 (0) [8]
Vegetables	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	124 (0) [8]
Fruit	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	58 (0) [8]
Milk and milk products	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	87 (0) [8]
Meat and meat products	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	98 (0) [8]
Game and poultry	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	48 (0) [8]
Salads	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	34 (0) [8]
Oil and butter	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	57 (0) [8]
Honey	^{137}Cs	-	3 - 239 $Bq \cdot kg^{-1}$	91 (18) [8]
Others	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	3 (0) [8]

[1] = Yearly average is shown.
[2] = Yearly total is shown.
[3] = A 68% confidence range is shown.
[4] = Frequency is depending on location.
[5] = Total number of samples taken combined over all locations.
[6] = Given range represents values of individual samples.
[7] = Samples were analysed for ^{134}Cs as well, but it was below the detection limit.
[8] = Total number of samples taken. Number of positive samples between brackets.

Tabel S2: Overzicht van de resultaten van het monitoringsprogramma in de nabijheid van Kerncentrale Borssele in 2007.
Table S2: Summary of the results of the monitoring program in the vicinity of the nuclear power plant at Borssele in 2007.

Matrix	Parameter	Locations	Values [1]	Frequency (per year)
Air dust	Gross α	5	0.007 - 0.64 $mBq \cdot m^{-3}$	12
	Gross β	5	0.048 - 0.97 $mBq \cdot m^{-3}$	12
	^{60}Co	5 [2]	< 0.034 - < 0.080 $mBq \cdot m^{-3}$	12
	$^{131}I_{el}$ [3]	5 [2]	< 0.1 - < 0.2 $mBq \cdot m^{-3}$	12
	$^{131}I_{or}$ [3]	5 [2]	< 0.1 - < 0.6 $mBq \cdot m^{-3}$	12
	^{137}Cs	5 [2]	< 0.032 - < 0.052 $mBq \cdot m^{-3}$	12
	Nat. [4]	5 [2]	1.1 - 2.13 $mBq \cdot m^{-3}$	12
Grass	^{60}Co	5 [2]	< 2 - < 5 $Bq \cdot kg^{-1}$	12
	^{131}I	5 [2]	< 2 - < 4 $Bq \cdot kg^{-1}$	12
	^{137}Cs	5 [2]	< 1 - < 4 $Bq \cdot kg^{-1}$	12
Soil	^{54}Mn	4	< 0.1 - < 0.3 $Bq \cdot kg^{-1}$	1
	^{60}Co	4	< 0.1 - < 0.4 $Bq \cdot kg^{-1}$	1
	^{134}Cs	4	< 0.1 - < 0.4 $Bq \cdot kg^{-1}$	1
	^{137}Cs	4	0.17 - 1.83 $Bq \cdot kg^{-1}$	1
Water	Residual β	4	0.03 - 0.201 $Bq \cdot L^{-1}$	12
	^{3}H	4	6.6 - 10.4 $Bq \cdot L^{-1}$	12
Suspended solids	Gross β	4	0.64 - 1.77 $kBq \cdot kg^{-1}$	12
Seaweed	^{60}Co	4 [2]	< 2 - < 8 $Bq \cdot kg^{-1}$	12
	^{131}I	4 [2]	1.4 - < 7 $Bq \cdot kg^{-1}$	12
	^{137}Cs	4 [2]	0.6 - < 7 $Bq \cdot kg^{-1}$	12
Sediment	^{60}Co	4 [2]	< 0.3 - < 1 $Bq \cdot kg^{-1}$	12
	^{131}I	4 [2]	< 0.2 - < 0.9 $Bq \cdot kg^{-1}$	12
	^{137}Cs	4 [2]	0.56 - 1.52 $Bq \cdot kg^{-1}$	12

[1] = Given range represents values of individual samples.
[2] = Analysis is performed on a combined sample of the monthly samples of all four or five locations.
[3] = Elemental respectively organically bound ^{131}I.
[4] = Natural occurring γ-emmitters.

1. Introduction

Levels of radioactive nuclides of natural origin, such as ^{40}K and daughters from the uranium and thorium series may be enhanced as a result of human activities, e.g. emissions from factories processing ores. Man-made radionuclides are found in the environment due to, for example, nuclear weapons tests or discharges from nuclear installations. It is advisable to monitor radiation in the environment to provide knowledge of levels of radiation under normal circumstances and to watch for any abnormalities. In this report results are presented of radioactivity measurements in the environment in the Netherlands. The aim of this report is threefold. Firstly, it presents a survey of measurements on radioactivity in the Dutch environment under normal circumstances in 2007. Secondly, it is aimed at determining compliance of monitoring programs in the Netherlands with the EU recommendation and at reporting omissions. Thirdly, it is the Dutch national report on radioactivity in the environment to the EU and to other Member States.

The definition used in this report for the residual β-activity is the total β-activity (gross β-activity) minus the β-activity of ^{40}K. In Appendix C a glossary is given of frequently occurring terms.
In the chapters the results will, in general, be presented in graphs and tables. More detailed tables are presented in Appendix A. Chapters 2 to 8 have been subdivided according to the structure of the Recommendation on the Application of Article 36 of the Euratom Treaty [1], and give the results of measurements for various environmental compartments. This year chapter 9 has been added, this chapter contains data on environmental samples taken around the nuclear power plant at Borssele. General conclusions are presented in chapter 10.

2. Airborne particles

The 2007 monitoring program for determining radioactive nuclides in air dust is given in Table 2.1. The sampling was done on the RIVM premises in Bilthoven. Air dust samples for the measurement of gross α, gross β and γ-emitters were collected weekly with a High Volume Sampler (HVS).
A detailed description of sampling, sample treatment and the analytical method is given in previous reports [2, 3, 4]. The data from 1991 to 2004 were reanalysed to determine the yearly averages by the method described in Appendix B [5]. This can result in small differences between results presented in this report and reports on data prior to 2005.

Table 2.1: Monitoring program in 2007 for the determination of radioactive nuclides in air dust.

Matrix	Location	Parameter	Sample period	Sample volume	Analysis frequency
Air dust	Bilthoven	gross α, gross β	week	500 m^3 (1)	weekly
	Bilthoven	γ-emitters (2)	week	50000 m^3	weekly

(1) *A sub sample of 1% from the filter through which about 50000 m^3 is sampled.*
(2) *γ-spectroscopic analysis of specific γ-emitting nuclides.*

2.1 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 dust thickness on the filters, gross α-activity concentrations in air dust should be regarded as indicative values [6]. The period between sampling and analysis is five to ten days, which is long compared 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 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 averages of the gross α- and β-activity concentrations of long-lived nuclides in 2007 are within the range of the results from the period 1992-2006 as is illustrated in Figure 2.4. Since 2007 a new (more realistic) calibration for gross α has been implemented. This new calibration is 1.4 times higher than the one for previous years, which results in lower reported gross α-activities.

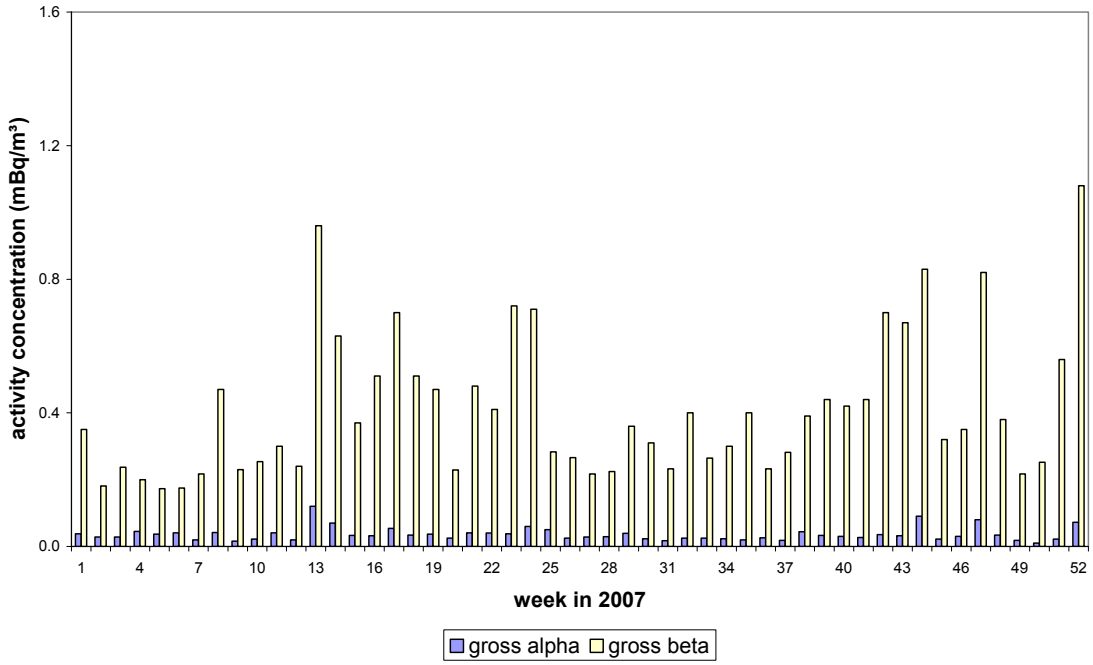


Figure 2.1: Weekly averaged gross α- and β-activity concentrations of long-lived nuclides in air dust sampled at RIVM in 2007.

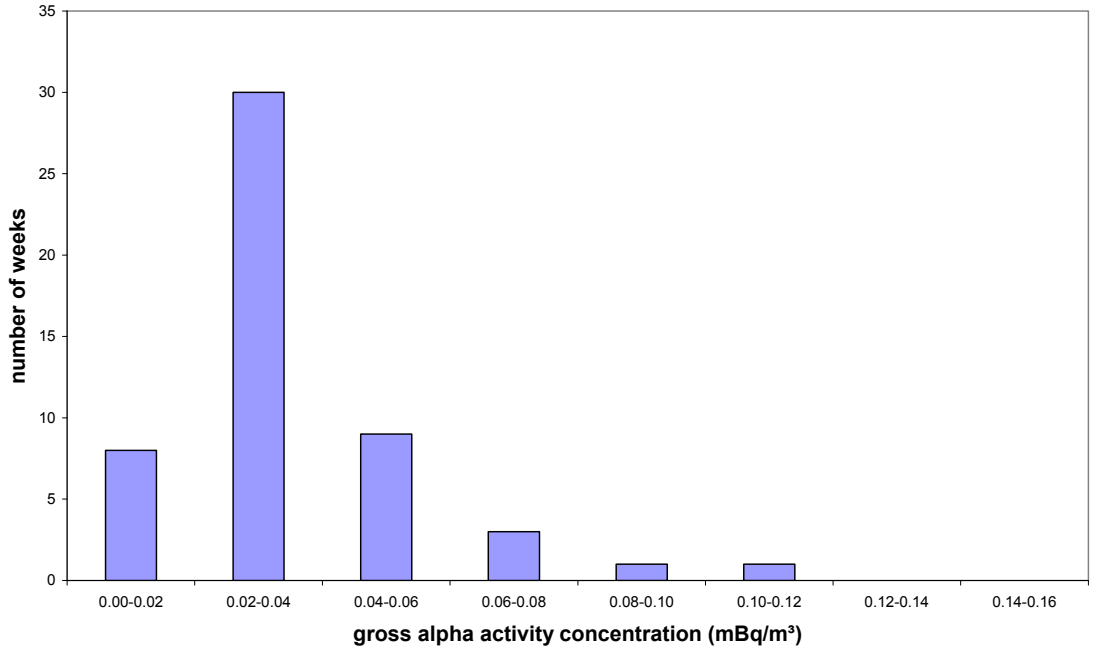


Figure 2.2: Frequency distribution of gross α-activity concentration of long-lived nuclides in air dust collected weekly in 2007. The yearly average is 0.04 (SD=0.02) mBq·m^{-3}. SD is the standard deviation and illustrates the variation in weekly averages during the year.

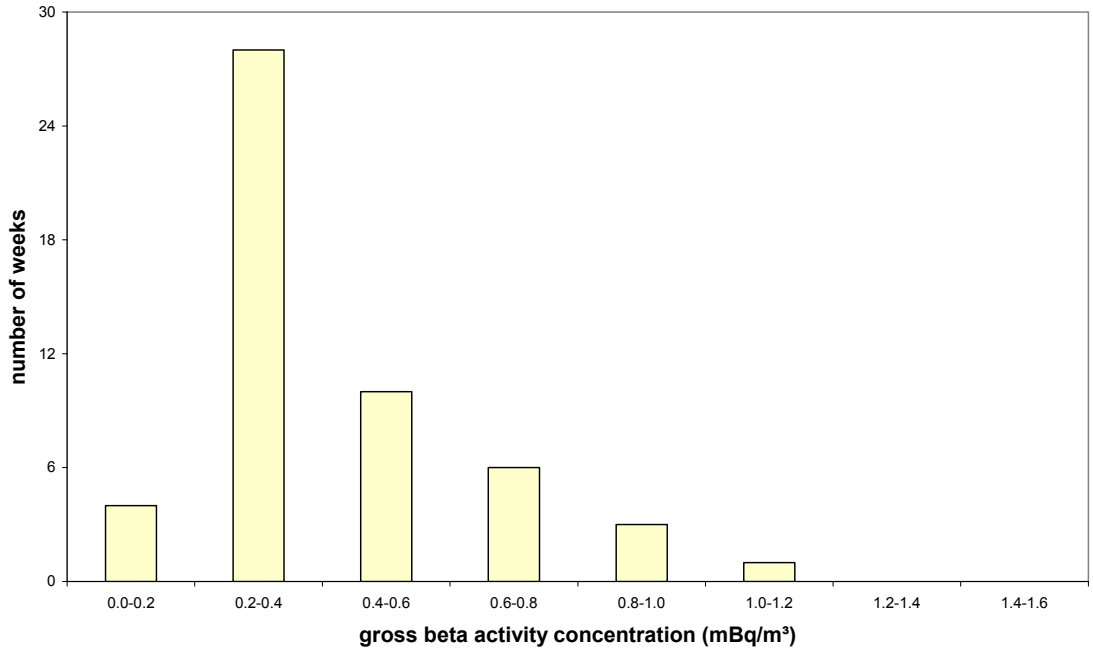


Figure 2.3: Frequency distribution of gross β-activity concentration of long-lived nuclides in air dust collected weekly in 2007. The yearly average is 0.411 ± 0.004 (SD=0.2) mBq·m^{-3}.

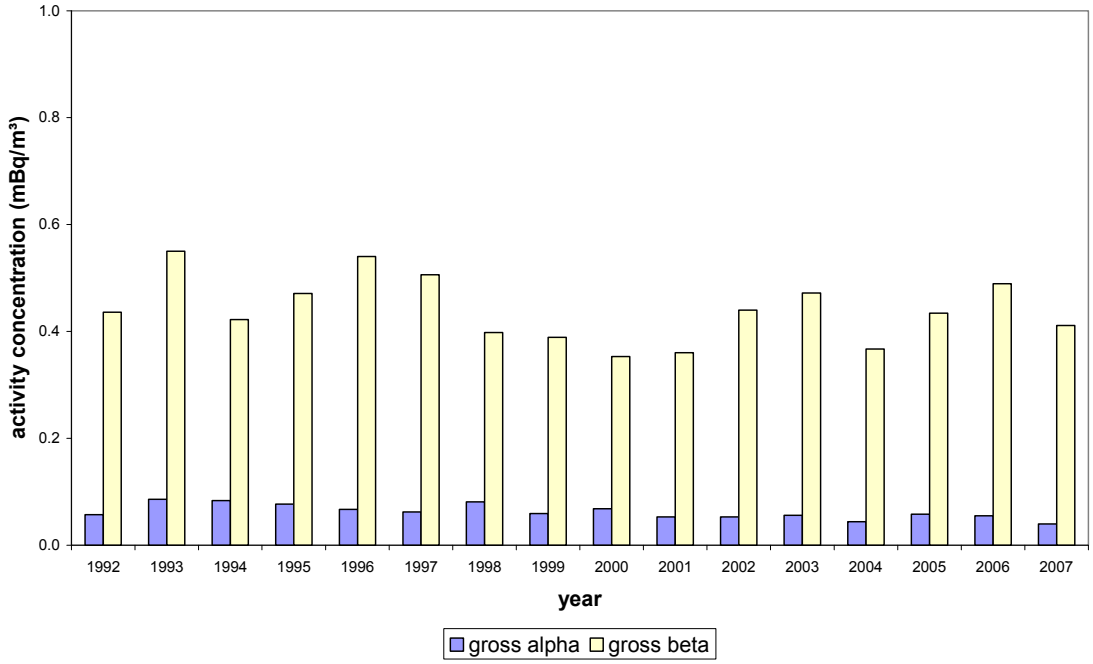


Figure 2.4: Yearly averaged gross α- and gross β-activity concentrations of long-lived nuclides in air dust at RIVM in 1992-2007.

2.2 γ-emitting nuclides

The detection limits for the nuclides considered in the gammaspectroscopic analysis of the HVS-samples are given in Table A2. The only nuclides that could be detected were ^{7}Be (52 times) and ^{210}Pb (52 times). The results are presented in Table A3, Figures 2.5, 2.6 and 2.7. Since late 1999 the detection limit of ^{137}Cs is higher (2.0 μBq·m^{-3}) than during 1991-1999 (0.1 μBq·m^{-3} [7]), due to a different detector set-up.

The behaviour of ^{7}Be in the atmosphere has been studied world-wide [8, 9, 10, 11, 12, 13, 14]. Natural ^{7}Be (half-life 53.3 days) is formed by spallation reactions of cosmogenic radiation with atmospheric nuclei, such as carbon, nitrogen and oxygen resulting in the formation of BeO or $Be(OH)_2$ molecules. Approximately 70% of ^{7}Be is produced in the stratosphere, with the remaining 30% being produced in the troposphere. A residence time is estimated at about one year in the stratosphere and about 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 midlatitudes, resulting in air exchange between stratosphere and 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 is 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 midlatitudes into 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 stratosphere to troposphere. Figure 2.5 further shows the influence of the solar cycle. The maximum at 1997 and the minimum at 2000-2002 are consistent with the solar minimum (measured by radio flux and sunspot count) of 1996-1997 and the solar maximum of 2000-2002 [15]. In the summer of 1991 two severe geomagnetic storms caused a significant world-wide disturbance of earth's geomagnetic field. This resulted in a considerable decrease in cosmogenic radiation, 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 2007 fit in the pattern described above.

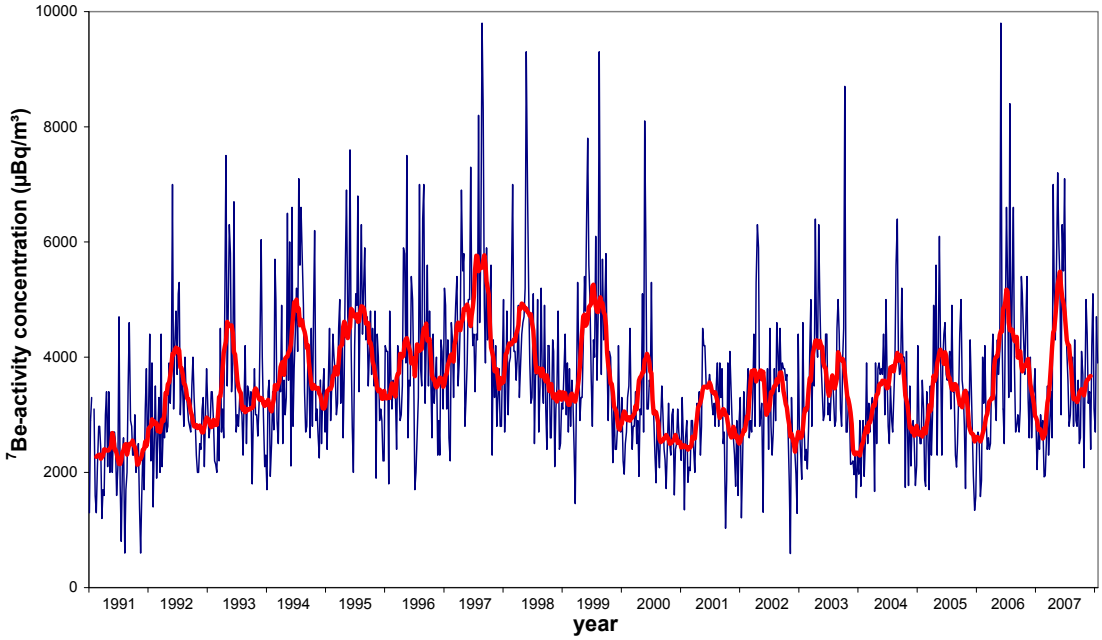


Figure 2.5: Weekly averaged ^{7}Be-activity concentrations (blue) in air dust at RIVM in 1991-2007. The red line is a moving average of 13 weeks. The yearly average for 2007 is 3790 ± 50 (SD=1300) µBq·m^{-3}.

The nuclide ^{137}Cs (half-life 30.2 years) is of anthropogenic origin. The two main sources of ^{137}Cs in the environment are nuclear weapons tests and the Chernobyl accident. Nowadays resuspension of already deposited activity is the main source of airborne ^{137}Cs-activity.
Figure 2.6 shows a peak during May 1992. During the same period several wildfires occurred near the Chernobyl area [17]. The level of airborne ^{137}Cs-activity increased ten times in the 30-km exclusion zone around Chernobyl. It is plausible that the airborne ^{137}Cs was transported to Western Europe due to the weather conditions in the same period, dry and a strong eastern wind [18]. On the 29th of 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 (29th of May until 5th of June 1998). Such slightly elevated levels are not uncommon as can be seen in Figure 2.6. These elevations may be related to resuspension of already deposited dust especially during a strong wind from the continent [19].

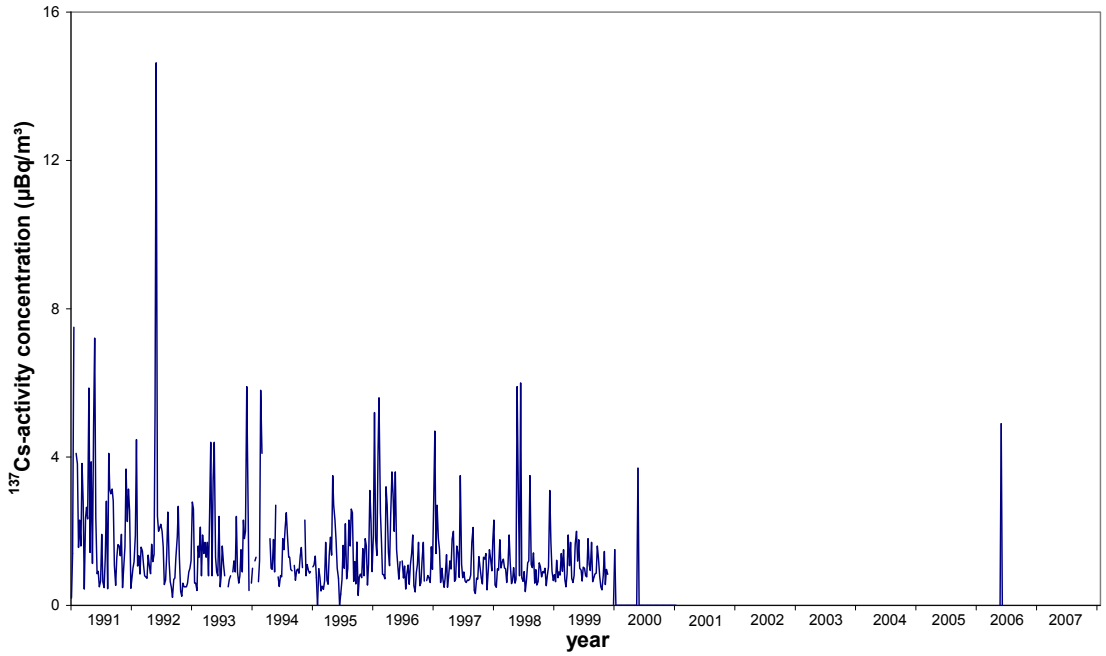


Figure 2.6: Weekly averaged ^{137}Cs-activity concentrations in air dust at RIVM in 1991-2007. In 2007 all measurements were below the detection limit. From 2000 onwards the detection limit was higher than during 1991-1999, due to a different detector set-up.

The primary source of atmospheric ^{210}Pb (half-life 22.3 years) is the decay of ^{222}Rn exhaled from continental surfaces. Therefore the atmospheric concentration of ^{210}Pb over the continental areas is in general higher than that over the oceanic ones (^{222}Rn exhalation from the ocean is 1000 times less than that from the continents). The reported reference value of ^{210}Pb in air dust is 500 µBq·m^{-3} [20]. In the atmosphere this radionuclide is predominantly associated with submicron-sized aerosols [21, 22]. The mean aerosol (carrying ^{210}Pb) residence time in the troposphere is approximately five days [23].

Other sources of ^{210}Pb in air dust are volcanic activity and industrial emissions [24, 25, 26, 27, 28]. Examples of industrial emissions are discharges of power plants using fossil fuels, fertiliser and phosphorus industries, and exhaust gasses of traffic. In the Netherlands the emission of power plants is only of local importance regarding ^{210}Pb deposition. The emission by other industries contributes a significant part of the yearly total ^{210}Pb deposition [26].Volcanic eruptions bring U-decay products in the atmosphere like ^{226}Ra, ^{222}Rn, ^{210}Pb and ^{210}Po. Beks et al. [26] estimate that volcanoes contribute 60 TBq·year^{-1} to the atmospheric ^{210}Pb stock. If the volcanic deposition is evenly distributed world-wide, the contribution to the yearly total ^{210}Pb deposition would be negligible.

Unusual ^{210}Pb values might be explained by natural phenomena like an explosive volcanic eruption, Saharan dust [29, 30, 31] and resuspension of (local) dust. The unusual value of week 45 in 2002 (3000 ± 300 µBq·m^{-3}) can not be explained by these natural sources [32].

Except for week 45 in 2002 there is a good correlation between activity concentrations of ^{210}Pb and activity concentrations of gross β, as is the case in 2007 (Figure 2.8). The weekly averaged activity concentrations of ^{210}Pb in 2007 are within range of those found in previous years.

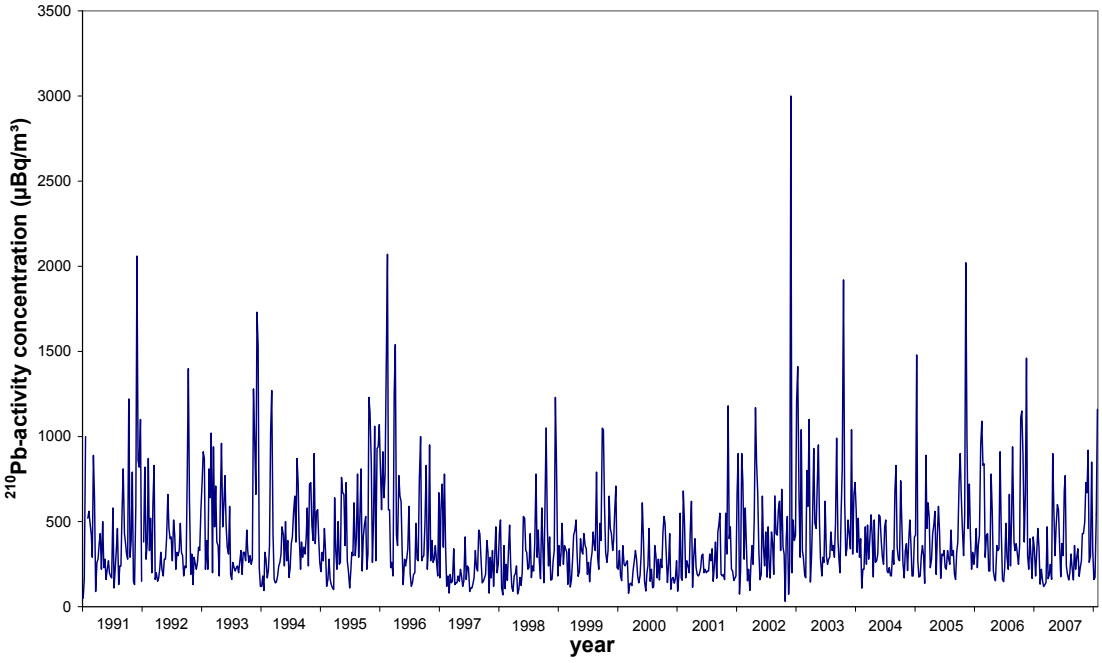


Figure 2.7: Weekly averaged ^{210}Pb-activity concentrations in air dust at RIVM in 1991-2007. The yearly average for 2007 is 372 ± 6 (SD=200) µBq·m^{-3}.

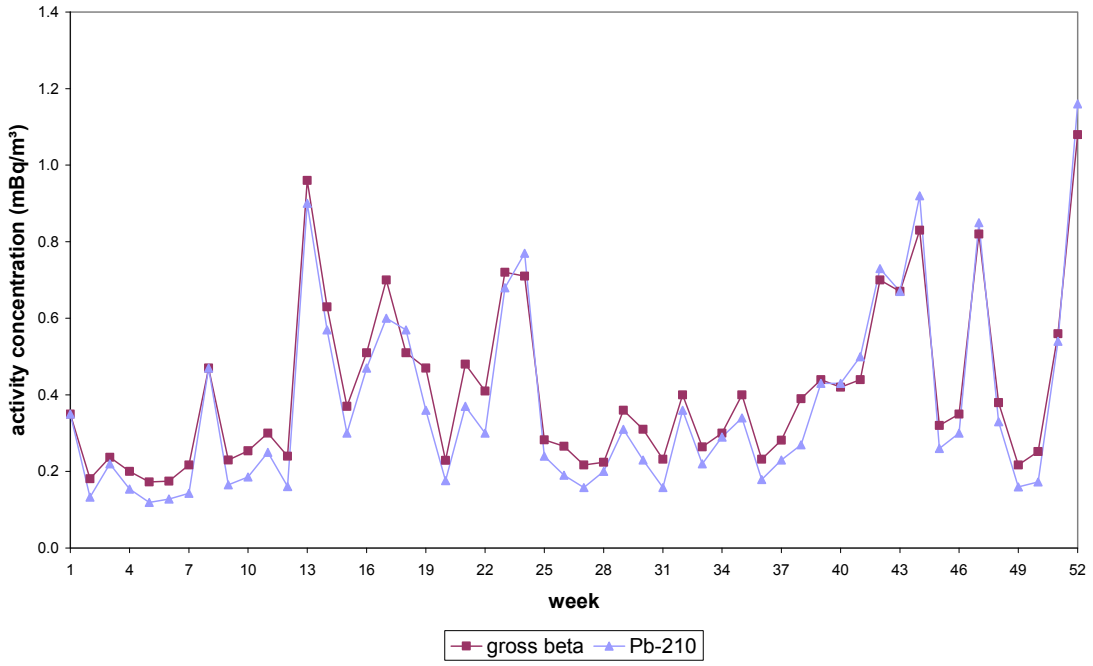


Figure 2.8: Correlation between weekly averaged gross β- and ^{210}Pb-activity concentrations in air dust at RIVM in 2007.

3. Deposition

The 2007 monitoring program for determining radioactive nuclides in deposition is given in Table 3.1. Sampling was done on the RIVM premises in Bilthoven. Samples were collected weekly for γ-emitters and monthly in case of gross α, gross β, ^{3}H and ^{210}Po. The data from 1993 to 2004 were reanalysed to determine the yearly totals by the method described in Appendix B [5]. This can result in small differences between results presented in this report and reports on data prior to 2005.

Table 3.1: The 2007 monitoring program for the determination of radioactive nuclides in deposition.

Matrix	Location	Parameter	Sample period	Sample volume	Analysis Frequency
Deposition	Bilthoven	γ-emitters (1)	week	variable	Weekly
	Bilthoven	gross α, gross β, and ^{210}Po	month	variable	Monthly
	Bilthoven	^{3}H	month	variable	Quarterly

(1) *γ-spectroscopic analysis of specific γ-emitting nuclides.*

3.1 Long-lived α- and β-activity

The monthly deposited gross α- and gross β-activities of long-lived nuclides are given in Figure 3.1, Figure 3.3 and Table A4. The yearly total deposition of gross α and gross β was 24.4 ± 1.2 and 85 ± 2 $Bq \cdot m^{-2}$, respectively. These values are within range of those from previous years, as illustrated in Figure 3.2, Figure 3.4 and Table A5. Due to vandalism the sample of May was lost up until the 22nd of May. The collected sample was from 22nd of May onwards.

The monthly deposition of ^{3}H is given in Table A4. In 2007 the yearly total deposition of ^{3}H ranged between 335 and 1600 $Bq \cdot m^{-2}$ (68% confidence level). There was no precipitation during April hence the yearly total consists of eleven samples. Eight out of eleven measurements were below the detection limit. Therefore detection limits were used for the contribution to the yearly total. Due to vandalism the sample of May was lost up until the 22nd of May. The collected sample was from 22nd of May onwards. The range of 2007 does not differ significantly from those measured since 1993, as illustrated in Figure 3.5 and Table A5. Until 1998 samples were electrolytic enriched before counting, which resulted in a much lower detection limit than that after 1997.

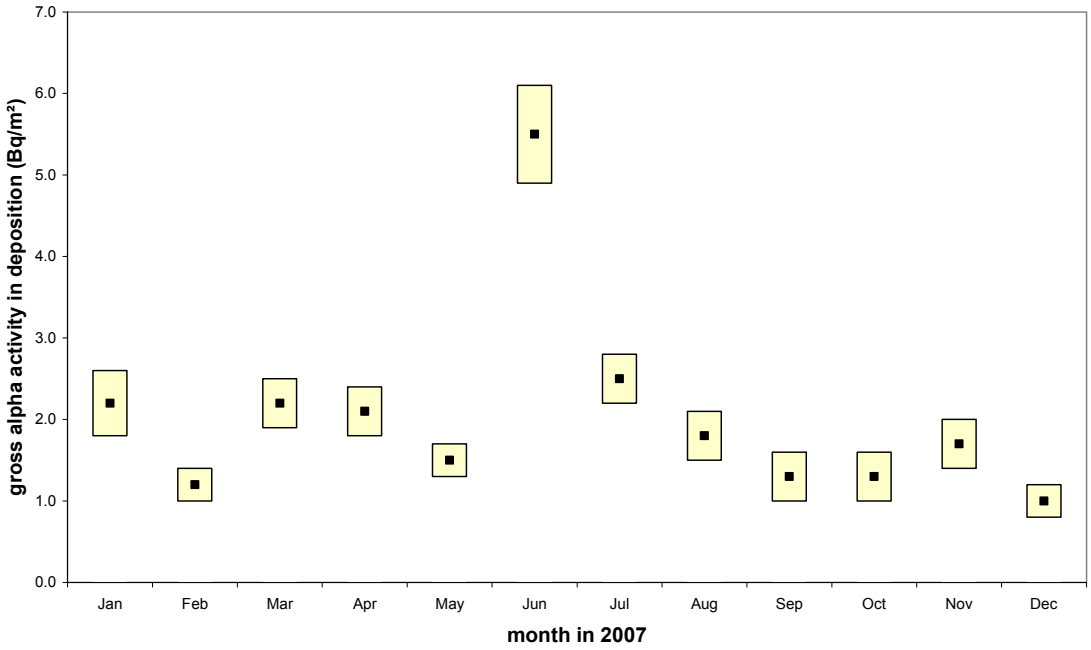


Figure 3.1: Monthly deposited gross α-activity of long-lived nuclides at RIVM in 2007. Given are monthly averages (black dot) with a 68% confidence range (colored bar).

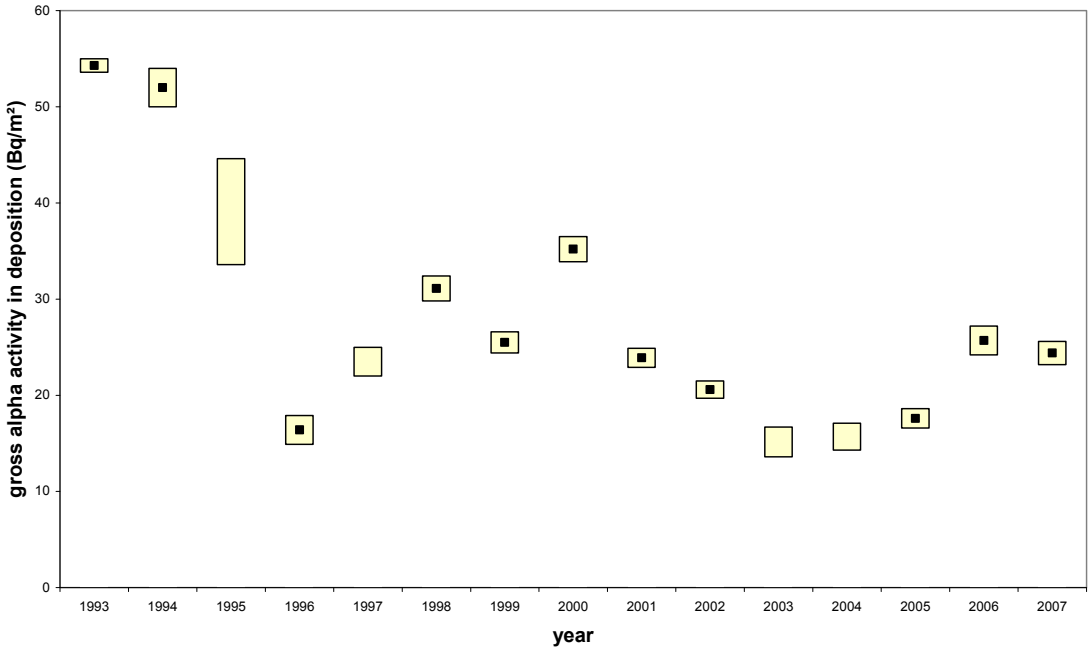


Figure 3.2: Yearly gross α-activity of long-lived nuclides deposited at RIVM from 1993 to 2007. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

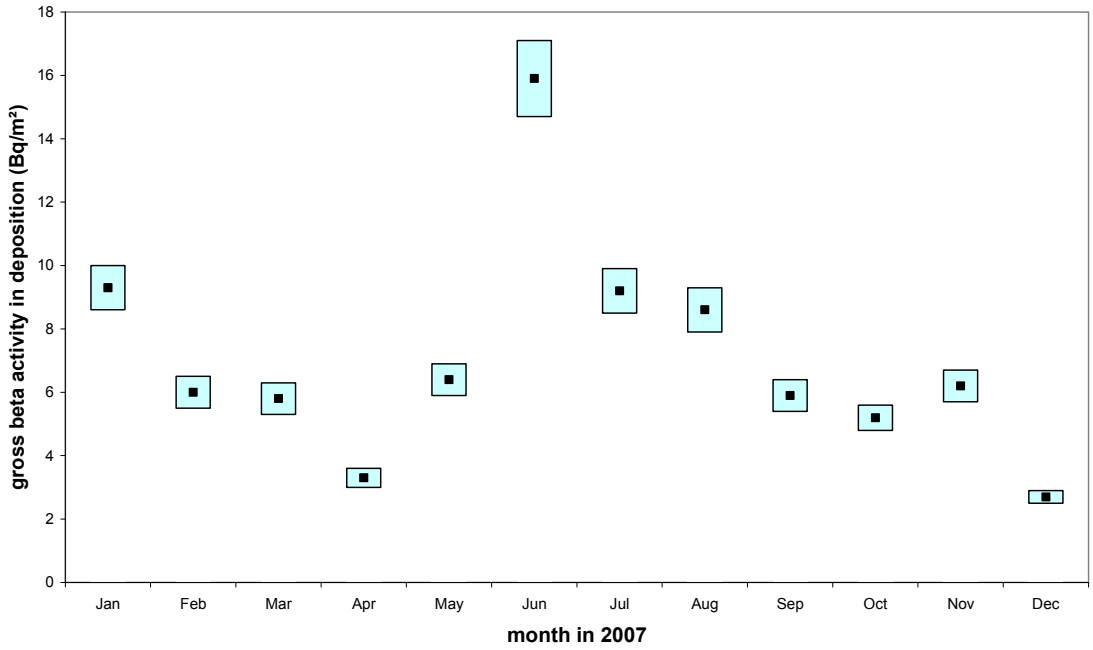


Figure 3.3: Monthly deposited gross β-activity of long-lived nuclides at RIVM in 2007. Given are monthly averages (black dot) with a 68% confidence range (colored bar).

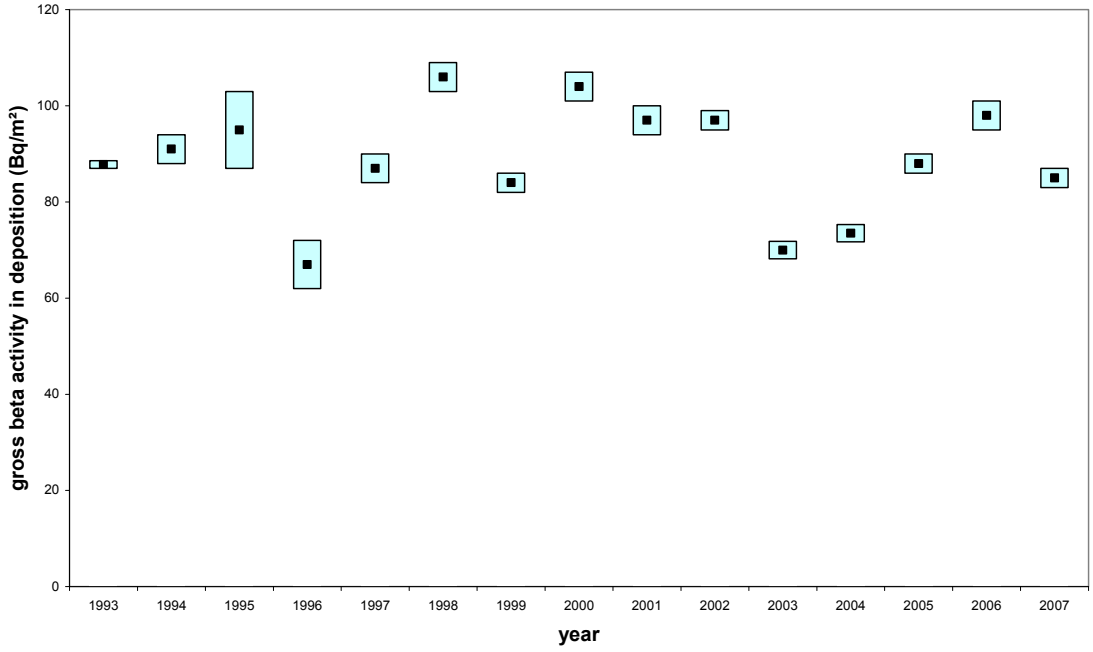


Figure 3.4: Yearly gross β-activity of long-lived nuclides deposited at RIVM from 1993 to 2007. Given are yearly averages (black dot) with a 68% confidence range (colored bar).

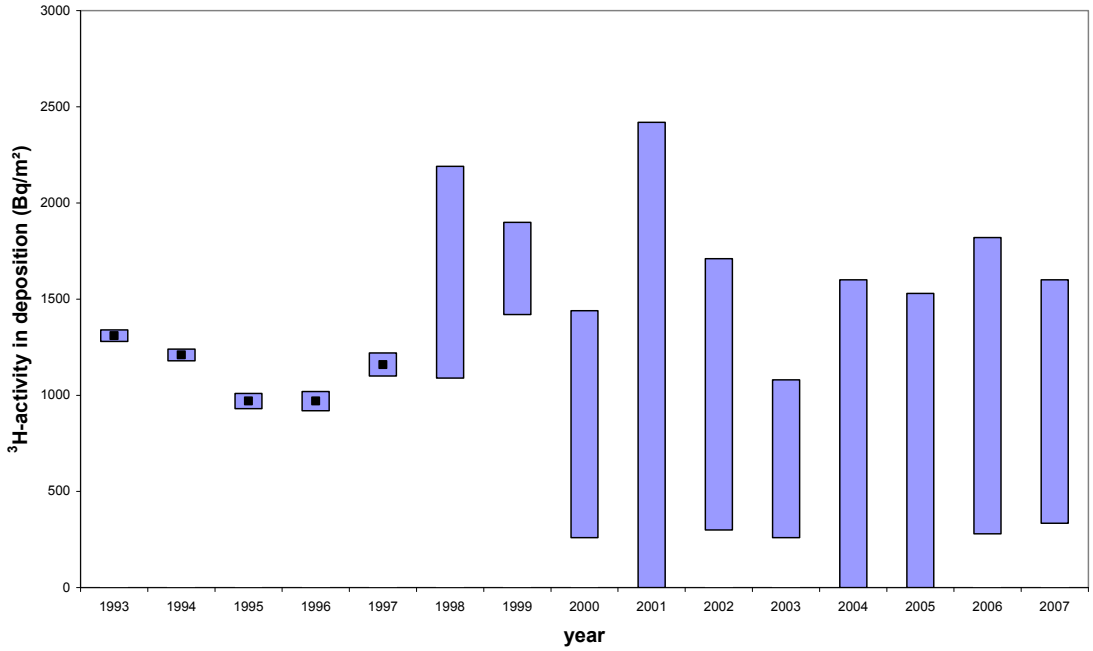


Figure 3.5: Yearly deposition of ^{3}H at RIVM from 1993 to 2007. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

The monthly α-spectroscopy results for ^{210}Po are given in Figure 3.6 and Table A6. The results for previous years are given in Figure 3.7 and Table A7. The yearly total deposition of ^{210}Po deposited in 2007 was 12.0 ± 0.4 Bq·m^{-2} (68% confidence level). Due to vandalism the sample of May was lost up until the 22nd of May. The collected sample was from 22nd of May onwards.

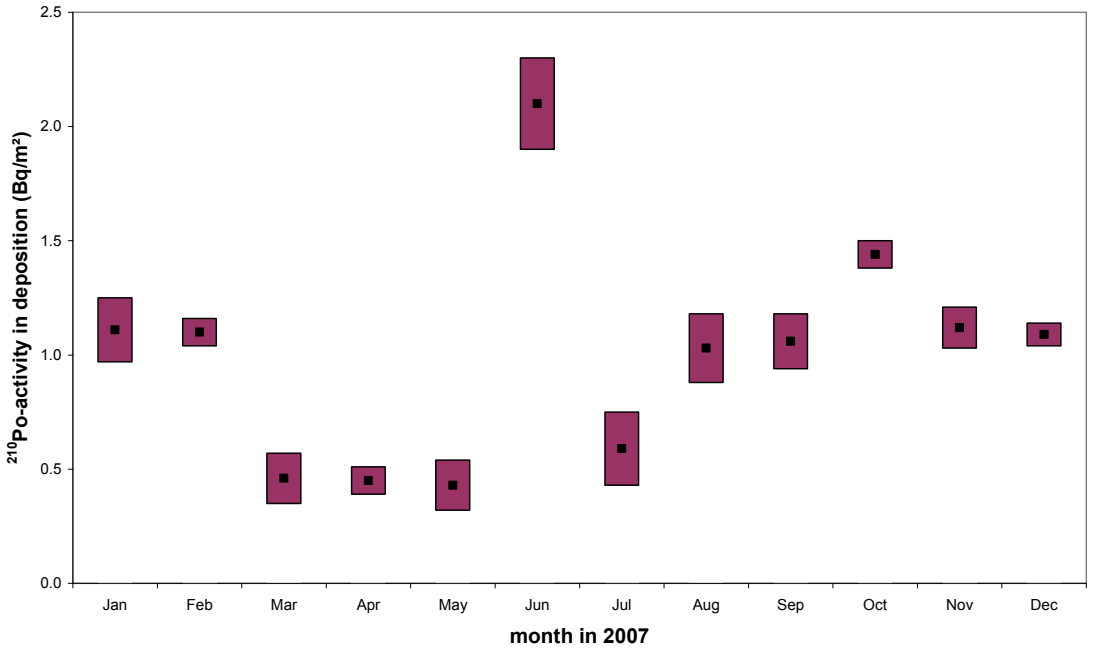


Figure 3.6: Monthly deposited ^{210}Po-activity at RIVM in 2007. Given are monthly averages (black dot) with a 68% confidence range (colored bar). Solely a black dot is given if the result is a detection limit.

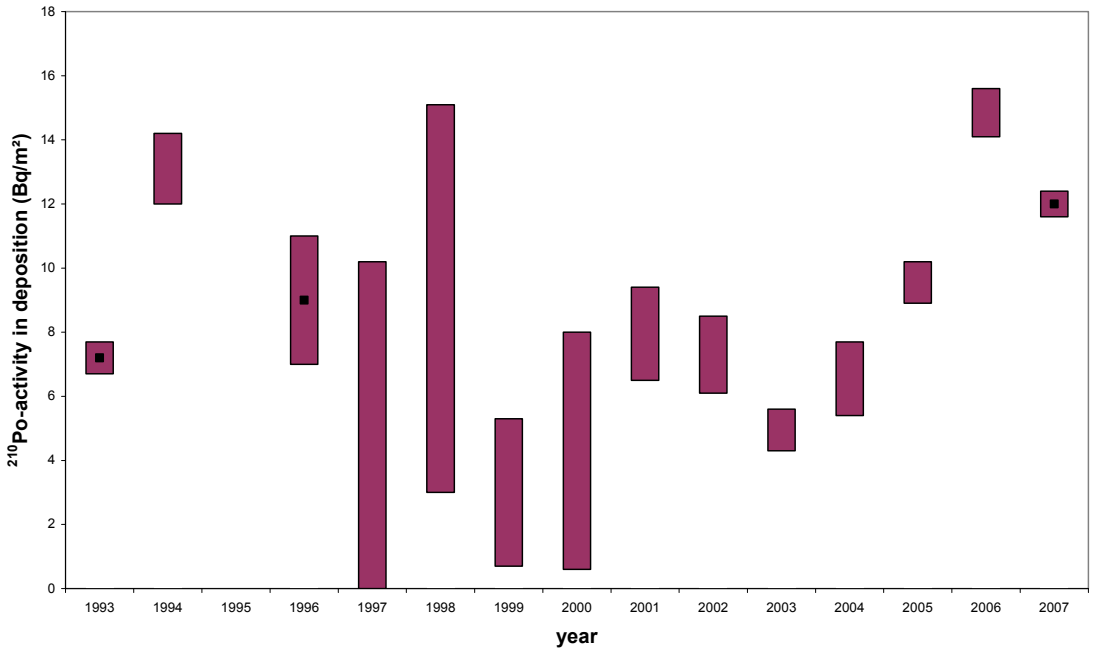


Figure 3.7: Yearly ^{210}Po-activity deposited at RIVM from 1993 to 2007. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

3.2 γ-emitting nuclides

Detectable quantities of the naturally occurring nuclides ^{7}Be and ^{210}Pb were found in 52 and respectively 23 out of 52 samples. The yearly total deposition of ^{7}Be is 1760 ± 40 Bq·m^{-2}. The yearly total deposition of ^{210}Pb ranged between 72 and 132 Bq·m^{-2} (68% confidence level). The nuclide ^{137}Cs was detected in 1 out of 52 samples (detection limit is about 0.1 Bq·m^{-2}). The yearly total deposition of ^{137}Cs ranged between 0.11 and 7.37 Bq·m^{-2} (68% confidence level). The weekly results for deposition of ^{7}Be, ^{137}Cs and ^{210}Pb are given in Table A8 and Figures 3.8 and 3.11. The results for previous years are given in Table A7, Figure 3.9, 3.10 and 3.12.

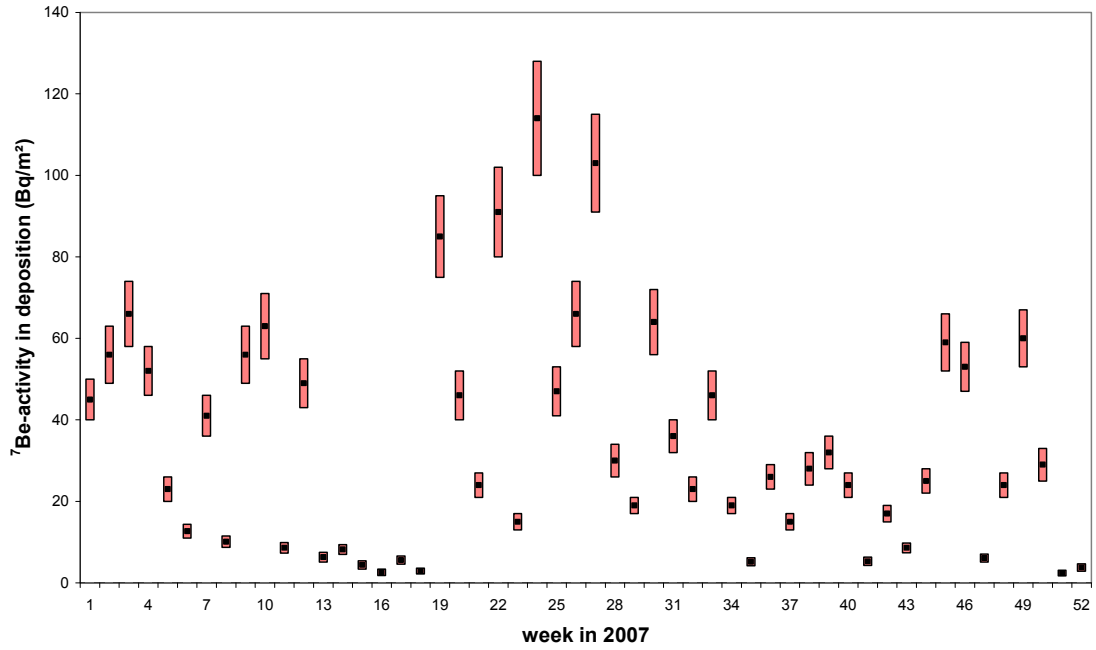


Figure 3.8: Weekly deposited ^{7}Be-activity at RIVM in 2007. Given are weekly averages (black dot) with a 68% confidence range (colored bar).

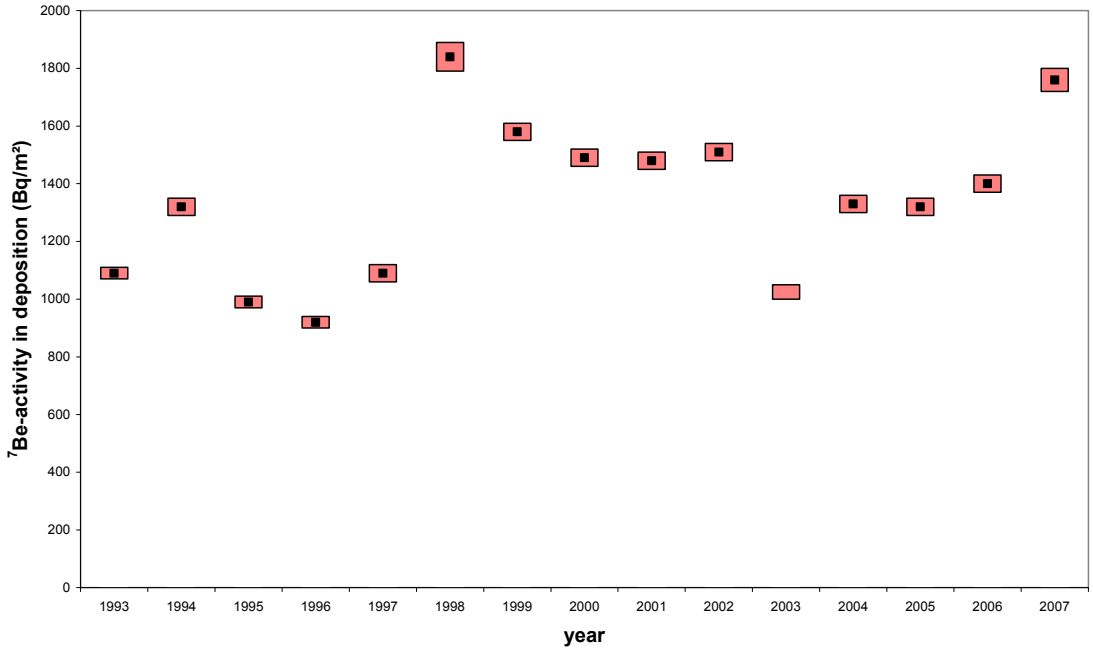


Figure 3.9: Yearly ^{7}Be-activity deposited at RIVM from 1993 to 2007. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

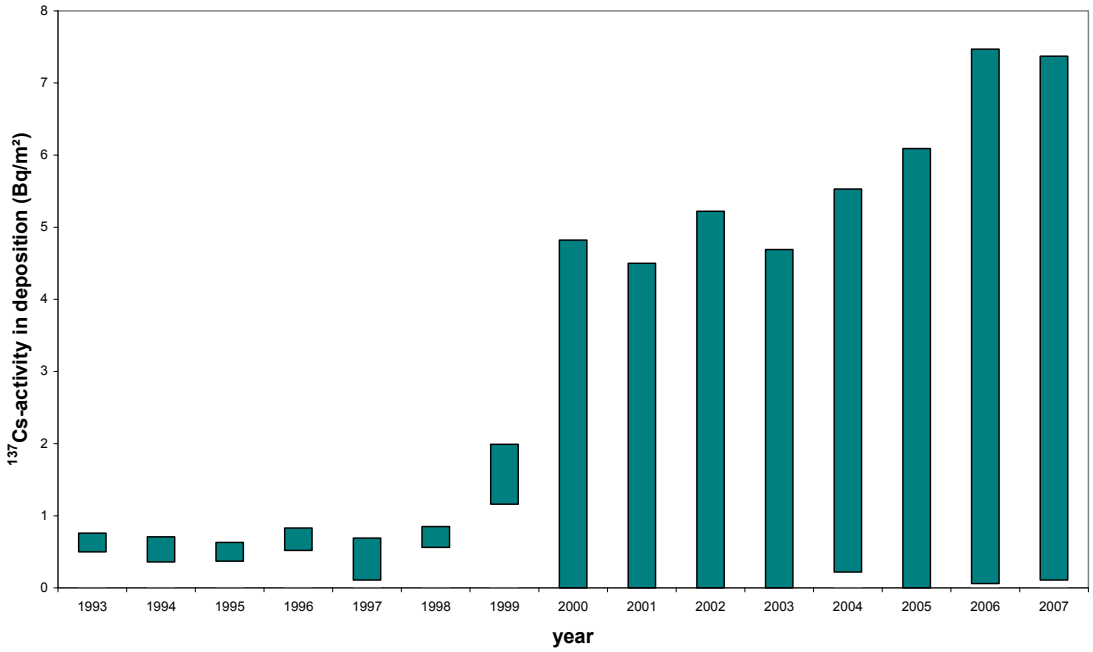


Figure 3.10: Yearly ^{137}Cs-activity deposited at RIVM from 1993 to 2007. Given are yearly averages, solely a 68% confidence range is given since the yearly result is made up of at least one detection limit. Since 2000 the detection limit is higher than during 1993-1999, due to a different detector set-up.

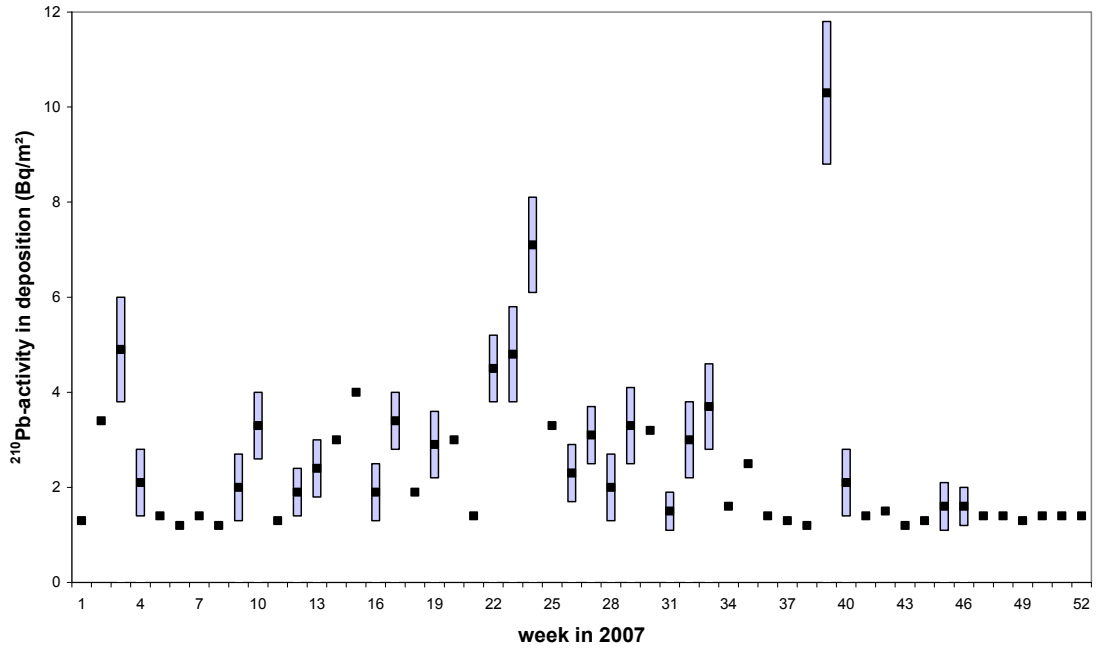


Figure 3.11: Weekly deposited ^{210}Pb-activity at RIVM in 2007. Given are weekly averages (black dot) with a 68% confidence range (colored bar). Solely a black dot is given if the result is a detection limit.

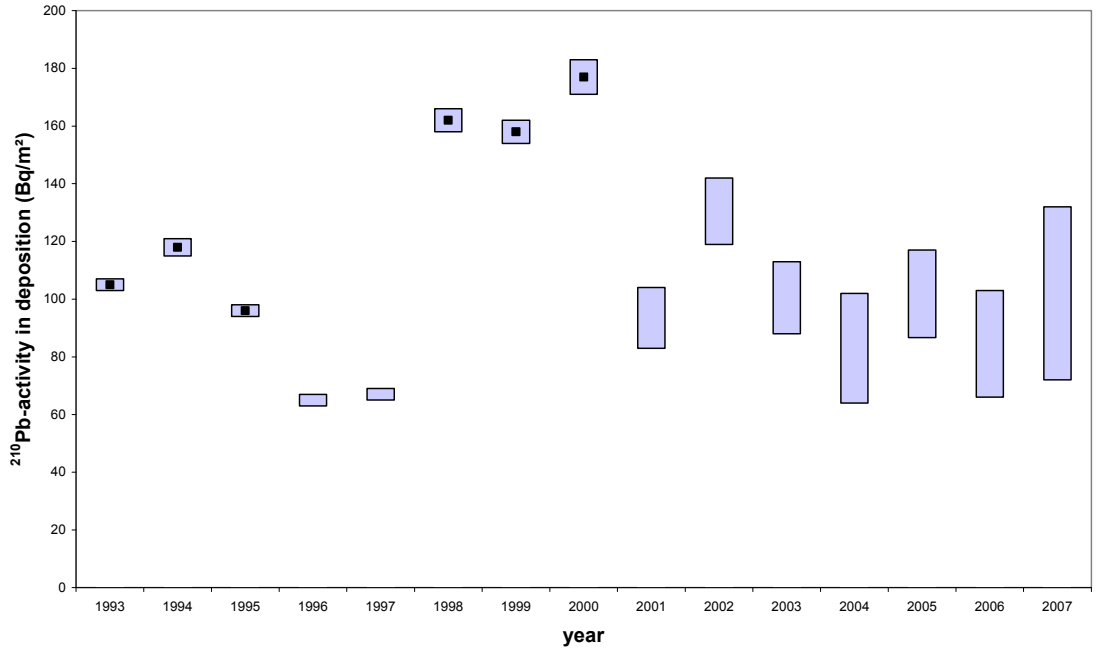


Figure 3.12: Yearly ^{210}Pb-activity deposited at RIVM from 1993 to 2007. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

4. National Radioactivity Monitoring Network

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 from those given in the previous chapter. The difference between the NMR data and those mentioned in the previous chapter is due to the contribution of short-lived natural radionuclides (radon daughters).

The NMR consists of 14 aerosol monitors for determining gross α- and artificial β-activity concentrations and 153 ambient dose equivalent rate monitors [33]. The 14 sites with an aerosol monitor are also equipped with a dose equivalent rate monitor. These 14 dose equivalent rate monitors are differently placed from the 153 dose equivalent rate monitors with regard to height (3.5 meter versus 1 meter above ground level) and surface covering. Therefore, results can differ between the two types of monitors [34]. Hence, these 14 dose equivalent rate monitors are not taken into account for calculating the yearly averaged 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 nuclides and algorithms the results for the activity concentrations 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 reports about 20% higher values than the FAG monitor [35]. The estimated random uncertainty for both types of monitor is about 20%. No correction is applied for the difference in the gross α-activity concentration between the Berthold and FAG monitor.

The data presented in this chapter are based on ten-minute measurements. Averages over the year are calculated per location using daily averages from the ten-minute measurements (Tables A9 and A10). The data on external radiation, expressed in ambient dose equivalent, contain a systematic uncertainty because of an overestimation of the cosmogenic dose rate and an underestimation of the terrestrial dose rate. Based upon earlier research [34, 36] it is assumed that the ambient dose equivalent rate is overestimated by 5 to 10 $nSv.h^{-1}$. However, NMR data are not corrected for these response uncertainties.

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

Figure 4.2 presents the yearly averages of gross α-activity concentration from 1990 to 2007, while Figure 4.4 presents the yearly averages of ambient dose equivalent rate from 1996 to 2007. In 2007 the yearly averaged gross α-activity concentration in air dust was 2.9 $Bq \cdot m^{-3}$ (based on the yearly averages of the 14 measurement locations). To compare this value with data before 2002 it should be noted that the Berthold values are 20% higher than FAG values, and the value can be corrected to 2.4 $Bq \cdot m^{-3}$. This value is within the range of those in previous years at the low end of that range. The year 2007

was a year with a higher amount of wet precipitation which leads to lower results. The yearly average of the calculated artificial β-activity concentration does not deviate significantly from zero.

Between 1996 and 2003 the analysis of the ambient dose equivalent rate has been based on a set of 163 stations. From 2004 onwards the analysis of the ambient dose equivalent rate has been based on the set of 153 stations, 10 stations have been dismantled. The yearly averaged ambient dose equivalent rate in 2007 is calculated using 149 stations. The remaining 4 stations were not operational.

For the ambient dose equivalent rate the yearly averaged measured value was 73.4 $nSv.h^{-1}$. It is assumed that this value is an overestimate of 5 to 10 $nSv.h^{-1}$. Figure 4.5 shows the influence of the 11-year solar cycle on the cosmogenic contribution to the effective dose rate, which is related to the ambient dose equivalent rate. The decrease in the ambient dose equivalent rate (as given by the NMR) during 1996 to 2003 (Figure 4.4) might be related to the decrease in the cosmogenic contribution. However the correlation between the increase in the cosmogenic contribution since 2004 and the measured ambient dose equivalent rate is less evident (Figure 4.4).

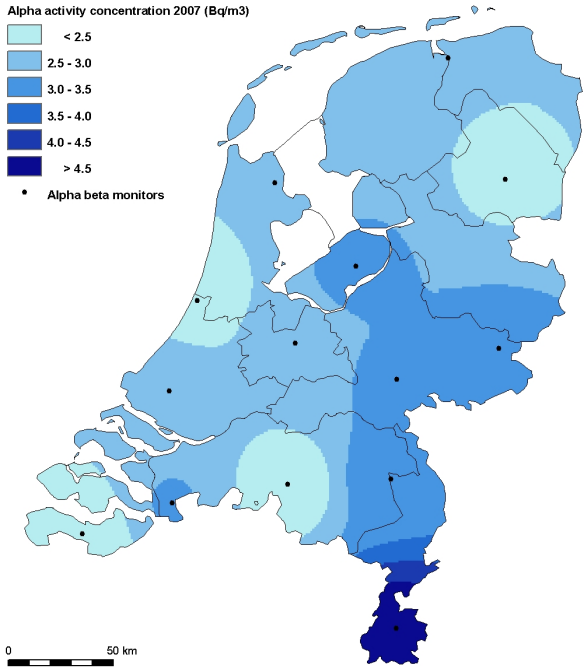


Figure 4.1: Spatial variation in the average gross α-activity concentration of (mainly) short-lived nuclides in air dust in 2007. The dots represent the locations of the aerosol monitors.

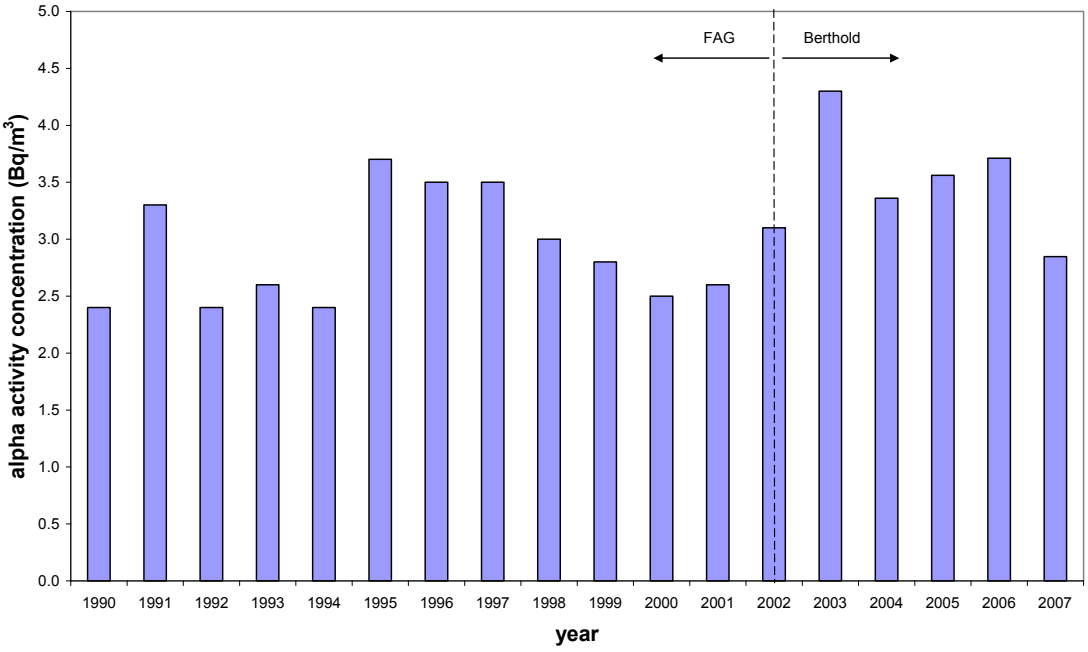


Figure 4.2: Yearly averaged gross α-activity concentration of (mainly) short-lived nuclides in air dust. During the second half of 2002 the FAG monitors were gradually replaced by the Berthold monitors.

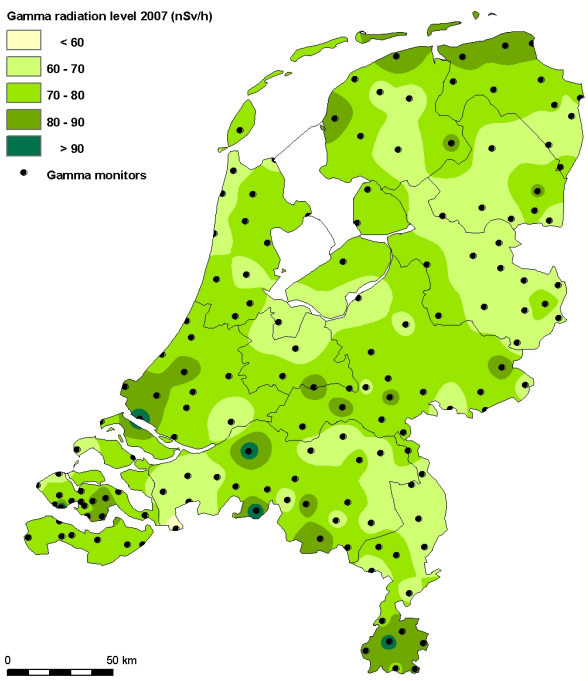


Figure 4.3: Spatial variation in the average ambient dose equivalent rate in 2007. The dots represent the locations of the dose equivalent rate monitors.

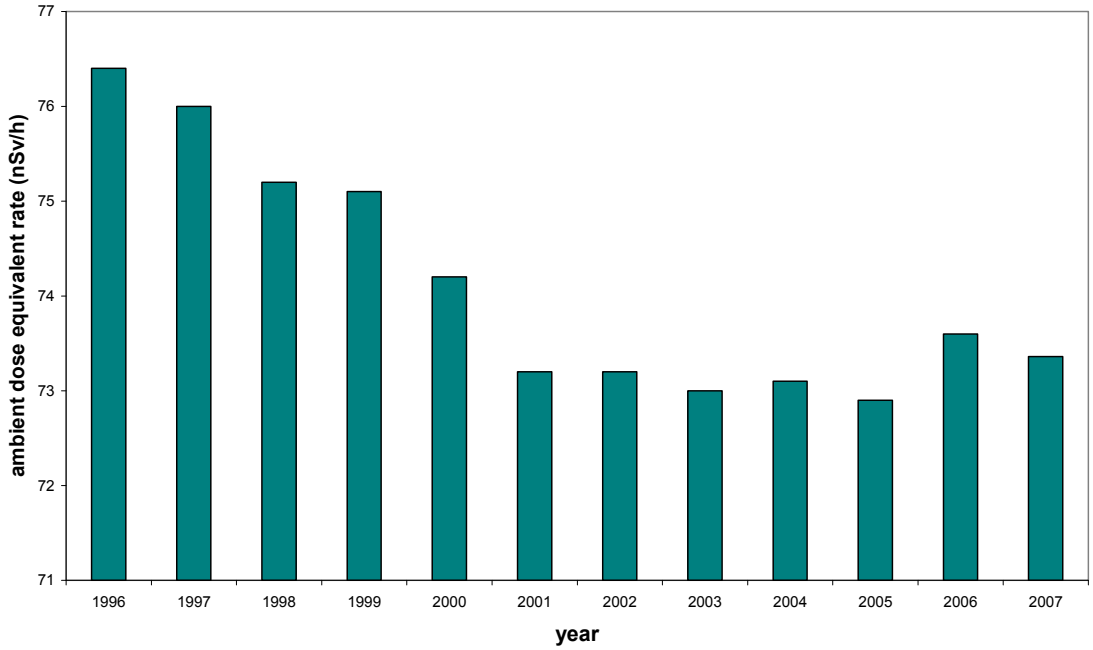


Figure 4.4: The yearly averaged ambient dose equivalent rate.

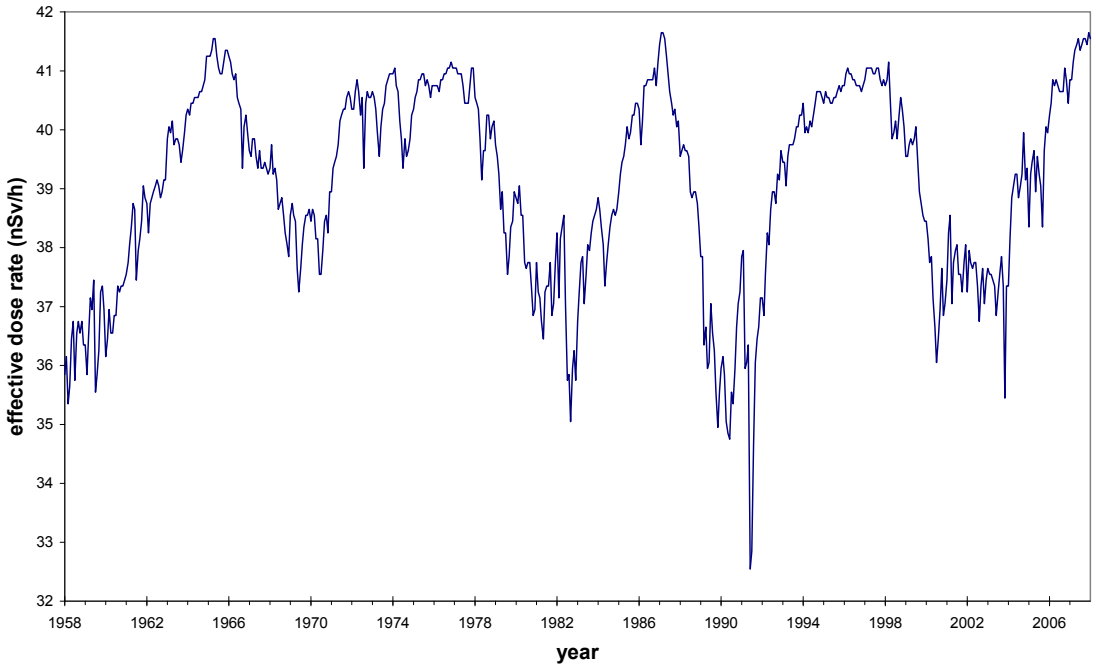


Figure 4.5: Cosmogenic contribution to the effective dose rate (at sea level), influenced by the solar cycle. Location 51° 26' north latitude and 3° 43' eastern longitude (in the south-west of the Netherlands), air pressure 1019 hPa. Figure derived from data supplied by Federal Aviation Administration [37]. In previous reports [32, 38] an error has been made by presenting this data as ambient dose equivalent rate, it should be presented as effective dose rate.

5. Surface water and seawater

5.1 Introduction

The RWS WD Centre for Water Management regularly monitors the concentration of a number of radioactive nuclides in surface water and seawater. The monitoring program presented here forms only part of the total monitoring program. A more detailed description of the monitoring program, underlying strategy and results of measurements on radioactivity in Dutch waters are reported elsewhere [39, 40, 41].

The locations presented in this report have been chosen to represent the major inland waters and seawater. The 2007 monitoring program is shown in Tables 5.1, 5.2 and Figure 5.1. Radioactive nuclides were determined in water and suspended solids. The samples were collected at equidistant times.

Table 5.1: Monitoring program for the determination of radioactive nuclides in surface water in 2007.

Location	Parameter	Matrix	Monitoring frequency (per year)
IJsselmeer	Gross α	Water	13
(Vrouwezand)	Residual β	Water	13
	^{3}H	Water	6
	^{60}Co	Suspended solids	13
	^{131}I	Suspended solids	13
	^{137}Cs	Suspended solids	13
Ketelmeer	^{60}Co	Suspended solids	7
(Ketelmeer West)	^{131}I	Suspended solids	7
	^{137}Cs	Suspended solids	7
Noordzeekanaal	Gross α	Water	6
(IJmuiden)	Residual β	Water	6
	^{3}H	Water	6
	^{60}Co	Suspended solids	6
	^{131}I	Suspended solids	6
	^{137}Cs	Suspended solids	6
Nieuwe Waterweg	Gross α	Water	13
(Maassluis)	Residual β	Water	13
	^{3}H	Water	7
	^{90}Sr	Water	7
	^{226}Ra	Water	7
	^{60}Co	Suspended solids	13
	^{131}I	Suspended solids	13
	^{137}Cs	Suspended solids	13
	^{210}Pb	Suspended solids	7

To be continued on the next page

Table 5.1: Continued.

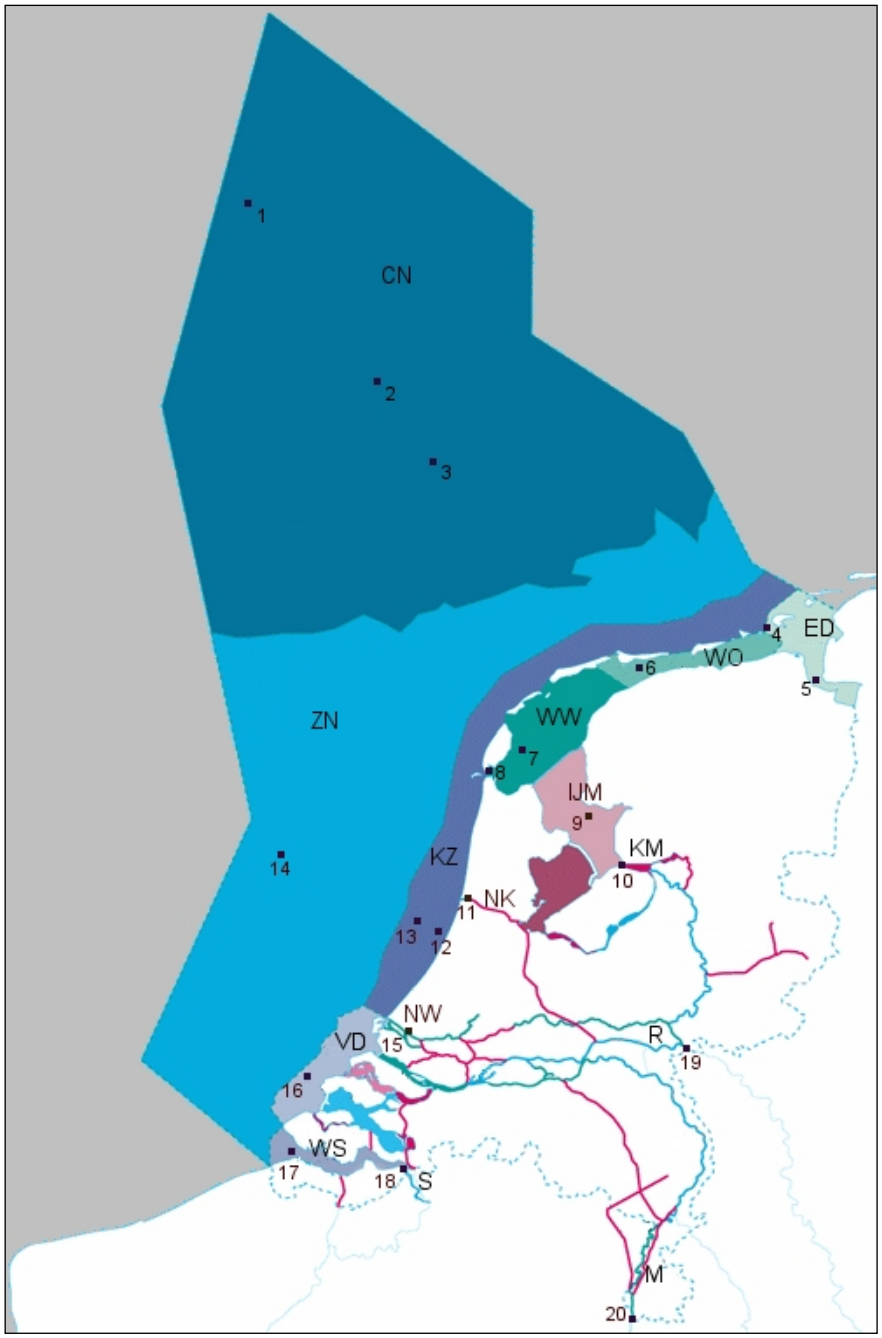
Location	Parameter	Matrix	Monitoring frequency (per year)
Rhine	Gross α	Water	13
(Lobith)	Residual β	Water	13
	^{3}H	Water	13
	^{90}Sr	Water	6
	^{226}Ra	Water	6
	^{60}Co	Suspended solids	13
	^{131}I	Suspended solids	13
	^{137}Cs	Suspended solids	13
	^{210}Pb	Suspended solids	6
Scheldt	Gross α	Water	13
(Schaar van Ouden Doel)	Residual β	Water	13
	^{3}H	Water	7
	^{226}Ra	Water	7
	^{60}Co	Suspended solids	13
	^{131}I	Suspended solids	13
	^{137}Cs	Suspended solids	13
	^{210}Pb	Suspended solids	7
Meuse	Gross α	Water	13
(Eijsden)	Residual β	Water	13
	^{3}H	Water	13
	^{90}Sr	Water	6
	^{226}Ra	Water	6
	^{60}Co	Suspended solids	52
	^{131}I	Suspended solids	52
	^{137}Cs	Suspended solids	52
	^{210}Pb	Suspended solids	6

The radioactive nuclides were determined according to standard procedures [40] and [42]. In the Netherlands target values are in use for radioactive materials in surface water, which are given in the Fourth memorandum on water management (Vierde Nota waterhuishouding) [43]. The yearly averages are compared with these target values.

Table 5.2: Monitoring program for the determination of radioactive nuclides in seawater in 2007.

Area	Location	Parameter	Matrix	Monitoring frequency (per year)
Coastal area (KZ)	Noordwijk 2 (1)	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{137}Cs	Suspended solids	2 (2)
		^{210}Po	Suspended solids	2 (2)
Southern North Sea (ZN)	Noordwijk 70 (1)	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{90}Sr	Water	4
Central North Sea (CN)	Terschelling 235 (1)	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{90}Sr	Water	4
Delta Coastal Waters (VD)	Schouwen 10 (1)	Gross α	Water	11 (3)
		Residual β	Water	11 (3)
		^{3}H	Water	4
		^{90}Sr	Water	4
Westerscheldt (WS)	Vlissingen Boei	Gross α	Water	13
		Residual β	Water	13
		^{3}H	Water	13
		^{90}Sr	Water	13
		^{137}Cs	Suspended solids	3 (2)
		^{210}Po	Suspended solids	3 (2)
Eems-Dollard (ED)	Huibergat Oost	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
	Bocht van Watum	^{137}Cs	Suspended solids	4
		^{210}Po	Suspended solids	4
Wadden Sea West (4) (WW)	Marsdiep Noord	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
Wadden Sea East (WO)	Dantziggat	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{137}Cs	Suspended solids	4
		^{210}Po	Suspended solids	4

(1) Number indicates distance from shore. For example Noordwijk 2 means Noordwijk 2 km offshore.
(2) Normally 4 times per year. Not all measurements could be performed due to insufficient amount of collected suspended solids.
(3) Normally 12 times per year. Not all measurements could be performed due to insufficient sample amount.
(4) Since 2006 ^{137}Cs and ^{210}Pb (in suspended solids) are not longer determined at Doove Balg West due to repeatedly insufficient amount of collected suspended solids in previous years.



Sea water areas:
CN = Central North Sea
ED = Eems-Dollard
WO = Wadden Sea East
WW = Wadden Sea West
ZN = Southern North Sea
KZ = Coastal area
VD = Delta Coastal Waters
WS = Westerscheldt

Fresh water areas:
IJM = IJsselmeer
KM = Ketelmeer
NK = Noordzeekanaal
NW = Nieuwe waterweg
R = Rhine
M = Meuse
S = Scheldt

1 = Terschelling 235
2 = Terschelling 135
3 = Terschelling 100
4 = Huibergat Oost
5 = Bocht van Watum
6 = Dantziggat
7 = Doove Balg West
8 = Marsdiep Noord
9 = Vrouwezand
10 = Ketelmeer West
11 = IJmuiden
12 = Noordwijk 2
13 = Noordwijk 10
14 = Noordwijk 70
15 = Maassluis
16 = Schouwen 10
17 = Vlissingen Boei
18 = Schaar van Ouden Doel
19 = Lobith
20 = Eijsden

Figure 5.1: Overview of monitoring locations for the monitoring program in surface water and in seawater.

Terschelling 135 km offshore and Terschelling 100 km offshore were the old monitoring locations for the Central North Sea during 1989 and 1988-1994 (except 1989), respectively. Terschelling 235 km offshore is the monitoring location for the Central North Sea from 1995 and onwards. Noordwijk 10 km offshore was the old monitoring location for the Coastal area during 1988-1998. Noordwijk 2 km offshore is the monitoring location for the Coastal area from 1999 and onwards [40]. Doove Balg West was the monitoring location for radionuclides in suspended solids for the Wadden Sea West during 1996-2005.

5.2 The results for surface water

The general monitoring strategy for surface water is to monitor the inland and border crossing waters 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 results for 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. The yearly averaged activity concentrations of gross α and residual β in 2007 are within the range of those in previous years. The gross α-activity concentration in the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg and Scheldt exceeds the target value (100 mBq·L^{-1}) in 1 out of 13, 4 out of 6, 5 out of 13 and 13 out of 13 samples taken, respectively. In 2007 the yearly averaged gross α-activity concentration in the Noordzeekanaal, Nieuwe Waterweg and Scheldt (121, 110 and 250 mBq·L^{-1}, respectively) are above the target value of 100 mBq·L^{-1}.

The yearly averaged residual β-activity concentrations are below the target value of 200 mBq·L^{-1}. Residual β in the Noordzeekanaal, Nieuwe Waterweg and Scheldt shows a change in the trend since 1994. This is caused by a change in measuring technique, which only applies to salt and brackish water [40]. Therefore, no change in trend is shown for the IJsselmeer, Rhine and Meuse.

The ^{3}H-activity concentration in the Scheldt and Meuse exceeds the target value (10 Bq·L^{-1}) in 1 out of 7 and 9 out of 13 samples taken, respectively. The elevated levels of ^{3}H in the Meuse (Figure 5.6) could originate from the nuclear power plants at Tihange (Belgium) or Chooz (France). The elevated levels of ^{3}H in the Scheldt could originate from the nuclear power plant at Doel (Belgium). The yearly averaged ^{3}H-activity concentrations in 2007 are within the range of those in previous years. In 2007 the yearly averaged ^{3}H-activity concentration in the Meuse (17.0 Bq·L^{-1}) is above the target value of 10 Bq·L^{-1}.

The nuclide ^{90}Sr is released into the environment by nuclear power plants and nuclear reprocessing plants. The yearly averaged ^{90}Sr-activity concentrations in 2007 are within the range of those in previous years. The yearly averaged ^{90}Sr-activity concentrations are below the target value of 10 mBq·L^{-1}.

The nuclide ^{226}Ra is released into the environment by the ore processing industry. The ^{226}Ra-activity concentration in the Scheldt exceeds the target value (5 mBq·L^{-1}) in 7 out of 7 samples taken. The yearly averaged ^{226}Ra-activity concentrations in 2007 are within the range of those in previous years. In 2007 the yearly averaged ^{226}Ra-activity concentration in the Scheldt (11.1 mBq·L^{-1}) is above the target value of 5 mBq·L^{-1}.

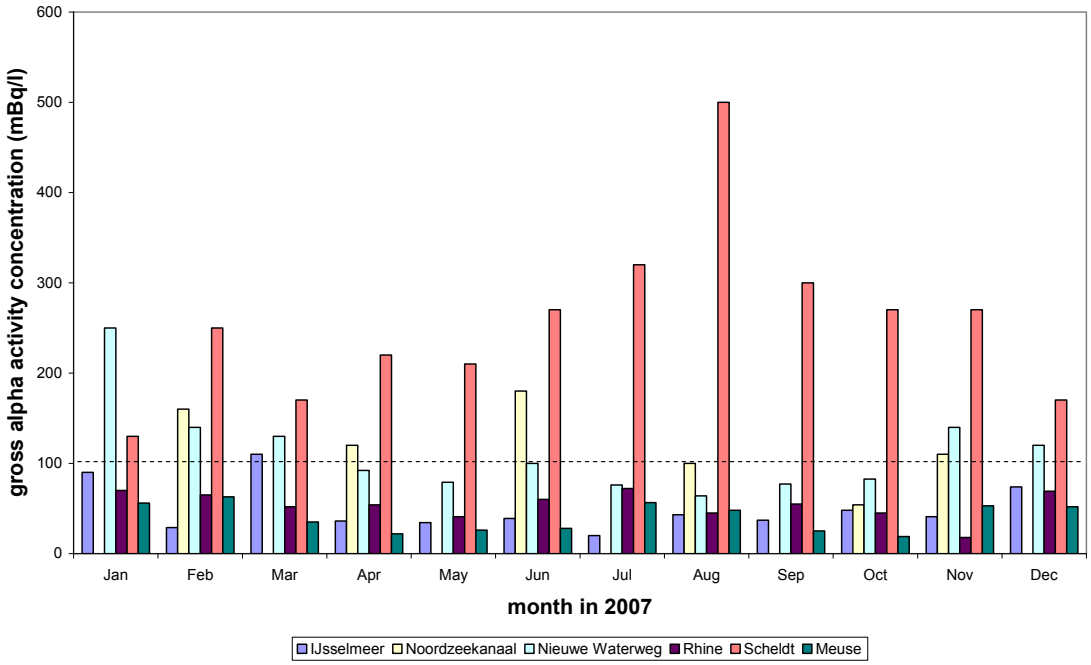


Figure 5.2: The gross α-activity concentration in 2007 for the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 49, 121, 110, 53, 250 and 42 mBq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 100 mBq·L^{-1} [43].

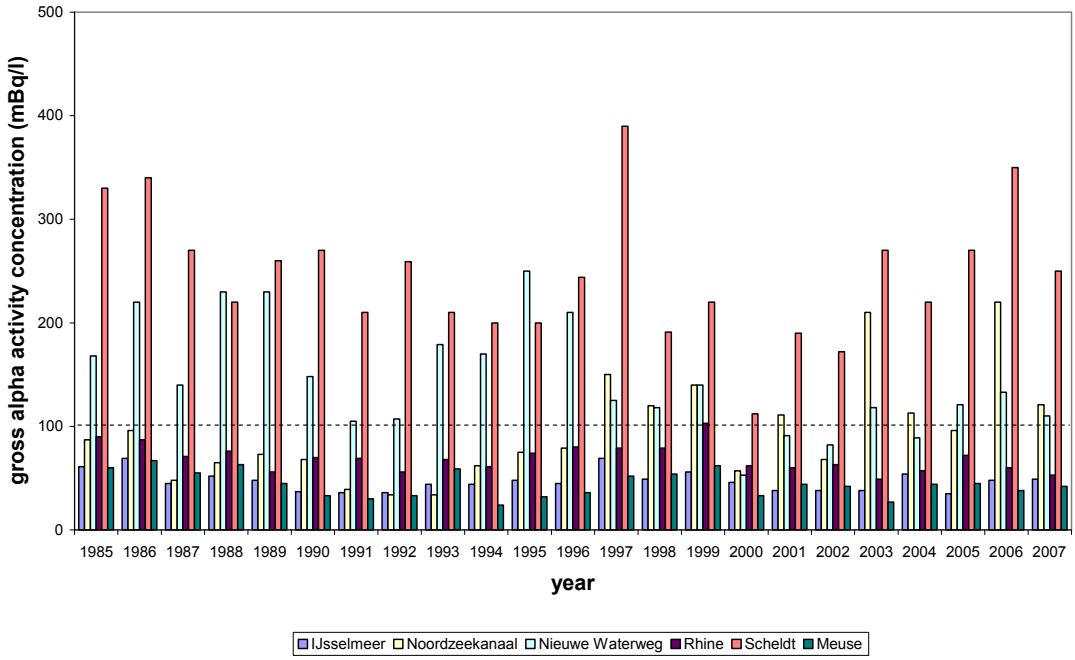


Figure 5.3: Yearly averaged gross α-activity concentrations.

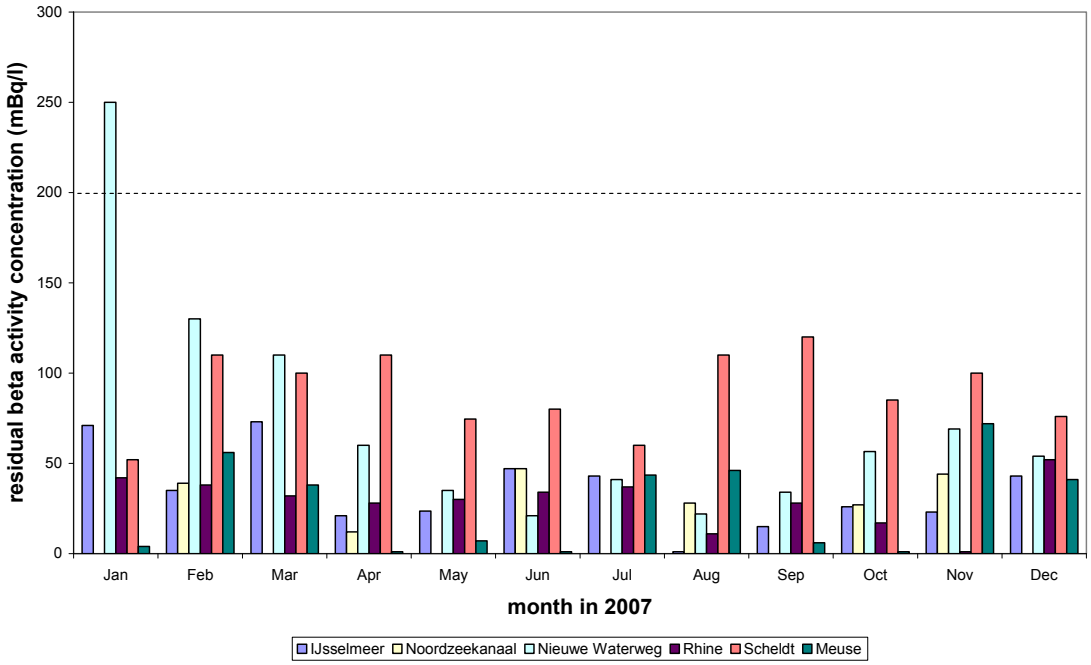


Figure 5.4: The residual β-activity concentration in 2007 for the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 34, 33, 72, 28, 89 and 28 mBq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 200 mBq·L^{-1} [43].

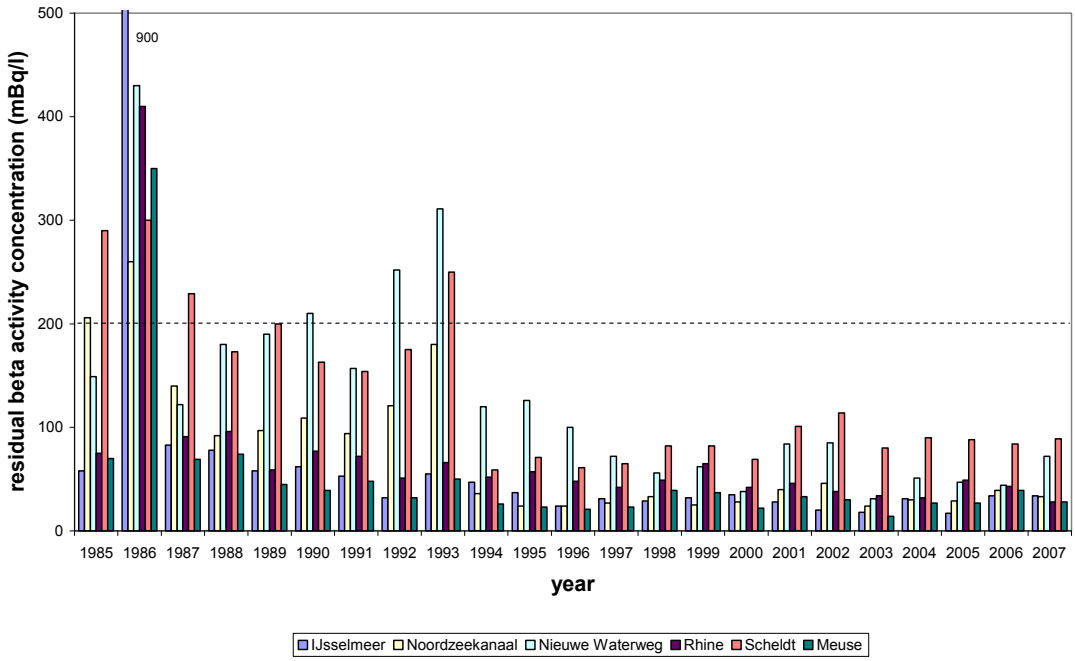


Figure 5.5: Yearly averaged residual β-activity concentrations.

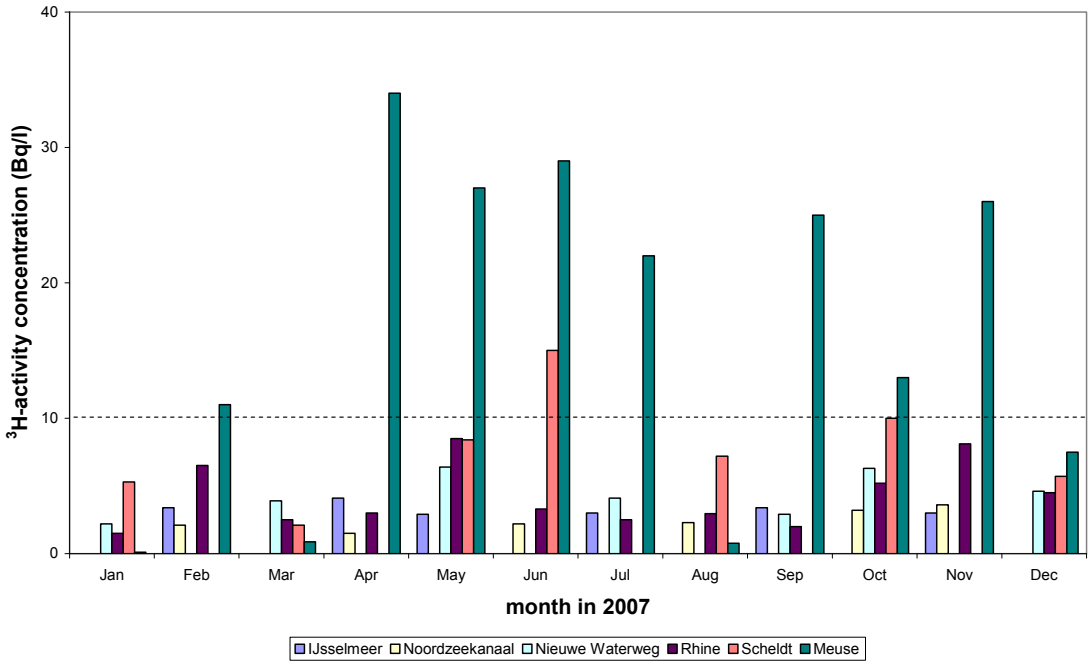


Figure 5.6: The ^{3}H-activity concentration in 2007 for the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 3.3, 2.5, 4.3, 4.1, 7.7 and 17.0 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 10 Bq·L^{-1} [43].

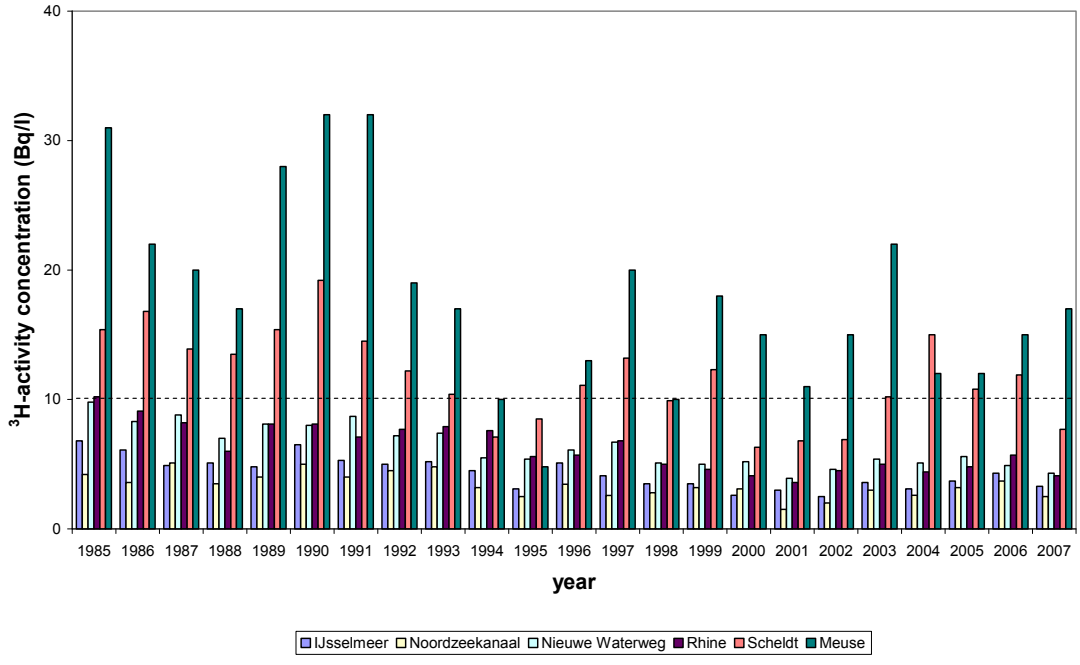


Figure 5.7: Yearly averaged ^{3}H-activity concentrations.

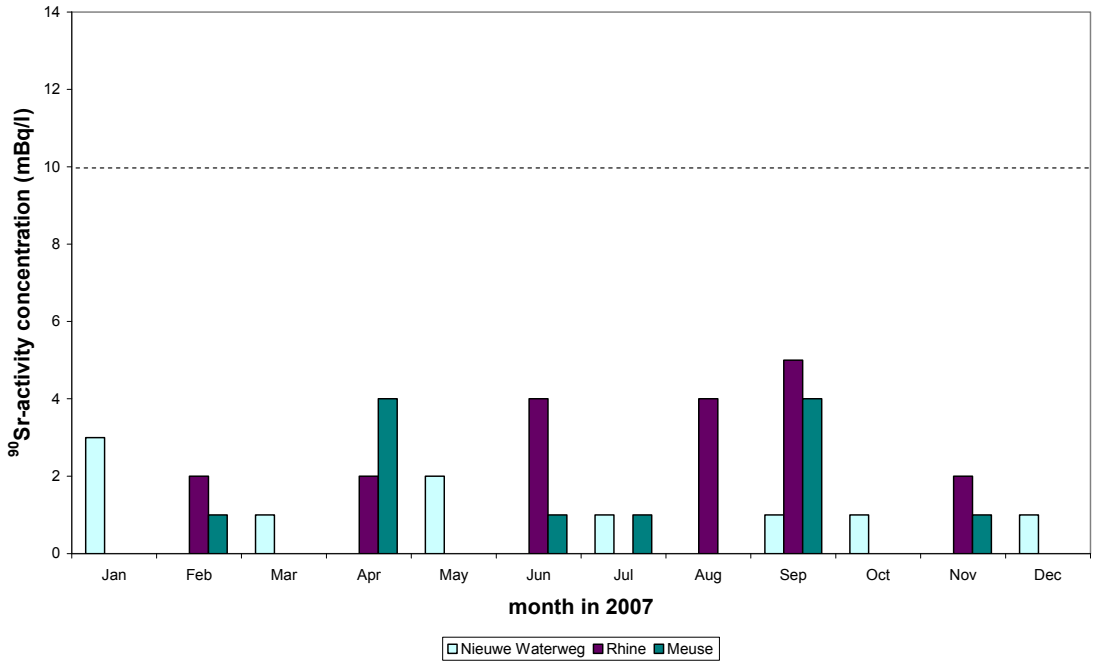


Figure 5.8: The ^{90}Sr-activity concentration in 2007 for the Nieuwe Waterweg, Rhine and Meuse, with yearly averages of < 1.1, 3.2 and < 1.7 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 10 mBq·L^{-1} [43].

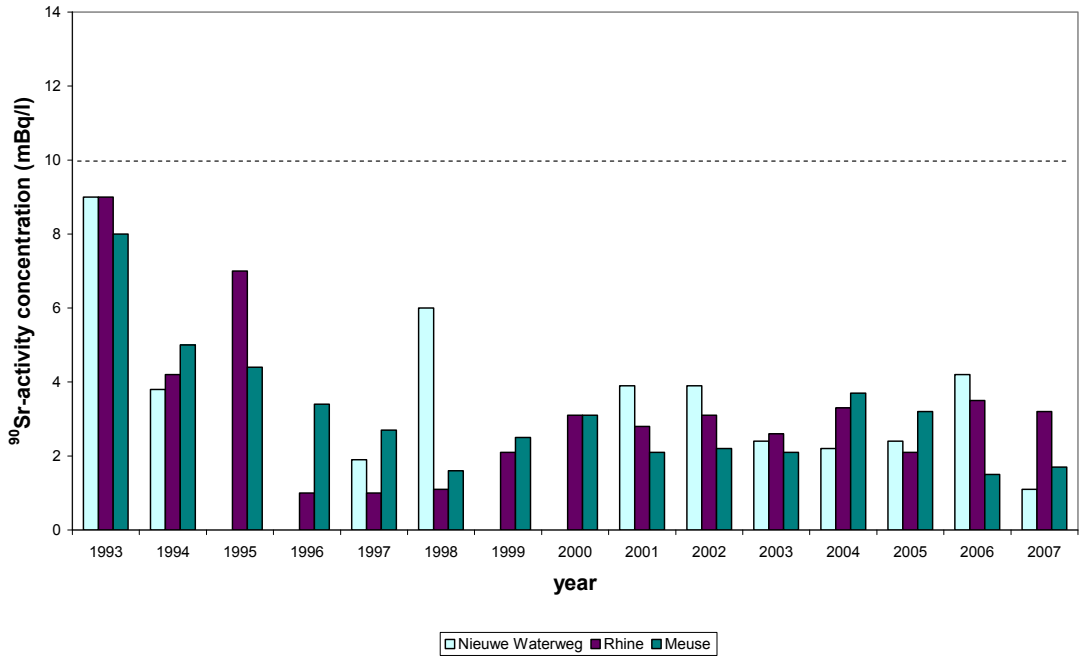


Figure 5.9: Yearly averaged ^{90}Sr-activity concentrations. Data is not available for the Nieuwe Waterweg in 1995, 1996, 1999 and 2000.

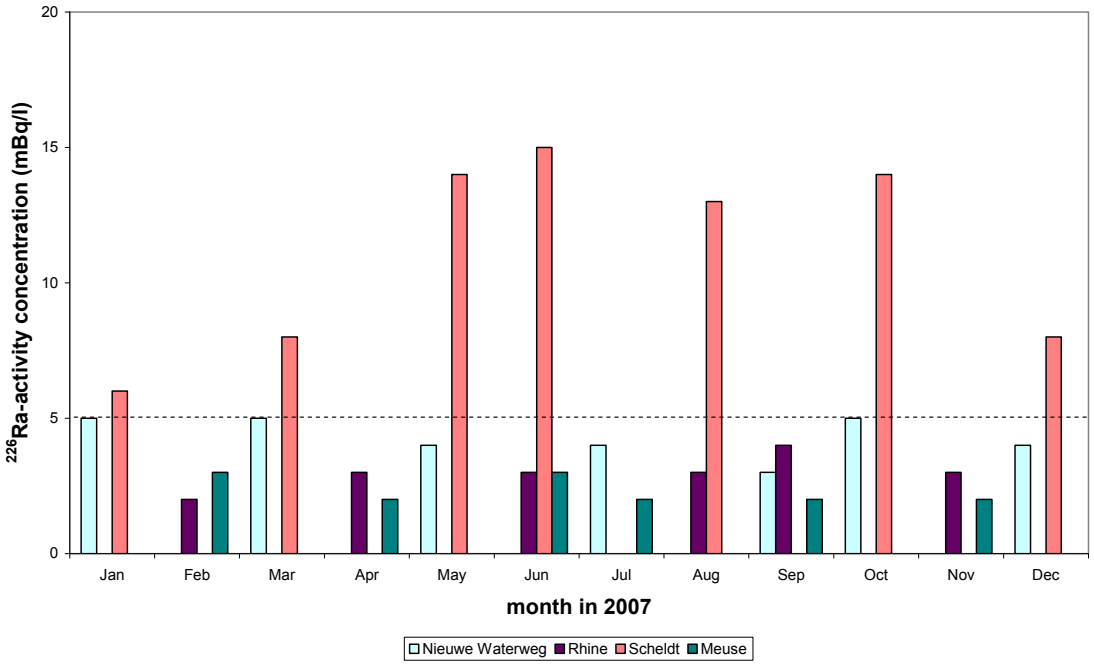


Figure 5.10: The ^{226}Ra-activity concentration in 2007 for the Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 4.3, 3.0, 11.1 and 2.3 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 5 mBq·L^{-1} [43].

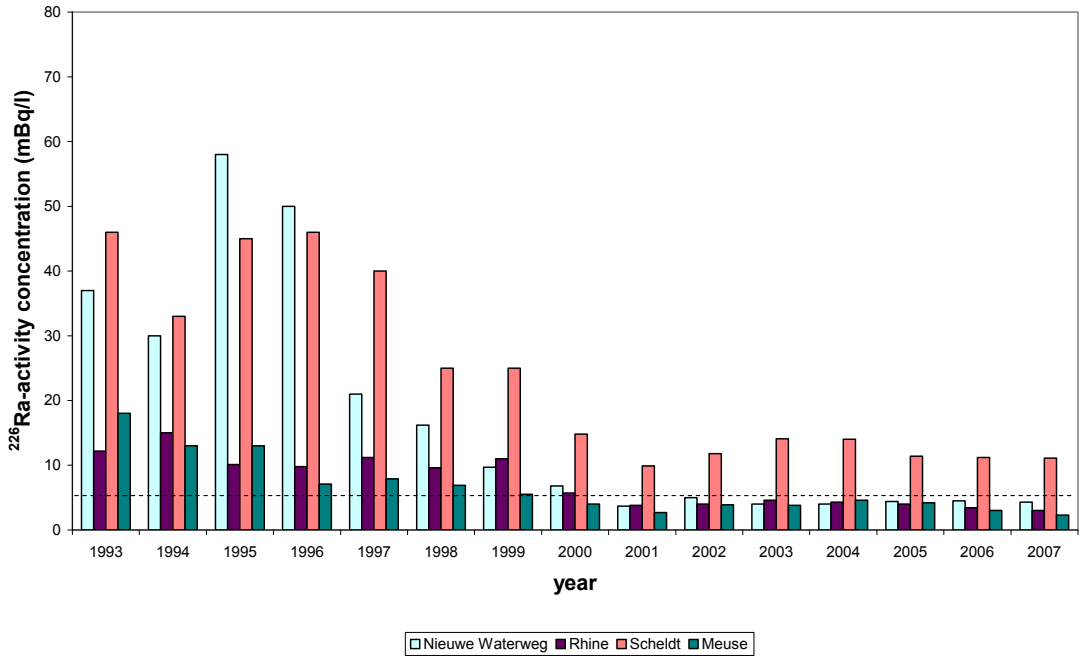


Figure 5.11: Yearly averaged ^{226}Ra-activity concentrations.

The nuclide ^{60}Co is a known corrosion product of nuclear power plants. The ^{60}Co-activity concentration in the Meuse exceeds the target value (10 Bq·kg^{-1}) in 4 out of 52 samples taken. In 2007 the yearly averaged ^{60}Co-activity concentrations are below the target value of 10 Bq·kg^{-1}.

The nuclide ^{131}I is released into the environment by medical facilities. The ^{131}I-activity concentration in the Noordzeekanaal and Meuse exceeds the target value (20 Bq·kg^{-1}) in 1 out of 6 and 25 out of 52 samples taken, respectively. In 2007 the yearly averaged ^{131}I-activity concentration in the Meuse (22 Bq·kg^{-1}) is above the target value of 20 Bq·kg^{-1}, but within range of those in previous years.

The yearly averaged concentrations of ^{137}Cs in 2007 are within the range of those in previous years. The yearly averaged ^{137}Cs-concentrations are below the target value of 40 Bq·kg^{-1}. Except for 2004 and 2007 the yearly averaged concentration of ^{137}Cs is consistently higher in the Ketelmeer compared to that in the Rhine at Lobith (Figure 5.17). This indicates an extra contribution besides the one currently originating from the Rhine, which can be explained by the following. The Ketelmeer serves as a sink for Rhine sediment and thus contains a large amount of sediment deposited in previous years. A considerable amount of sediment, containing ^{137}Cs originating from the Chernobyl accident, resuspends in the relatively shallow Ketelmeer due to wind influences [44].

In suspended solids ^{210}Po is mostly in equilibrium with ^{210}Pb. Therefore the Centre for Water Management only reports ^{210}Pb. The nuclides ^{210}Po and ^{210}Pb originate from the uranium decay chain and are released by the phosphate processing industry. The ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine and Meuse exceeds the target value (100 Bq·kg^{-1}) in 1 out of 7, 5 out of 6 and 6 out of 6 samples taken, respectively. In 2007 the yearly averaged ^{210}Pb-activity concentration in the Rhine and Meuse (112 and 150 Bq·kg^{-1}, respectively) are above the target value of 100 Bq·kg^{-1}, but within range of those in previous years.

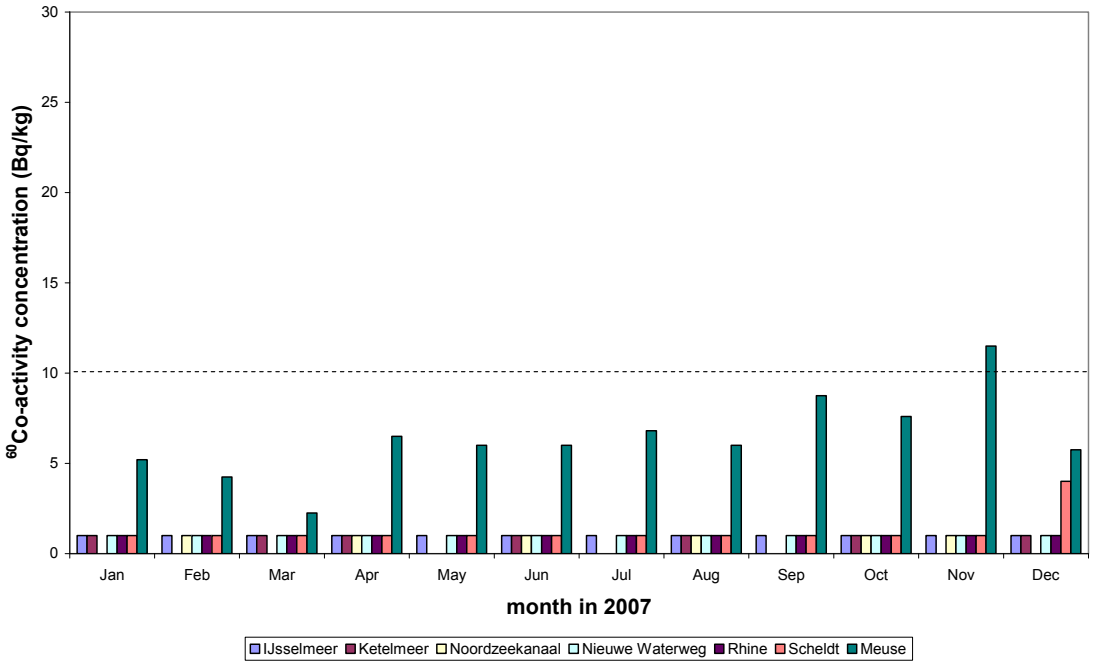


Figure 5.12: The ^{60}Co-activity concentration in suspended solids in 2007 for the IJsselmeer, Ketelmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse. The yearly averages of all except for the Meuse (6.3 Bq·kg^{-1}) are < 1 Bq·kg^{-1}. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 10 Bq·kg^{-1} [43].

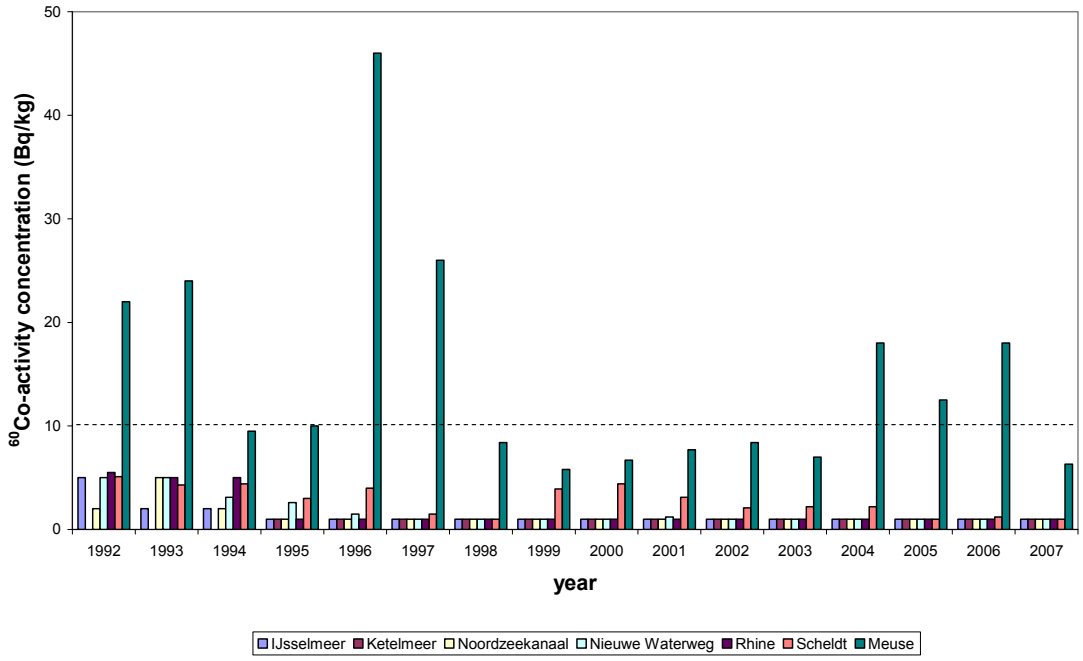


Figure 5.13: Yearly averaged ^{60}Co-activity concentrations in suspended solids. Data on Ketelmeer are available since 1995.

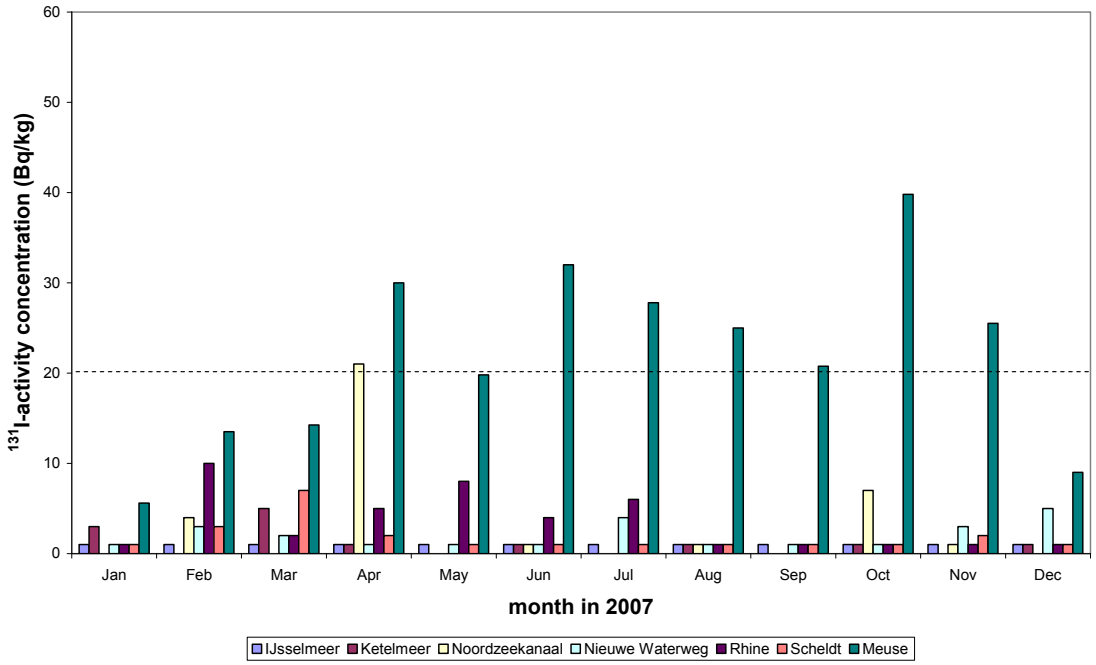


Figure 5.14: The ^{131}I-activity concentration in suspended solids in 2007 for the IJsselmeer, Ketelmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of < 1, < 1.5, 6, < 1.6, < 3.0, < 1.4, and 22 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 20 Bq·kg^{-1} [43].

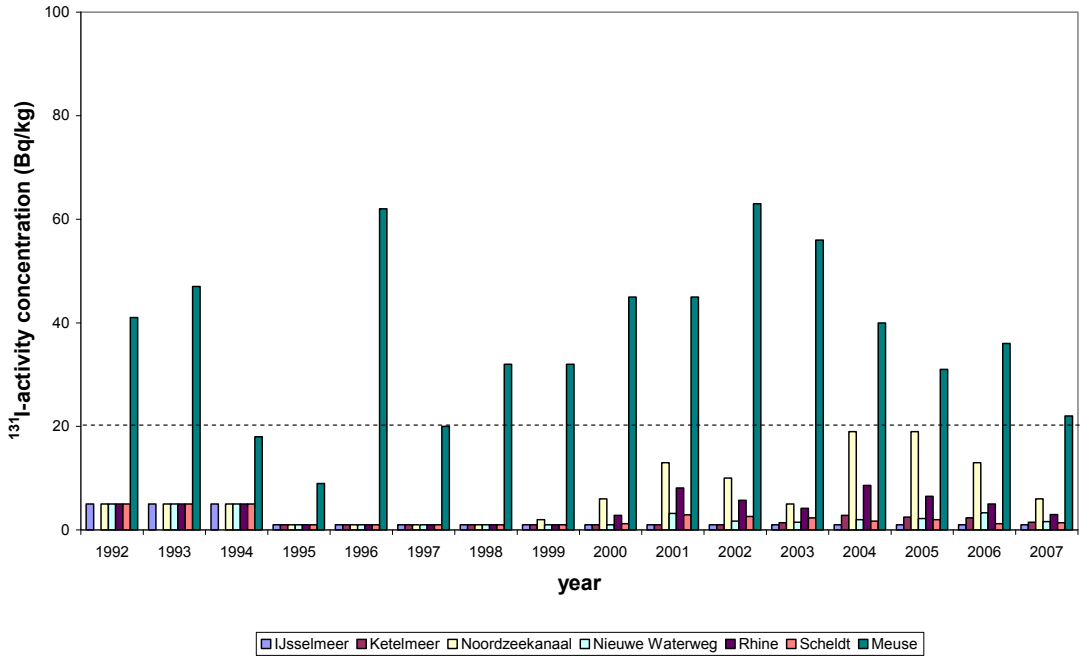


Figure 5.15: Yearly averaged ^{131}I-activity concentrations in suspended solids. Data on Ketelmeer are available since 1995.

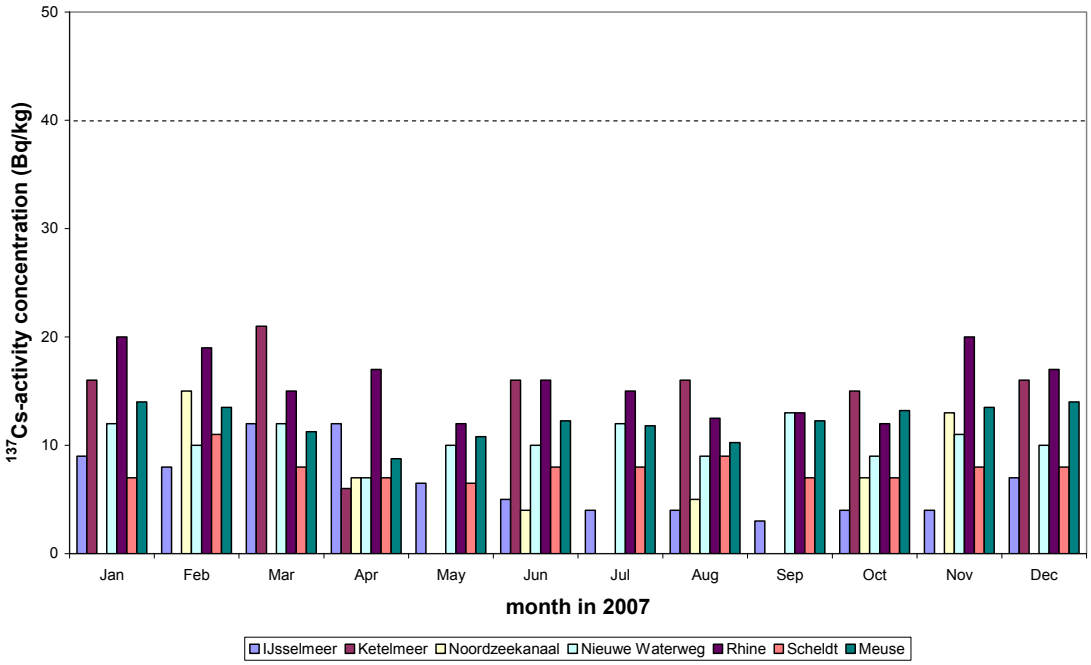


Figure 5.16: The ^{137}Cs-activity concentration in suspended solids in 2007 for the IJsselmeer, Ketelmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 6.5, 15.1, 8.5, 10.3, 15.5, 7.8, and 12.2 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 40 Bq·kg^{-1} [43].

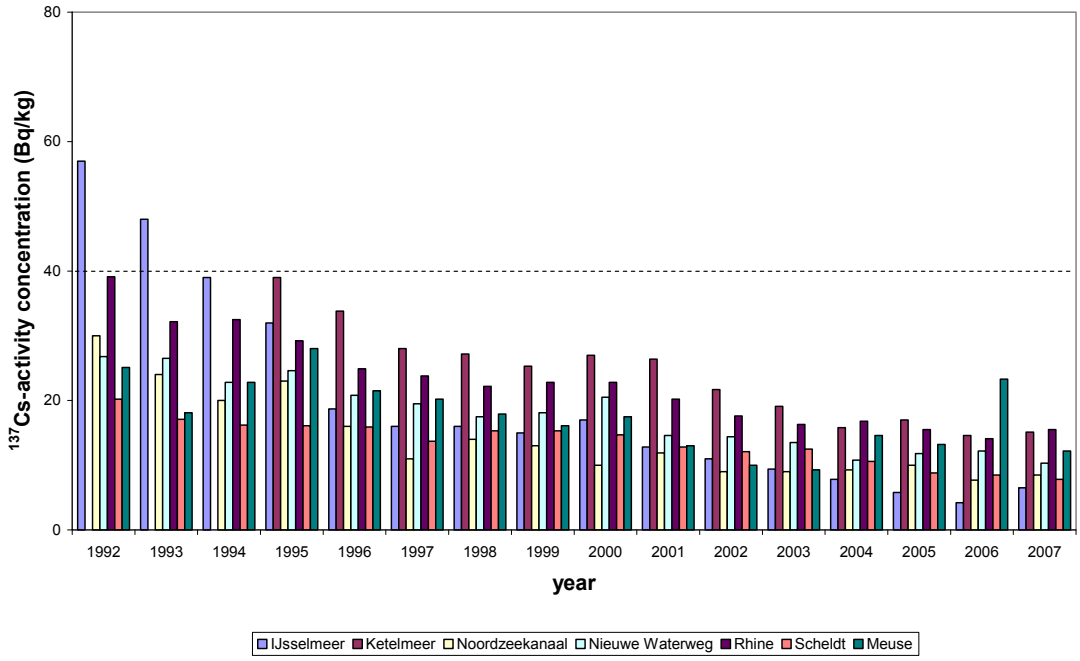


Figure 5.17: Yearly averaged ^{137}Cs-activity concentrations in suspended solids. Data on Ketelmeer are available since 1995.

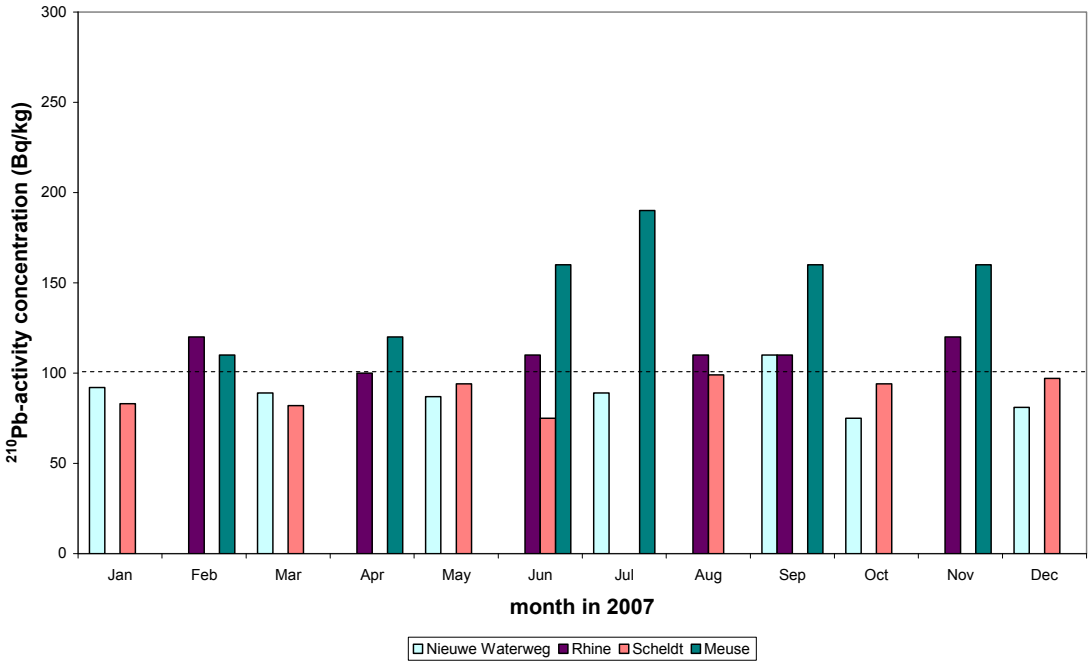


Figure 5.18: The ^{210}Pb-activity concentration in suspended solids in 2007 for the Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 89, 112, 89, and 150 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 100 Bq·kg^{-1} [43].

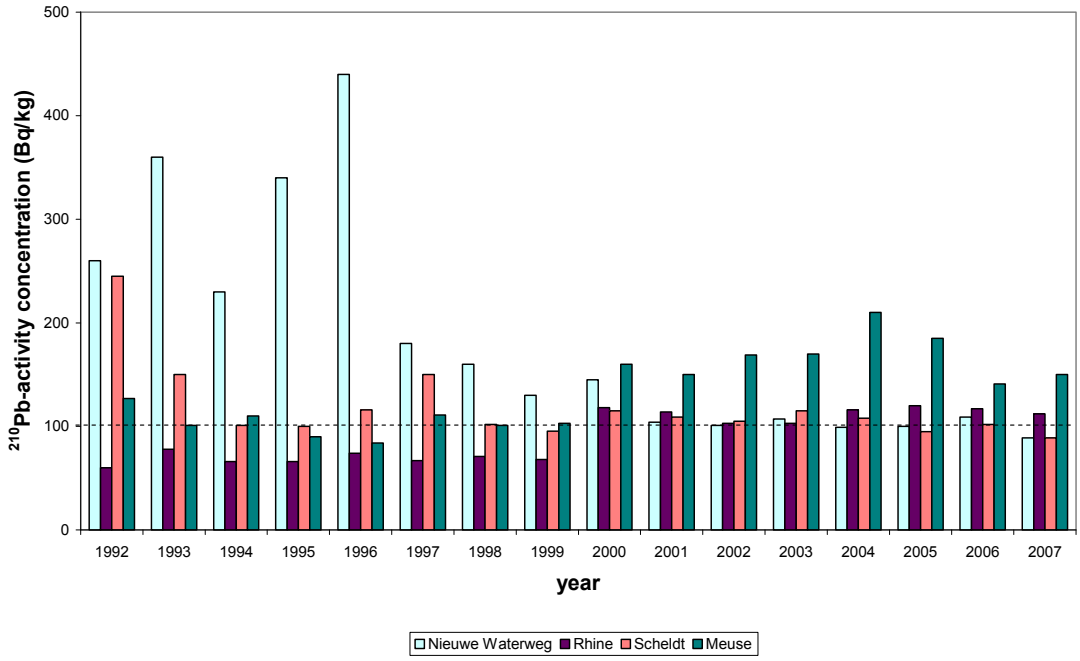


Figure 5.19: Yearly averaged ^{210}Pb-activity concentrations in suspended solids.

5.3 The results for seawater

The results for seawater are presented in Tables A13 and A14 and in Figures 5.20 to 5.31.
Gross α and residual β are indicative parameters [40]. 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 averaged concentrations of gross α in 2000 are 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 [40]. The yearly averaged gross α concentrations in 2007 are within the range of those in the period 1994-2006 (Figure 5.21).

Residual β shows an apparent change in the trend since 1994 (Figure 5.23). This is caused by a change in measuring technique, which only applies to salt and brackish water [40]. The yearly averaged residual β concentrations in 2007 are within the range of those in the period 1994-2006.

Nuclear power plants discharge the nuclides ^{3}H and ^{137}Cs. Nuclear fuel reprocessing plants discharge the nuclides ^{3}H and ^{90}Sr. Discharges by the research centre at Doel (Belgium) and the nuclear power plants at Doel and Borssele (the Netherlands) are monitored in the Westerscheldt (WS). 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), respectively [40]. The impact of both sources (nuclear power and reprocessing plants) is monitored indirectly in the Delta Coastal Waters (VD).

The yearly averaged ^{3}H-concentrations in 2007 are within the range of those in previous years (Figure 5.25). The yearly averaged ^{90}Sr-concentrations in 2007 are within the range of those in previous years (Figure 5.27).

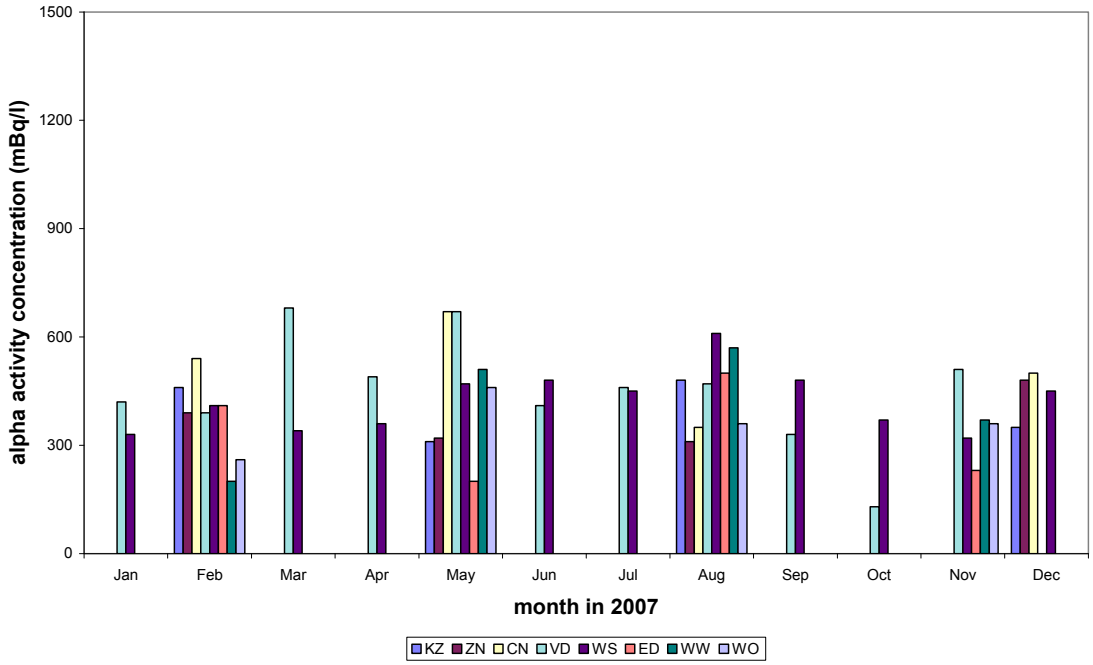


Figure 5.20: The gross α-activity concentration in seawater in 2007. The yearly averages for the Coastal area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Westerscheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO) are 400, 380, 520, 450, 420, 340, 410 and 360 mBq·L^{-1}, respectively.

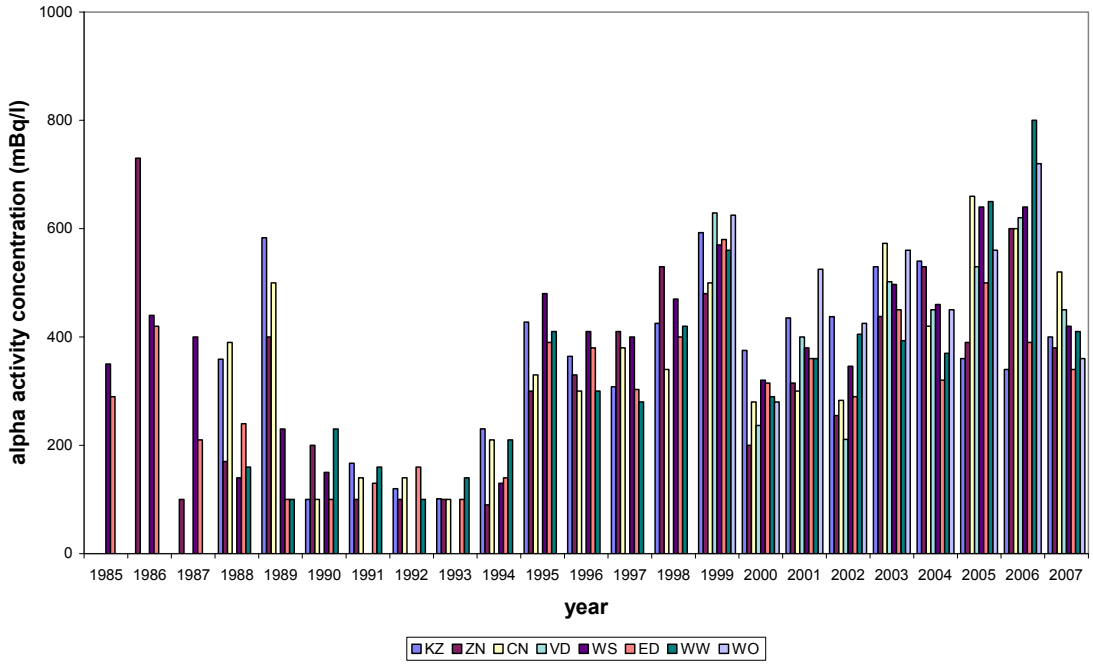


Figure 5.21: Yearly averaged gross α-activity concentrations.

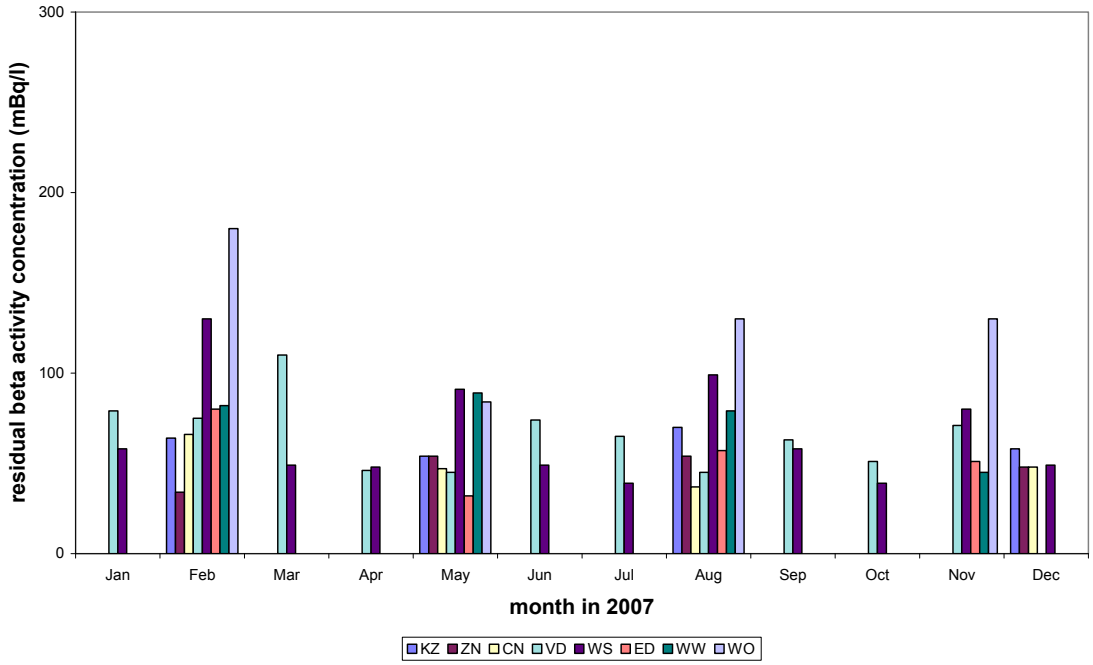


Figure 5.22: The residual β-activity concentration in seawater in 2007. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 62, 48, 50, 66, 66, 55, 74 and 131 mBq·L^{-1}, respectively.

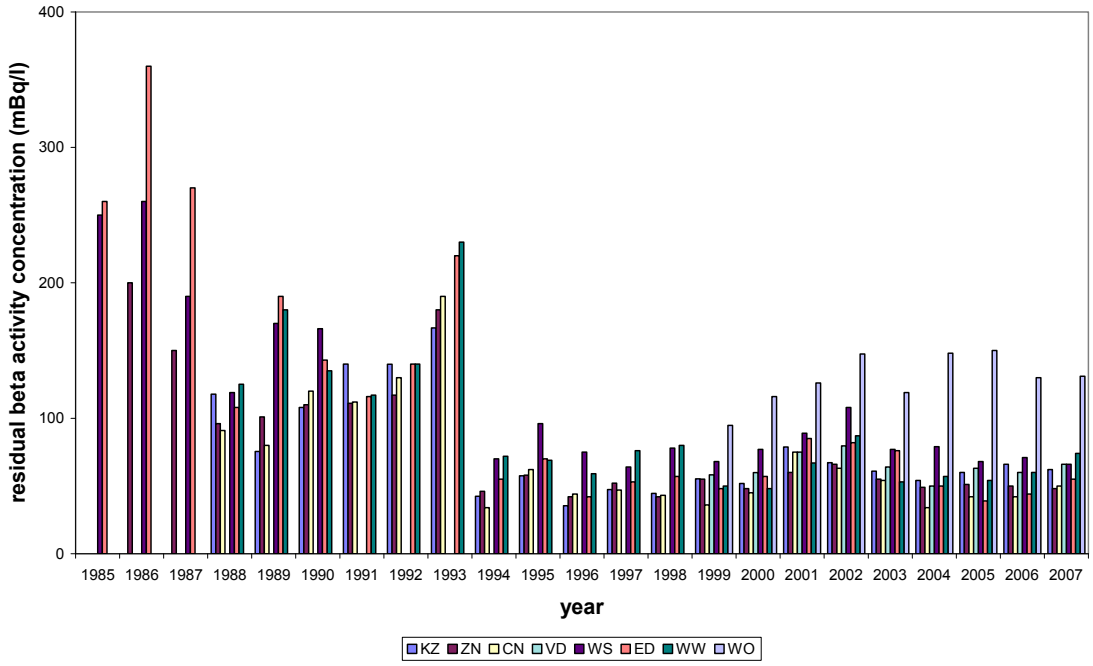


Figure 5.23: Yearly averaged residual β-activity concentrations.

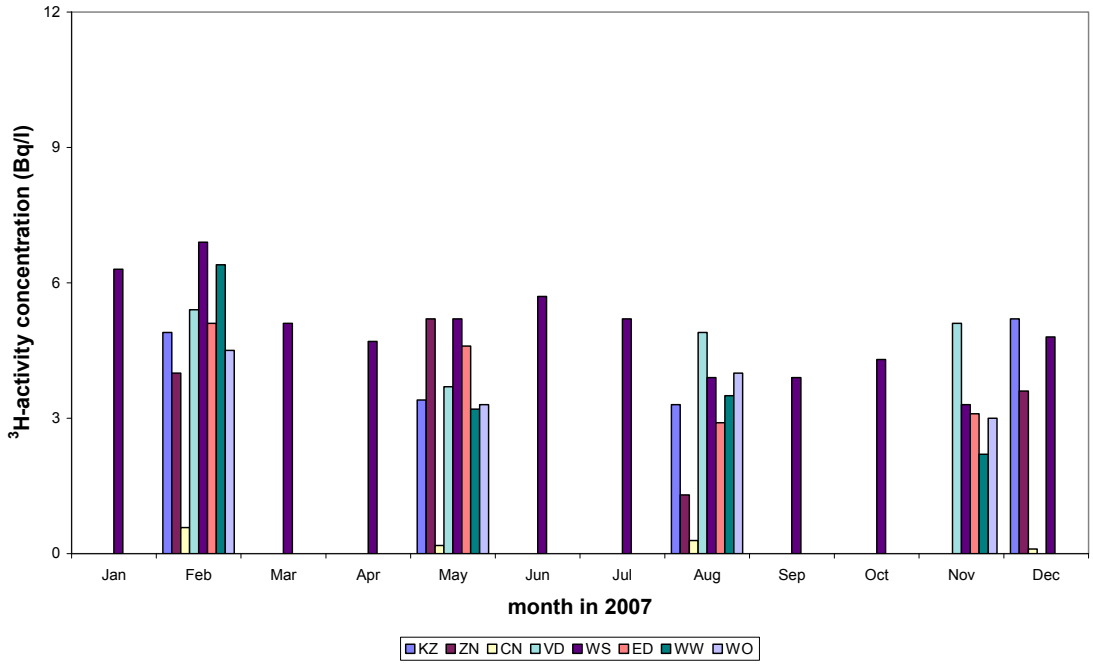


Figure 5.24: The ^{3}H-activity concentration in seawater in 2007. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 4.2, 3.5, 0.3, 4.8, 4.9, 3.9, 3.8 and 3.7 Bq·L^{-1}, respectively.

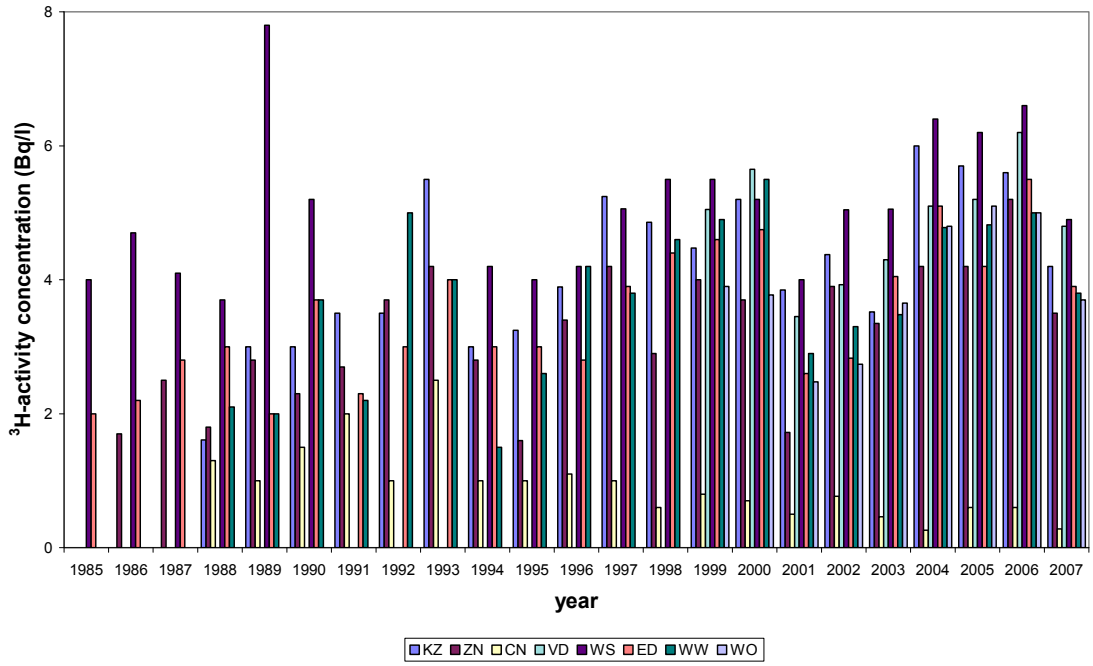


Figure 5.25: Yearly averaged ^{3}H-activity concentrations.

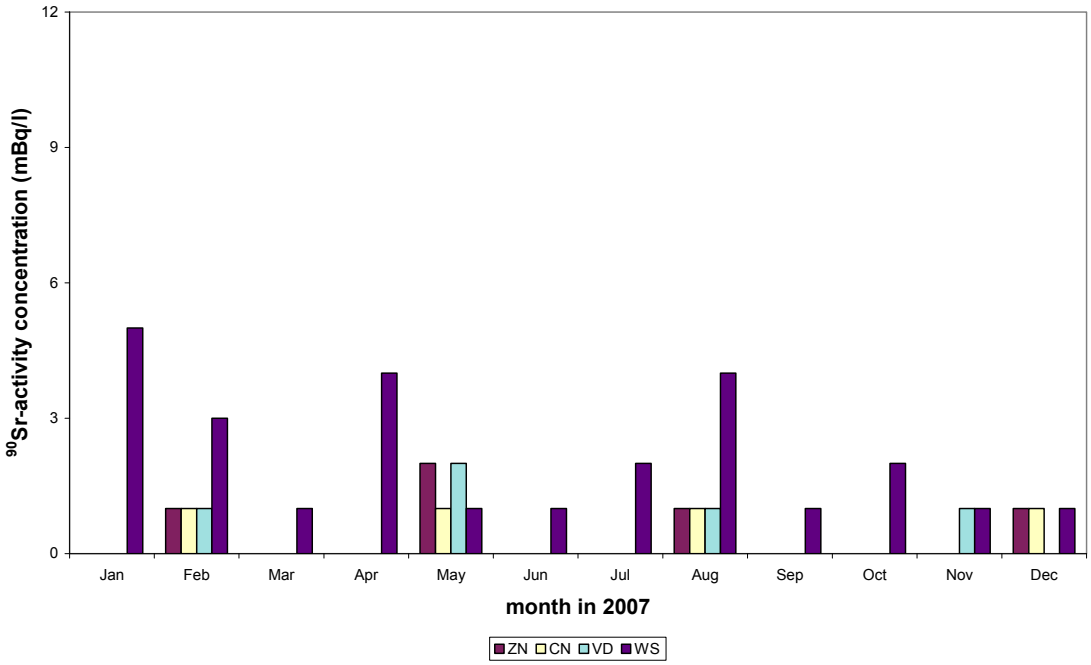


Figure 5.26: The ^{90}Sr-activity concentration in seawater in 2007. The yearly averages for the Southern North Sea, Central North Sea, Delta Coastal Waters and Westerscheldt are < 1, < 1, < 1 and 1.9 mBq·L^{-1}, respectively.

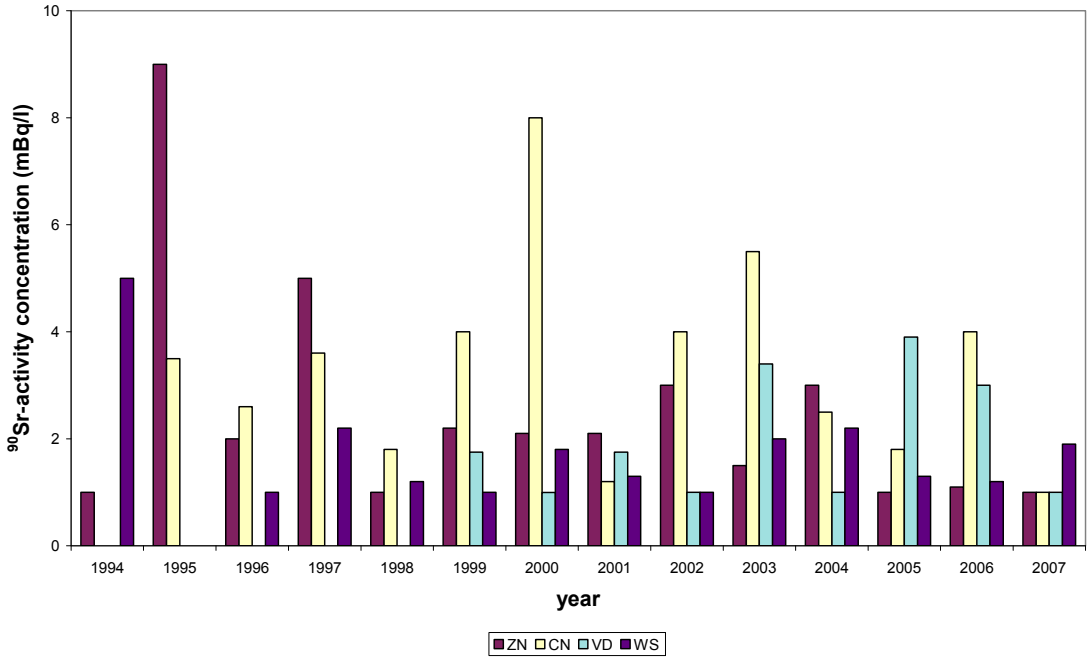


Figure 5.27: Yearly averaged ^{90}Sr-activity concentrations.

The yearly averaged concentrations of ^{137}Cs in 2007 are within the range of those in previous years (Figure 5.29). In 2001 and 2003 data were not available for Wadden Sea West due to insufficient amount of collected suspended solids. Since 2006 ^{137}Cs is not longer determined at Wadden Sea West due to repeatedly insufficient amount of collected suspended solids in previous years.

The nuclide ^{210}Po originates from the uranium decay chain and is released by the phosphate processing industry and production platforms for oil and gas [40]. Discharges via the main rivers are monitored in the Coastal area (KZ). Discharges by ore and phosphate processing industries in Belgium and the Netherlands are monitored in the Westerscheldt (WS). Discharges by Germany, Delfzijl and Eemshaven are monitored in the Eems-Dollard (ED). The impact of these discharges is monitored indirectly in the Wadden Sea (WW and WO) together with activity originating from the North Sea.

The yearly averaged concentrations of ^{210}Po in 2007 are within the range of those in previous years (Figure 5.31). In 2001 and 2003 data were not available for Wadden Sea West due to insufficient amount of collected suspended solids. Since 2006 ^{210}Po is no longer determined at Wadden Sea West due to repeatedly insufficient amount of collected suspended solids in previous years.

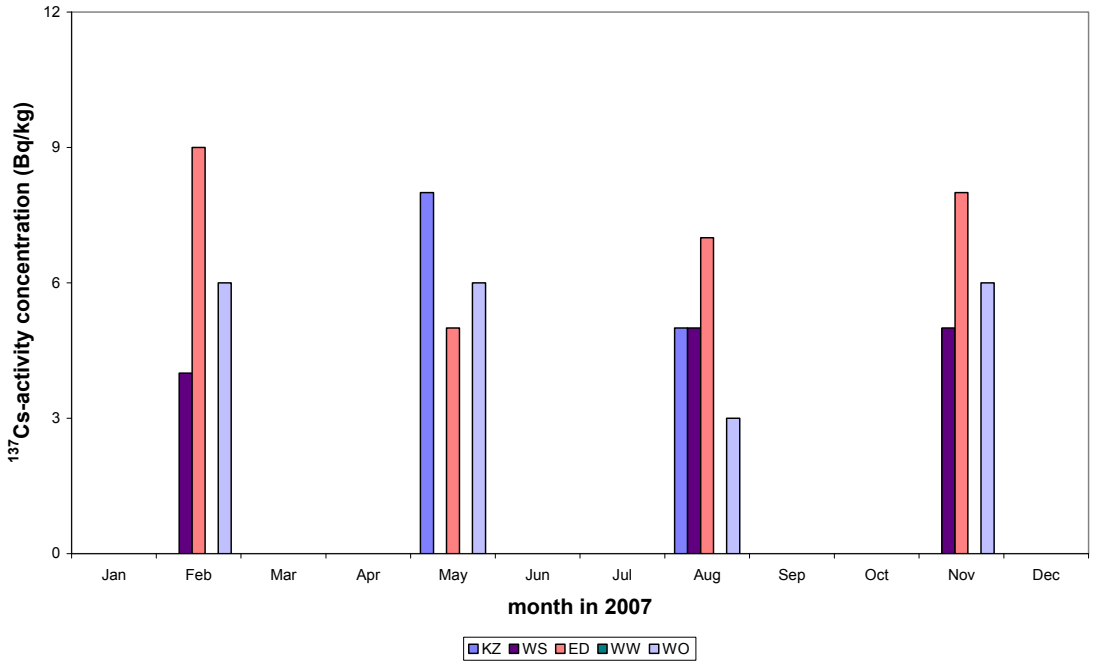


Figure 5.28: The ^{137}Cs-activity concentration in suspended solids in seawater in 2007. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard and Wadden Sea East are 6.5, 4.7, 7.2 and 5.2 Bq·kg^{-1}, respectively. Since 2006 ^{137}Cs is not longer determined at Wadden Sea West due to repeatedly insufficient amount of collected suspended solids in previous years.

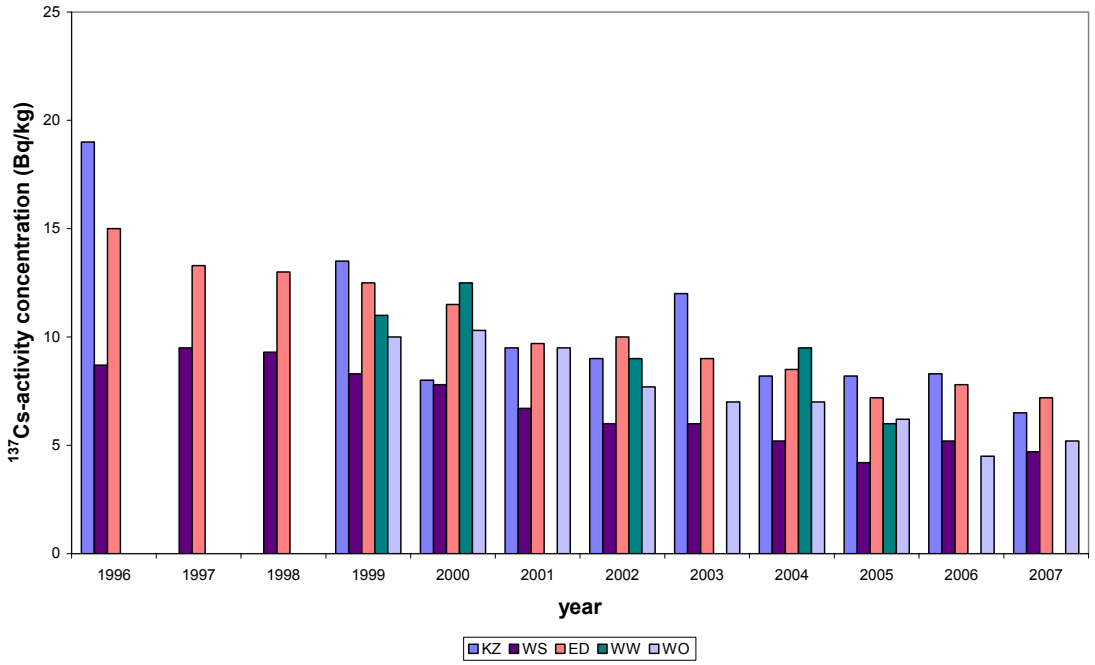


Figure 5.29: Yearly averaged ^{137}Cs-activity concentrations in suspended solids.

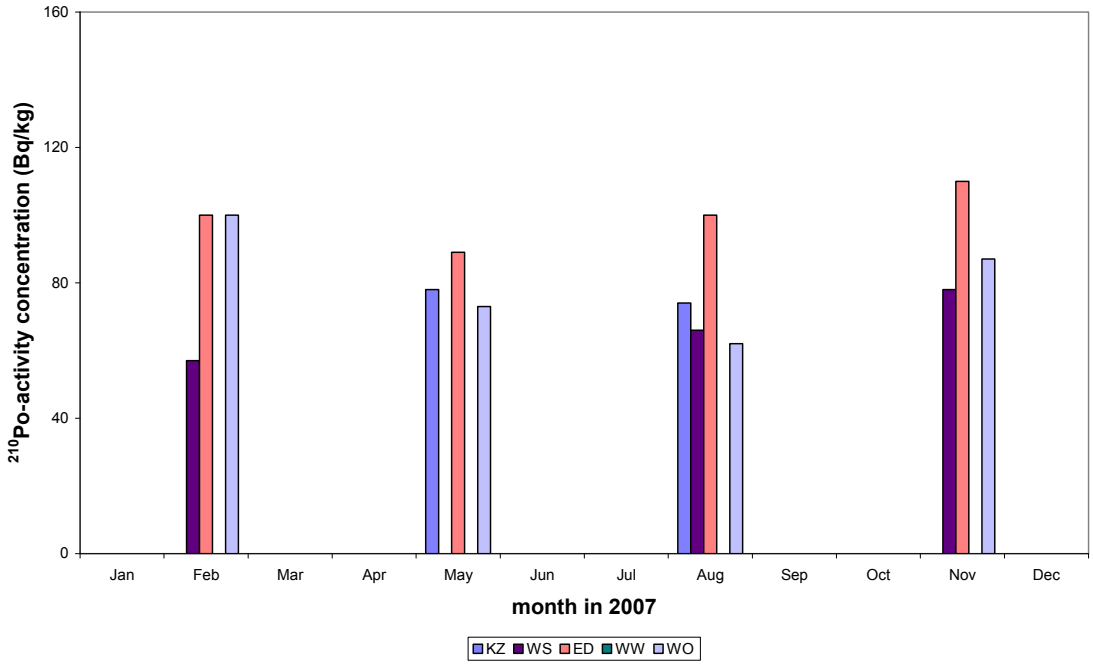


Figure 5.30: The ^{210}Po-activity concentration in suspended solids in seawater in 2007. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard and Wadden Sea East are 76, 67, 100 and 80 Bq·kg^{-1}, respectively. Since 2006 ^{210}Pb is not longer determined at Wadden Sea West due to repeatedly insufficient amount of collected suspended solids in previous years.

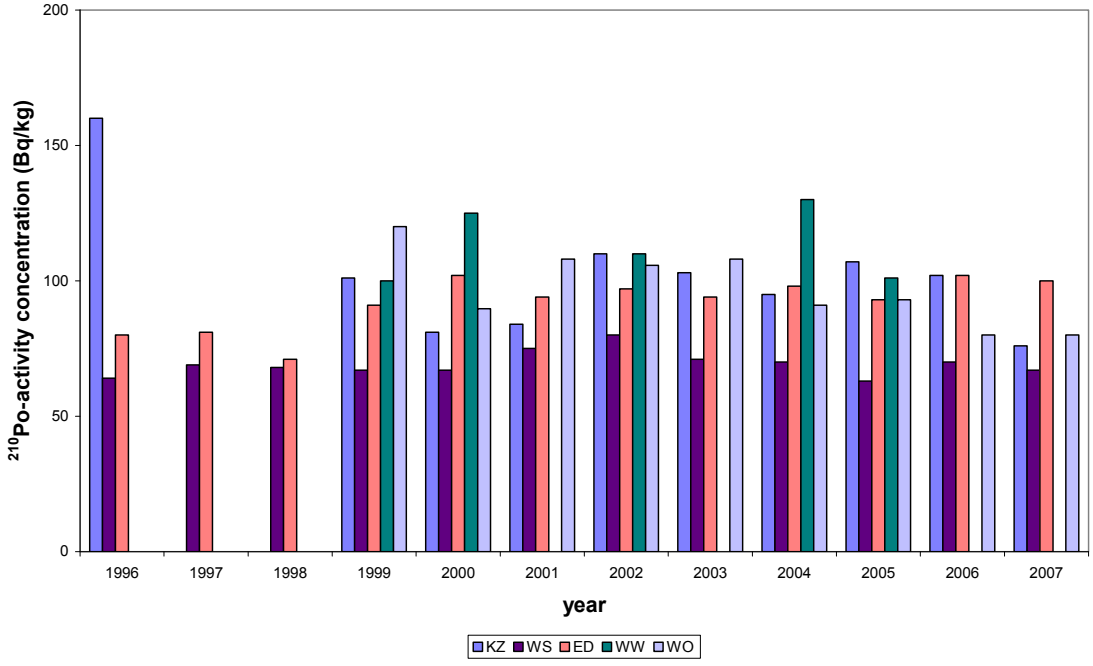


Figure 5.31: Yearly averaged ^{210}Po-activity concentrations in suspended solids.

6. Water for human consumption

In addition to the Recommendation on the Application of Article 36 of the Euratom Treaty [1] regulations for drinking water are given in Council Directive 98/83/EC [45]. As parameters tritium and the total indicative dose should be monitored. To monitor the total indicative dose screening methods for gross α- and gross β-activity concentrations may be used. If the gross α- and gross β-activity concentrations are less than 0.1 and 1.0 $Bq \cdot L^{-1}$, respectively, one may assume that the total indicative dose is less than the set limit of 0.1 $mSv \cdot year^{-1}$ [46].

In the Netherlands, water pumping-stations monitor raw input water for ^{3}H-, gross α-, gross β- and residual β-activity concentrations. The monitoring frequency per location ranges from once to 26 times per year depending on the volume of water produced. The activity concentrations are averaged per pumping station.

The results for 2007 are presented in Table 6.1. For gross α, ^{3}H, gross β and residual β several hundred analyses were performed divided over about 150 pumping stations.

Table 6.1: Analyses on drinking water in 2007.

Parameter	Gross α	^{3}H	Residual β	Gross β
Average value [(1)]	< 0.1 $Bq \cdot L^{-1}$	<3.1 $Bq \cdot L^{-1}$	< 0.3 $Bq \cdot L^{-1}$	< 0.3 $Bq \cdot L^{-1}$
No. of all pumping stations	148	147	135	153
No. of all analyses	371	401	342	411
Maximum value [(2)]	0.3 $Bq \cdot L^{-1}$	8 $Bq \cdot L^{-1}$	< 0.5 $Bq \cdot L^{-1}$	< 0.5 $Bq \cdot L^{-1}$
No. of pumping stations [(3)]	1	1	10	10
No. of analyses [(4)]	1	1	2 - 23	2 - 23

(1) Activity concentration averaged over all the pumping stations.
(2) Maximum value of the activity concentration averaged per pumping station.
(3) Number of pumping stations with the maximum value.
(4) Number of analyses per pumping station which lead to the maximum value.

In 2007 at three of the 148 pumping stations the gross α-activity concentration averaged per pumping station exceeds 0.1 $Bq \cdot L^{-1}$. These values were not thoroughly investigated. Future values above 0.1 $Bq \cdot L^{-1}$ for the gross α-activity concentration will be investigated.

For ^{3}H, gross β and residual β the results are within the range of those in previous years [5, 32, 38, 47, 48]. Since there is almost no ^{40}K present, gross β- and residual β-activity concentrations are equal. The gross β-activity concentrations were below 1.0 $Bq \cdot L^{-1}$. The ^{3}H-activity concentrations were below the set limit of 100 $Bq \cdot L^{-1}$ [45].

The activity of natural nuclides, such as ^{226}Ra and ^{222}Rn, in Dutch drinking water is very low. In 1994 a survey was carried out to determine the radon activity of Dutch water [49]. The average concentration found was 2.2 $Bq \cdot L^{-1}$ for drinking water produced from groundwater. The difference between this value and those mentioned in Table 6.1 is due to the contribution of short-lived and volatile natural radionuclides (radon daughters), which are not included in the gross α-, gross β- and residual β-activity concentrations.

7. Milk

The Institute of Food Safety monitors radioactivity in milk on a weekly base via the National Monitoring Network Radioactivity in Food (Landelijk Meetnet Radioactiviteit in Voedsel, LMRV). The LMRV is a monitoring network that in principal is set up as an emergency network for monitoring relatively high contamination levels. The LMRV consists of 70 NaI-monitors of which 24 are stationed at dairy factories. The weekly samples of all locations are combined into a monthly average for the whole country. The monthly averages for 2007 are presented in Table 7.1.

Table 7.1: Monthly averaged activity concentrations in milk in 2007.

Month	Number of samples	^{40}K Bq·L^{-1}	^{60}Co Bq·L^{-1}	^{131}I Bq·L^{-1}	^{134}Cs Bq·L^{-1}	^{137}Cs Bq·L^{-1}
January	103	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
February	83	49 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
March	79	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
April	74	47 ± 4	< 1.4	< 0.6	< 0.6	< 0.5
May	84	49 ± 4	< 1.4	< 0.6	< 0.6	< 0.5
June	75	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
July	89	47 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
August	83	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
September	66	48 ± 4	< 1.4	< 0.6	< 0.6	< 0.5
October	95	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
November	79	48 ± 4	< 1.4	< 0.6	< 0.6	< 0.5
December	76	48 ± 6	< 1.4	< 0.6	< 0.6	< 0.5
Average	986 (1)	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5

(1) *Yearly total.*

The detection limits for ^{60}Co, ^{131}I, ^{134}Cs and ^{137}Cs are lower since 2006 then in previous years. The Institute for Food Safety analysed 27 milk samples for ^{90}Sr in the last quarter of 2007. The samples were taken across the Netherlands on 27 locations of which one was a farm. The ^{90}Sr-activity concentration was below the detection limit (5 Bq·L^{-1}) in all samples taken. The detection limit in 2007 is higher than in 2005 (0.1 Bq·L^{-1}) due to a difference in sample preparation and measurement. No measurements on ^{90}Sr were performed in 2006.

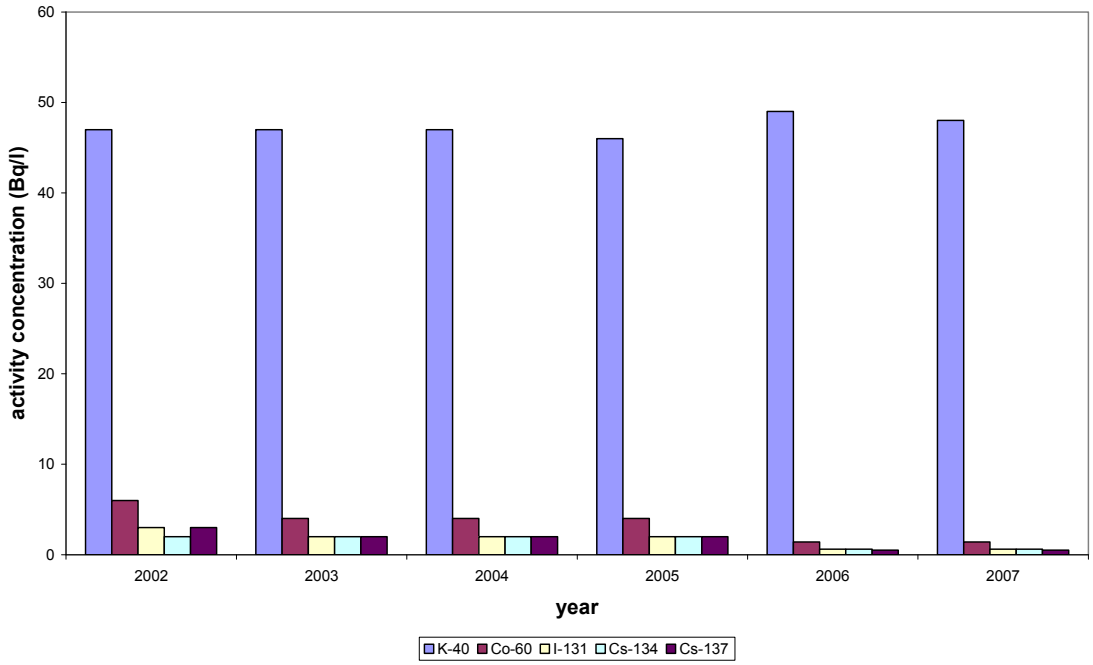


Figure 7.1: Yearly averaged activity concentrations of ^{40}K, ^{60}Co, ^{131}I, ^{134}Cs and ^{137}Cs in milk.

8. Food

The measurements are performed by the Food and Consumer Product Safety Authority. Measurements were carried out according to standard procedures [50, 51]. The results for 2007 are presented in Table 8.1, in total 713 samples were analysed. None of the samples exceed the set limit of 600 $Bq \cdot kg^{-1}$ [52].

Since 2005 the Food and Consumer Product Safety Authority monitors activity concentrations in a mixed diet. The mixed diet is yearly sampled, mainly as separate ingredients but also as some complete meals. Over a period of two weeks in five different regions a standard sampling was carried out which consisted of 622 samples, which were taken from retail shops, auctions and distribution centres [53]. The separate ingredients were divided in the following product groups: grain products, vegetables, fruit, milk and dairy products, meat and meat products, game and poultry, salads and oil and butter.

Radioactivity is also measured in food suspected to contain more than the normal activity concentrations, in this case honey. In 2007 analyses were not performed on ^{90}Sr in mixed diet.

8.1 Honey

In total 91 samples of honey were analysed [53]. The activity (sum of ^{134}Cs and ^{137}Cs) was found to be below the set limit of 600 $Bq \cdot kg^{-1}$ [52]. Only 18 samples of honey contained ^{137}Cs. The activity varied from 3 up to 239 $Bq \cdot kg^{-1}$.

8.2 Other products

Except for natural occurring ^{40}K, radioactivity was not detected in the other product categories. Since 2006 the detection limits are higher than in 2005 [5] due to a shorter measurement time.

Table 8.1: Results of analysis of food for ^{134}Cs and ^{137}Cs in 2007.

Product	Number of samples	Number of positive samples	^{134}Cs $Bq \cdot kg^{-1}$	^{137}Cs $Bq \cdot kg^{-1}$
Grain products	113	0	< 3.8	< 3.0
Vegetables	124	0	< 3.8	< 3.0
Fruit	58	0	< 3.8	< 3.0
Milk and milk products	87	0	< 3.8	< 3.0
Meat and meat products	98	0	< 3.8	< 3.0
Game and poultry	48	0	< 3.8	< 3.0
Salads	34	0	< 3.8	< 3.0
Oil and butter	57	0	< 3.8	< 3.0
Honey	91	18	< 3.8	3 - 239
Others	3	0	< 3.8	< 3.0

9. Nuclear power plant at Borssele

The Nuclear Research & consultancy Group (NRG) is commissioned by Elektriciteits-Productiemaatschappij Zuid-Nederland (N.V. EPZ) to perform monthly measurements on environmental samples taken in the vicinity of the nuclear power plant at Borssele (owned by N.V. EPZ). Samples are taken to monitor the compartments air, water and soil. The monitoring program presented here forms only part of the total monitoring program. A more detailed description of the monitoring program, underlying strategy and results are reported elsewhere [54, 55]. The 2007 monitoring program is shown in Table 9.1 and Figure 9.1. Radioactive nuclides were determined in air dust, grass, soil, water, suspended solids, seaweed and sediment.

Table 9.1: Monitoring program for environmental samples in the vicinity of the nuclear power plant at Borssele in 2007. The location numbers correspond with the location numbers given in Figure 9.1.

Matrix	Location	Parameter	Monitoring frequency (per year)
Air dust	21, 22, 23, 27 and 29	gross α, gross β	12
		γ-emitters [(1)]	12 [(2)]
Grass	21, 22, 23, 27 and 29	γ-emitters [(3)]	12 [(2)]
Sand	O1, O2, O3, O4 [(4)]	γ-emitters [(5)]	1
Water	1, 2, 3 and 4	residual β, ^{3}H	12
Suspended solids	1, 2, 3 and 4	gross β	12
Seaweed	1, 2, 3 and 4	γ-emitters [(3)]	12 [(2)]
Sediment	1, 2, 3 and 4	γ-emitters [(3)]	12 [(2)]

[(1)] γ-spectroscopic analysis of specific γ-emitting nuclides: ^{60}Co, ^{137}Cs, natural occurring radionuclides and elemental and organically bound ^{131}I.
[(2)] Analysis is performed on a combined sample of the monthly samples of all four or five locations.
[(3)] γ-spectroscopic analysis of specific γ-emitting nuclides: ^{60}Co, ^{131}I and ^{137}Cs.
[(4)] The four samples taken near the outlet are not shown in Figure 9.1.
[(5)] γ-spectroscopic analysis of specific γ-emitting nuclides: ^{54}Mn, ^{60}Co, ^{134}Cs and ^{137}Cs.

9.1 Air

The results of gross α- and β-activity concentrations in air dust are presented in Tables A15 and A16. Gross α-activity concentrations in air dust should be regarded as indicative values. The period between sampling and analysis is at least five days, which is long compared 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.

Where possible the samples taken at locations 27 and 29 (medium range) are analysed separately from the samples taken at locations 21, 22 and 23 (close range). Therefore the results of these samples can be seen as a reference value. The results for the nuclides considered in the gammaspectroscopic analysis are given in Table A17.

9.2 Soil

The results for the nuclides considered in the gammaspectroscopic analysis in grass and soil are given in Tables A18 and A19. The four soil samples are taken near the outlet of the nuclear power plant. The yearly averaged concentrations of ^{54}Mn, ^{60}Co, ^{134}Cs and ^{137}Cs in soil in 2007 are within the range of those in previous years [55].

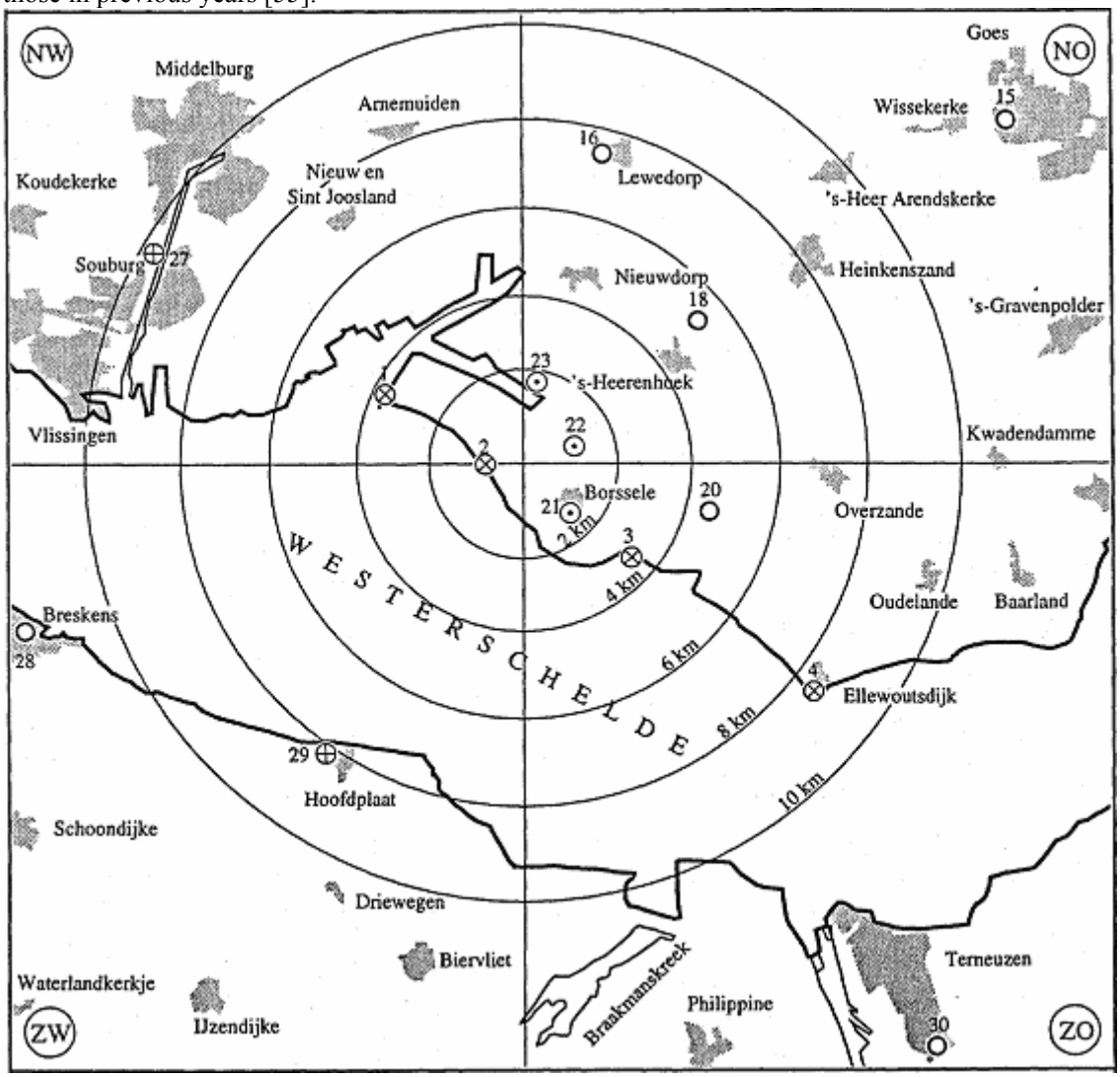


Figure 9.1: Overview of monitoring locations for the monitoring program in the vicinity of the nuclear power plant at Borssele as conducted by NRG. The location numbers correspond with the location numbers given in Table 9.1.

9.3 Water

The results of residual β and ^{3}H-activity concentrations in water and gross β-activity concentrations in suspended solids from the Westerscheldt are presented in Tables A20, A21 and A22. The results for the nuclides considered in the gammaspectroscopic analysis in seaweed and sediment are given in Tables A23 and A24.

10. Conclusions

Since 2007 a new (more realistic) calibration for gross α in air dust has been implemented. This new calibration is 1.4 times higher than the one for previous years, which results in lower reported gross α-activities in air dust.

The gross α-activity concentration in the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg and Scheldt exceeds the target value (100 $mBq \cdot L^{-1}$) in one out of thirteen, four out of six, five out of thirteen and thirteen out of thirteen samples taken, respectively. The yearly averaged gross α-activity concentrations in the Noordzeekanaal, Nieuwe Waterweg and Scheldt (121, 110 and 250 $mBq \cdot L^{-1}$, respectively) are above the target value, but within the range of those in previous years.

The ^{3}H-activity concentration in the Scheldt and Meuse exceeds the target value (10 $Bq \cdot L^{-1}$) in one out of seven and nine out of thirteen samples taken, respectively. The yearly averaged ^{3}H-activity concentration in the Meuse (17.0 $Bq \cdot L^{-1}$, respectively) is above the target value, but within the range of those in previous years.

The ^{226}Ra-activity concentration in the Scheldt exceeds the target value (5 $mBq \cdot L^{-1}$) in seven out of seven samples taken, respectively. The yearly averaged ^{226}Ra-activity concentration in the Scheldt (11.1 $mBq \cdot L^{-1}$) is above the target value, but within the range of those in previous years.

The ^{60}Co-activity concentration in the Meuse exceeds the target value (10 $Bq \cdot kg^{-1}$) in four out of fifty-two samples taken. However the yearly averaged ^{60}Co-activity concentration in the Meuse is below the target value.

The ^{131}I-activity concentration in the Noordzeekanaal and Meuse exceeds the target value (20 $Bq \cdot kg^{-1}$) in one out of six and twenty-five out of fifty-two samples taken, respectively. The yearly averaged ^{131}I-activity concentration in the Meuse (22 $Bq \cdot kg^{-1}$) is above the target value, but within the range of those in previous years.

The ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine and Meuse exceeds the target value (100 $Bq \cdot kg^{-1}$) in one out of seven, five out of six and six out of six samples taken, respectively. The yearly averaged ^{210}Pb-activity concentration in the Rhine and Meuse (112 and 150 $Bq \cdot kg^{-1}$, respectively) are above the target value, but within the range of those in previous years.

In 2007 at three of the 148 pumping stations the gross α-activity concentration averaged per pumping station exceeds 0.1 $Bq \cdot L^{-1}$. These values were not thoroughly investigated. Future values above 0.1 $Bq \cdot L^{-1}$ for the gross α-activity concentration will be investigated.

The results of all other radioactivity measurements are within the range of those in previous years. Since 2007 data on environmental samples taken around the nuclear power plant at Borssele has been added to this report.
In 2007 the Netherlands complied to the Euratom recommendations except for the determination of strontium-90 in mixed diet.

Appendix A Result tables

Table A1: Weekly averaged gross α- and gross β-activity concentrations in air dust sampled with a High Volume Sampler at RIVM in 2007.

Week [1] Number	Gross α mBq.m^{-3}	Gross β mBq.m^{-3}		Week [1] number	Gross α mBq.m^{-3}	Gross β mBq.m^{-3}	
1	0.038	0.35	± 0.02	27	0.028	0.217	± 0.015
2	0.028	0.181	± 0.013	28	0.029	0.224	± 0.016
3	0.028	0.237	± 0.016	29	0.039	0.36	± 0.02
4	0.045	0.200	± 0.014	30	0.023	0.31	± 0.02
5 [2]	0.037	0.173	± 0.013	31	0.017	0.232	± 0.016
6 [2]	0.041	0.175	± 0.013	32	0.025	0.40	± 0.03
7	0.020	0.217	± 0.015	33	0.025	0.264	± 0.018
8	0.042	0.47	± 0.03	34	0.023	0.30	± 0.02
9	0.016	0.230	± 0.016	35	0.020	0.40	± 0.03
10	0.022	0.254	± 0.017	36	0.026	0.232	± 0.016
11	0.041	0.30	± 0.02	37	0.018	0.282	± 0.019
12	0.020	0.240	± 0.017	38	0.044	0.39	± 0.03
13	0.12	0.96	± 0.06	39	0.033	0.44	± 0.03
14	0.07	0.63	± 0.04	40 [3]	0.030	0.42	± 0.03
15	0.033	0.37	± 0.02	41	0.027	0.44	± 0.03
16	0.032	0.51	± 0.03	42 [3]	0.035	0.70	± 0.05
17	0.054	0.70	± 0.05	43	0.032	0.67	± 0.04
18	0.034	0.51	± 0.03	44	0.09	0.83	± 0.05
19	0.037	0.47	± 0.03	45	0.022	0.32	± 0.02
20	0.025	0.229	± 0.016	46	0.030	0.35	± 0.02
21	0.041	0.48	± 0.03	47 [2, 3]	0.08	0.82	± 0.05
22	0.040	0.41	± 0.03	48 [2]	0.034	0.38	± 0.03
23	0.038	0.72	± 0.05	49 [2]	0.018	0.217	± 0.015
24	0.06	0.71	± 0.05	50	< 0.010	0.252	± 0.014
25	0.050	0.283	± 0.019	51 [2]	0.022	0.56	± 0.04
26	0.025	0.266	± 0.018	52 [3]	0.072	1.08	± 0.05
				Average	0.04 [4]	0.411	± 0.004 [5]
				SD [6]	0.02		0.2

[1] The precise sampling period is given in Table A3.
[2] Due to problems with on the High Volume Sampler sampling occurred with a lower flow (about one third of regular flow) during 0.2 to 1.3 days of the week.
[3] Due to problems with or maintenance on the High Volume Sampler sampling did not occur at all during 0.3 to 2.4 days of the week.
[4] Due to large uncertainties caused by variations in dust thickness on the filters, gross α-activity concentrations in air dust are given as indicative values [6].
[5] 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.
[6] SD is the standard deviation of the weekly results.

Table A2: Detection limits (µBq·m^{-3}) in the residue measurement of air dust sampled during a seven days sampling period with a HVS at RIVM in 2007. Measurements were carried out on a coaxial detector with a ten days delay between sampling and start of measurement, a counting time of 100,000 seconds and a sample volume of about 50,000 m^3. The detection limits are higher than before 2000 [7] due to a different detector set-up.

Nuclide	Detection limit µBq·m^{-3}	Nuclide	Detection limit µBq·m^{-3}
^{7}Be	9	^{113}Sn	1.1
^{22}Na	0.9	^{115m}Cd	45
^{24}Na	600 (1)	^{115}Cd	44
^{40}K	17	^{123m}Te	1.2
^{51}Cr	11	^{124}Sb	1.1
^{54}Mn	0.6	^{125}Sb	2
^{57}Co	0.4	^{129m}Te	28
^{58}Co	0.6	^{131}I	1.3 (2)
^{59}Fe	1.3	^{132}Te	5
^{60}Co	1.2	^{134}Cs	0.9
^{65}Zn	1.3	^{136}Cs	1.2
^{75}Se	1.1	^{137}Cs	2
^{95}Nb	0.9	^{140}Ba	4
^{95}Zr	0.7	^{140}La	43
^{99}Mo	56	^{141}Ce	0.9
^{103}Ru	0.9	^{144}Ce	3
^{106}Ru	6	^{202}Tl	1.2
^{109}Cd	9	^{210}Pb	13
^{110m}Ag	1.3		

(1) Due to the relatively short half-life of ^{24}Na and the long delay between the sampling and the measurement this nuclide cannot be determined in the residue measurement on the coaxial detector. Therefore, the detection limit for the filter measurement on the coaxial detector is given (3 days delay time, 100,000 seconds counting time).

(2) Due to the sample preparation procedure the volatile nuclide ^{131}I cannot be determined in the residue measurement on the coaxial detector. Therefore, the detection limit for the filter measurement on the coaxial detector is given (3 days delay time, 100,000 seconds counting time).

Table A3: Weekly averaged ^{7}Be-, ^{137}Cs- and ^{210}Pb-activity concentrations in air dust sampled with a HVS at RIVM in 2007. Empty fields indicate that the value was below the detection limit given in Table A2.

Week number	Period	^{7}Be μBq·m^{-3}			^{137}Cs μBq·m^{-3}	^{210}Pb μBq·m^{-3}		
1	29/12-05/01	2400	±	200		350	±	40
2	05/01-12/01	3000	±	300		133	±	15
3	12/01-19/01	2700	±	200		220	±	20
4	19/01-26/01	2900	±	300		154	±	15
5 (1)	26/01-02/02	1920	±	170		119	±	11
6 (1)	02/02-09/02	1940	±	170		128	±	17
7	09/02-16/02	2500	±	200		143	±	14
8	16/02-23/02	3500	±	300		470	±	50
9	23/02-02/03	2300	±	200		165	±	15
10	02/03-09/03	2800	±	200		186	±	19
11	09/03-16/03	3400	±	300		250	±	30
12	16/03-23/03	2600	±	200		161	±	15
13	23/03-30/03	7000	±	600		900	±	80
14	30/03-06/04	5200	±	500		570	±	50
15	06/04-13/04	4300	±	400		300	±	30
16	13/04-20/04	5500	±	500		470	±	50
17	20/04-27/04	7200	±	600		600	±	50
18	27/04-04/05	6000	±	500		570	±	60
19	04/05-11/05	5300	±	500		360	±	30
20	11/05-18/05	3000	±	300		176	±	16
21	18/05-25/05	6300	±	600		370	±	40
22	25/05-01/06	5500	±	500		300	±	30
23	01/06-08/06	7100	±	600		680	±	60
24	08/06-15/06	4800	±	400		770	±	70
25	15/06-22/06	4100	±	400		240	±	40
26	22/06-29/06	3600	±	300		190	±	18

To be continued on the next page.

Table A3: Continued

Week number	Period	^{7}Be µBq·m^{-3}			^{137}Cs µBq·m^{-3}		^{210}Pb µBq·m^{-3}		
27	29/06-06/07	2800	±	200			158	±	19
28	06/07-13/07	3000	±	300			200	±	20
29	13/07-20/07	3500	±	300			310	±	30
30	20/07-27/07	4000	±	300			230	±	20
31	27/07-03/08	2800	±	200			158	±	15
32	03/08-10/08	4300	±	400			360	±	30
33	10/08-17/08	2900	±	200			220	±	20
34	17/08-24/08	2800	±	200			290	±	30
35	24/08-31/08	3600	±	300			340	±	30
36	31/08-07/09	2500	±	200			179	±	17
37	07/09-14/09	2600	±	200			230	±	20
38	14/09-21/09	4100	±	400			270	±	30
39	21/09-28/09	3700	±	300			430	±	40
40 [2]	28/09-05/10	2080	±	180			430	±	40
41	05/10-12/10	3600	±	300			500	±	40
42 [2]	12/10-19/10	5000	±	400			730	±	70
43	19/10-26/10	4400	±	400			670	±	70
44	26/10-02/11	3200	±	300			920	±	80
45	02/11-09/11	3400	±	300			260	±	20
46	09/11-16/11	2400	±	200			300	±	30
47 [1, 2]	16/11-23/11	4200	±	400			850	±	80
48 [1]	23/11-29/11	5100	±	400			330	±	30
49 [1]	29/11-07/12	3100	±	300			160	±	20
50	07/12-14/12	2700	±	200			173	±	19
51 [1]	14/12-21/12	4700	±	400			540	±	50
52 [2]	21/12-28/12	3900	±	300			1160	±	110
	Average	3790	±	50 [3]		-	372	±	6 [3]
	SD [4]			1300		-			200

[1] Due to problems with on the High Volume Sampler sampling occurred with a lower flow (about one third of regular flow) during 0.2 to 1.3 days of the week.
[2] Due to problems with or maintenance on the High Volume Sampler sampling did not occur at all during 0.3 to 2.4 days of the week.
[3] 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.
[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 2007.

Month	Precipitation mm	^{3}H (1) Bq·m^{-2}			Gross α Bq·m^{-2}			Gross β Bq·m^{-2}		
January	135.1	<	220		2.2	±	0.4	9.3	±	0.7
February	93.6	<	150		1.2	±	0.2	6.0	±	0.5
March	76.1	<	120		2.2	±	0.3	5.8	±	0.5
April	0.0		- (2)		2.1	±	0.3	3.3	±	0.3
May (3)	132.9 (35.0) (3)	<	60		1.5	±	0.2	6.4	±	0.5
June	98.0	<	160		5.5	±	0.6	15.9	±	1.2
July	156.3	<	250		2.5	±	0.3	9.2	±	0.7
August	38.5	<	60		1.8	±	0.3	8.6	±	0.7
September	78.0	<	130		1.3	±	0.3	5.9	±	0.5
October	36.5		90	± 20	1.3	±	0.3	5.2	±	0.4
November	60.2		160	± 30	1.7	±	0.3	6.2	±	0.5
December	78.4		150	± 40	1.0	±	0.2	2.7	±	0.2
Total	984 (886) (3)		-		24.4	±	1.2 (4)	85	±	2 (4)
Lower limit (5)	-		335		-			-		
Upper limit (5)	-		1600		-			-		

(1) The detection limit (Bq·m^{-2}) is mainly dependent on the amount of precipitation since the detection limit of the counting sample itself is more or less constant (1.6 Bq·l^{-1}).

(2) No wet precipitation occurred during this month hence no sample for ^{3}H was collected.

(3) Due to vandalism the samples for ^{3}H, gross α and gross β of May was lost up until the 22nd of May. The collected sample was from 22nd of May onwards. Between brackets a corrected precipitation (mm) is given which takes into account this shorten period in May.

(4) The uncertainty in the sum is equal to the square root of the sum of the squared monthly uncertainties. Uncertainties are given as 1σ.

(5) The lower and upper limits are defined in Appendix B.

Table A5: Yearly totals for long-lived gross α-, gross β- and ^{3}H-activity in deposition for 1993-2007. Either the yearly total with uncertainty [(1)] or the lower and upper limits [(2)] of the 68% confidence range are given.

Year	Precipitation mm	^{3}H Bq·m^{-2}			Gross α Bq·m^{-2}			Gross β Bq·m^{-2}		
1993	886	1310	±	30	54.3	±	0.7	87.8	±	0.8
1994	1039	1210	±	30	52	±	2	91	±	3
1995	724	970	±	40	33.6	-	44.6	95	±	8
1996	626	970	±	50	16.4	±	1.5	67	±	5
1997	760	1160	±	60	22.0	-	25.0	87	±	3
1998	1238	1090	-	2190	31.1	±	1.3	106	±	3
1999	916	1420	-	1900	25.5	±	1.1	84	±	2
2000	935	260	-	1440	35.2	±	1.3	104	±	3
2001	1053	0	-	2420	23.9	±	1	97	±	3
2002	965	300	-	1710	20.6	±	0.9	97	±	2
2003	605	260	-	1080	13.6	-	16.7	70.0	±	1.8
2004	875	0	-	1600	14.3	-	17.1	73.5	±	1.8
2005	856	0	-	1530	17.6	±	1.0	88	±	2
2006	854	280	-	1820	25.7	±	1.5	98	±	3
2007	984	335	-	1600	24.4	±	1.2	85	±	2

(1) Uncertainties are given as 1σ.
(2) A lower and upper limit is given as defined in Appendix B.

Table A6: Monthly deposited ^{210}Po-activity [(1)] sampled at RIVM in 2007.

Month	^{210}Po Bq·m^{-2}		
January	1.11	±	0.14
February	1.10	±	0.06
March	0.46	±	0.11
April	0.45	±	0.06
May [(2)]	0.43	±	0.11
June	2.1	±	0.2
July	0.59	±	0.16
August	1.03	±	0.15
September	1.06	±	0.12
October	1.44	±	0.06
November	1.12	±	0.09
December	1.09	±	0.05
Total	12.0	±	0.4
Lower limit [(3)]	-		
Upper limit [(3)]	-		

(1) Measurements are carried out using α-spectroscopy. Uncertainties are given as 1σ.
(2) Due to vandalism the samples for ^{210}Po of May was lost up until the 22nd of May. The collected sample was from 22nd of May onwards.
(3) The lower and upper limits are defined in Appendix B.

Table A7: Yearly totals for ^{7}Be, ^{137}Cs, ^{210}Pb- and ^{210}Po-activity in deposition for 1993-2007. Either the yearly total with uncertainty [1] or the lower and upper limits [2] of the 68% confidence range are given.

Year	^{7}Be [3]	^{137}Cs [3]	^{210}Pb [3]	^{210}Pb [4]	^{210}Po [4]
	$Bq \cdot m^{-2}$	$Bq \cdot m^{-2}$	$Bq \cdot m^{-2}$	$Bq \cdot m^{-2}$	$Bq \cdot m^{-2}$
1993	1090 ± 20	0.50 - 0.76	105 ± 2	78 ± 3	7.2 ± 0.5
1994	1320 ± 30	0.36 - 0.71	118 ± 3	82 ± 3	12.0 - 14.2
1995	990 ± 20	0.37 - 0.63	96 ± 2	- [5]	- [5]
1996	920 ± 20	0.52 - 0.83	63 - 67	57 ± 3	9 ± 2
1997	1090 ± 30	0.11 - 0.69	65 - 69	80 ± 4	0 - 10.2
1998	1840 ± 50	0.56 - 0.85	162 ± 4	91 ± 4	3.0 - 15.1
1999	1580 ± 30	1.16 - 1.99	158 ± 4	- [6]	0.7 - 5.3
2000	1490 ± 30	0.00 - 4.82	177 ± 6	-	0.6 - 8.0
2001	1480 ± 30	0.00 - 4.50	83 - 104	-	6.5 - 9.4
2002	1510 ± 30	0.00 - 5.22	119 - 142	-	6.1 - 8.5
2003	1000 - 1050	0.00 - 4.69	88 - 113	-	4.3 - 5.6
2004	1330 ± 30	0.22 - 5.53	64 - 102	-	5.4 - 7.7
2005	1320 ± 30	0.00 - 6.09	87 - 117	-	8.9 - 10.2
2006	1400 ± 30	0.06 - 7.47	66 - 103	-	14.1 - 15.6
2007	1760 ± 40	0.11 - 7.37	72 - 132	-	12.0 ± 0.4

[1] Uncertainties are given as 1σ.
[2] A lower and upper limit is given as defined in Appendix B.
[3] Data from γ-spectroscopy.
[4] Data from α-spectroscopy.
[5] Result rejected [56].
[6] α-spectroscopy analysis of ^{210}Pb stopped in 1999.
(-) No analysis.

Table A8: Weekly deposited ^{7}Be-, ^{137}Cs- and ^{210}Pb-activity (1) sampled at RIVM in 2007.

Week Number	Period	Precipitation mm	^{7}Be Bq·m^{-2}	^{137}Cs Bq·m^{-2}	^{210}Pb Bq·m^{-2}
1	29/12-05/01	28.0	45 ± 5	< 0.12	< 1.3
2	05/01-12/01	36.0	56 ± 7	< 0.14	< 3.4
3	12/01-19/01	47.5	66 ± 8	< 0.37	4.9 ± 1.1
4	19/01-26/01	17.0	52 ± 6	< 0.13	2.1 ± 0.7
5	26/01-02/02	6.6	23 ± 3	< 0.14	< 1.4
6	02/02-09/02	9.0	12.7 ± 1.7	< 0.12	< 1.2
7	09/02-16/02	34.5	41 ± 5	< 0.11	< 1.4
8	16/02-23/02	2.6	10.1 ± 1.4	< 0.11	< 1.2
9	23/02-02/03	47.5	56 ± 7	< 0.12	2.0 ± 0.7
10	02/03-09/03	46.5	63 ± 8	< 0.14	3.3 ± 0.7
11	09/03-16/03	4.6	8.6 ± 1.3	< 0.37	< 1.3
12	16/03-23/03	25.0	49 ± 6	< 0.12	1.9 ± 0.5
13	23/03-30/03	0.0	6.3 ± 1.2	< 0.21	2.4 ± 0.6
14	30/03-06/04	0.3	8.2 ± 1.2	< 0.15	< 3.0
15	06/04-13/04	0.0	4.4 ± 1.0	< 0.08	< 4.0
16	13/04-20/04	0.0	2.6 ± 0.8	< 0.13	1.9 ± 0.6
17	20/04-27/04	0.0	5.6 ± 1.0	< 0.10	3.4 ± 0.6
18	27/04-04/05	0.0	2.9 ± 0.7	< 0.12	< 1.9
19	04/05-11/05	74.0	85 ± 10	< 0.10	2.9 ± 0.7
20	11/05-18/05	20.5	46 ± 6	< 0.10	< 3.0
21	18/05-25/05	3.4	24 ± 3	< 0.12	< 1.4
22	25/05-01/06	35.0	91 ± 11	< 0.13	4.5 ± 0.7
23	01/06-08/06	0.0	15 ± 2	< 0.17	4.8 ± 1.0
24	08/06-15/06	31.0	114 ± 14	< 0.13	7.1 ± 1.0
25	15/06-22/06	18.0	47 ± 6	< 0.13	< 3.3
26	22/06-29/06	49.0	66 ± 8	< 0.11	2.3 ± 0.6

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Table A8: Continued.

Week Number	Period	Precipitation mm	^{7}Be Bq·m^{-2}	^{137}Cs Bq·m^{-2}	^{210}Pb Bq·m^{-2}
27	29/06-06/07	71.5	103 ± 12	< 0.13	3.1 ± 0.6
28	06/07-13/07	10.2	30 ± 4	< 0.13	2.0 ± 0.7
29	13/07-20/07	3.6	19 ± 2	< 0.14	3.3 ± 0.8
30	20/07-27/07	39.0	64 ± 8	< 0.14	< 3.2
31	27/07-03/08	32.0	36 ± 4	< 0.13	1.5 ± 0.4
32	03/08-10/08	1.7	23 ± 3	< 0.12	3.0 ± 0.8
33	10/08-17/08	28.0	46 ± 6	< 0.16	3.7 ± 0.9
34	17/08-24/08	8.7	19 ± 2	0.16 ± 0.05	< 1.6
35	24/08-31/08	0.1	5.2 ± 1.0	< 0.17	< 2.5
36	31/08-07/09	22.5	26 ± 3	< 0.12	< 1.4
37	07/09-14/09	7.0	15 ± 2	< 0.10	< 1.3
38	14/09-21/09	20.0	28 ± 4	< 0.23	< 1.2
39	21/09-28/09	28.5	32 ± 4	< 0.14	10.3 ± 1.5
40	28/09-05/10	17.5	24 ± 3	< 0.21	2.1 ± 0.7
41	05/10-12/10	0.5	5.3 ± 1.0	< 0.13	< 1.4
42	12/10-19/10	8.3	17 ± 2	< 0.14	< 1.5
43	19/10-26/10	0.6	8.6 ± 1.2	< 0.12	< 1.2
44	26/10-02/11	9.6	25 ± 3	< 0.11	< 1.3
45	02/11-09/11	22.0	59 ± 7	< 0.12	1.6 ± 0.5
46	09/11-16/11	25.8	53 ± 6	< 0.12	1.6 ± 0.4
47	16/11-23/11	3.4	6.1 ± 1.0	< 0.13	< 1.4
48	23/11-30/11	9.0	24 ± 3	< 0.14	< 1.4
49	30/11-07/12	61.0	60 ± 7	< 0.10	< 1.3
50	07/12-14/12	16.5	29 ± 4	< 0.11	< 1.4
51	14/12-21/12	0.1	2.4 ± 0.7	< 0.15	< 1.4
52	21/12-28/12	0.9	3.8 ± 0.9	< 0.14	< 1.4
Total [2]		984	1760 ± 40	-	-
Lower limit [3]		-	-	0.11	72
Upper limit [3]		-	-	7.37	132

[1] Measurements are 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 averaged α-activity concentration in air and ambient dose equivalent rate in 2007 as measured by the NMR stations equipped with aerosol monitors.

Station	No.	α-Activity concentration $Bq.m^{-3}$	Ambient dose equivalent rate [1] $nSv.h^{-1}$
Arnhem (2)	970	3.1	67
Kollumerwaard	972	2.5	71
Valthermond (3)	974	2.4	61
Vlaardingen	976	3.0	71
Braakman	978	2.1	67
Huijbergen	980	3.0	58
Houtakker	982	2.2	63
Wijnandsrade	984	4.8	71
Eibergen	986	3.1	61
De Zilk	988	2.2	65
Wieringerwerf	990	2.5	69
Vredepeel (4)	992	3.3	69
Biddinghuizen (4)	994	3.1	74
Bilthoven	998	2.8	61

[1] These dose equivalent rate monitors are differently placed from the 153 dose equivalent rate monitors (Table A10) with regard to height and surface covering.
[2] Since December 2006 the station Wageningen has been replaced by the station Arnhem.
[3] This station was formerly known as Witteveen.
[4] During 2006 the dose equivalent rate monitors (RS02) were replaced by a newer model (RS03). For the other stations the replacement took place in 2005.

Table A10: The yearly averaged ambient dose equivalent rate for the NMR stations in 2007.

Station	No.	Ambient dose equivalent rate nSv.h^{-1}	Station	No.	Ambient dose equivalent rate nSv.h^{-1}
Den Burg	1001	78	Urk	1105	76
Den Oever	1003	69	Eemshaven	1106	84
Julianadorp	1004	65	Uithuizen	1107	83
Petten	1006	61	Wagenborgen	1109	75
Kolhorn	1007	79	Winschoten	1110	71
Egmond Aan Zee	1009	67	Ter Apel	1111	72
Heerhugowaard	1011	73	Stadskanaal	1112	63
Haarlem-Noord	1014	74	Nieuweschans	1113	72
Nederhorst den Berg	1015	60	Bellingwolde	1114	60
Enkhuizen	1018	80	Groningen	1116	75
Oosthuizen	1019	78	Leens	1117	84
Zaandam	1021	67	Grijpskerk	1118	72
Gouda	1024	71	Meppel	1125	67
Dordrecht	1027	62	Hoogeveen	1126	61
Zuid Beijerland	1028	74	Steenwijksmoer	1129	65
Pijnacker	1032	87	Nieuw Amsterdam	1130	79
Rotterdam-Crooswijk	1033	73	Nw Schoonebeek/	1131	61
Rotterdam-Waalhaven	1034	71	Weiteveen		
Maasvlakte	1035	84	Emmen	1132	81
Maassluis	1037	82	Hengelo (Ov)	1135	69
Hellevoetsluis	1038	92	Hengelo (Gld) [(1)]	1136	-
Ouddorp	1039	73	Enschede [(1)]	1139	-
Wekerom	1041	73	Losser	1140	62
Wageningen	1043	69	Oldenzaal	1141	77
Hooglanderveen [(1)]	1046	-	Westerhaar	1142	63
Harderwijk	1050	65	Rijssen	1143	66
Wijk Bij Duurstede	1056	82	's Heerenberg	1144	62
Rhenen	1061	75	Dinxperlo	1145	78
Nieuwegein	1062	80	Varsseveld	1146	72
Apeldoorn	1066	70	Groenlo	1147	83
Heerenveen	1071	63	Deventer	1148	77
Oosterwolde	1072	80	Etten-Leur	1154	69
Bergum	1074	68	Den Bosch	1157	69
Witmarsum	1076	88	Raamsdonkveer	1159	92
Sneek	1077	71	Ulvenhout	1160	73
St Jacobiparochie	1081	78	Baarle-Nassau	1161	92
Holwerd	1082	88	Uden	1162	71
Leeuwarden	1085	68	Mill	1163	64
Zwolle-Zuid	1087	73	Oss	1167	65
Ommen	1093	64	Nuenen	1172	71
Hardenberg	1095	64	Bergeijk	1174	88
Assen	1097	65	Waalre	1175	69
Rutten	1099	75	Someren (Dorp)	1176	69
Lelystad	1103	76	Oisterwijk	1178	73

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Table A10: Continued.

Station	No.	Ambient dose equivalent rate nSv.h^{-1}	Station	No.	Ambient dose equivalent rate nSv.h^{-1}
Riel	1179	71	Hoensbroek	1225	83
Oostelbeers	1180	83	Gennep	1228	79
Hilvarenbeek	1181	65	Elst (Gld)	1229	82
Venray	1183	62	Zevenaar	1230	72
Nieuw-Bergen	1184	62	Nijmegen	1231	74
Sevenum	1185	69	Amstelveen	1233	73
Reuver	1188	65	Amsterdam Oost (1)	1234	-
Nederweert	1189	71	Aalsmeer	1236	71
Heythuysen	1190	74	Nispen	1237	62
Mariahoop	1191	69	Groesbeek	1240	77
Stramproy	1192	64	Tubbergen	1243	66
Arnhem-Oosterbeek	1193	76	Haaksbergen	1244	67
Leiden	1196	72	Scheveningen	1247	77
Hulst	1197	75	Zaltbommel	1251	71
Terneuzen	1199	71	IJzendijke	1252	77
Sluis	1201	74	Ritthem	1253	99
Vlissingen	1202	77	Vlissingen Haven	1254	72
Halsteren	1204	64	Nieuwdorp	1255	75
Oud Gastel	1206	66	's Heerenhoek	1256	74
Goes	1207	83	Driewegen	1257	82
Bruinisse	1209	74	Arnemuiden	1258	72
Burgh-Haamstede	1211	62	Heinkenszand	1259	83
Vrouwenpolder	1212	64	Baarland	1260	86
Wemeldinge	1214	76	Biervliet	1261	76
Middelburg	1215	77	Nummer Één	1262	76
Westkapelle	1216	68	Rilland	1263	75
Noordwijk-Binnen	1217	74	Putte	1264	56
Stein	1219	79	Nieuw Namen	1265	80
Maastricht	1220	89	Beneden Leeuwen	1272	83
Ravensbos	1221	92	Denekamp	1278	64
Vaals	1222	82	Winterswijk/Kotten	1279	69
Gulpen	1223	80	Bilthoven	1280	61
Kerkrade	1224	89	Maarheze/Gastel	1281	74

(1) *Station was not operational in 2007.*

Table A11: Gross α, residual β, ^{3}H-, ^{90}Sr- and ^{226}Ra-activity concentrations (mBq·L^{-1}) in surface water in 2007 as measured by RIZA.

Date	Gross α mBq·L^{-1}	Residual β mBq·L^{-1}	^{3}H mBq·L^{-1}	^{90}Sr mBq·L^{-1}	^{226}Ra mBq·L^{-1}
Location	**IJsselmeer**				
10/01/07	90	71			
06/02/07	29	35	3400		
06/03/07	110	73			
03/04/07	36	21	4100		
02/05/07	26	21			
30/05/07	43	26	2900		
26/06/07	39	47			
24/07/07	20	43	3000		
21/08/07	43	< 1			
18/09/07	37	15	3400		
16/10/07	48	26			
13/11/07	41	23	3000		
11/12/07	74	43			
Average	49	34	3300		
Location	**Nieuwe Waterweg**				
24/01/07	250	250	2200	3	5
21/02/07	140	130			
21/03/07	130	110	3900	< 1	5
18/04/07	92	60			
15/05/07	79	35	6400	2	4
13/06/07	100	21			
11/07/07	76	41	4100	< 1	4
08/08/07	64	22			
05/09/07	77	34	2900	< 1	3
03/10/07	73	44			
31/10/07	92	69	6300	1	5
28/11/07	140	69			
27/12/07	120	54	4600	< 1	4
Average	110	72	4300	< 1.1	4.3
Location	**Noordzeekanaal**				
19/02/07	160	39	2100		
19/04/07	120	12	1500		
11/06/07	180	47	2200		
06/08/07	100	28	2300		
01/10/07	54	27	3200		
26/11/07	110	44	3600		
Average	121	33	2500		

To be continued on the next page.

Table A11: Continued.

Date	Gross α	Residual β	^{3}H	^{90}Sr	^{226}Ra
	mBq·L^{-1}	mBq·L^{-1}	mBq·L^{-1}	mBq·L^{-1}	mBq·L^{-1}
Location	**Rhine**				
17/01/07	70	42	1500		
14/02/07	65	38	6500	2	2
14/03/07	52	32	2500		
11/04/07	54	28	3000	2	3
09/05/07	41	30	8500		
06/06/07	60	34	3300	4	3
04/07/07	72	37	2500		
01/08/07	22	7	3800	4	3
29/08/07	68	15	2100		
26/09/07	55	28	2000	5	4
24/10/07	45	17	5200		
21/11/07	18	< 1	8100	2	3
19/12/07	69	52	4500		
Average	53	28	4100	3.2	3.0
Location	**Scheldt**				
08/01/07	130	52	5300		6
05/02/07	250	110			
07/03/07	170	100	2100		8
04/04/07	220	110			
02/05/07	140	89	8400		14
29/05/07	280	60			
25/06/07	270	80	15000		15
23/07/07	320	60			
20/08/07	500	110	7200		13
17/09/07	300	120			
15/10/07	270	85	10000		14
14/11/07	270	100			
12/12/07	170	76	5700		8
Average	250	89	7700		11.1
Location	**Meuse**				
16/01/07	56	4	110		
13/02/07	63	56	11000	< 1	3
13/03/07	35	38	870		
10/04/07	22	1	34000	4	2
08/05/07	26	7	27000		
05/06/07	28	< 1	29000	< 1	3
03/07/07	44	27	29000		
31/07/07	69	60	15000	< 1	2
28/08/07	48	46	760		
25/09/07	25	6	25000	4	2
23/10/07	19	< 1	13000		
20/11/07	53	72	26000	< 1	2
18/12/07	52	41	7500		
Average	42	28	17000	< 1.7	2.3

Table A12: ^{60}Co-, ^{131}I-, ^{137}Cs- and ^{210}Pb-activity concentrations in suspended solids (Bq·kg^{-1}) in surface water in 2007 as measured by RIZA.

Date	^{60}Co Bq·kg^{-1}	^{131}I Bq·kg^{-1}	^{137}Cs Bq·kg^{-1}	^{210}Pb Bq·kg^{-1}
Location	**IJsselmeer**			
10/01/07	< 1	< 1	9	
06/02/07	< 1	< 1	8	
06/03/07	< 1	< 1	12	
03/04/07	< 1	< 1	12	
02/05/07	< 1	< 1	7	
30/05/07	< 1	< 1	6	
26/06/07	< 1	< 1	5	
24/07/07	< 1	< 1	4	
21/08/07	< 1	< 1	4	
18/09/07	< 1	< 1	3	
16/10/07	< 1	< 1	4	
13/11/07	< 1	< 1	4	
11/12/07	< 1	< 1	7	
Average	< 1	< 1	6.5	
Location	**Ketelmeer**			
05/01/07	< 1	3	16	
01/03/07	< 1	5	21	
26/04/07	< 1	< 1	6	
21/06/07	< 1	< 1	16	
16/08/07	< 1	< 1	16	
11/10/07	< 1	< 1	15	
07/12/07	< 1	< 1	16	
Average	< 1	< 1.5	15.1	
Location	**Nieuwe Waterweg**			
24/01/07	< 1	< 1	12	92
21/02/07	< 1	3	10	
21/03/07	1	2	12	89
18/04/07	< 1	< 1	7	
15/05/07	< 1	< 1	10	87
13/06/07	< 1	< 1	10	
11/07/07	< 1	4	12	89
08/08/07	< 1	< 1	9	
05/09/07	< 1	< 1	13	110
03/10/07	< 1	< 1	11	
31/10/07	< 1	< 1	7	75
28/11/07	< 1	3	11	
27/12/07	< 1	5	10	81
Average	< 1	< 1.6	10.3	89

To be continued on the next page.

Table A12: Continued.

Date	^{60}Co	^{131}I	^{137}Cs	^{210}Pb
	Bq·kg^{-1}	Bq·kg^{-1}	Bq·kg^{-1}	Bq·kg^{-1}
Location	**Noordzeekanaal**			
19/02/07	< 1	4	15	
19/04/07	< 1	21	7	
11/06/07	< 1	< 1	4	
06/08/07	< 1	< 1	5	
01/10/07	< 1	7	7	
26/11/07	< 1	< 1	13	
Average	< 1	6	8.5	
Location	**Rhine**			
17/01/07	< 1	< 1	20	
14/02/07	< 1	10	19	120
14/03/07	< 1	2	15	
11/04/07	< 1	5	17	100
09/05/07	< 1	8	12	
06/06/07	< 1	4	16	110
04/07/07	< 1	6	15	
01/08/07	< 1	< 1	12	110
29/08/07	< 1	< 1	13	
26/09/07	< 1	< 1	13	110
24/10/07	< 1	< 1	12	
21/11/07	< 1	< 1	20	120
19/12/07	< 1	< 1	17	
Average	< 1	< 3	15.5	112
Location	**Scheldt**			
08/01/07	< 1	< 1	7	83
05/02/07	< 1	3	11	
07/03/07	< 1	7	8	82
04/04/07	< 1	2	7	
02/05/07	< 1	< 1	7	94
29/05/07	< 1	< 1	6	
25/06/07	< 1	< 1	8	75
23/07/07	< 1	< 1	8	
20/08/07	< 1	< 1	9	99
17/09/07	< 1	< 1	7	
15/10/07	< 1	< 1	7	94
14/11/07	< 1	2	8	
12/12/07	4	< 1	8	97
Average	< 1	< 1.4	7.8	89

To be continued on the next page.

Table A12: Continued.

Date	^{60}Co	^{131}I	^{137}Cs	^{210}Pb
	Bq·kg^{-1}	Bq·kg^{-1}	Bq·kg^{-1}	Bq·kg^{-1}
Location	Meuse			
02/01/07	15	11	14	
09/01/07	< 1	< 1	14	
16/01/07	3	11	15	
23/01/07	< 1	4	12	
30/01/07	6	< 1	15	
06/02/07	3	18	15	
13/02/07	3	19	11	110
20/02/07	10	7	16	
27/02/07	< 1	10	12	
06/03/07	1	5	14	
13/03/07	1	5	11	
20/03/07	4	25	9	
27/03/07	3	22	11	
03/04/07	6	15	10	
11/04/07	9	49	10	120
17/04/07	5	55	7	
24/04/07	6	< 1	8	
01/05/07	8	27	9	
08/05/07	8	25	12	
15/05/07	6	45	10	
22/05/07	< 1	< 1	13	
29/05/07	7	< 1	10	
05/06/07	5	25	11	160
12/06/07	8	66	13	
19/06/07	5	16	12	
26/06/07	6	21	13	
03/07/07	7	18	11	
10/07/07	8	18	11	
17/07/07	7	12	12	
24/07/07	5	27	11	
31/07/07	7	64	14	190
07/08/07	5	42	3	
15/08/07	8	33	14	
21/08/07	3	7	10	
28/08/07	8	18	14	
04/09/07	9	28	11	
11/09/07	8	32	13	
18/09/07	8	< 1	11	
25/09/07	10	22	14	160
02/10/07	7	21	12	
09/10/07	9	70	14	
16/10/07	7	31	13	
23/10/07	7	44	11	
31/10/07	8	33	16	

To be continued on the next page.

Table A12: Continued.

Date	^{60}Co	^{131}I	^{137}Cs	^{210}Pb
	Bq·kg^{-1}	Bq·kg^{-1}	Bq·kg^{-1}	Bq·kg^{-1}
Location	Meuse			
06/11/07	10	44	13	
13/11/07	5	19	14	
20/11/07	13	< 1	16	160
27/11/07	18	38	11	
04/12/07	< 1	< 1	12	
11/12/07	< 1	< 1	14	
19/12/07	12	< 1	15	
27/12/07	9	33	15	
Average	6.3	22	12.2	150

Table A13: Gross α-, residual β-, ^{3}H- and ^{90}Sr-activity concentrations ($mBq \cdot L^{-1}$) in seawater in 2007 as measured by RIZA.

Date	Gross α $mBq \cdot L^{-1}$	Residual β $mBq \cdot L^{-1}$	^{3}H $mBq \cdot L^{-1}$	^{90}Sr $mBq \cdot L^{-1}$
Location	**Coastal area**			
15/02/07	460	64	4900	
09/05/07	310	54	3400	
16/08/07	480	70	3300	
19/12/07	350	58	5200	
Average	400	62	4200	
Location	**Southern North Sea**			
14/02/07	390	34	4000	< 1
23/05/07	320	54	5200	2
23/08/07	310	54	1300	< 1
19/12/07	480	48	3600	< 1
Average	380	48	3500	< 1
Location	**Central North Sea**			
14/02/07	540	66	580	< 1
22/05/07	670	47	180	< 1
28/08/07	350	37	290	< 1
18/12/07	500	48	< 100	< 1
Average	520	50	280	< 1
Location	**Delta Coastal Waters**			
23/01/07	420	79		
15/02/07	390	75	5400	< 1
22/03/07	680	110		
23/04/07	490	46		
23/05/07	670	45	3700	2
14/06/07	410	74		
25/07/07	460	65		
23/08/07	470	45	4900	< 1
13/09/07	330	63		
22/10/07	130	51		
28/11/07	510	71	5100	< 1
17/12/07	n/a	n/a		
Average	450	66	4800	< 1

To be continued on the next page.

Table A13: Continued.

Date	Gross α mBq·L^{-1}	Residual β mBq·L^{-1}	^{3}H mBq·L^{-1}	^{90}Sr mBq·L^{-1}
Location	**Westerscheldt**			
15/01/07	330	58	6300	5
05/02/07	410	130	6900	3
05/03/07	340	49	5100	< 1
02/04/07	360	48	4700	4
02/05/07	640	72	5600	< 1
29/05/07	300	110	4800	< 1
27/06/07	480	49	5700	< 1
25/07/07	450	39	5200	2
22/08/07	610	99	3900	4
19/09/07	480	58	3900	< 1
16/10/07	370	39	4300	2
12/11/07	320	80	3300	< 1
10/12/07	450	49	4800	< 1
Average	420	66	4900	1.9
Location	**Eems-Dollard**			
14/02/07	410	80	5100	
14/05/07	200	32	4600	
22/08/07	500	57	2900	
21/11/07	230	51	3100	
Average	340	55	3900	
Location	**Wadden Sea West**			
16/02/07	200	82	6400	
16/05/07	510	89	3200	
10/08/07	570	79	3500	
13/11/07	370	45	2200	
Average	410	74	3800	
Location	**Wadden Sea East**			
16/02/07	260	180	4500	
11/05/07	460	84	3300	
16/08/07	360	130	4000	
07/11/07	360	130	3000	
Average	360	131	3700	

n/a = data not available due to insufficient amount of collected suspended solids.

Table A14: ^{137}Cs- and ^{210}Po-activity concentrations in suspended solids (Bq·kg^{-1}) in seawater in 2007 as measured by RIZA. Since 2006 ^{137}Cs and ^{210}Pb are no longer determined at Wadden Sea West due to repeatedly insufficient amount of collected suspended solids in previous years.

Date	^{137}Cs Bq·kg^{-1}	^{210}Po Bq·kg^{-1}
Location	**Coastal area**	
12/02/07	n/a	n/a
14/05/07	8	78
13/08/07	5	74
12/11/07	n/a	n/a
Average	6.5	76
Location	**Westerscheldt**	
05/02/07	4	57
30/04/07	n/a	n/a
21/08/07	5	66
15/11/07	5	78
Average	4.7	67
Location	**Eems-Dollard**	
06/02/07	9	100
04/05/07	5	89
16/08/07	7	100
02/11/07	8	110
Average	7.2	100
Location	**Wadden Sea East**	
16/02/07	6	100
11/05/07	6	73
14/08/07	3	62
07/11/07	6	87
Average	5.2	80

n/a = data not available due to insufficient amount of collected suspended solids.

Table A15: Monthly averaged gross α-activity concentrations in air dust in the vicinity of the nuclear power plant at Borssele.

Date [1]			Gross α [2] mBq·m^{-3}		
Location	**21**	**22**	**23**	**27**	**29**
07/02/07	0.152	0.208	0.55	0.015	0.032
07/03/07	0.047	0.115	0.169	0.023	0.007
05/04/07	0.046	0.062	0.221	0.039	0.121
03/05/07	0.051	0.064	0.095	0.064	0.071
06/06/07	0.043	0.123	0.084	0.038	0.058
05/07/07	0.040	0.096	0.54	0.098	0.040
06/08/07	0.056	0.059	0.159	0.028	0.057
05/09/07	0.021	0.055	0.367	0.039	0.032
03/10/07	0.060	0.050	0.34	0.014	0.070
07/11/07	0.145	0.259	0.153	0.031	0.034
06/12/07	0.118	0.162	0.64	0.032	0.048
07/01/08	0.056	0.105	0.189	0.145	0.028

[1] End date of monthly sampling period.

[2] Gross α-activity concentrations in air dust are given as indicative values.

Table A16: Monthly averaged gross β-activity concentrations in air dust in the vicinity of the nuclear power plant at Borssele.

Date [1]			Gross β mBq·m^{-3}		
Location	**21**	**22**	**23**	**27**	**29**
07/02/07	0.21 ± 0.02	0.297 ± 0.014	0.51 ± 0.02	0.048 ± 0.019	0.130 ± 0.011
07/03/07	0.13 ± 0.03	0.220 ± 0.018	0.21 ± 0.02	0.13 ± 0.02	0.100 ± 0.014
05/04/07	0.34 ± 0.03	0.40 ± 0.02	0.47 ± 0.03	0.18 ± 0.03	0.397 ± 0.016
03/05/07	0.34 ± 0.03	0.382 ± 0.019	0.37 ± 0.02	0.34 ± 0.03	0.270 ± 0.015
06/06/07	0.152 ± 0.014	0.371 ± 0.015	0.236 ± 0.014	0.130 ± 0.012	0.283 ± 0.014
05/07/07	0.110 ± 0.012	0.291 ± 0.020	0.88 ± 0.06	0.30 ± 0.03	0.212 ± 0.016
06/08/07	0.16 ± 0.02	0.194 ± 0.014	0.30 ± 0.02	0.090 ± 0.020	0.188 ± 0.012
05/09/07	0.11 ± 0.02	0.212 ± 0.018	0.34 ± 0.02	0.19 ± 0.02	0.159 ± 0.014
03/10/07	0.08 ± 0.03	0.182 ± 0.017	0.97 ± 0.06	0.25 ± 0.03	0.186 ± 0.017
07/11/07	0.40 ± 0.02	0.457 ± 0.018	0.44 ± 0.02	0.35 ± 0.02	0.266 ± 0.016
06/12/07	0.35 ± 0.03	0.359 ± 0.018	0.93 ± 0.03	0.17 ± 0.02	0.33 ± 0.02
07/01/08	0.42 ± 0.03	0.49 ± 0.02	0.47 ± 0.02	0.62 ± 0.04	0.73 ± 0.04

[1] End date of monthly sampling period.

Table A17: Monthly averaged activity concentrations of γ-emitters in air dust in the vicinity of the nuclear power plant at Borssele. Analysis is performed on a combined sample of the monthly samples of all five locations (21, 22, 23, 27 and 29).

Date [1]	^{60}Co	$^{131}I_{el}$ [2]	$^{131}I_{or}$ [2]	^{137}Cs	Nat. [3]
Location	mBq·m^{-3}	mBq·m^{-3}	mBq·m^{-3}	mBq·m^{-3}	mBq·m^{-3}
07/02/07	< 0.06	< 0.1	< 0.2	< 0.042	1.68 ± 0.19
07/03/07	< 0.08	< 0.1	< 0.6	< 0.052	1.2 ± 0.2
05/04/07	< 0.034	< 0.2	< 0.3	< 0.034	1.4 ± 1.0
03/05/07	< 0.038	< 0.2	< 0.3	< 0.032	1.24 ± 0.11
06/06/07	< 0.051	< 0.1	< 0.1	< 0.036	2.13 ± 0.17
05/07/07	< 0.07	< 0.1	< 0.3	< 0.052	1.99 ± 0.18
06/08/07	< 0.06	< 0.1	< 0.2	< 0.045	1.1 ± 0.2
05/09/07	< 0.038	< 0.1	< 0.1	< 0.033	1.23 ± 0.04
03/10/07	< 0.045	< 0.1	< 0.3	< 0.039	1.1 ± 0.2
07/11/07	< 0.07	< 0.2	< 0.2	< 0.050	1.54 ± 0.08
06/12/07	< 0.036	< 0.1	< 0.3	< 0.036	1.63 ± 0.08
07/01/08	< 0.044	< 0.2	< 0.1	< 0.038	2.09 ± 0.17

[1] End date of monthly sampling period.
[2] Elemental respectively organically bound ^{131}I.
[3] Natural occurring γ-emmitters.

Table A18: Activity concentrations of γ-emitters in grass in the vicinity of the nuclear power plant at Borssele. Analysis is performed on a combined sample of the monthly samples of all five locations (21, 22, 23, 27 and 29).

Date	Mass	^{60}Co	^{131}I	^{137}Cs
Location	kg·m^{-2}	Bq·kg^{-1} [1]	Bq·kg^{-1} [1]	Bq·kg^{-1} [1]
07/02/07	0.226	< 3	< 2	< 2
07/03/07	0.171	< 5	< 4	< 3
05/04/07	0.171	< 5	< 4	< 4
03/05/07	0.194	< 3	< 3	< 2
06/06/07	0.256	< 2	< 2	< 2
05/07/07	0.161	< 4	< 3	< 3
06/08/07	0.236	< 3	< 2	< 2
05/09/07	0.214	< 4	< 3	< 3
03/10/07	0.294	< 2	< 2	< 2
07/11/07	0.182	< 3	< 3	< 3
06/12/07	0.374	< 2	< 2	< 1
07/01/08	0.159	< 4	< 3	< 3

[1] Dry weight.

Table A19: Activity concentrations of γ-emitters in soil in the vicinity of the nuclear power plant at Borssele. Analysis is performed on four samples taken near the outlet of the plant on the 24th of May 2007.

Location	Mass	^{54}Mn	^{60}Co	^{134}Cs	^{137}Cs
	kg·m^{-2}	Bq·kg^{-1} [1]	Bq·kg^{-1} [1]	Bq·kg^{-1} [1]	Bq·kg^{-1} [1]
O1	74	< 0.3	< 0.4	< 0.4	0.81 ± 0.11
O2	68.8	< 0.3	< 0.1	< 0.3	0.81 ± 0.08
O3	71.6	< 0.1	< 0.1	< 0.1	0.17 ± 0.016
O4	74.8	< 0.3	< 0.4	< 0.3	1.83 ± 0.09

[1] Dry weight.

Table A20: Residual β-activity concentrations in water from the Westerscheldt.

Date	Residual β Bq·L^{-1}											
Location	1			2			3			4		
07/02/07	0.036	±	0.006	0.033	±	0.005	0.052	±	0.006	0.048	±	0.005
07/03/07	0.093	±	0.006	0.114	±	0.006	0.087	±	0.005	0.042	±	0.005
05/04/07	0.036	±	0.006	0.030	±	0.006	0.062	±	0.006	0.041	±	0.006
03/05/07	0.153	±	0.008	0.114	±	0.007	0.193	±	0.007	0.101	±	0.006
06/06/07	0.070	±	0.007	0.058	±	0.006	0.060	±	0.006	0.085	±	0.005
05/07/07	0.083	±	0.007	0.092	±	0.008	0.059	±	0.006	0.084	±	0.007
06/08/07	0.053	±	0.007	0.069	±	0.006	0.031	±	0.006	0.201	±	0.009
05/09/07	0.073	±	0.007	0.069	±	0.007	0.064	±	0.007	0.097	±	0.005
03/10/07	0.037	±	0.006	0.063	±	0.007	0.061	±	0.006	0.113	±	0.006
07/11/07	0.129	±	0.008	0.125	±	0.007	0.130	±	0.007	0.066	±	0.006
06/12/07	0.048	±	0.006	0.082	±	0.006	0.065	±	0.006	0.132	±	0.006
07/01/08	0.043	±	0.005	0.053	±	0.006	0.042	±	0.005	0.031	±	0.004

Table A21: ^{3}H-activity concentrations in water from the Westerscheldt.

Date	^{3}H Bq·L^{-1}											
Location	1			2			3			4		
07/02/07	7.8	±	1.3	8.9	±	1.3	10.4	±	1.4	9.0	±	1.4
07/03/07	7.9	±	1.3	9.9	±	1.4	8.3	±	1.3	7.1	±	1.3
05/04/07	7.3	±	1.4	8.1	±	1.4	7.6	±	1.4	8.0	±	1.3
03/05/07	8.1	±	1.4	8.7	±	1.4	8.4	±	1.4	7.1	±	1.4
06/06/07	6.6	±	1.4	8.5	±	1.4	9.1	±	1.4	6.8	±	1.4
05/07/07	7.5	±	1.4	9.2	±	1.4	7.8	±	1.4	8.1	±	1.4
06/08/07	8.8	±	1.4	9.6	±	1.4	9.7	±	1.4	8.9	±	1.4
05/09/07	8.8	±	1.4	9.8	±	1.5	9.0	±	1.4	8.7	±	1.4
03/10/07	9.1	±	1.4	9.3	±	1.4	8.3	±	1.4	8.6	±	1.4
07/11/07	8.6	±	1.4	8.9	±	1.4	9.1	±	1.4	8.0	±	1.5
06/12/07	9.0	±	1.4	9.0	±	1.4	8.1	±	1.4	8.7	±	1.4
07/01/08	8.1	±	1.4	7.4	±	1.4	7.1	±	1.4	9.1	±	1.4

Table A22: Gross β-activity concentrations in suspended solids from the Westerscheldt.

Date	Gross β kBq·kg^{-1}											
Location	1			2			3			4		
07/02/07	0.71	±	0.03	0.85	±	0.04	0.85	±	0.03	0.65	±	0.02
07/03/07	0.81	±	0.06	0.90	±	0.07	0.69	±	0.06	0.90	±	0.06
05/04/07	1.2	±	0.2	1.08	±	0.10	0.87	±	0.06	0.96	±	0.08
03/05/07	0.93	±	0.09	1.40	±	0.11	1.77	±	0.11	1.24	±	0.05
06/06/07	1.16	±	0.16	0.68	±	0.06	0.83	±	0.03	0.78	±	0.04
05/07/07	0.80	±	0.05	0.96	±	0.05	0.64	±	0.02	0.66	±	0.03
06/08/07	0.82	±	0.05	0.95	±	0.06	0.73	±	0.03	0.88	±	0.06
05/09/07	0.647	±	0.015	0.75	±	0.03	0.88	±	0.04	1.04	±	0.10
03/10/07	0.69	±	0.05	0.96	±	0.07	0.68	±	0.08	0.95	±	0.06
07/11/07	0.99	±	0.06	1.49	±	0.08	1.31	±	0.09	1.19	±	0.06
06/12/07	1.22	±	0.05	0.74	±	0.11	0.80	±	0.04	0.95	±	0.05
07/01/08	1.15	±	0.06	0.90	±	0.06	0.95	±	0.06	0.79	±	0.05

Table A23: Activity concentrations of γ-emitters in seaweed from the Westerscheldt. Analysis is performed on a combined sample of the monthly samples of all four locations (1, 2, 3 and 4).

Location	Mass kg·m^{-2}	^{60}Co Bq·kg^{-1} (1)	^{131}I Bq·kg^{-1} (1)	^{137}Cs Bq·kg^{-1} (1)
07/02/07	0.198	< 2	2.0 ± 0.3	< 2
07/03/07	0.165	< 3	1.7 ± 0.3	0.6 ± 0.3
05/04/07	0.107	< 4	< 3	2.1 ± 0.6
03/05/07	0.186	< 3	< 2	< 2
06/06/07	0.051	< 8	< 7	< 6
05/07/07	0.099	< 4	1.4 ± 0.5	< 3
06/08/07	0.031	< 4	< 3	< 3
05/09/07	0.024	< 8	< 7	< 7
03/10/07	0.026	< 7	< 4	< 5
07/11/07	0.025	< 5	< 3	< 3
06/12/07	0.028	< 5	< 4	< 4
07/01/08	0.022	< 5	< 4	< 4

(1) *Dry weight.*

Table A24: Activity concentrations of γ-emitters in sediment from the Westerscheldt. Analysis is performed on a combined sample of the monthly samples of all four locations (1, 2, 3 and 4).

Location	Mass $kg \cdot m^{-2}$	^{60}Co $Bq \cdot kg^{-1}$ (1)	^{131}I $Bq \cdot kg^{-1}$ (1)	^{137}Cs $Bq \cdot kg^{-1}$ (1)
07/02/07	38.5	< 0.3	< 0.2	0.56 ± 0.07
07/03/07	38.9	< 0.3	< 0.2	0.74 ± 0.06
05/04/07	31.8	< 0.3	< 0.2	0.93 ± 0.08
03/05/07	31.0	< 0.3	< 0.2	1.52 ± 0.08
06/06/07	37.1	< 0.3	< 0.3	1.06 ± 0.06
05/07/07	38.3	< 0.3	< 0.2	1.19 ± 0.07
06/08/07	31.6	< 0.3	< 0.3	1.24 ± 0.07
05/09/07	35.7	< 0.3	< 0.2	1.34 ± 0.07
03/10/07	31.4	< 0.3	< 0.2	1.22 ± 0.12
07/11/07	29.3	< 1	< 0.9	0.9 ± 0.3
06/12/07	30.7	< 0.4	< 0.3	1.19 ± 0.10
07/01/08	32.9	< 0.4	< 0.3	1.43 ± 0.09

(1) *Dry weight.*

Appendix B The presentation of data

The methods described below have been applied to the data provided by RIVM/LSO (e.g. air dust and deposition). Data from the other institutes are reported as provided.

B.1 Correction for radioactive decay

The activities of specific nuclides, in general, are corrected for radioactive decay. The measured activities in the sample are multiplied with a decay factor containing the time from the middle of the sampling period to the time of analysis, the decay during the measurement and the half-life of the nuclide. In cases where the nuclides are unknown, as with gross α and gross β, a correction for radioactive decay is not 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 nuclide cannot be measured, the detection limit is used in the calculation of the sums. In that case solely 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 level.

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 which is not a detectionlimit
$\sqrt{\sum s_i^2}$	The uncertainty in the sum
s_i	Uncertainty in the weekly or monthly result (1σ)
MDA_i	Weekly or monthly result which is a detectionlimit

The detection limits are omitted in the calculation of the averages. If no data are reported (e.g. no sample is analysed) 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 to A8 are a combination of the statistical uncertainty 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.

Appendix C Glossary

Ambient dose equivalent	An operational quantity used when monitoring radiation in the environment. The unit of ambient dose equivalent is the Sievert (Sv).
Becquerel (Bq)	One radioactive transformation per second.
Decay product	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 daughter product may be stable or it may decay to form a daughter product of its own.
Dose rate	The radiation dose delivered per unit of time.
Effective dose	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).
Gross alpha activity	Gross α (or total α) activity is the total activity of nuclides emitting α radiation.
Gross beta activity	Gross β (or total β) activity is the total activity of nuclides emitting β radiation. Depending on the measurement methodology it might exclude tritium and/or radon daughters.
Radioactivity	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).
Radionuclide	An unstable form of an element that undergoes radioactive decay.
Residual beta activity	The residual β activity is the total β activity (gross β activity) minus the β activity of naturally occurring ^{40}K.

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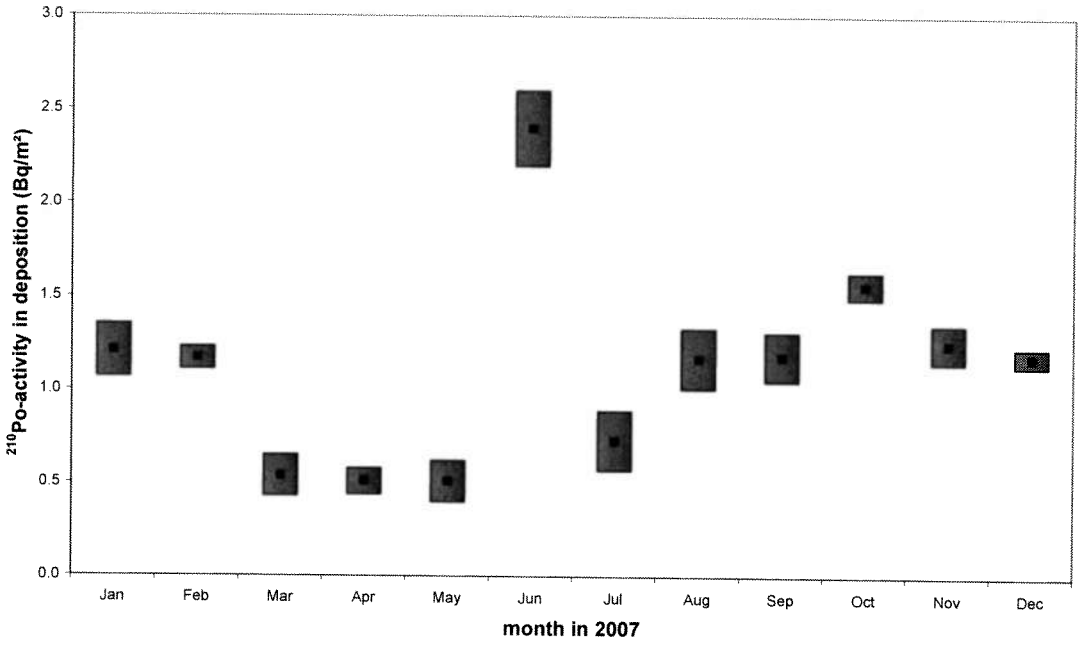
Erratum report 610791002/2008

The ^{210}Po results for 2007 have been revised. Due to an increasing influence of a ^{209}Po impurity in the ^{208}Po tracer (used in the analysis of ^{210}Po) a correction has been applied. As a result the underlying results have changed to:

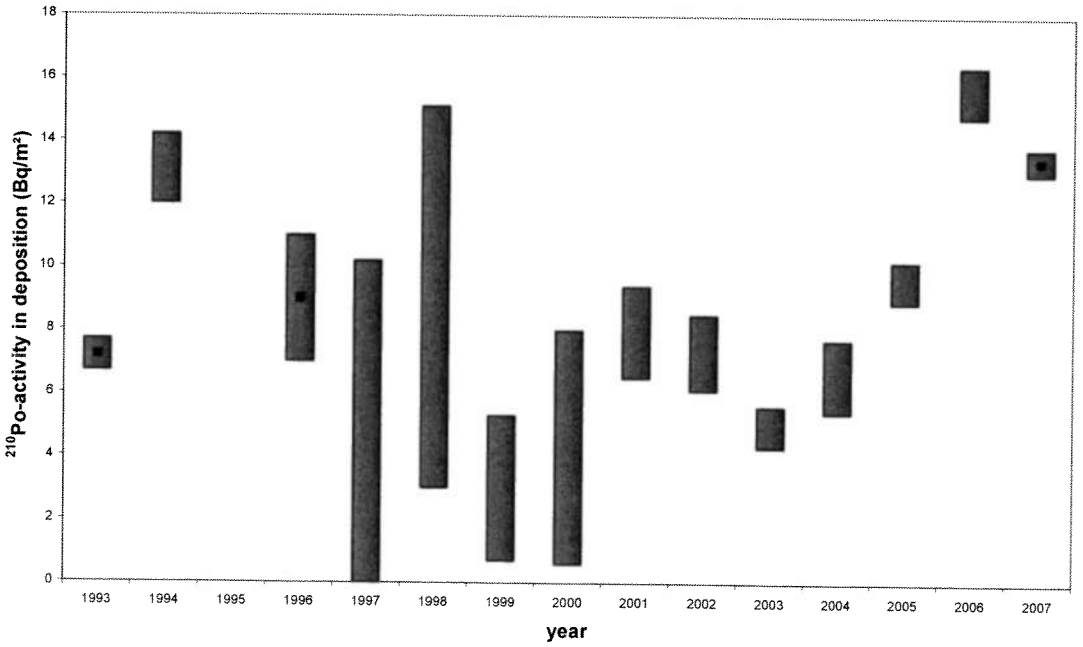
p.13 Table S1; in the column Values 13.4 Bq·m^{-2} for ^{210}Po in deposition.

p.30 3rd line; "...in 2007 was 13.4 ± 0.4 Bq·m^{-2} (68% confidence level)."

p.31 Figure 3.6;



p.31 Figure 3.7;



p.80 Table A6;

Month	^{210}Po Bq·m^{-2}		
January	1.21	±	0.14
February	1.17	±	0.06
March	0.54	±	0.11
April	0.51	±	0.07
May [2]	0.51	±	0.11
June	2.4	±	0.2
July	0.73	±	0.16
August	1.17	±	0.16
September	1.18	±	0.13
October	1.56	±	0.07
November	1.25	±	0.10
December	1.18	±	0.05
Total	13.4	±	0.4
Lower limit [3]	-		
Upper limit [3]	-		

p.81 Table A7; in the column ^{210}Po in deposition 14.8 – 16.4 Bq·m^{-2} and 13.4 ± 0.4 Bq·m^{-2} for respectively 2006 and 2007.

Ter akkoord

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