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Environmental radioactivity in the Netherlands
Results in 2005

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Rapport in het kort

Radioactiviteit in het Nederlandse milieu
Resultaten in 2005

Met ingang van 2005 is het nationale meetprogramma “Radioactiviteit en straling in het milieu” uitgebreid met radioactiviteitsbepalingen in een standaard voedselpakket en controlemetingen in melk. Het meetprogramma voldeed daarmee voor het eerst aan de Europese aanbevelingen uit 2000, die een nieuwe uitleg geven aan de meetverplichting voor lidstaten van de EU zoals vastgelegd in het EURATOM-verdrag uit 1957.

Metingen in lucht en omgeving lieten voor 2005 een spreiding zien die geheel verklaard kan worden door de normale variaties in de natuurlijke achtergrond. In voedsel en melk zijn geen radioactiviteitniveaus aangetroffen boven de in Europees verband vastgestelde limieten voor export en consumptie.

In oppervlaktewater is op een aantal locaties voor een aantal radionucliden de streefwaarde overschreden zoals vastgelegd in de Vierde Nota Waterhuishouding. De streefwaarden zijn mede gebaseerd op achtergrondwaarden voor oppervlaktewater in Nederland. Streefwaarden zijn waarden die bij voorkeur niet overschreden worden, maar het zijn geen limieten.

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

Abstract

Environmental radioactivity in the Netherlands
Results in 2005

From 2005 onwards the national monitoring program “Radioactivity and radiation in the environment” is extended with measurements in milk and in mixed diet. With that the monitoring program complies for the first time with the recommendations of the European Union of 2000. These recommendations accentuate the obligation to measure radioactivity in the environment, as stated in the Euratom Treaty of 1957.

Measurements in air and environment show levels which are attributed to the normal variations in the natural background. 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. The target values, as established in the “Vierde Nota Waterhuishouding”, are partly based upon background values for fresh water in the Netherlands. Target values are values that should preferably not be exceeded, however they are not limits.

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

Preface

The following institutes have contributed to the report:

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

The Institute for Inland Water Management and Waste Water Treatment
Rijksinstituut voor Integraal Zoetwaterbeheer en Afvalwaterbehandeling (RIZA)
Data on surface water from the main inland waters.
drs. J.M. van Steenwijk, mw. M. Holierhoek, C. Engeler, ing. M van der Weijden.

The National Institute for Coastal and Marine Management
Rijksinstituut voor Kust en Zee (RIKZ)
Data on seawater.
drs. V.T. Langenberg, ing. R.W. Bovelander.

The Food and Consumer Product Safety Authority
Voedsel en Waren Autoriteit (VWA)
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Data on milk.
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Contents

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 2005. De metingen zijn verricht door RIVM, RIZA, RIKZ, RIKILT en VWA.

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.

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 3,6 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 72,9 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 Noordzeekanaal, de Nieuwe Waterweg, de Rijn, de Schelde en de Maas overschreed de streefwaarde (100 mBq·L^{-1}) in respectievelijk drie van de zes, zes van de dertien, twee van de dertien, dertien van de dertien en één van de dertien genomen monsters. De jaargemiddelde totaal α-activiteitsconcentraties in de Nieuwe Waterweg en de Schelde (121 respectievelijk 270 mBq·L^{-1}) zijn boven de streefwaarde, maar vallen binnen het bereik van voorgaande jaren.

De ^{3}H-activeitsconcentratie in de Maas en de Schelde overschreed de streefwaarde (10 Bq·L^{-1}) in respectievelijk in vijf van de dertien en drie van de zeven genomen monsters. De jaargemiddelde ^{3}H-activiteitsconcentraties in de Maas en de Schelde (12,0 respectievelijk 10,8 Bq·L^{-1}) zijn boven de streefwaarde, maar vallen binnen het bereik van voorgaande jaren.

De ^{226}Ra-activiteitsconcentratie in de Nieuwe Waterweg, de Rijn, de Schelde en de Maas overschreed de streefwaarde (5 mBq·L^{-1}) in respectievelijk één van de zeven, één van de zes, zeven van de zeven en één van de zes genomen monsters. De jaargemiddelde ^{226}Ra-activiteitsconcentratie in de Schelde (11 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 zesentwintig van de tweeënvijftig genomen monsters. De jaargemiddelde ^{60}Co-activiteitsconcentratie in de Maas (12,5 Bq·kg^{-1}) is boven de streefwaarde.

De ^{131}I-activiteitsconcentratie in het Noordzeekanaal en de Maas overschreed de streefwaarde (20 Bq·kg^{-1}) in respectievelijk twee van de zes en zevenendertig van de tweeënvijftig genomen monsters. De jaargemiddelde ^{131}I-activiteitsconcentratie in de Maas (31 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 drie van de zeven, zes van de zes en zes van de zes genomen monsters. De jaargemiddelde ^{210}Pb-activiteitsconcentraties in de Rijn en de Maas (120 respectievelijk 185 Bq·kg^{-1}) zijn boven de streefwaarde, maar vallen binnen het bereik van voorgaande jaren.

De jaargemiddelde totaal α-activiteitsconcentraties in zeewater zijn hoger in 2005 dan in voorgaande jaren. De jaargemiddelde ^{90}Sr-activiteitsconcentratie in de Voordelta was de hoogste sinds 1999.

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.
Het meetprogramma is vanaf 2005 uitgebreid met de controle van melk en een standaard voedselpakket. De resultaten zijn weergegeven in Tabel S1. In tegenstelling tot voorgaande jaren voldoet het Nederlandse meetprogramma nu aan de aanbevelingen van de Europese Unie.

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, in which are described the matrices to be measured (air dust, ambient dose equivalent rate, 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 2005. The measurements were carried out by RIVM, RIZA, RIKZ, RIKILT and VWA.

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.

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 3.6 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 72.9 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 Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse exceeded the target value (100 mBq·L^{-1}) in three out of six, six out of thirteen, two out of thirteen, thirteen out of thirteen and one out of thirteen samples taken, respectively. The yearly averaged gross α-activity concentrations in the Nieuwe Waterweg and Scheldt (121 and 270 mBq·L^{-1} respectively) are above the target value, but within range of those in previous years.

The ^{3}H-activity concentration in the Meuse and Scheldt exceeded the target value (10 Bq·L^{-1}) in five out of thirteen and three out of seven samples taken, respectively. The yearly averaged ^{3}H-activity concentrations in the Meuse and Scheldt (12.0 and 10.8 Bq·L^{-1}, respectively) are above the target value, but within range of those in previous years.

The ^{226}Ra-activity concentration in the Nieuwe Waterweg, Rhine, Scheldt and Meuse exceeded the target value (5 mBq·L^{-1}) in one out of seven, one out of six, seven out of seven and one out of six samples taken, respectively. The yearly averaged ^{226}Ra-activity concentration in the Scheldt (11 mBq·L^{-1}) is above the target value, but within range of those in previous years.

The ^{60}Co-activity concentration in the Meuse exceeded the target value (10 Bq·kg^{-1}) in twenty-six out of fifty-two samples taken. The yearly averaged ^{60}Co-activity concentration in the Meuse (12.5 Bq·kg^{-1}) is above the target value.

The ^{131}I-activity concentration in the Noordzeekanaal and Meuse exceeded the target value (20 Bq·kg^{-1}) in two out of six and thirty-seven out of fifty-two samples taken, respectively. The yearly averaged ^{131}I-activity concentration in the Meuse (31 Bq·kg^{-1}) is above the target value, but within range of those in previous years.

The ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine and Meuse exceeded the target value (100 Bq·kg^{-1}) in three out of seven, six out of six and six out of six samples taken, respectively. The yearly averaged ^{210}Pb-activity concentrations in the Rhine and Meuse (120 and 185 Bq·kg^{-1} respectively) are above the target value, but within range of those in previous years.

The yearly averaged gross α-activity concentrations in seawater are higher in 2005 than in previous years. The yearly averaged ^{90}Sr-activity concentration of 2005 in the Delta Coastal Waters was de highest since 1999.

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 2005 the program was extended with measurements in milk and in mixed diet. The results are presented in Table S1. Contrary to previous reports the Dutch monitoring program now complies with the recommendations of the European Union.

Tabel S1: Overzicht van de resultaten in 2005.
Table S1: Summary of the results in 2005.

Matrix	Parameter	Locations	Values	Frequency (per year)
Air dust [1]	Gross α	1	0.06 mBq·m^{-3}	52
	Gross β	1	0.434 mBq·m^{-3}	52
	^{7}Be	1	3.260 mBq·m^{-3}	52
	^{137}Cs	1	<0.002 mBq·m^{-3} [2]	52
	^{210}Pb	1	0.428 mBq·m^{-3}	52
Deposition [3]	Gross α	1	17.6 Bq·m^{-2}	12
	Gross β	1	88 Bq·m^{-2}	12
	^{3}H	1	0 - 1530 Bq·m^{-2} [4]	12
	^{7}Be	1	1320 Bq·m^{-2}	52
	^{137}Cs	1	0 - 6.09 Bq·m^{-2} [4]	52
	^{210}Pb	1	87 - 117 Bq·m^{-2} [4]	52
	^{210}Po	1	8.9 - 10.2 Bq·m^{-2} [4]	12
Surface water [1]	Gross α	6	35 - 270 mBq·L^{-1}	6 or 13 [5]
	Residual β	6	17 - 88 mBq·L^{-1}	6 or 13 [5]
	^{3}H	6	3200 - 12000 mBq·L^{-1}	6, 7 or 13 [5]
	^{90}Sr	3	2.1 - 3.2 mBq·L^{-1}	6 or 7 [5]
	^{226}Ra	4	4 - 11 mBq·L^{-1}	6 or 7 [5]
	^{60}Co	7	<1 - 12.5 Bq·kg^{-1}	6, 13 or 52 [5]
	^{131}I	7	<1 - 31 Bq·kg^{-1}	6, 13 or 52 [5]
	^{137}Cs	7	5.8 - 17.0 Bq·kg^{-1}	6, 13 or 52 [5]
	^{210}Pb	4	95 - 185 Bq·kg^{-1}	6 or 7 [5]
Seawater [1]	Gross α	8	360 - 660 mBq·L^{-1}	4, 12 or 13 [5]
	Residual β	8	39 - 150 mBq·L^{-1}	4, 12 or 13 [5]
	^{3}H	8	600 - 6200 mBq·L^{-1}	4, 12 or 13 [5]
	^{90}Sr	4	<1 - 3.9 mBq·L^{-1}	4 or 13 [5]
	^{137}Cs	5	4.2 - 8.2 Bq·kg^{-1}	2 or 4 [5]
	^{210}Po	5	63 - 107 Bq·kg^{-1}	2 or 4 [5]

To be continued on the next page.

Tabel S1: Vervolg.
Table S1: Continued.

Matrix	Parameter	Locations	Values	Frequency (per year)
Drinking water [1]	Gross β	209	<0.2 $Bq \cdot L^{-1}$	669
	Residual β	191	<0.3 $Bq \cdot L^{-1}$	594
	^{3}H	206	<5 $Bq \cdot L^{-1}$	682
Milk [1]	^{40}K	26	46 $Bq \cdot L^{-1}$	1012
	^{60}Co	26	<4 $Bq \cdot L^{-1}$	1012
	^{90}Sr	27	<0.1 $Bq \cdot L^{-1}$	27
	^{131}I	26	<2 $Bq \cdot L^{-1}$	1012
	^{134}Cs	26	<2 $Bq \cdot L^{-1}$	1012
	^{137}Cs	26	<2 $Bq \cdot L^{-1}$	1012
Food [6, 7]				
Grain	^{137}Cs	-	< 0.5 $Bq \cdot kg^{-1}$	68 (0) [8]
Vegetables	^{137}Cs	-	< 0.5 $Bq \cdot kg^{-1}$	124 (0) [8]
Fruit	^{137}Cs	-	< 0.5 $Bq \cdot kg^{-1}$	47 (0) [8]
Milk and milk products	^{137}Cs	-	< 0.5 $Bq \cdot kg^{-1}$	60 (0) [8]
Meat and meat products	^{137}Cs	-	< 0.5 $Bq \cdot kg^{-1}$	70 (0) [8]
Game and poultry	^{137}Cs	-	< 0.5 $Bq \cdot kg^{-1}$	133 (0) [8]
Salads	^{137}Cs	-	< 0.5 $Bq \cdot kg^{-1}$	40 (0) [8]
Oil and butter	^{137}Cs	-	< 0.5 $Bq \cdot kg^{-1}$	35 (0) [8]
Honey	^{137}Cs	-	15 - 494 $Bq \cdot kg^{-1}$	275 (13) [8]
Miscellaneous	^{137}Cs	-	< 0.5 $Bq \cdot kg^{-1}$	8 (0) [8]

[1] = Yearly average is shown.
[2] = Detection limit of individual measurement is shown.
[3] = Yearly total is shown.
[4] = A 68% confidence range is shown.
[5] = Frequency is depending on location.
[6] = Given range represents values of individual samples.
[7] = Samples were analysed for ^{134}Cs as well, but it was not detectable.
[8] = Total number of samples taken. Number of positive samples between brackets.

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 2005. 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. In Chapter 9 general conclusions are presented.

2 Airborne particles

The 2005 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 onwards were reanalysed to determine the yearly averages by the method described in Appendix B. This can result in small differences between results presented in this report and previous reports.

Table 2.1: Monitoring program in 2005 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 [5]. 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. Usually there is a good correlation between activity concentrations of gross β and activity concentrations of ^{210}Pb (Figure 2.8) as is the case in 2005. 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.

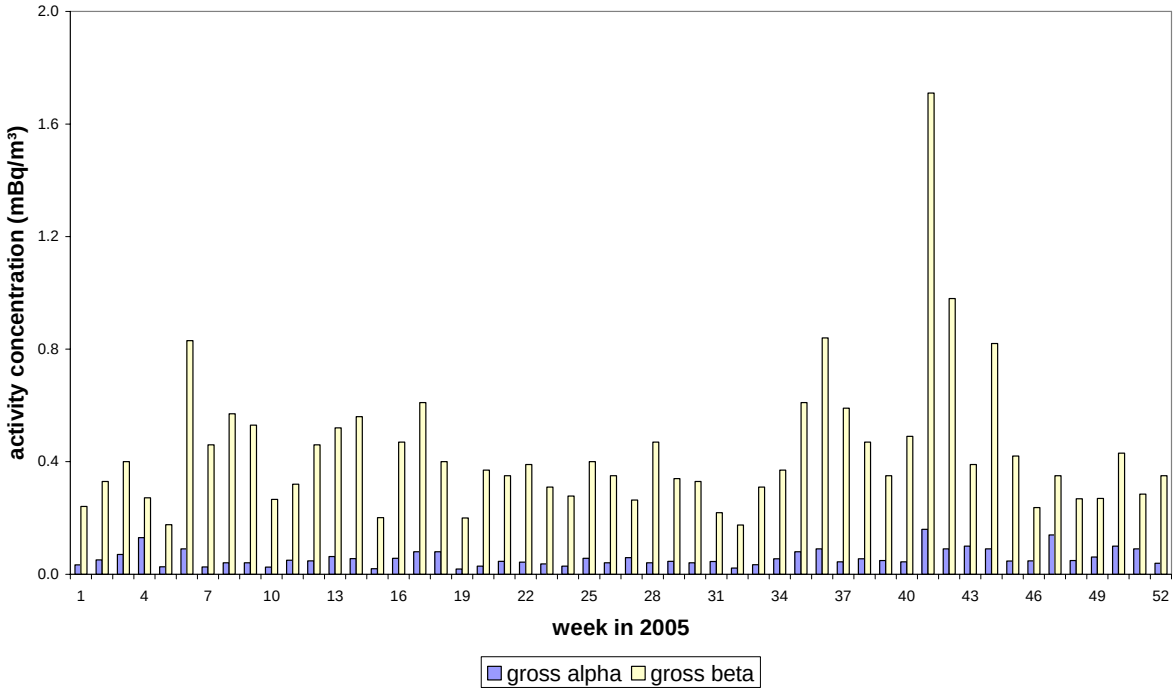


Figure 2.1: Weekly averaged gross α- and β-activity concentrations of long-lived nuclides in air dust sampled at RIVM in 2005.

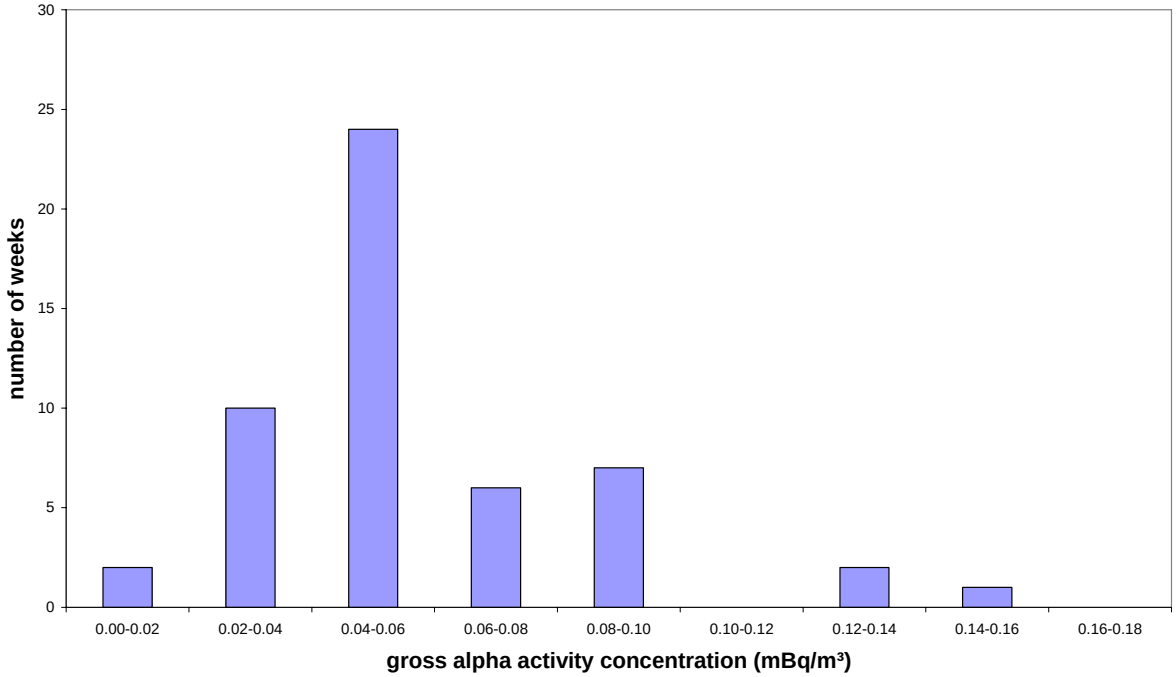


Figure 2.2: Frequency distribution of gross α-activity concentration of long-lived nuclides in air dust collected weekly in 2005. The yearly average is 0.06 (SD=0.03) mBq·m^{-3}. SD is the standard deviation and illustrates the variation in weekly averages during the year.

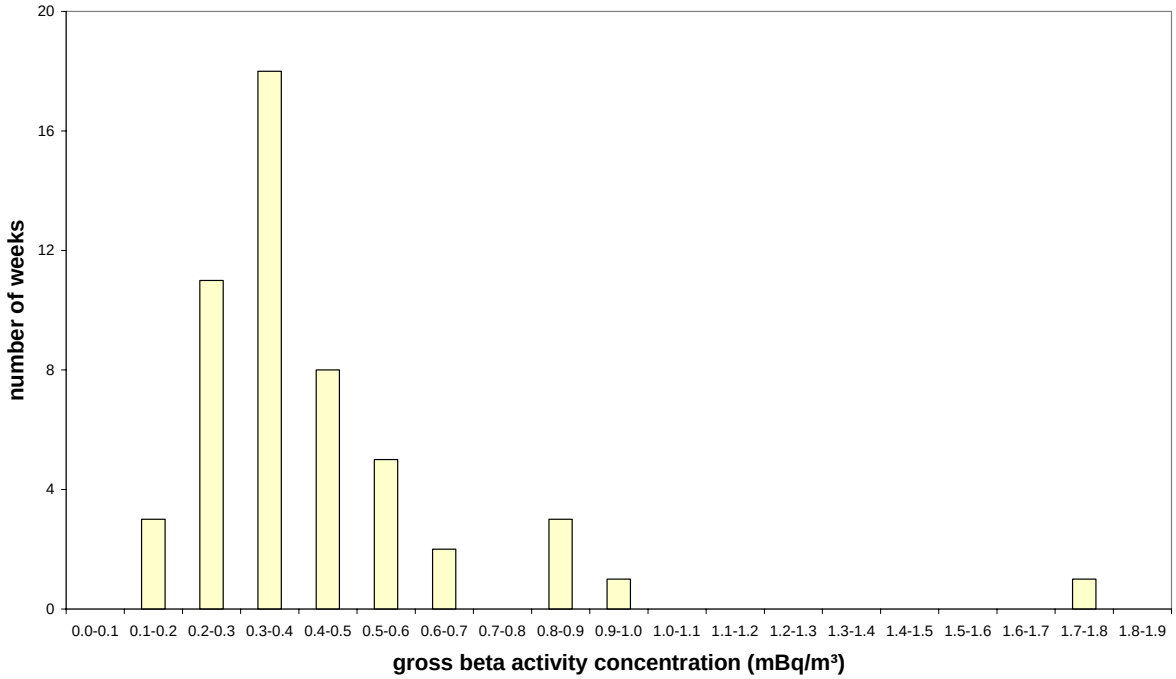


Figure 2.3: Frequency distribution of gross β-activity concentration of long-lived nuclides in air dust collected weekly in 2005. The yearly average is 0.434 ± 0.005 (SD=0.2) mBq·m^{-3}.

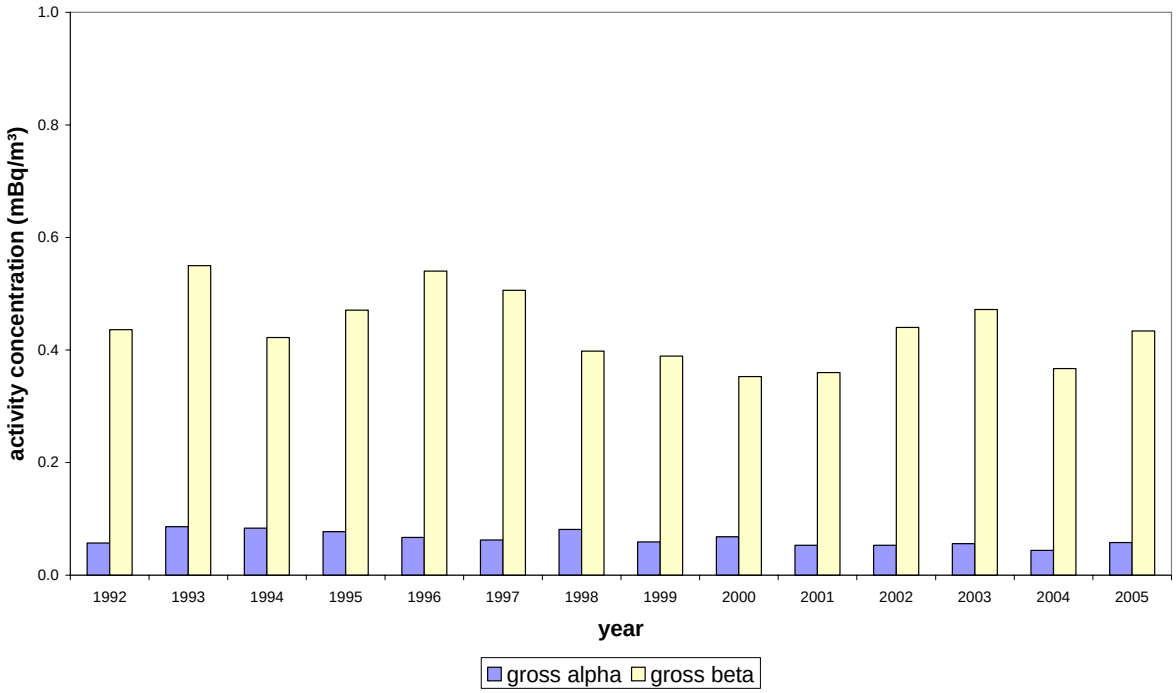


Figure 2.4: Yearly averaged gross α- and gross β-activity concentrations of long-lived nuclides in air dust at RIVM in 1992-2005.

The yearly averages of the gross α- and β-activity concentrations of long-lived nuclides in 2005 are within the range of the results from the period 1992-2004.

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 and ^{210}Pb (Table A3, Figure 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}), due to a different detector set-up.

The behaviour of ^{7}Be in the atmosphere has been studied world-wide [6, 7, 8, 9, 10, 11, 12]. 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 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 [13]. Geomagnetic storms, a result of solar activities, are affected by the 11-year solar cycle. 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 [14]. 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 2005 fit in the pattern described above.

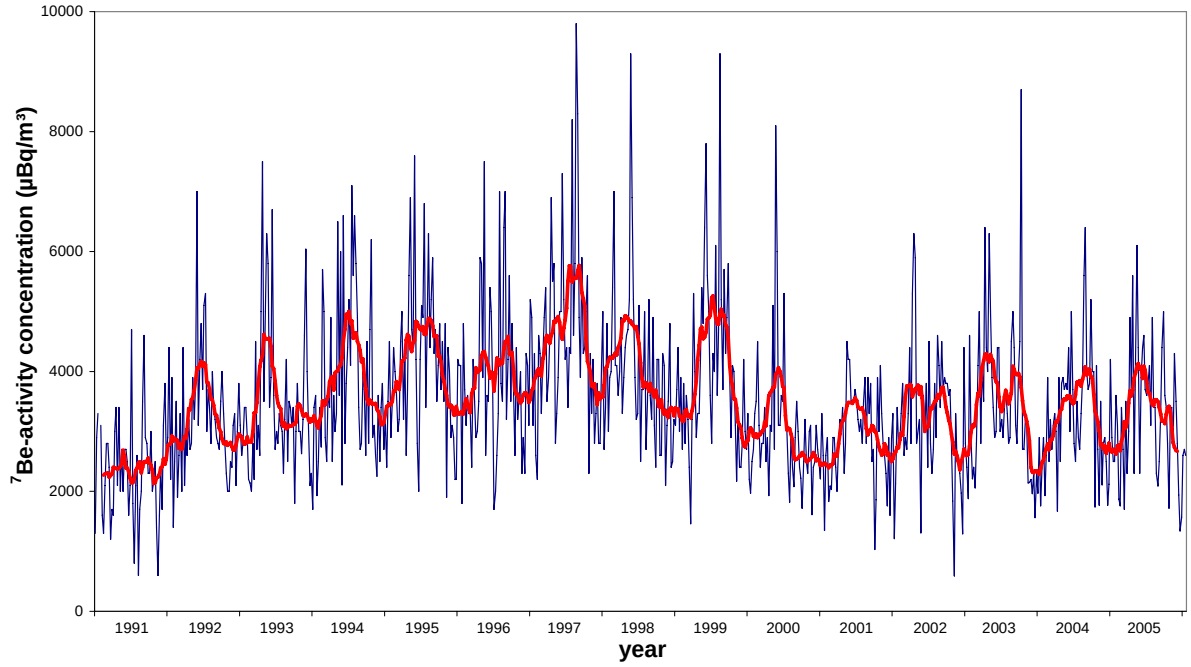


Figure 2.5: Weekly averaged ^{7}Be-activity concentrations (blue) in air dust at RIVM in 1991-2005. The red line represents a moving average of 13 weeks. Yearly average for 2005 is 3260 ± 40 (SD=1100) µBq·m^{-3}.

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 [15]. 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 [16]. On the 29th of May 1998 an incident occurred at Algeciras (Spain), an iron foundry melted a ^{137}Cs-source concealed in scrap metal [17]. 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 [17].

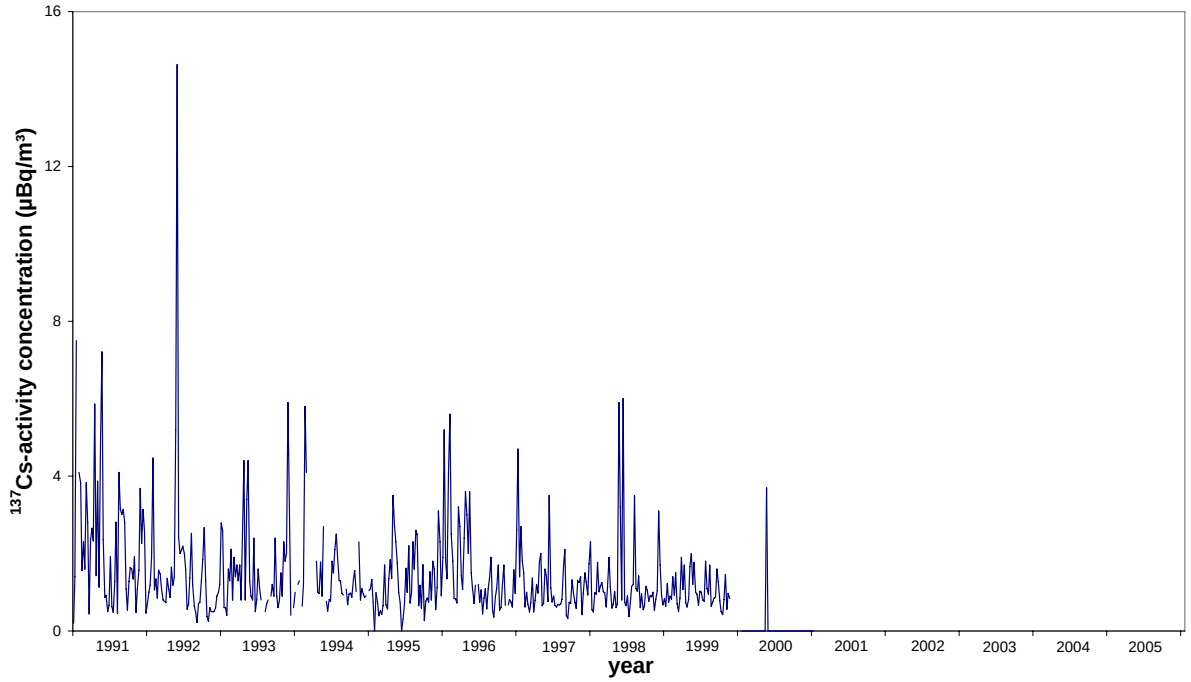


Figure 2.6: Weekly averaged ^{137}Cs-activity concentrations in air dust at RIVM in 1991-2005. In 2005 all measurements were below the detection limit. The detection limit was higher than during 1991-1999, due to a different detector set-up.

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} [18]. In the atmosphere this radionuclide is predominantly associated with submicron-sized aerosols [19, 20]. The mean aerosol (carrying ^{210}Pb) residence time in the troposphere is approximately five days [21].

Other sources of ^{210}Pb in air dust are volcanic activity and industrial emissions [22, 23, 24, 25, 26]. 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 [24]. Volcanic eruptions bring U-decay products in the atmosphere like ^{226}Ra, ^{222}Rn, ^{210}Pb and ^{210}Po. Beks et al. [24] 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 [27, 28, 29] and resuspension of (local) dust. The unusual value of

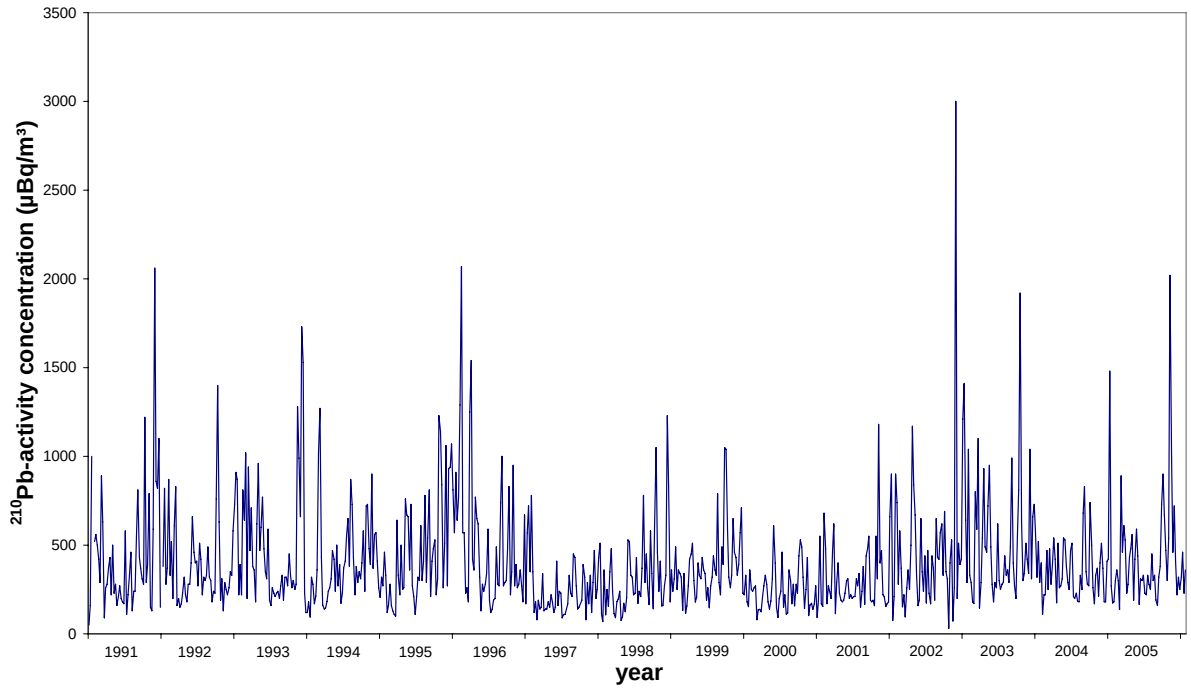


Figure 2.7: Weekly averaged ^{210}Pb-activity concentrations in air dust at RIVM in 1991-2005. Yearly average for 2005 is 428 ± 7 (SD=300) µBq·m^{-3}.

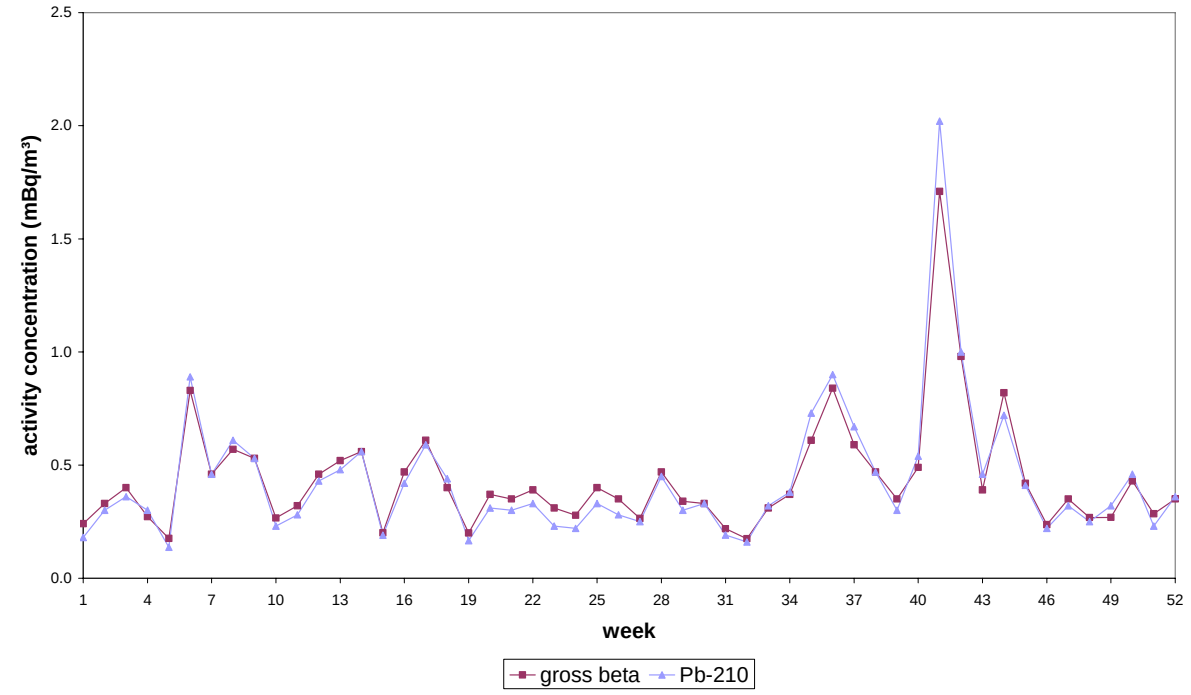


Figure 2.8: Correlation between weekly averaged gross β- and ^{210}Pb-activity concentrations in air dust at RIVM in 2005.

week 45 in 2002 (3000 ± 300 µBq·m^{-3}) can not be explained by these natural sources [30]. Except for week 45 in 2002 there is a good correlation between (high) activity concentrations of ^{210}Pb and (high) activity concentrations of gross β, as is the case in 2005 (Figure 2.8). The weekly averaged activity concentrations of ^{210}Pb in 2005 are within range of those found in previous years.

3 Deposition

The 2005 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 onwards were reanalysed to determine the yearly totals by the method described in Appendix B. This can result in small differences between results presented in this report and previous reports.

Table 3.1: The 2005 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 deposition of ^{3}H is given in Table A4. In 2005 the yearly total deposition of ^{3}H ranged between 0 and 1530 $Bq \cdot m^{-2}$ (68% confidence level). All measurements were below the detection limit. Therefore detection limits were used for the calculation of the yearly total. This range does not differ significantly from those measured since 1993, as illustrated in Figure 3.1. Until 1998 samples were electrolytic enriched before counting.

The monthly deposited gross α- and gross β-activities of long-lived nuclides are given in Figure 3.2, Figure 3.4 and Table A4. The yearly total deposition of gross α and gross β was 17.6 ± 1.0 and 88 ± 2 $Bq \cdot m^{-2}$, respectively. These values do not differ significantly from those measured in previous years, as illustrated in Figure 3.3, Figure 3.5 and Table A5.

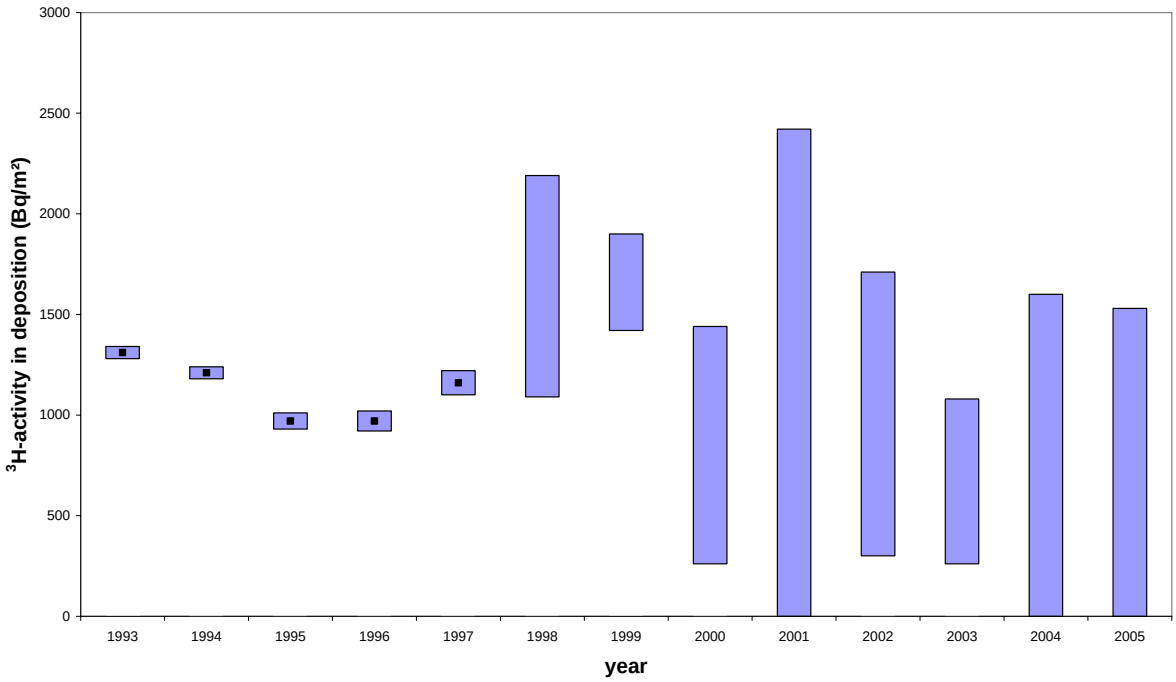


Figure 3.1: Yearly deposition of ^{3}H at RIVM from 1993 to 2005. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

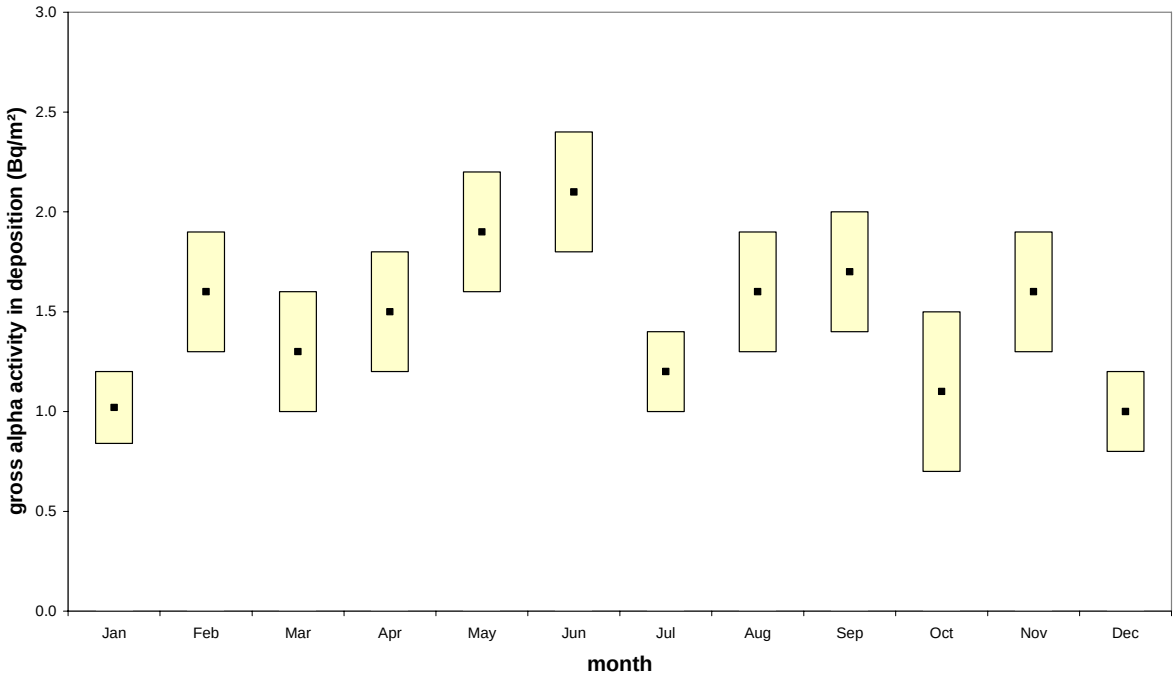


Figure 3.2: Monthly deposited gross α-activity of long-lived nuclides at RIVM in 2005. Given are monthly averages (black dot) with a 68% confidence range (colored bar).

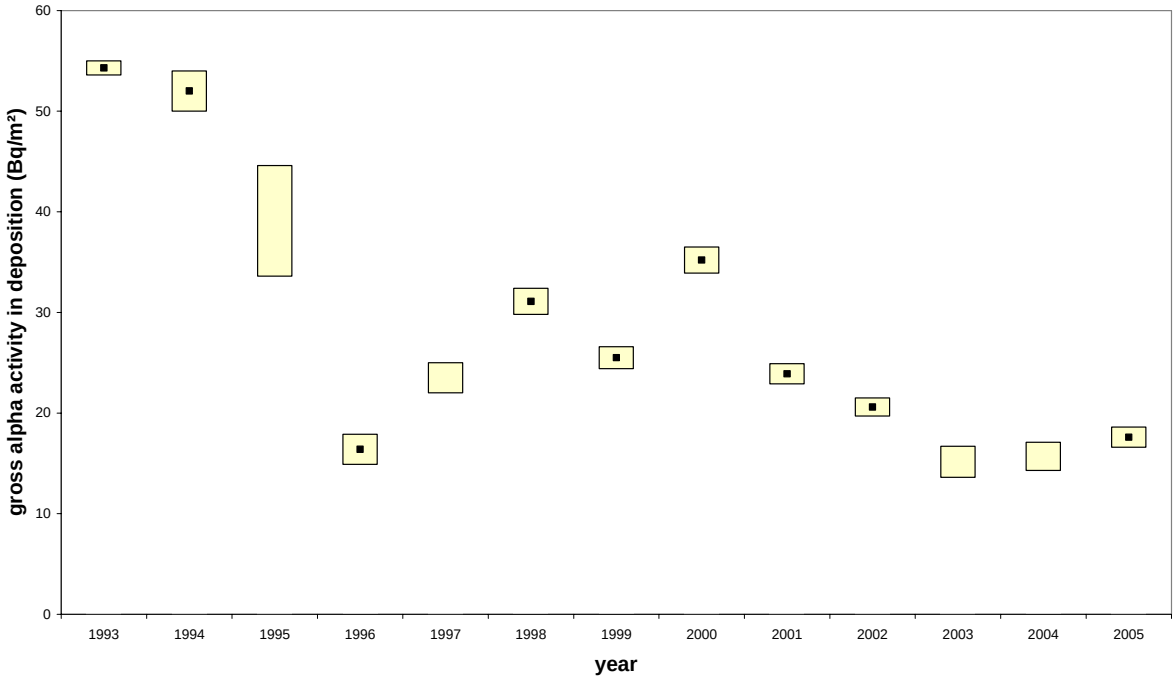


Figure 3.3: Yearly gross α-activity of long-lived nuclides deposited at RIVM from 1993 to 2005. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

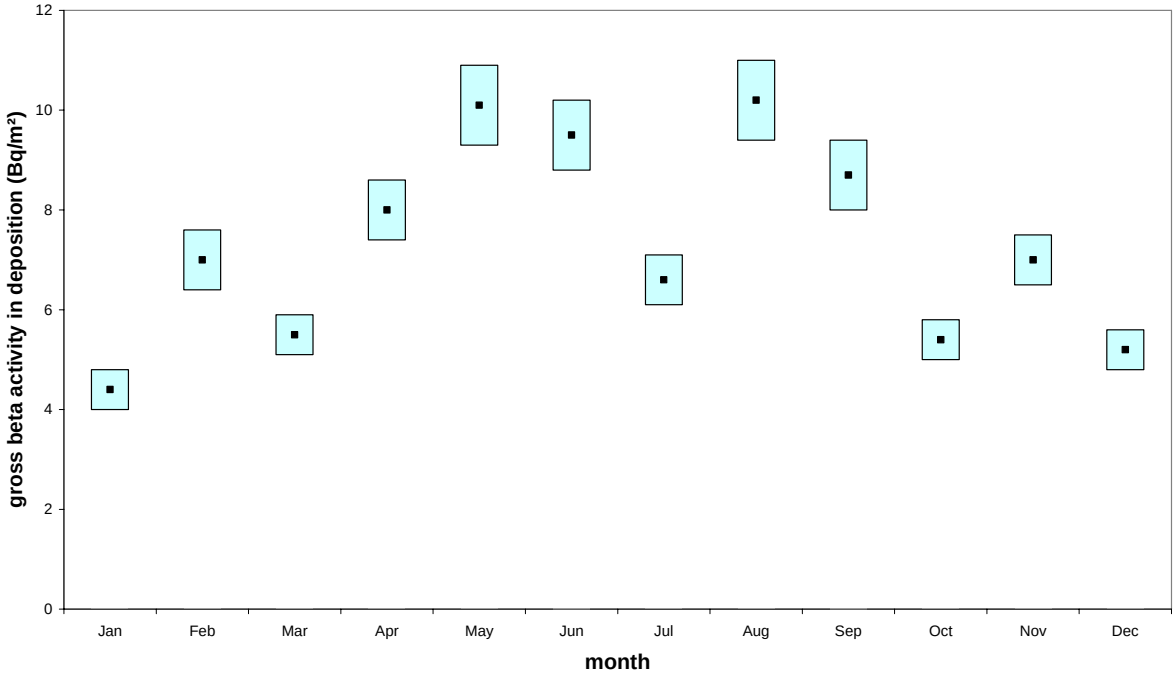


Figure 3.4: Monthly deposited gross β-activity of long-lived nuclides at RIVM in 2005. Given are monthly averages (black dot) with a 68% confidence range (colored bar).

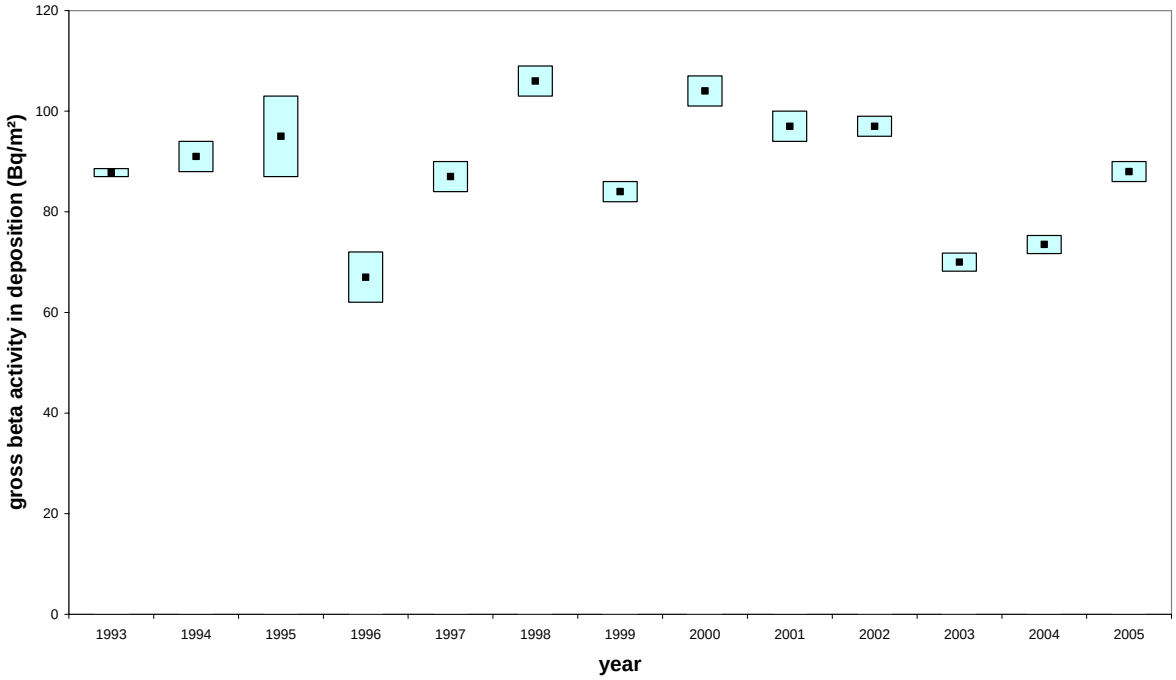


Figure 3.5: Yearly gross β-activity of long-lived nuclides deposited at RIVM from 1993 to 2005. Given are yearly averages (black dot) with a 68% confidence range (colored bar).

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 amount of ^{210}Po deposited in 2005 ranged between 8.9 and 10.2 Bq·m^{-2} (68% confidence level). ^{210}Po was not detected in the sample from January. Therefore the detection limit was used for the contribution to the yearly total.

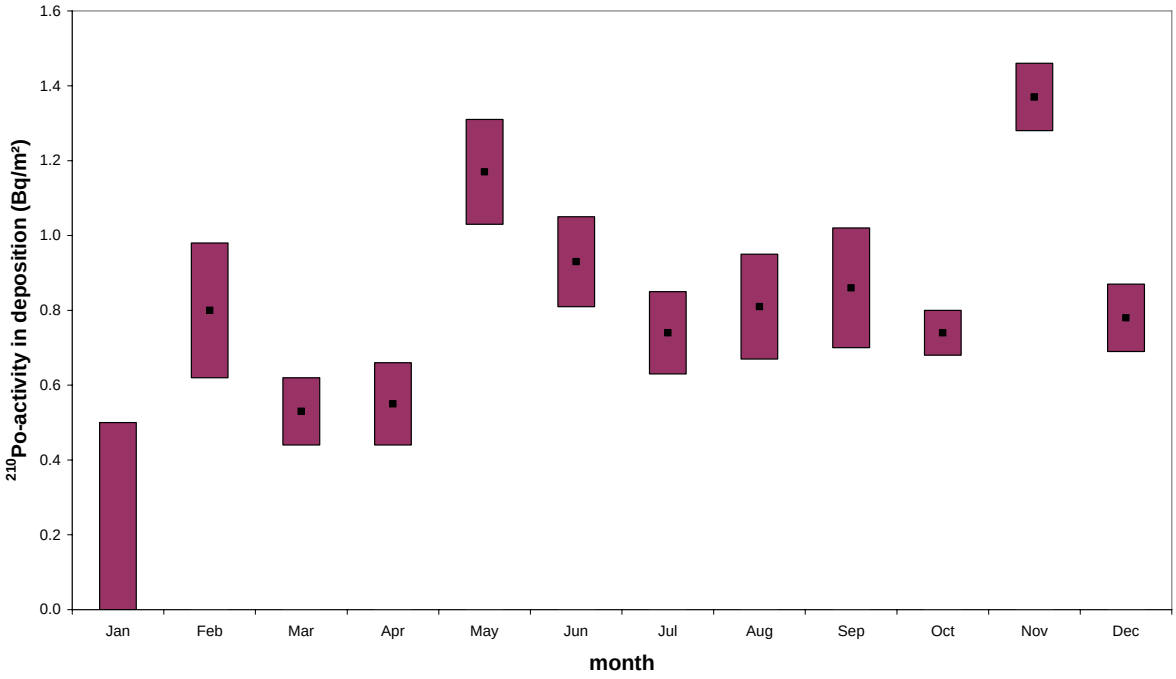


Figure 3.6: Monthly deposited ^{210}Po-activity at RIVM in 2005. Given are monthly averages (black dot) with a 68% confidence range (colored bar).

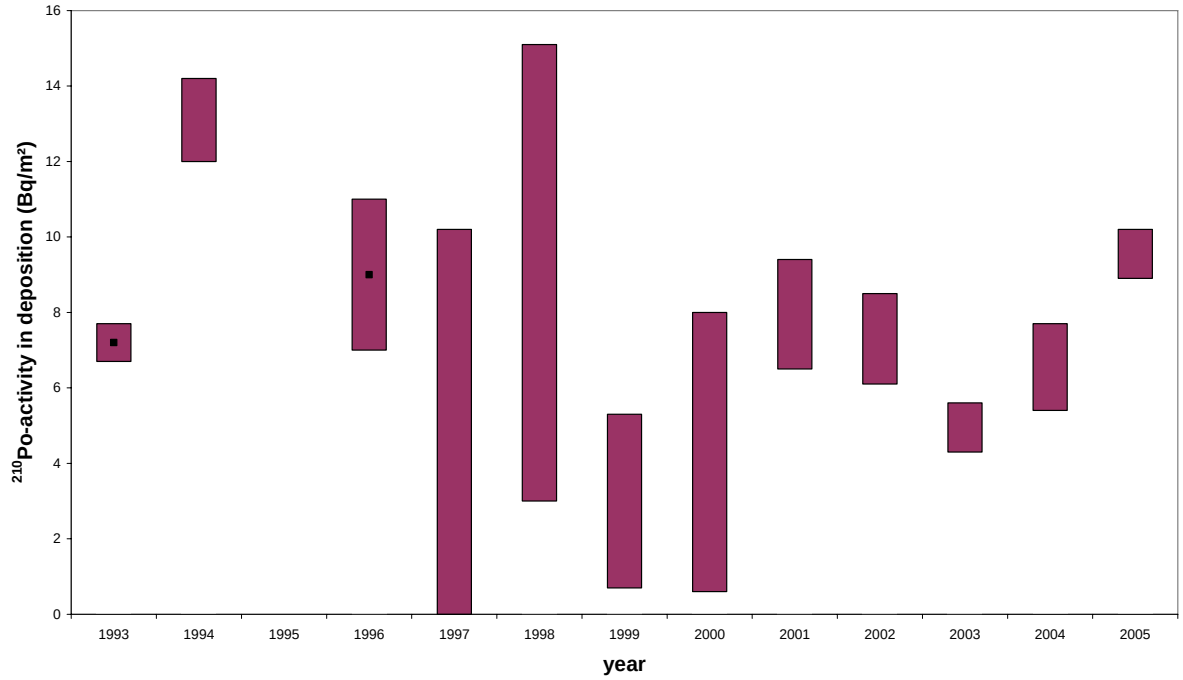


Figure 3.7: Yearly ^{210}Po-activity deposited at RIVM from 1993 to 2005. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

3.2 γ-emitting nuclides

Detectable quantities of the naturally occurring nuclides ^{7}Be and ^{210}Pb were found in 52 respectively 36 out of 52 samples. The yearly total deposition of ^{7}Be is 1320 ± 30 Bq·m^{-2}. The yearly total deposition of ^{210}Pb ranged between 87 and 117 Bq·m^{-2} (68% confidence level). The nuclide ^{137}Cs was not found (detection limit is about 0.1 Bq·m^{-2}) in all samples. The yearly total deposition of ^{137}Cs ranged between 0 and 6.09 Bq·m^{-2} (68% confidence level). The weekly results for deposition of ^{7}Be, ^{137}Cs and ^{210}Pb are given in Table A8. The results for previous years are given in Table A7, Figure 3.9, 3.10 and 3.12.

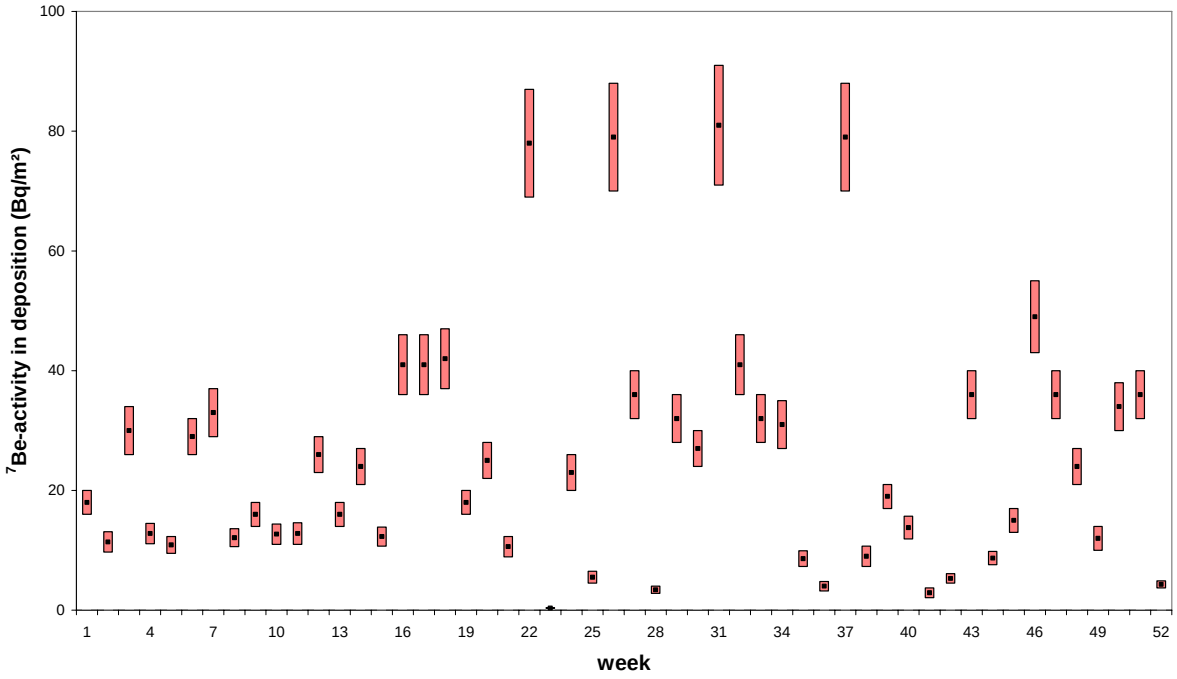


Figure 3.8: Weekly deposited ^{7}Be-activity at RIVM in 2005. Given are weekly averages (black dot) with a 68% confidence range (colored bar).

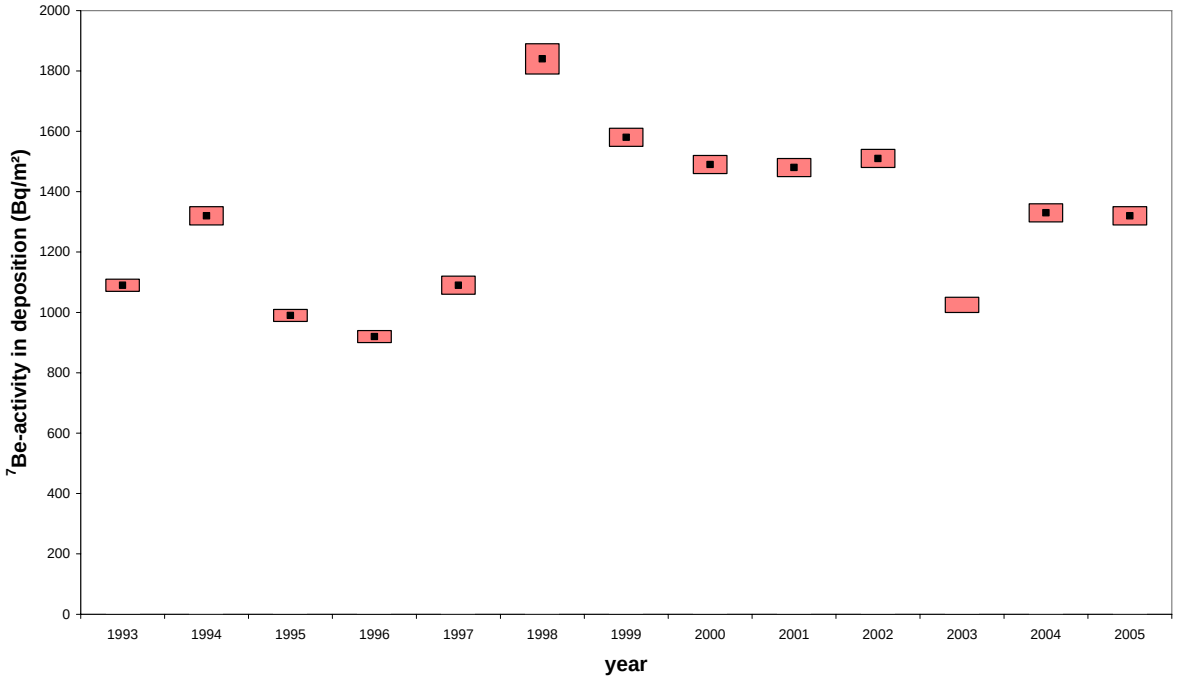


Figure 3.9: Yearly ^{7}Be-activity deposited at RIVM from 1993 to 2005. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

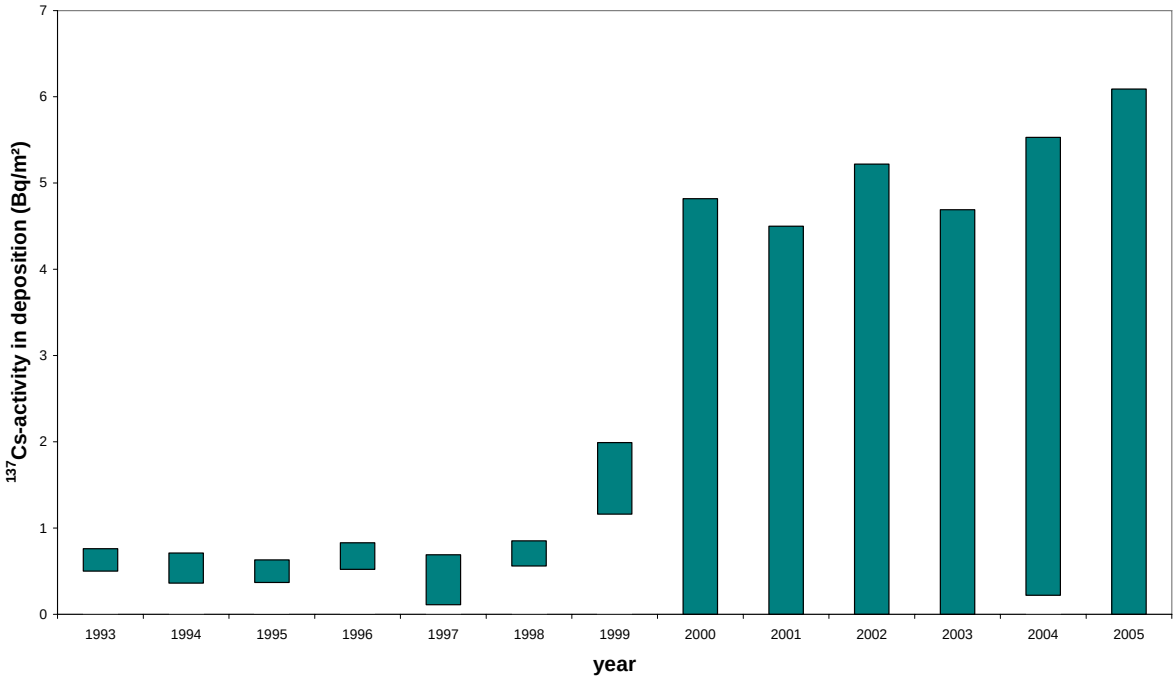


Figure 3.10: Yearly ^{137}Cs-activity deposited at RIVM from 1993 to 2005. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit. Since 2000 the detection limit is higher than during 1991-1999, due to a different detector set-up.

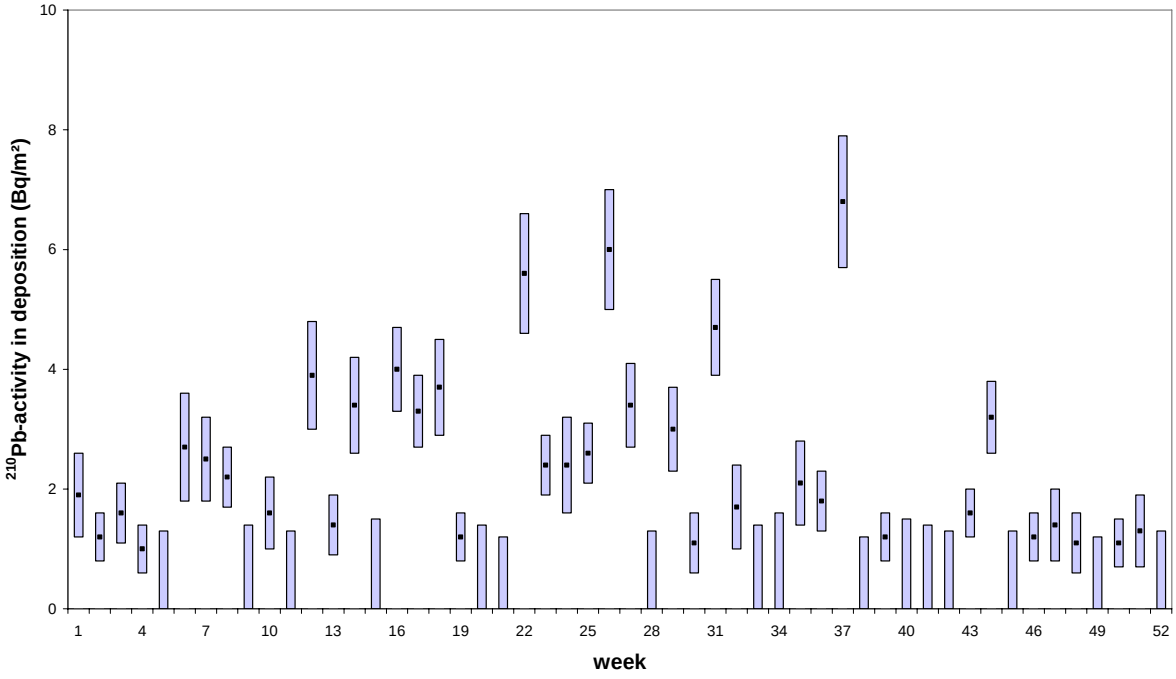


Figure 3.11: Weekly deposited ^{210}Pb-activity at RIVM in 2005. Given are weekly averages (black dot) with a 68% confidence range (colored bar).

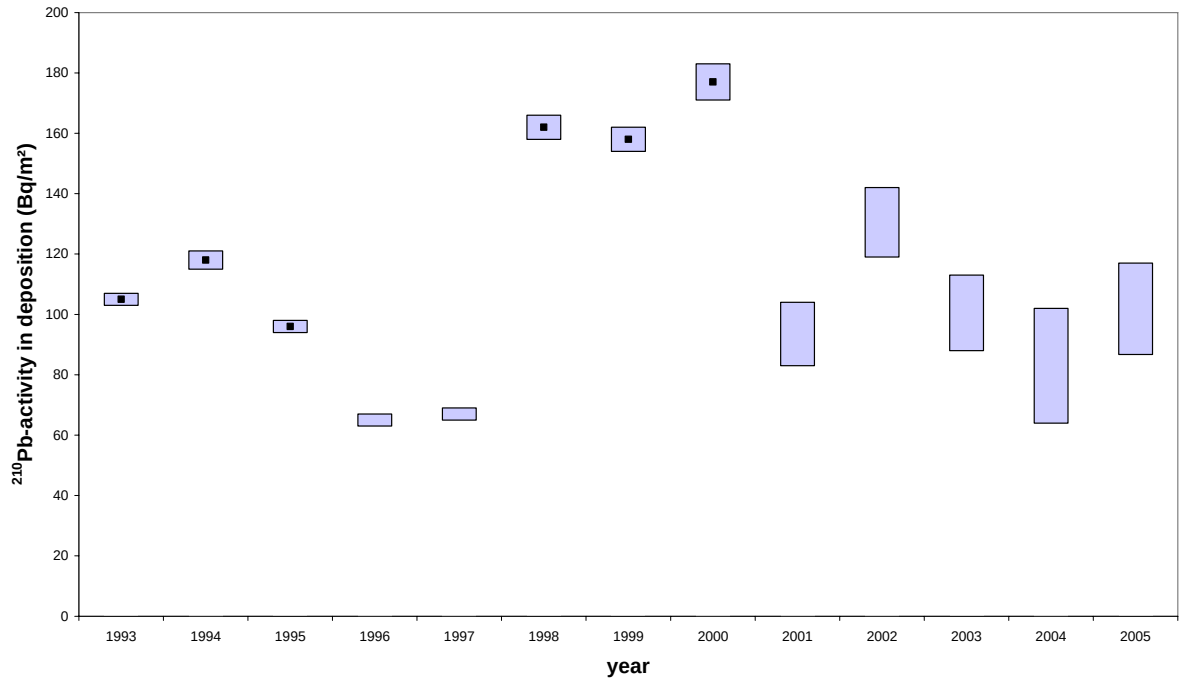


Figure 3.12: Yearly ^{210}Pb-activity deposited at RIVM from 1993 to 2005. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

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). 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 [31]. 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 [32]. 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 [33]. 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 error because of an overestimation of the cosmogenic dose rate and an underestimation of the terrestrial dose rate. Based upon earlier research [32, 34] 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 errors.

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 2005, while Figure 4.4 presents the yearly averages of ambient dose equivalent rate from 1996 to 2005. In 2005 the yearly averaged gross α-activity concentration in air dust was 3.6 $Bq \cdot m^{-3}$ (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 3.0 $Bq \cdot m^{-3}$. This value is within the range of those in

previous years. 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 2005 is calculated using 147 stations. The remaining 6 stations were not operational.

For the ambient dose equivalent rate the yearly averaged measured value was 72.9 $nSv.h^{-1}$. 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 increase in the cosmogenic contribution since 2004 does not result in an increase in the measured ambient dose equivalent rate (Figure 4.4).

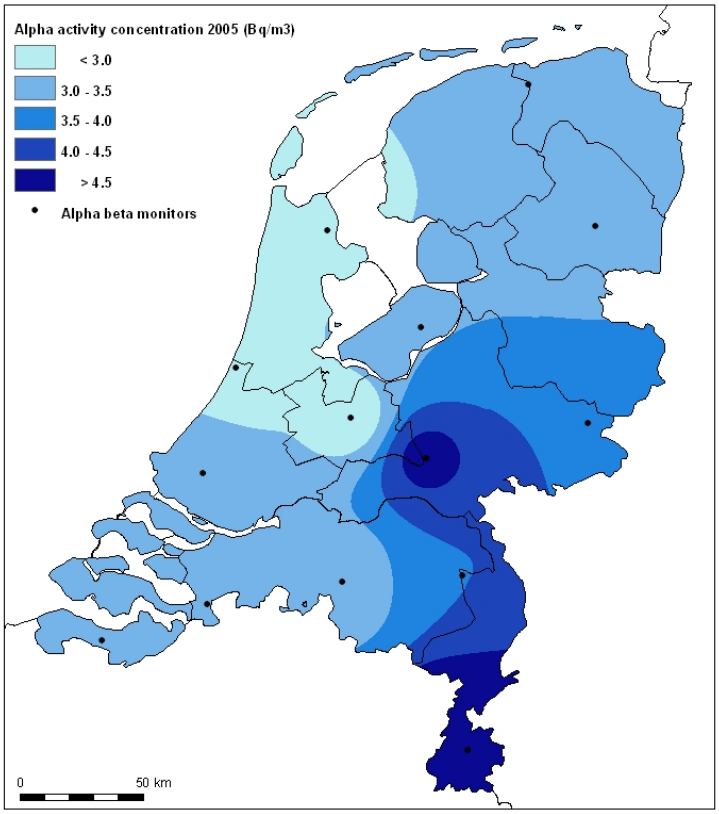


Figure 4.1: Spatial variation in the average gross α-activity concentration of (mainly) short-lived nuclides in air dust in 2005. The dots represent the locations of the aerosol monitors.

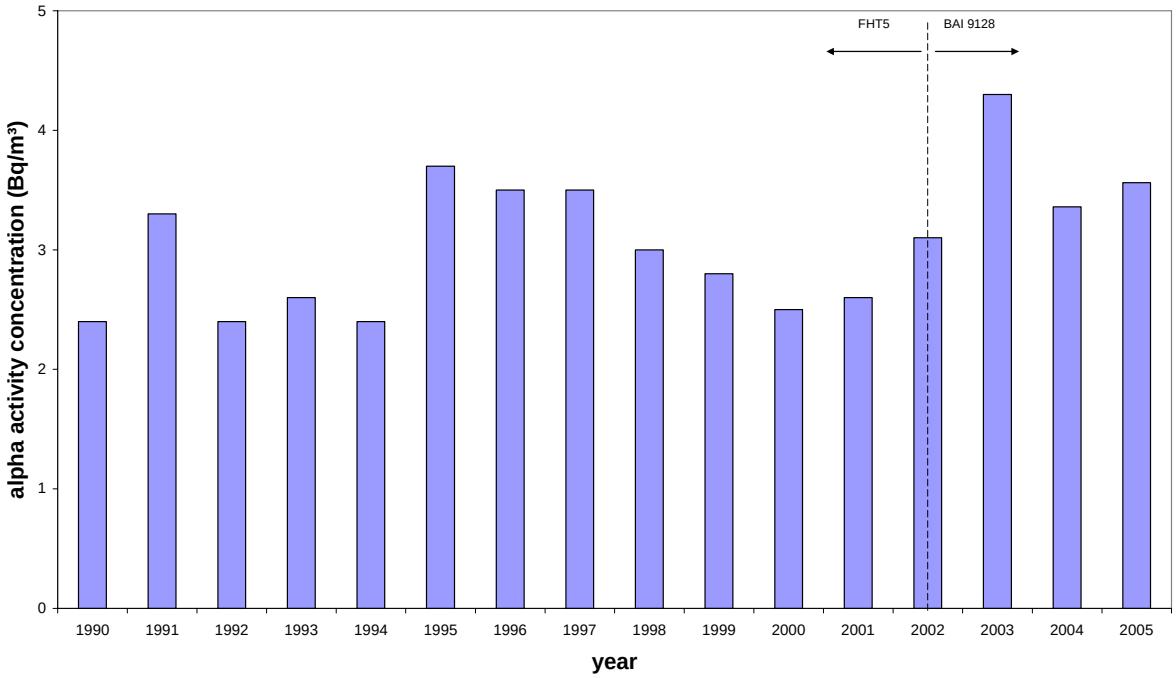


Figure 4.2: Yearly averaged gross α-activity concentration of (mainly) short-lived nuclides in air dust. During the second half of 2002 the FAG FHT59S monitors were gradually replaced by the Berthold BAI 9128 monitors. The Berthold monitor reports about 20% higher values than the FAG monitor. No correction is applied for the difference between both types of monitor.

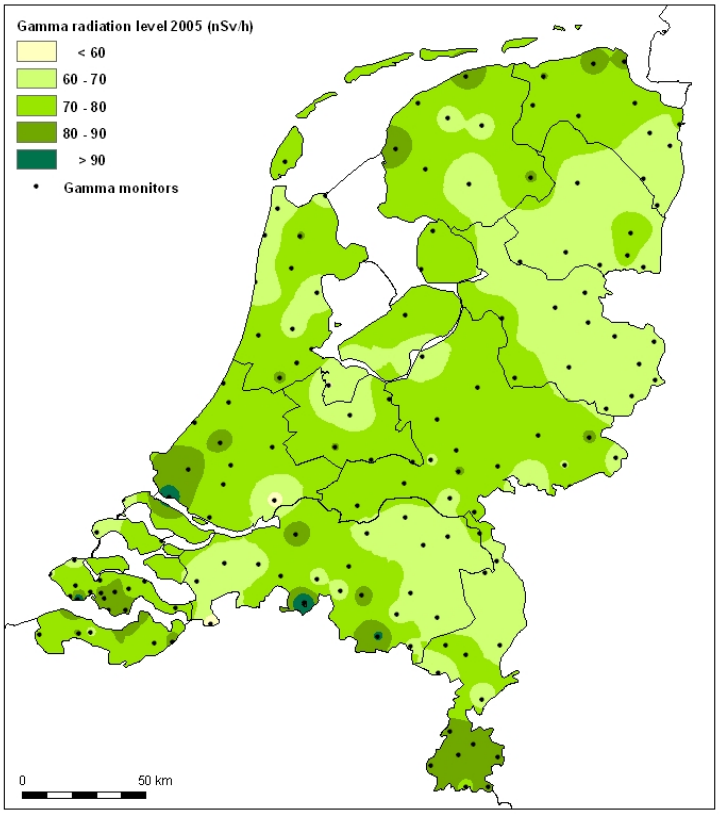


Figure 4.3: Spatial variation in the average ambient dose equivalent rate in 2005. The dots represent the locations of the dose equivalent rate monitors.

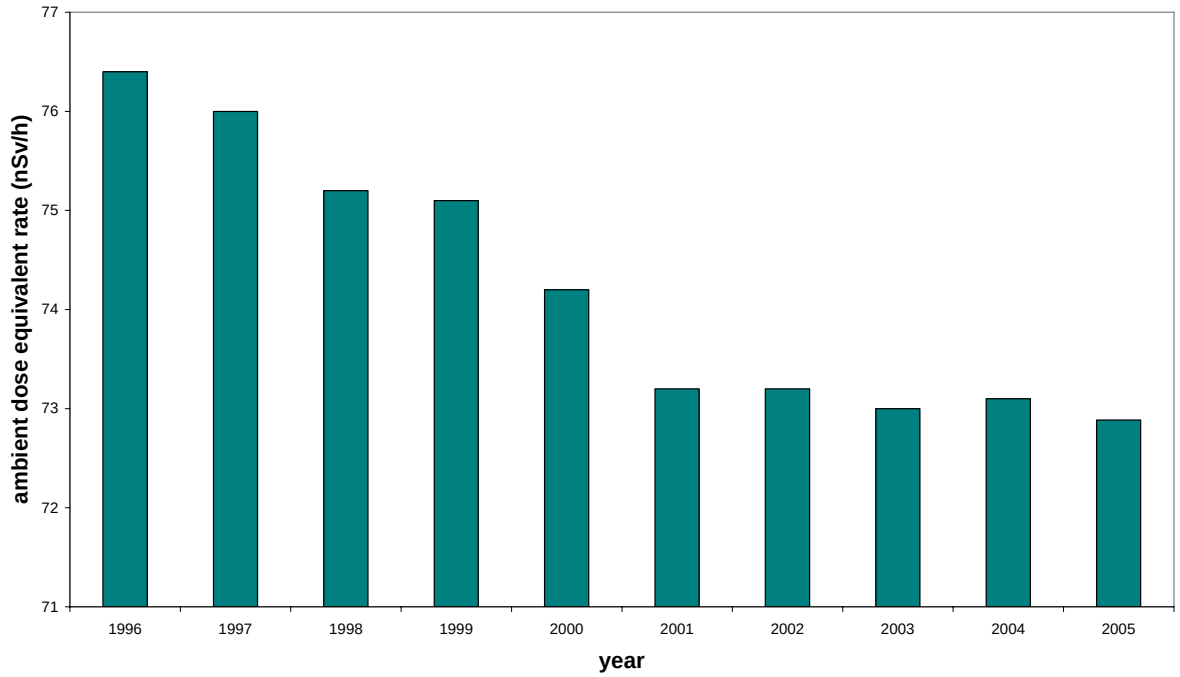


Figure 4.4: The yearly averaged ambient dose equivalent rate.

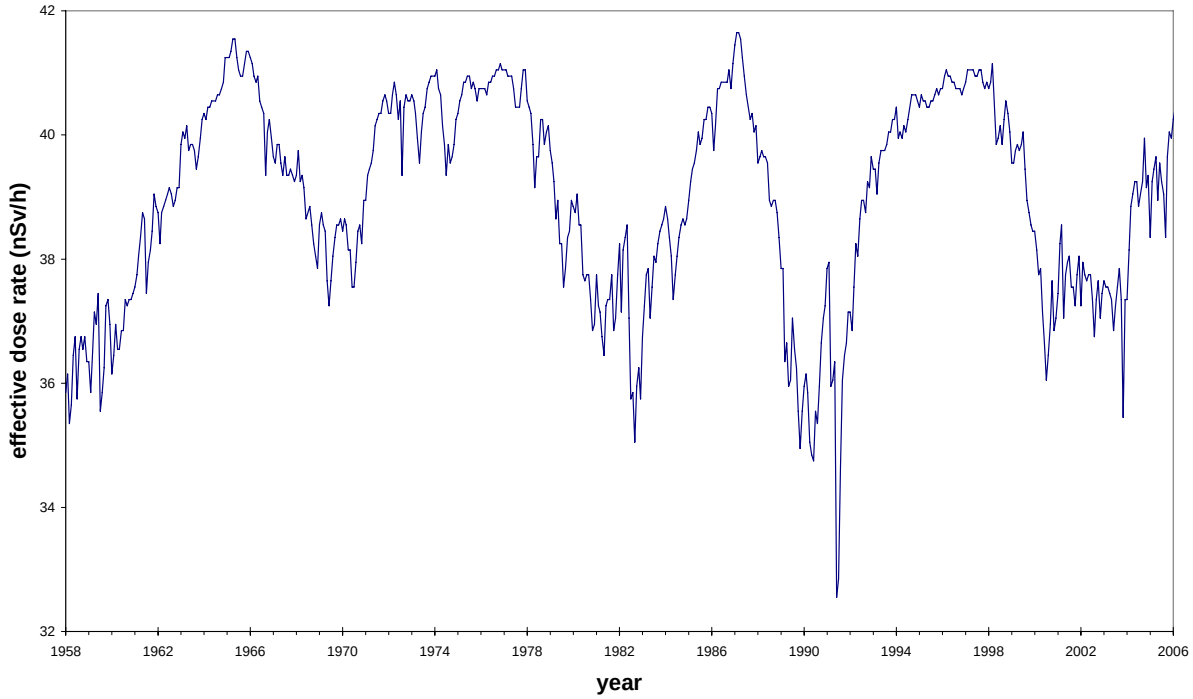


Figure 4.5: Cosmogenic contribution to the effective dose rate (at sea level), influenced by the solar cycle. Location 51° 26' north latitude and 3° 43' eastern longitude (in the south-west of the Netherlands), air pressure 1019 hPa. Figure derived from data supplied by Office of Aerospace Medicine [35]. In previous reports [30, 36] an error has been made be 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 Institute for Inland Water Management and Waste Water Treatment (RIZA) and the National Institute for Coastal and Marine Management (RIKZ) regularly monitor 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 [37, 38, 39].

The locations presented in this report have been chosen to represent the major inland waters and seawater. The 2005 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 2005.

Location	Parameter	Compartment	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	13
(Ketelmeer West)	^{131}I	Suspended solids	13
	^{137}Cs	Suspended solids	13
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.

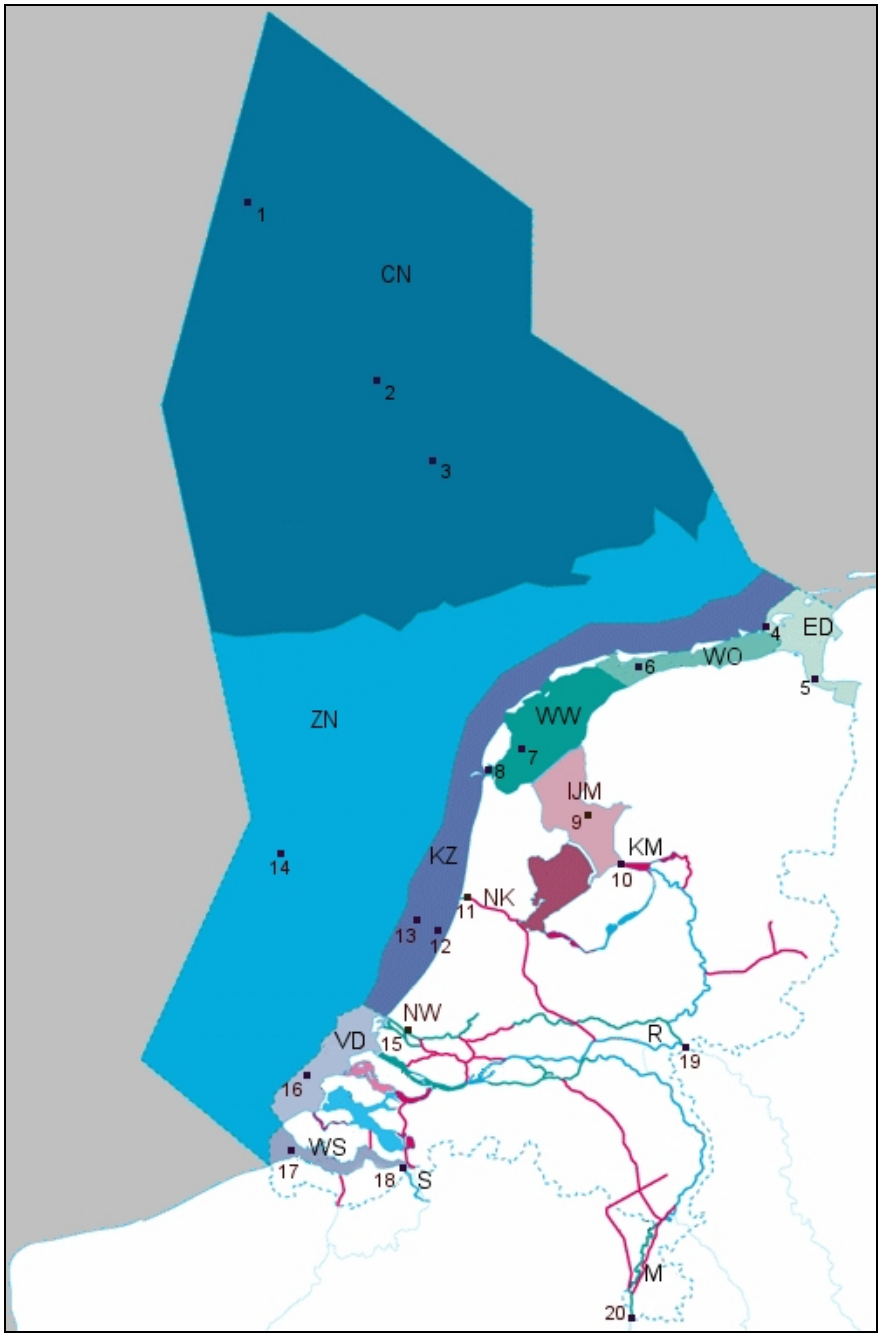
Location	Parameter	Compartment	Monitoring frequency (per year)
Rhine	Gross α	Water	13
(Lobith)	Residual β	Water	13
	^{3}H	Water	13
	^{90}Sr	Water	6
	^{226}Ra	Water	6
	^{60}Co	Suspended solids	13
	^{131}I	Suspended solids	13
	^{137}Cs	Suspended solids	13
	^{210}Pb	Suspended solids	6
Scheldt	Gross α	Water	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 results for surface water are presented in Tables A11 and A12 and in Figures 5.2 to 5.19. The results for seawater are presented in Tables A13 and A14 and in Figures 5.20 to 5.31. The samples were analysed at the RIZA laboratory in Lelystad. The radioactive nuclides were determined according to standard procedures [38] and [40]. 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") [41]. The yearly averages are compared with these target values.

Table 5.2: Monitoring program for the determination of radioactive nuclides in seawater in 2005.

Area	Location	Parameter	Compartment	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	4
		^{210}Po	Suspended solids	4
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	12
		Residual β	Water	12
		^{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	4
		^{210}Po	Suspended solids	4
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 (WW)	Marsdiep Noord	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
	Doove Balg West	^{137}Cs	Suspended solids	2 (2)
		^{210}Po	Suspended solids	2 (2)
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.



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

Noordwijk 2 means Noordwijk 2 km offshore.

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 [38].

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 monitored as they represent the major inland, incoming and outgoing waters of the Netherlands.

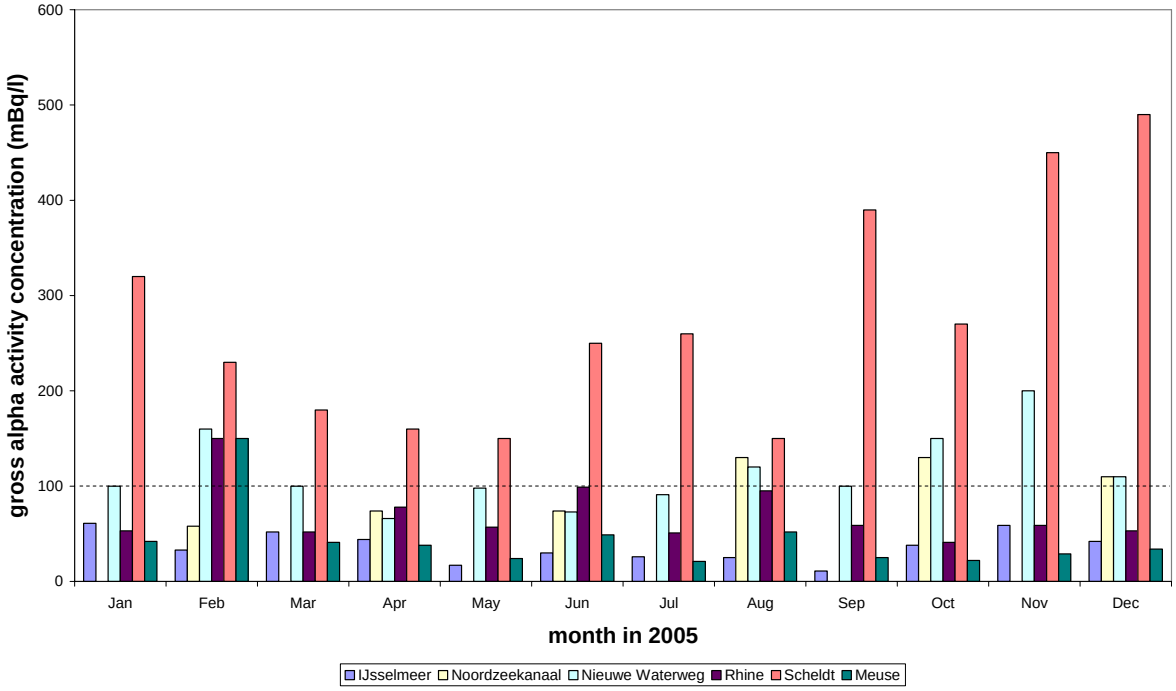


Figure 5.2: The gross α-activity concentration in 2005 for the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 35, 96, 121, 72, 270 and 45 mBq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 100 mBq·L^{-1} [41].

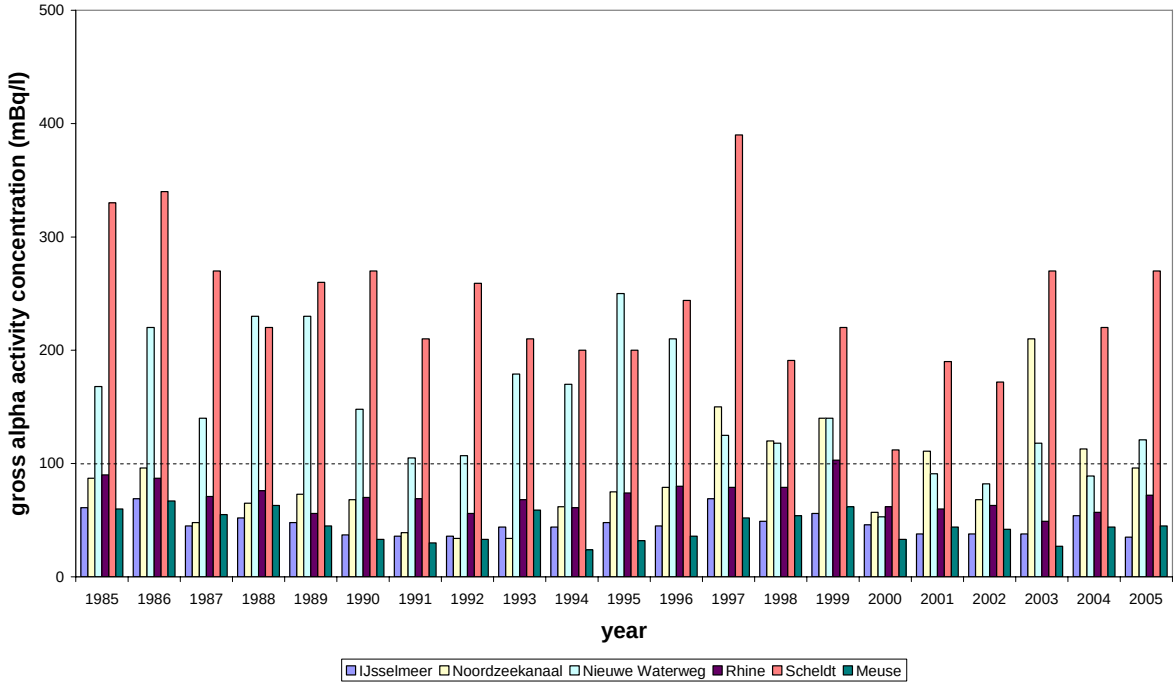


Figure 5.3: Yearly averaged gross α-activity concentrations.

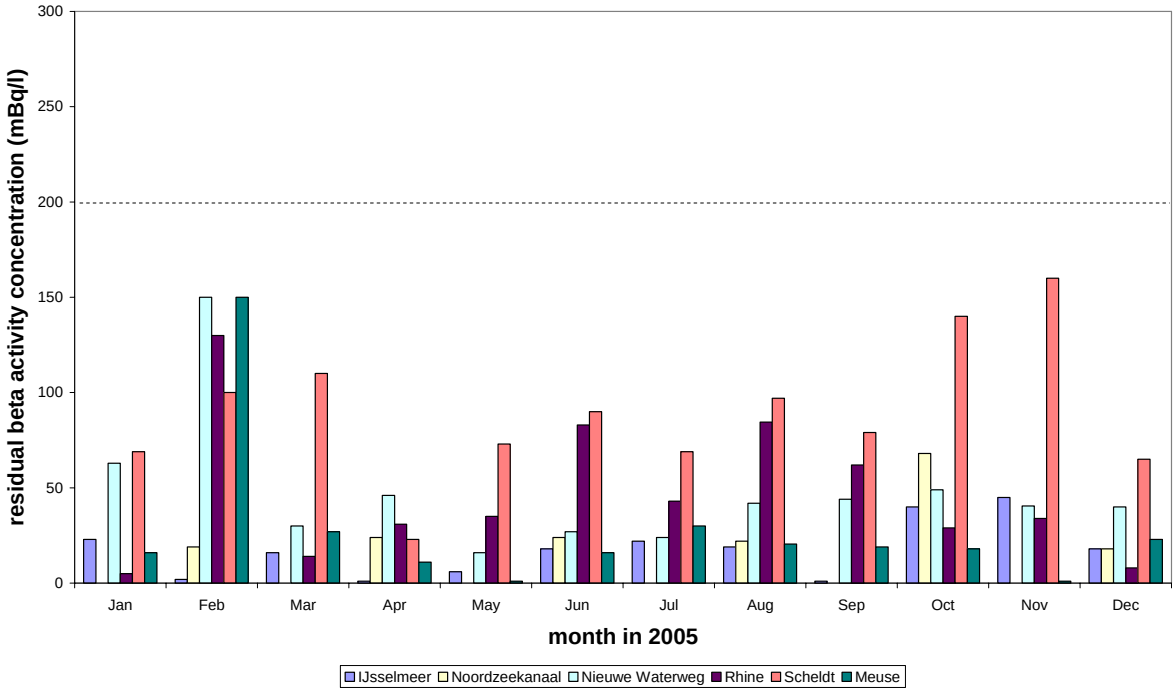


Figure 5.4: The residual β-activity concentration in 2005 for the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 17, 29, 47, 49, 88 and 27 mBq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 200 mBq·L^{-1} [41].

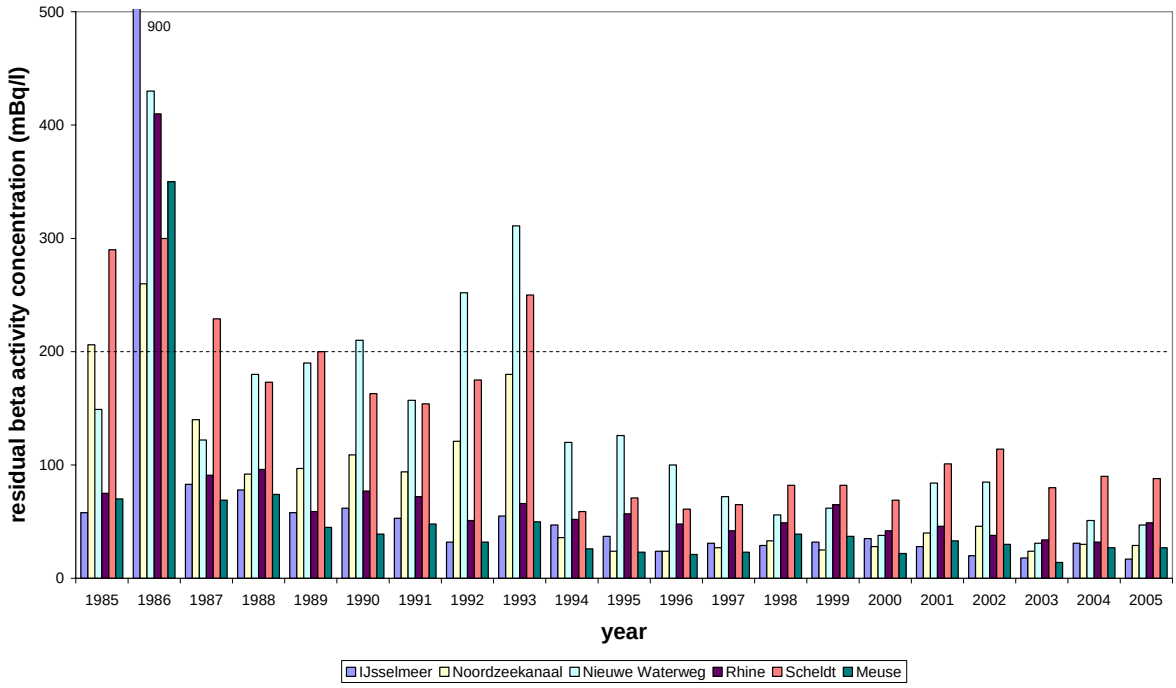


Figure 5.5: Yearly averaged residual β-activity concentrations.

Gross α and residual β are indicative parameters. The yearly averaged activity concentrations of gross α and residual β in 2005 are within the range of those in previous years.

The gross α-activity concentration in the Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse exceeded the target value (100 $mBq \cdot L^{-1}$) 3 out of 6, 6 out of 13, 2 out of 13, 13 out of 13 and 1 out of 13 times, respectively. In 2005 the yearly averaged gross α-activity concentration in the Nieuwe Waterweg and Scheldt (121 and 270 $mBq \cdot L^{-1}$, respectively) are above the target value of 100 $mBq \cdot L^{-1}$.

The yearly averaged residual β-activity concentrations are below the target value of 200 $mBq \cdot L^{-1}$. 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 [38]. Therefore, no change in trend is shown for the IJsselmeer, Rhine and Meuse.

The ^{3}H-activity concentrations in the Scheldt and Meuse exceeded the target value (10 $Bq \cdot L^{-1}$) 3 out of 7, respectively 5 out of 13 times. 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 2005 are within the range of those in previous years. In 2005 the yearly averaged ^{3}H-activity concentration in the Scheldt and Meuse (10.8 and 12.0 $Bq \cdot L^{-1}$, respectively) are above the target value of 10 $Bq \cdot L^{-1}$.

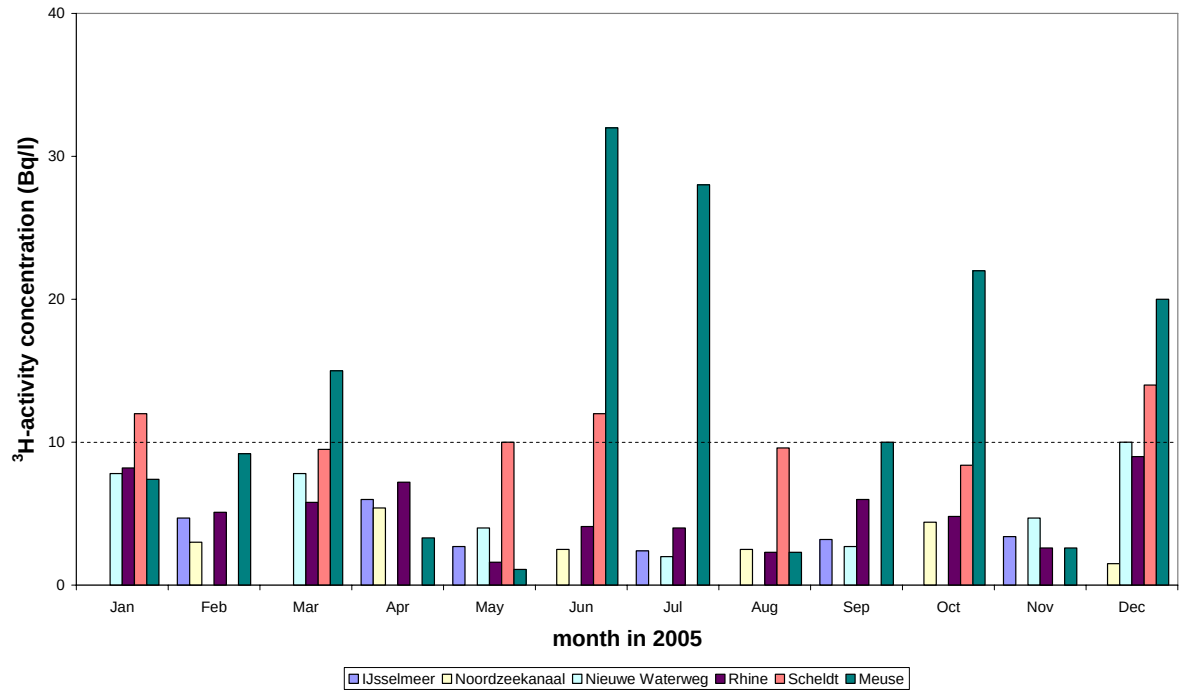


Figure 5.6: The ^{3}H-activity concentration in 2005 for the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 3.7, 3.2, 5.6, 4.8, 10.8 and 12.0 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 10 Bq·L^{-1} [41].

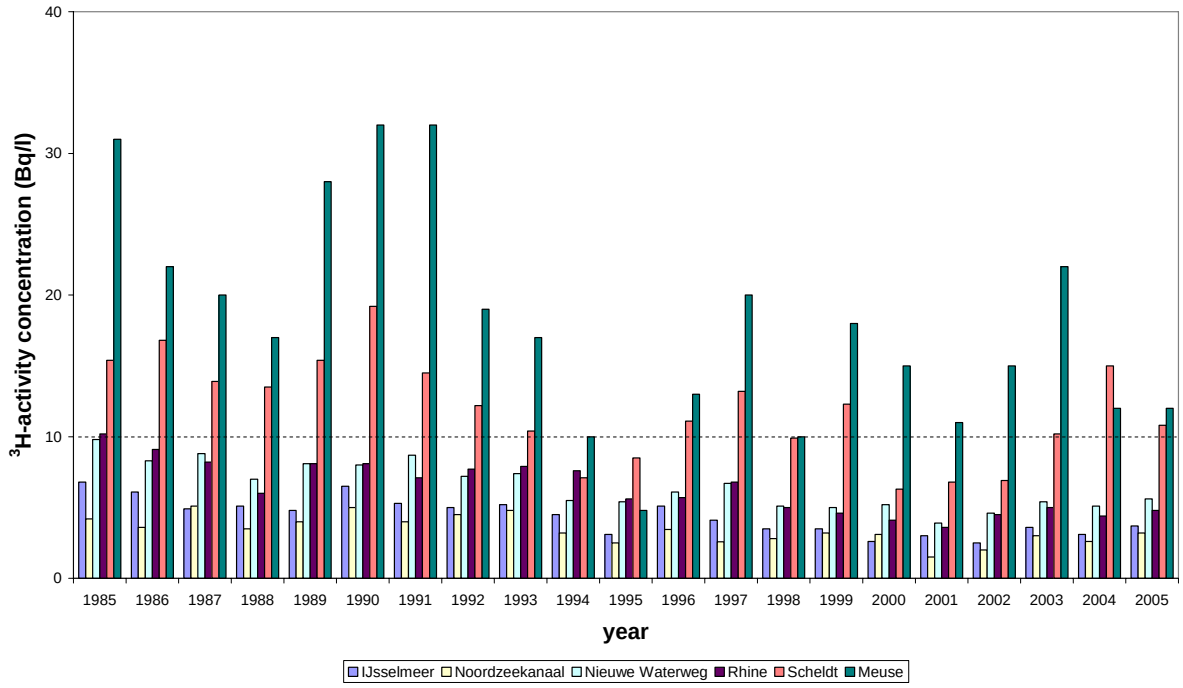


Figure 5.7: Yearly averaged ^{3}H-activity concentrations.

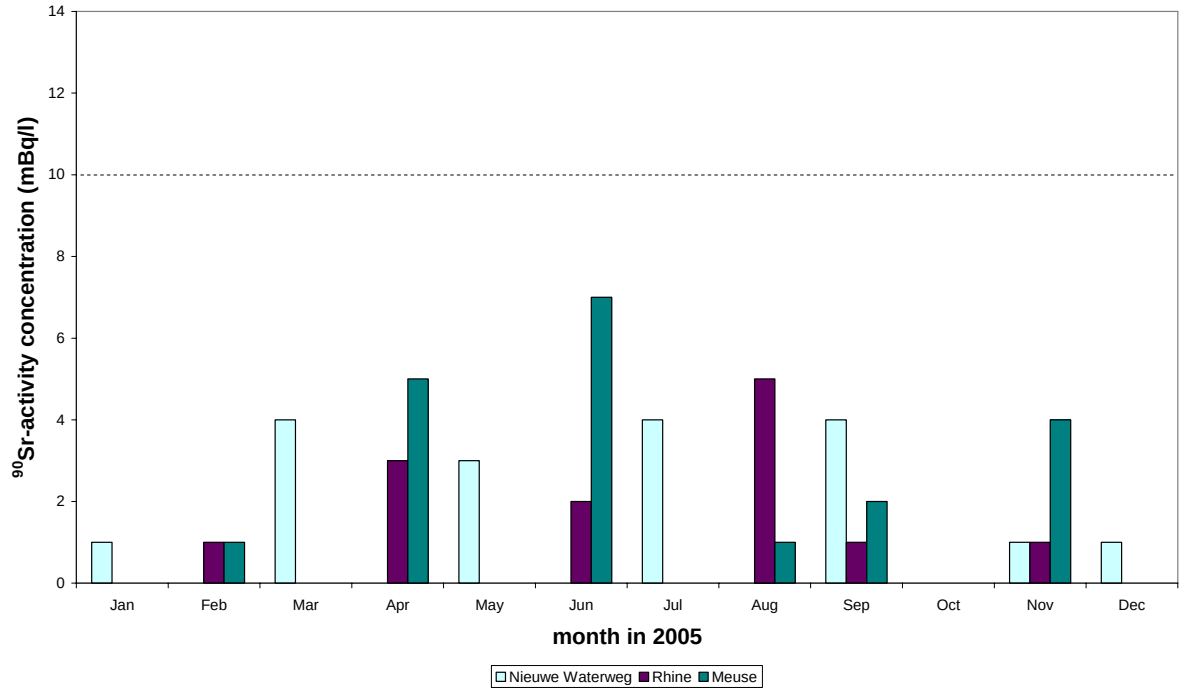


Figure 5.8: The ^{90}Sr-activity concentration in 2005 for the Nieuwe Waterweg, Rhine and Meuse, with yearly averages of 2.4, 2.1 and 3.2 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 10 mBq·L^{-1} [41].

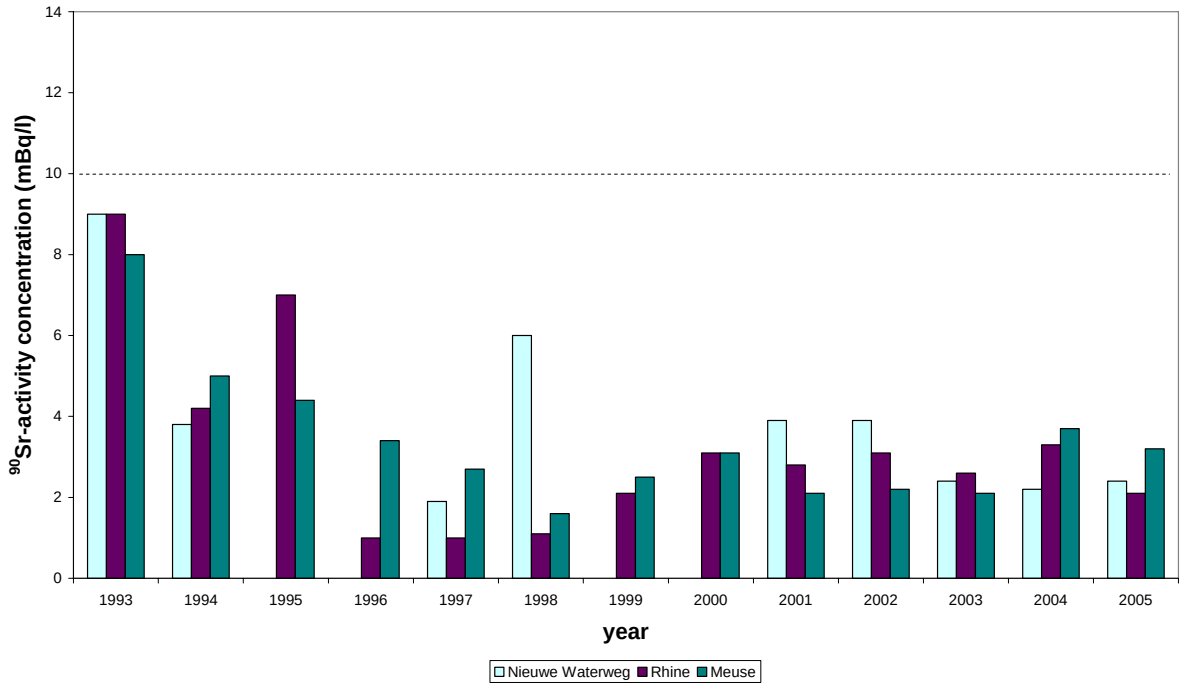


Figure 5.9: Yearly averaged ^{90}Sr-activity concentrations. No data available for the Nieuwe Waterweg in 1995, 1996, 1999 and 2000.

The nuclide ^{90}Sr is discharged into the environment by nuclear power plants and nuclear reprocessing plants. The yearly averaged ^{90}Sr-activity concentrations in 2005 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}.

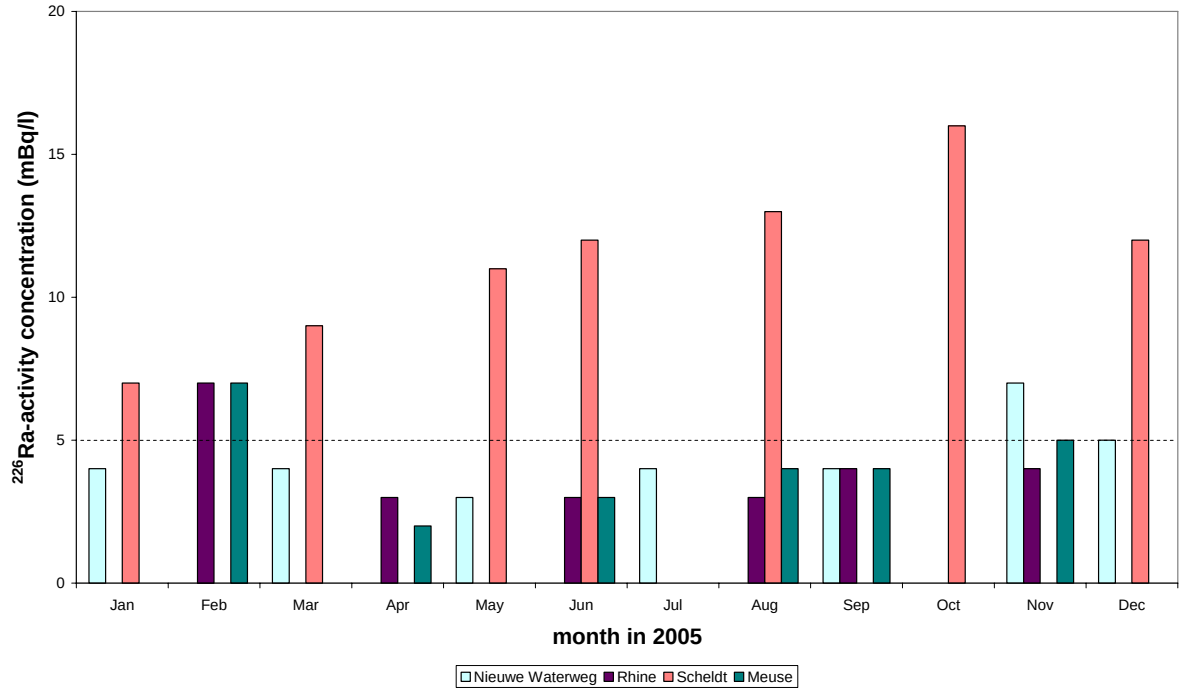


Figure 5.10: The ^{226}Ra-activity concentration in 2005 for the Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 4.4, 4.0, 11 and 4.2 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 5 mBq·L^{-1} [41].

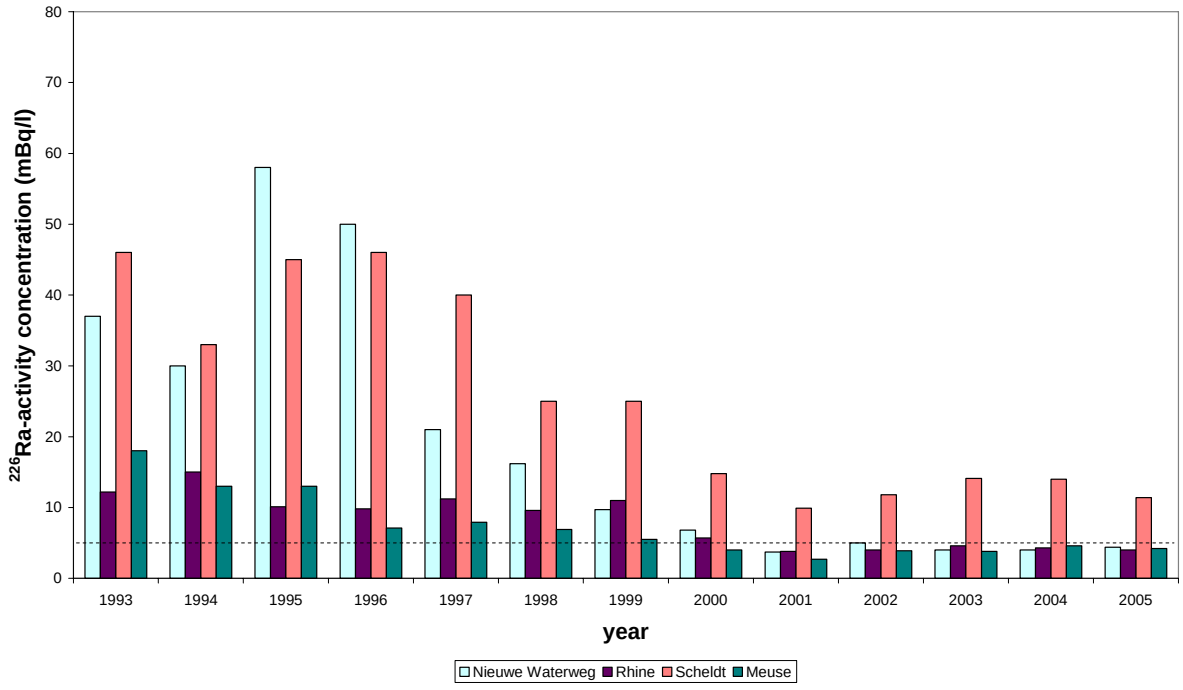


Figure 5.11: Yearly averaged ^{226}Ra-activity concentrations.

The nuclide ^{226}Ra is discharged into the environment by the ore processing industry. The ^{226}Ra-activity concentrations in the Nieuwe Waterweg, Rhine, Scheldt and Meuse exceeded the target value (5 mBq·L^{-1}) 1 out of 7, 1 out of 6, 7 out of 7 and 1 out of 6 times, respectively. The yearly averaged ^{226}Ra-activity concentrations in 2005 are within the range of those in

previous years. In 2005 the yearly averaged ^{226}Ra-activity concentration in the Scheldt (11 mBq·L^{-1}) is above the target value of 5 mBq·L^{-1}.

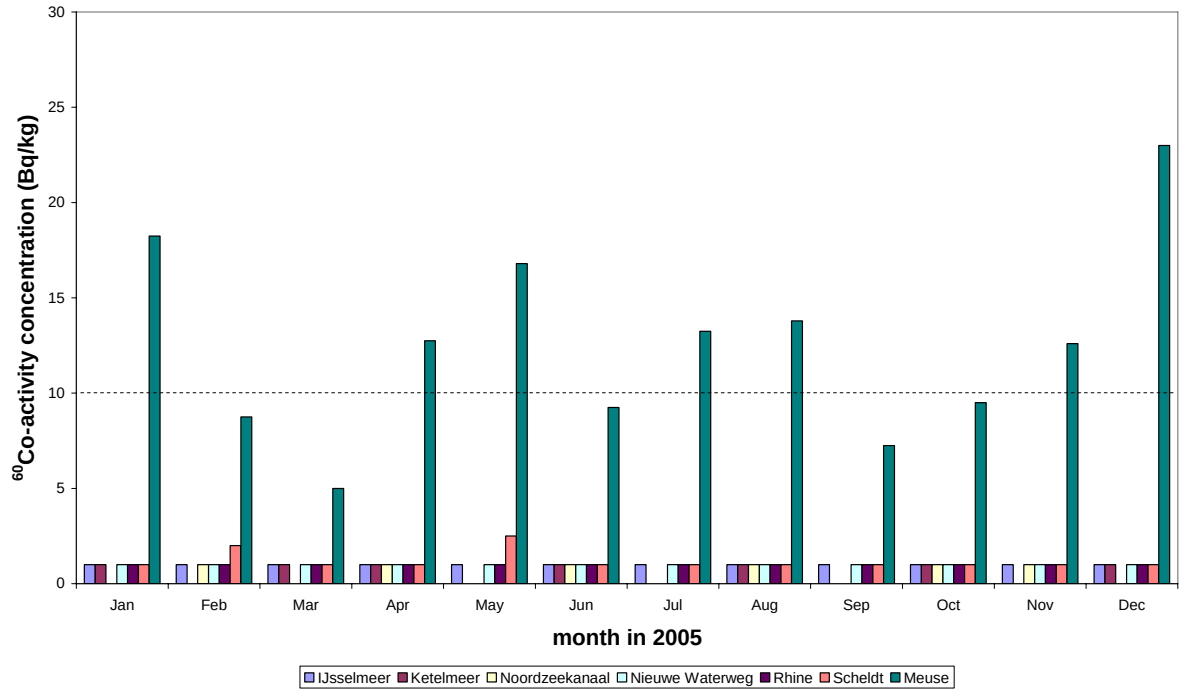


Figure 5.12: The ^{60}Co-activity concentration in suspended solids in 2005 for the IJsselmeer, Ketelmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse. The yearly averages of all except for the Meuse (12.5 Bq·kg^{-1}) are < 1 Bq·kg^{-1}. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 10 Bq·kg^{-1} [41].

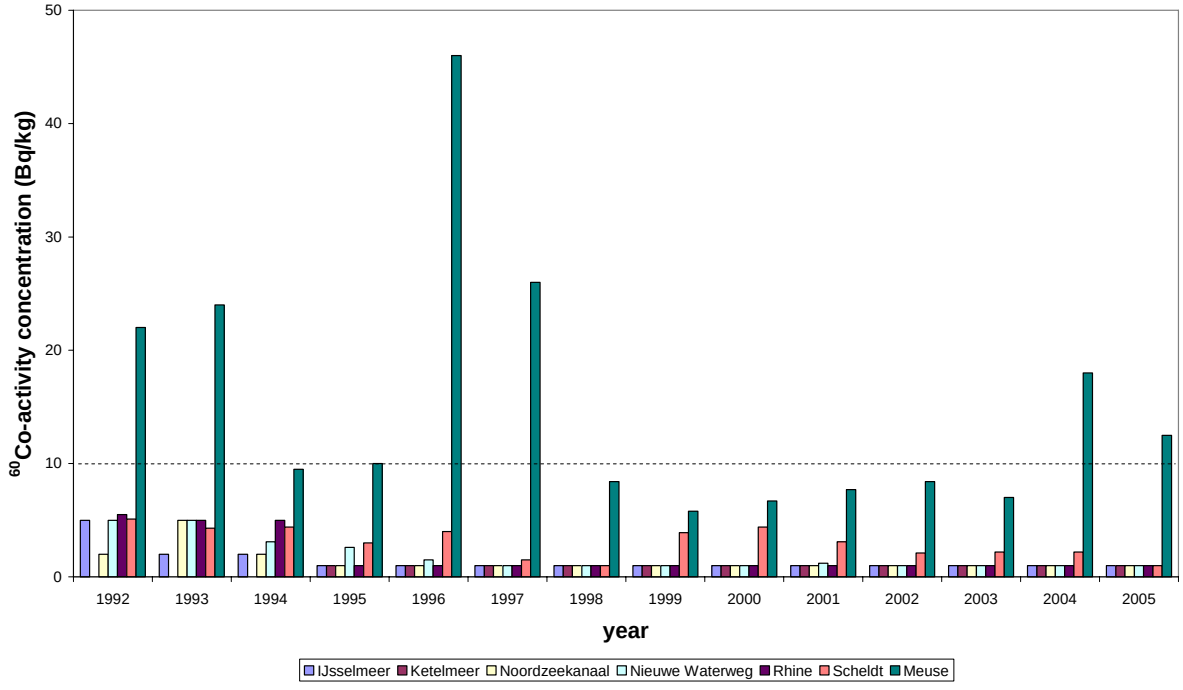


Figure 5.13: Yearly averaged ^{60}Co-activity concentrations in suspended solids. Data on Ketelmeer are available since 1995.

The nuclide ^{60}Co is a known corrosion product of nuclear power plants. The ^{60}Co-activity concentrations in the Meuse exceeded the target value (10 Bq·kg^{-1}) 26 out of 52 times. In 2005 the yearly averaged ^{60}Co-activity concentration in the Meuse (12.5 Bq·kg^{-1}) is above the target value of 10 Bq·kg^{-1}.

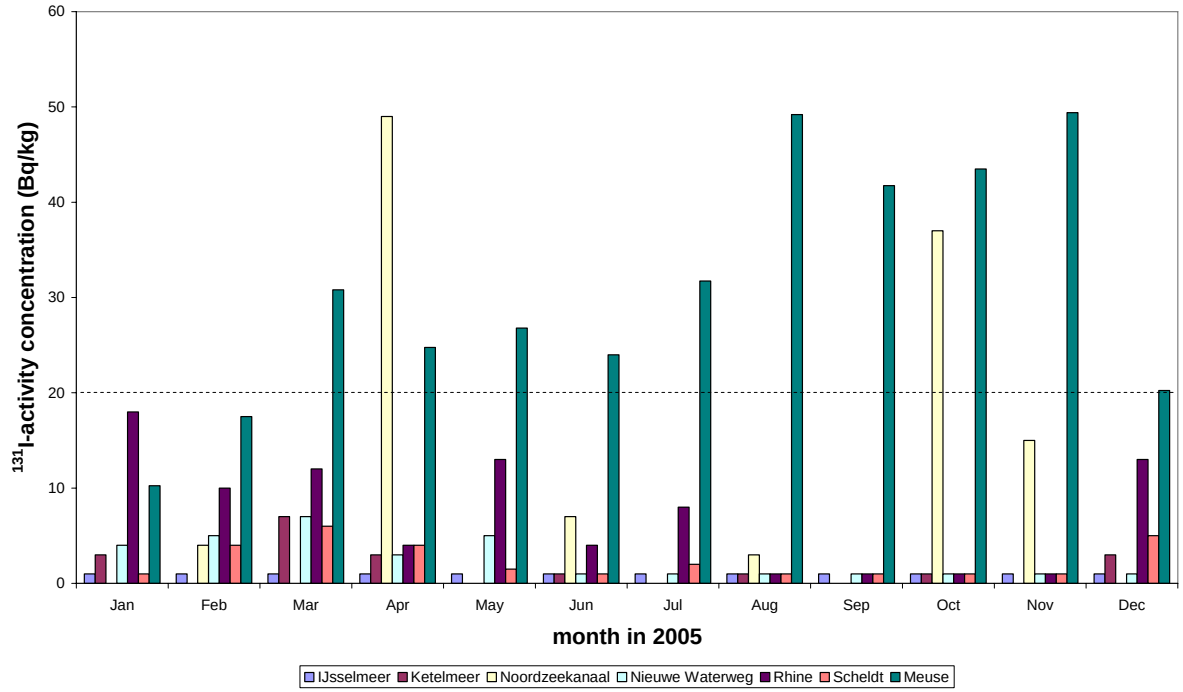


Figure 5.14: The ^{131}I-activity concentration in suspended solids in 2005 for the IJsselmeer, Ketelmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of < 1, 3.0, 19, 2.2, 6.5, < 2, and 31 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 20 Bq·kg^{-1} [41].

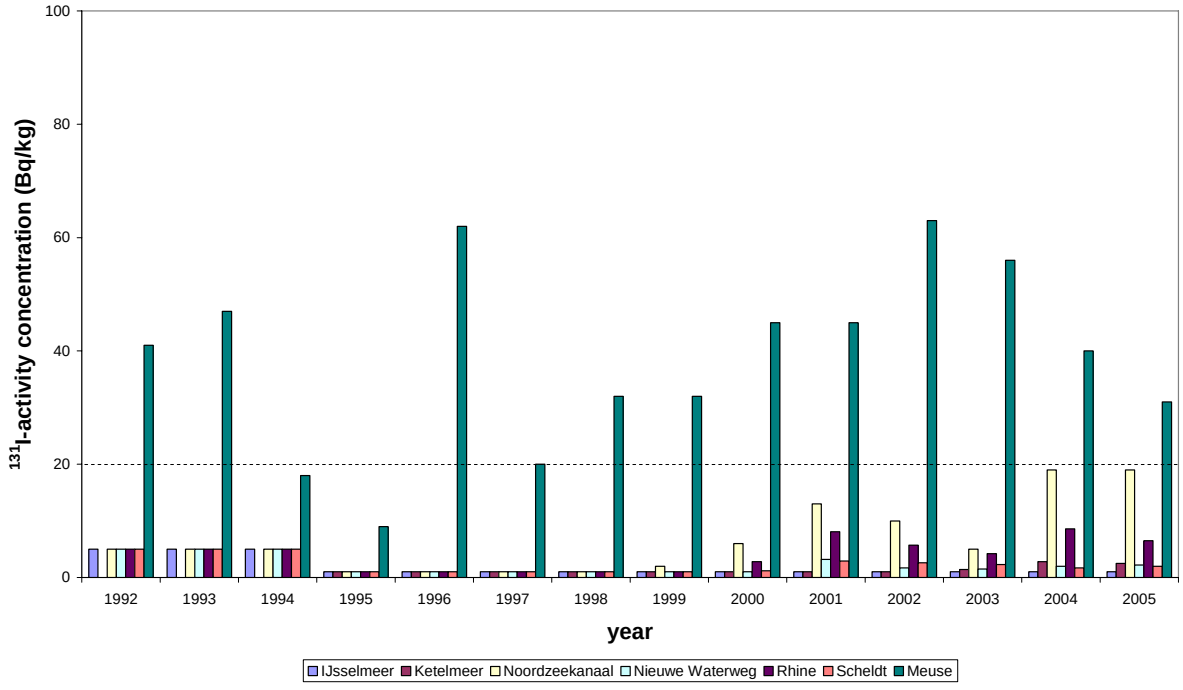


Figure 5.15: Yearly averaged ^{131}I-activity concentrations in suspended solids. Data on Ketelmeer are available since 1995.

The nuclide ^{131}I is discharged into the environment by medical facilities. The ^{131}I-activity concentrations in the Noordzeekanaal and Meuse exceeded the target value (20 Bq·kg^{-1}) 2 out of 6 and 37 out of 52 times, respectively. In 2005 the yearly averaged ^{131}I-activity concentration in the Meuse (31 Bq·kg^{-1}) is above the target value of 20 Bq·kg^{-1}.

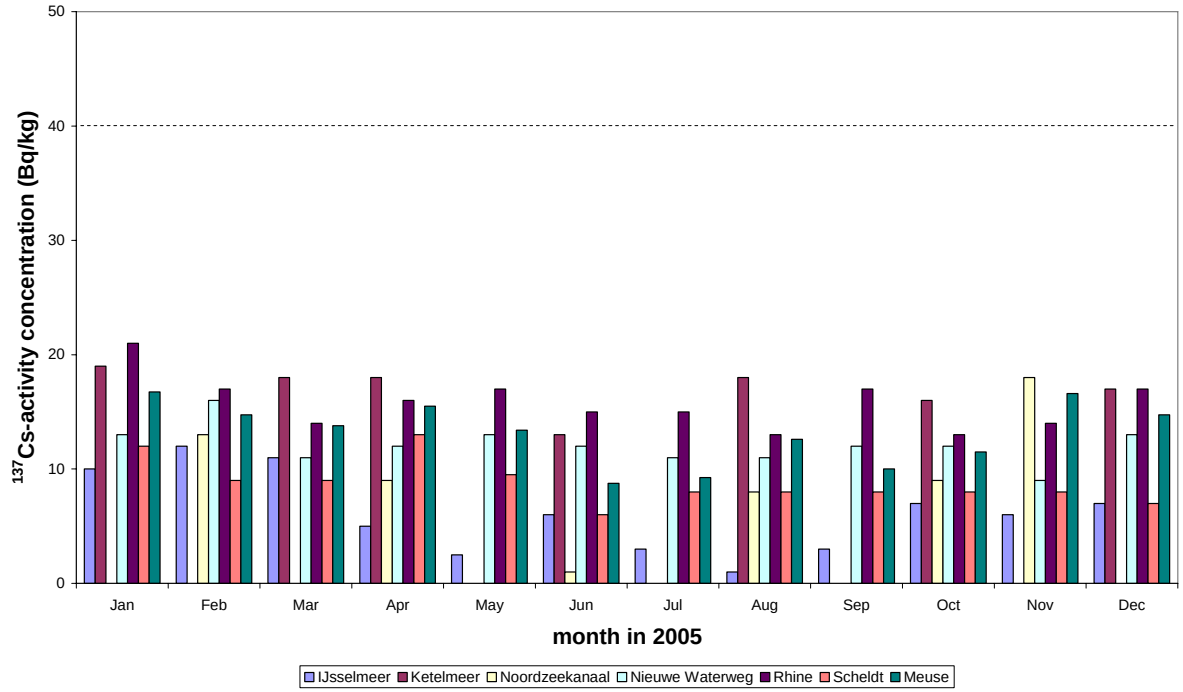


Figure 5.16: The ^{137}Cs-activity concentration in suspended solids in 2005 for the IJsselmeer, Ketelmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 6, 17, 10, 12, 16, 9, and 13 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 40 Bq·kg^{-1} [41].

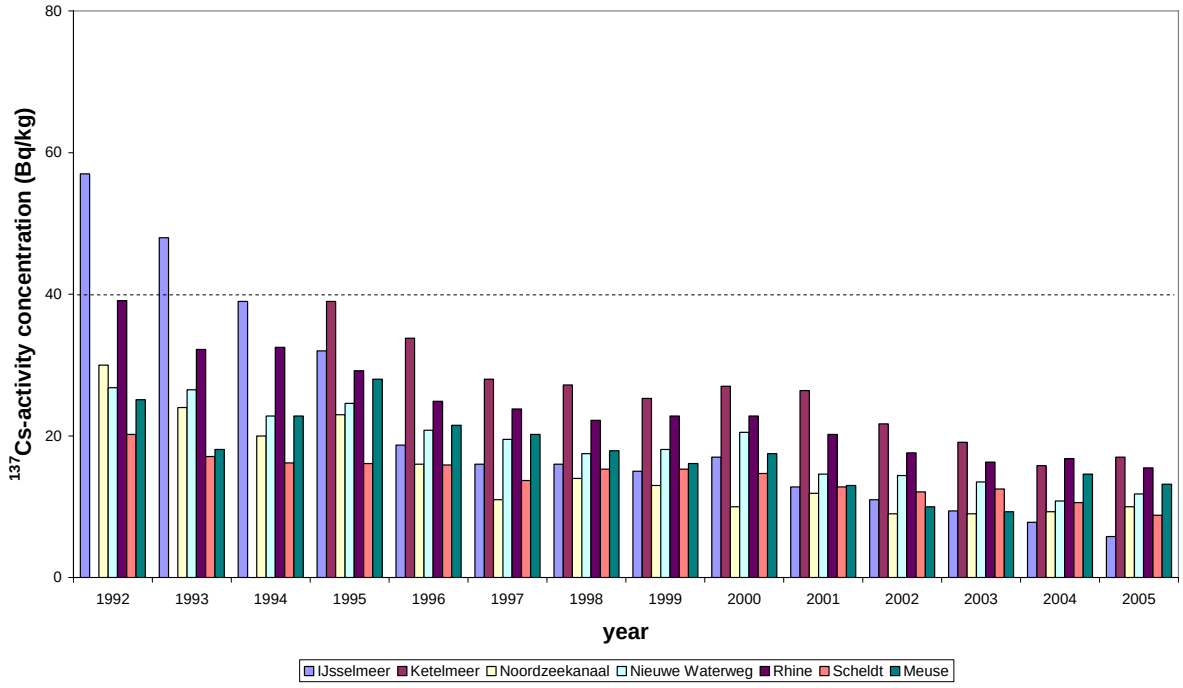


Figure 5.17: Yearly averaged ^{137}Cs-activity concentrations in suspended solids. Data on Ketelmeer are available since 1995.

The yearly averaged concentrations of ^{137}Cs in 2005 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 the yearly averaged concentration of ^{137}Cs is consistently higher in the Ketelmeer compared to that in the Rhine at Lobith. 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 [42].

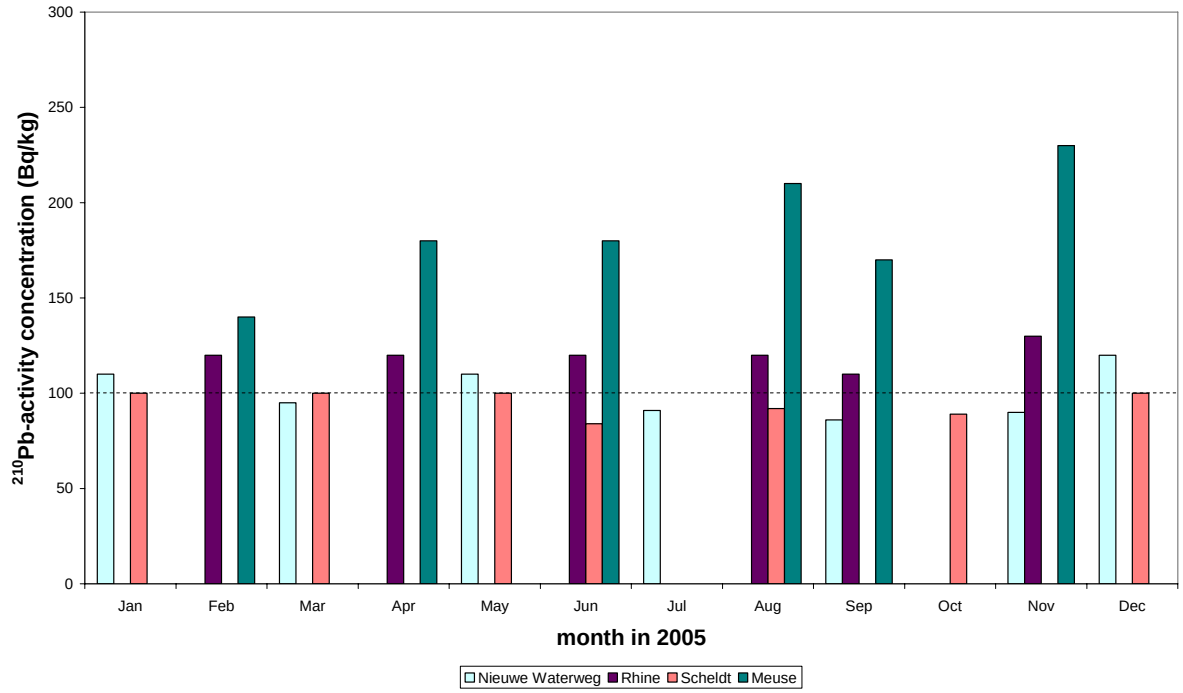


Figure 5.18: The ^{210}Pb-activity concentration in suspended solids in for the Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 100, 120, 95, and 185 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 100 Bq·kg^{-1} [41].

In suspended solids ^{210}Po is almost always in equilibrium with ^{210}Pb. Therefore the Institute for Inland Water Management and Waste Water Treatment (RIZA) only reports ^{210}Pb. The nuclides ^{210}Po and ^{210}Pb originate from the uranium decay chain and are discharged by the phosphate processing industry.

The ^{210}Pb-activity concentrations in the Nieuwe Waterweg, Rhine and Meuse exceeded the target value (100 Bq·kg^{-1}) 3 out of 7, 6 out of 6 and 6 out of 6 times, respectively.
In 2005 the yearly averaged ^{210}Pb-activity concentration in the Rhine and Meuse (120 and 185 Bq·kg^{-1}, respectively) are above the target value of 100 Bq·kg^{-1}.

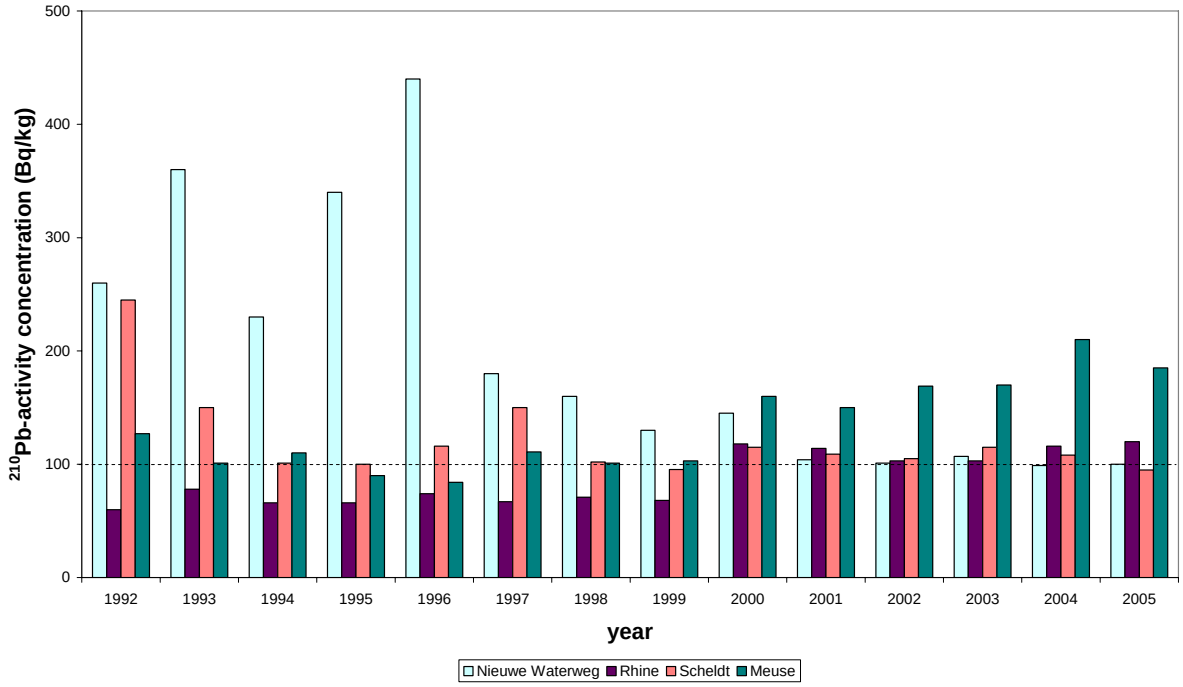


Figure 5.19: Yearly averaged ^{210}Pb-activity concentrations in suspended solids.

5.3 The results for seawater

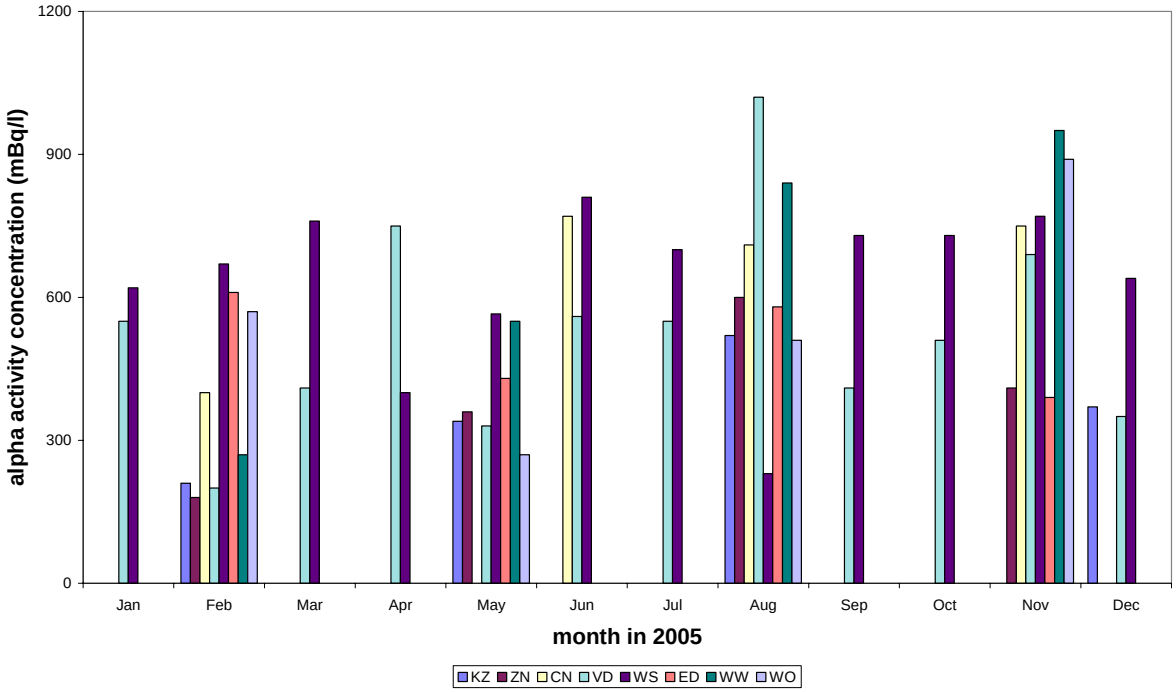


Figure 5.20: The gross α-activity concentration in seawater in 2005. The yearly averages for the Coastal area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Westerscheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO) are 360, 390, 660, 530, 640, 500, 650 and 560 mBq·L^{-1}, respectively.

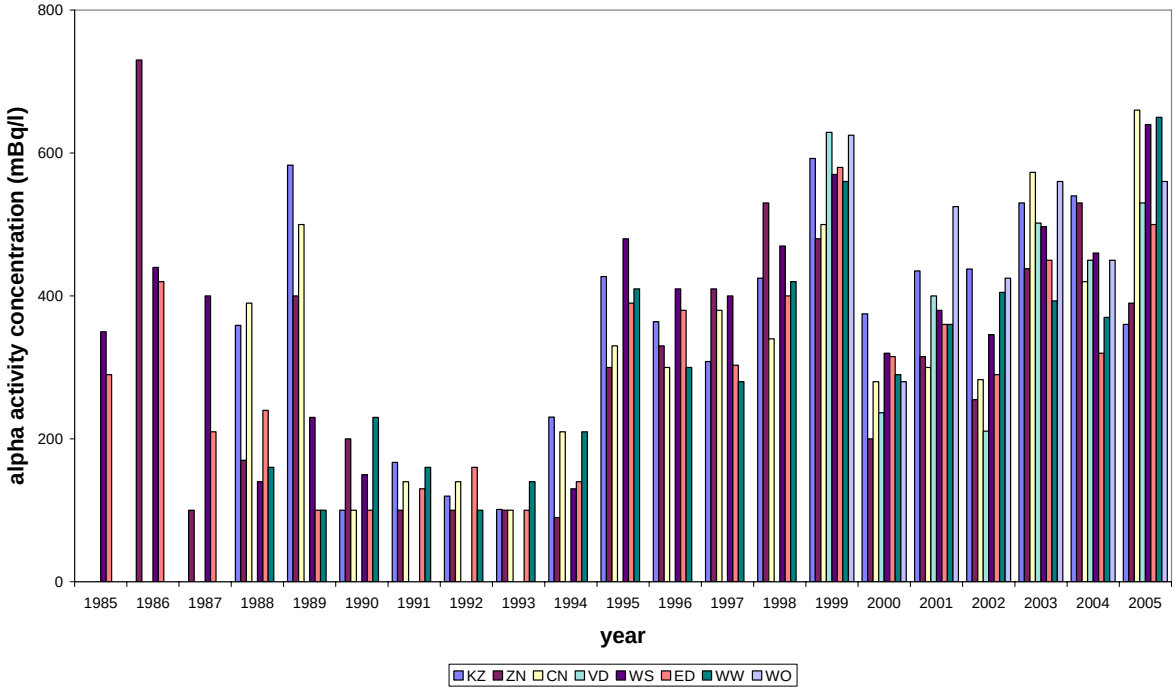


Figure 5.21: Yearly averaged gross α-activity concentrations.

Gross α and residual β are indicative parameters [38]. 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 in the period 1985-1997 are explained elsewhere [38]. The gross α results of 2005 are higher than in previous years.

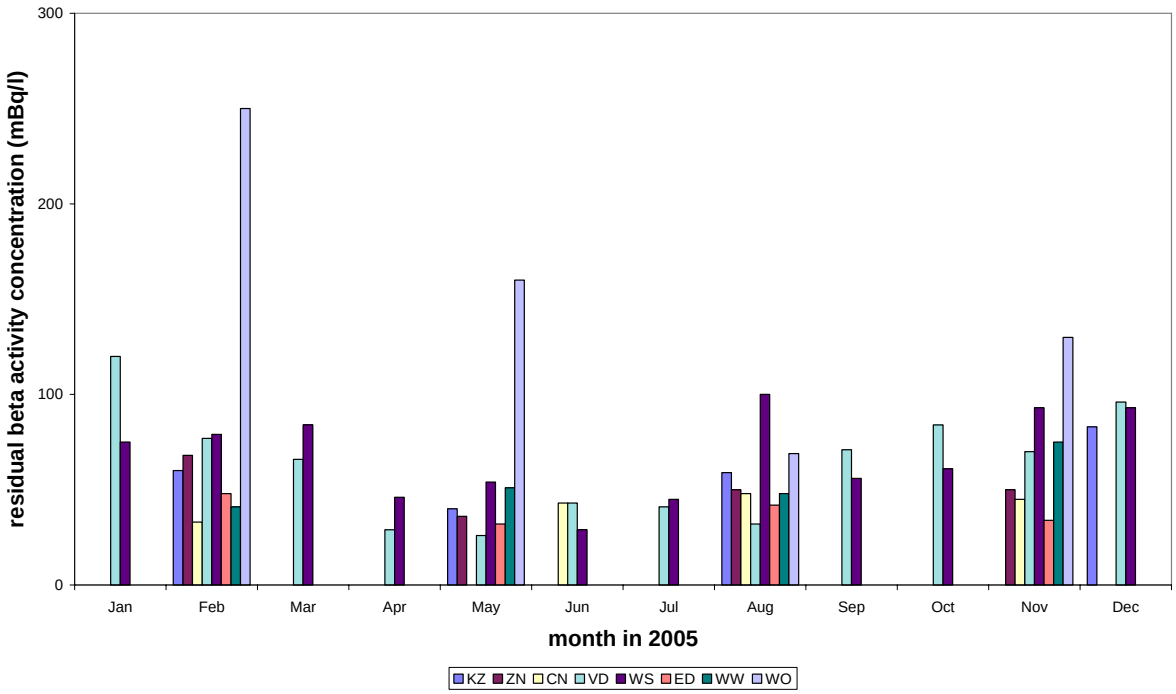


Figure 5.22: The residual β-activity concentration in seawater in 2005. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 60, 51, 42, 63, 68, 39, 54 and 150 mBq·L^{-1}, respectively.

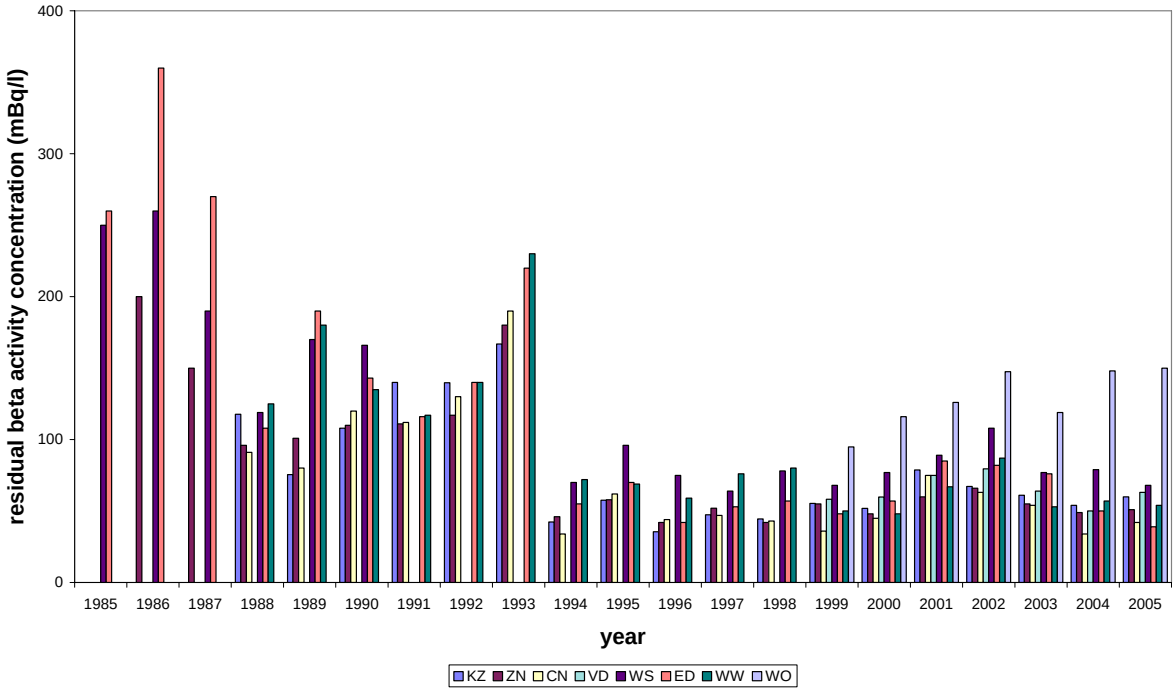


Figure 5.23: Yearly averaged residual β-activity concentrations.

Residual β 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 [38]. The yearly averaged concentrations of residual β in 2005 are within the range of those in the period 1994-2004.

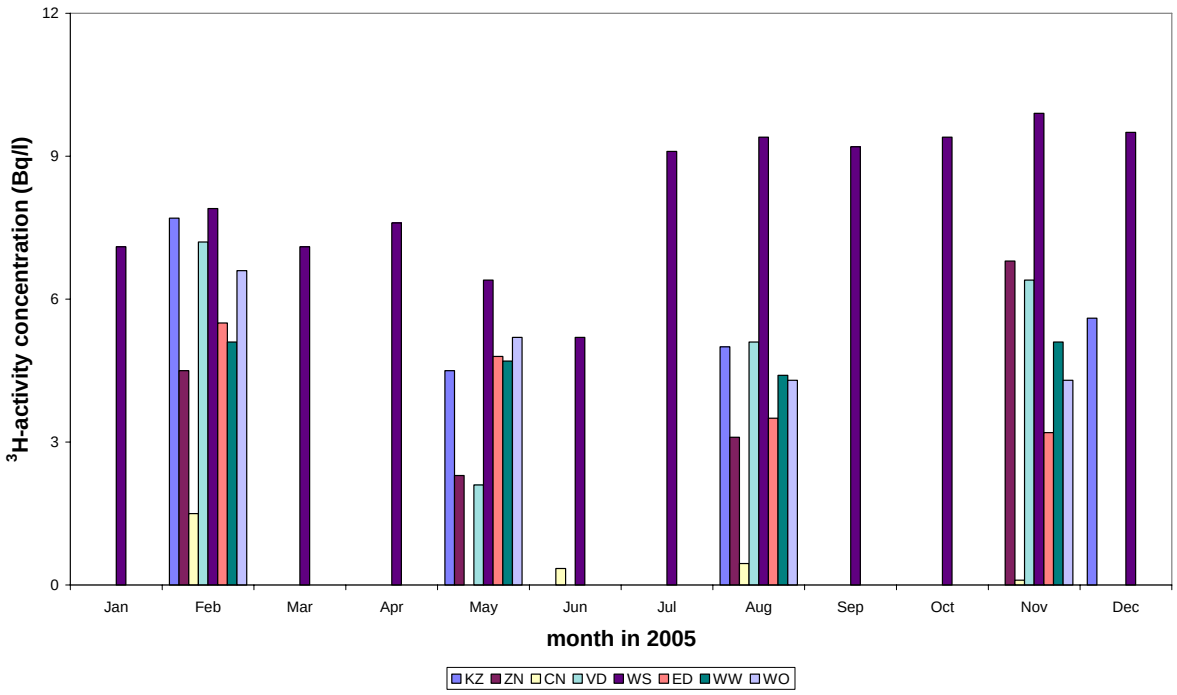


Figure 5.24: The ^{3}H-activity concentration in seawater in 2005. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 5.7, 4.2, 0.6, 5.2, 6.2, 4.2, 4.8 and 5.1 Bq·L^{-1}, respectively.

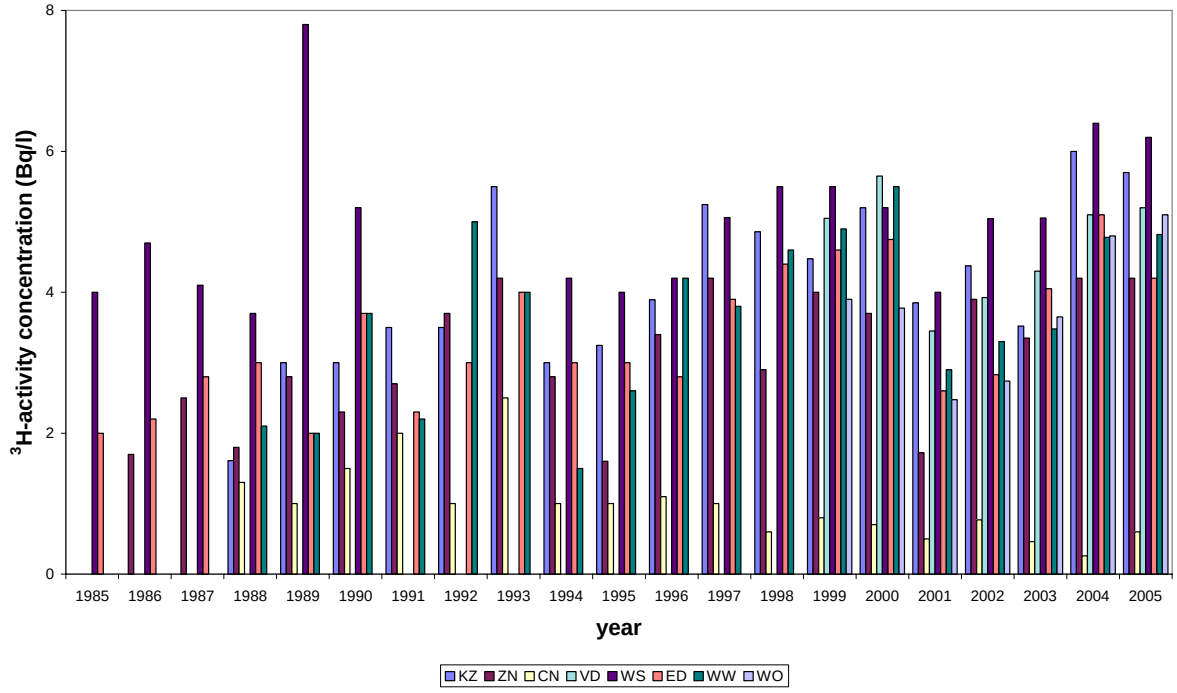


Figure 5.25: Yearly averaged ^{3}H-activity concentrations.

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 [38]. The impact of both sources (nuclear power and reprocessing plants) is monitored indirectly in the Delta Coastal Waters (VD). The yearly averaged concentrations of ^{3}H in 2005 are within the range of those in previous years.

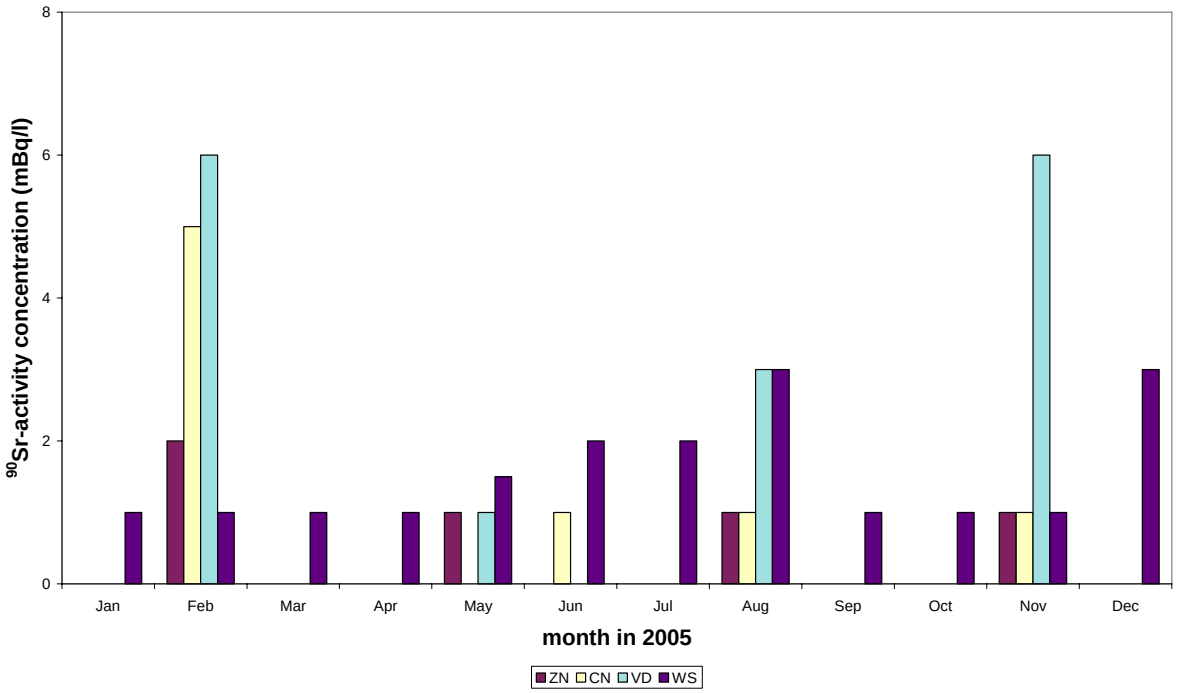


Figure 5.26: The ^{90}Sr-activity concentration in seawater in 2005. The yearly averages for the Southern North Sea, Central North Sea, Delta Coastal Waters and Westerscheldt are < 1, 1.8, 3.9 and 1.3 mBq·L^{-1}, respectively.

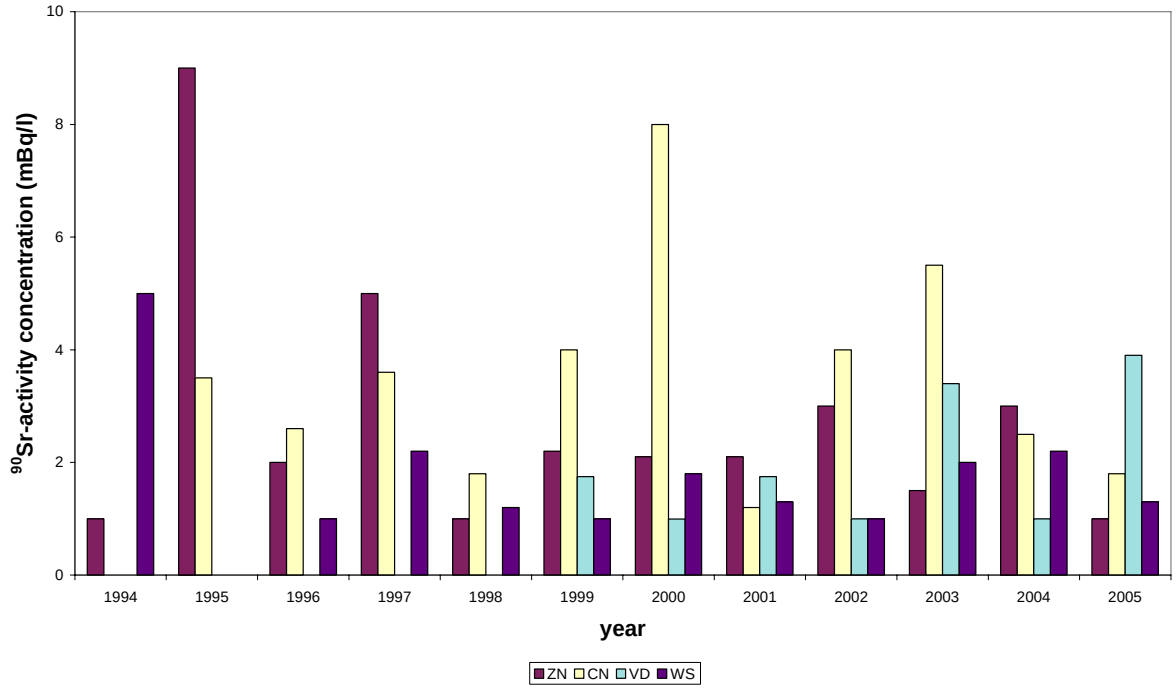


Figure 5.27: Yearly averaged ^{90}Sr-activity concentrations.

In 2005 the yearly averaged concentration of ^{90}Sr in the Delta Coastal Waters was de highest since 1999. The other yearly averaged concentrations of ^{90}Sr in 2005 are within the range of those in previous years.

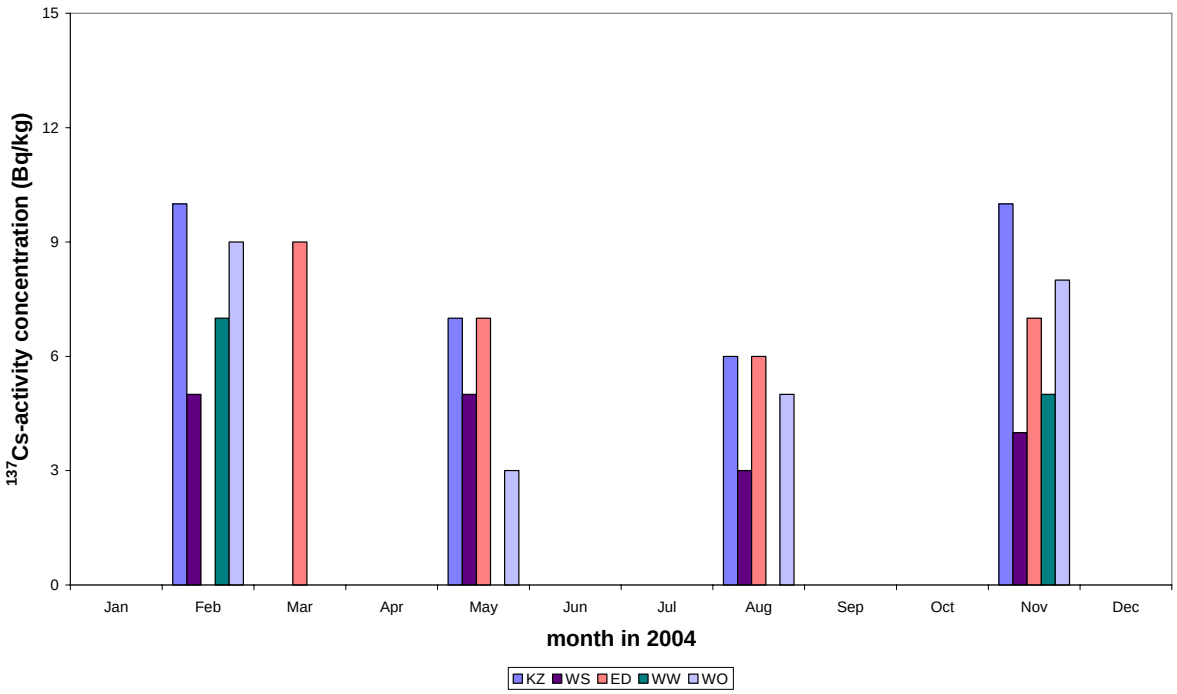


Figure 5.28: The ^{137}Cs-activity concentration in suspended solids in seawater in 2005. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 8.2, 4.2, 7.2, 6.0 and 6.2 $Bq \cdot kg^{-1}$, respectively. Data were not available for some samples taken due to insufficient amount of collected suspended solids (May and August for Wadden Sea West).

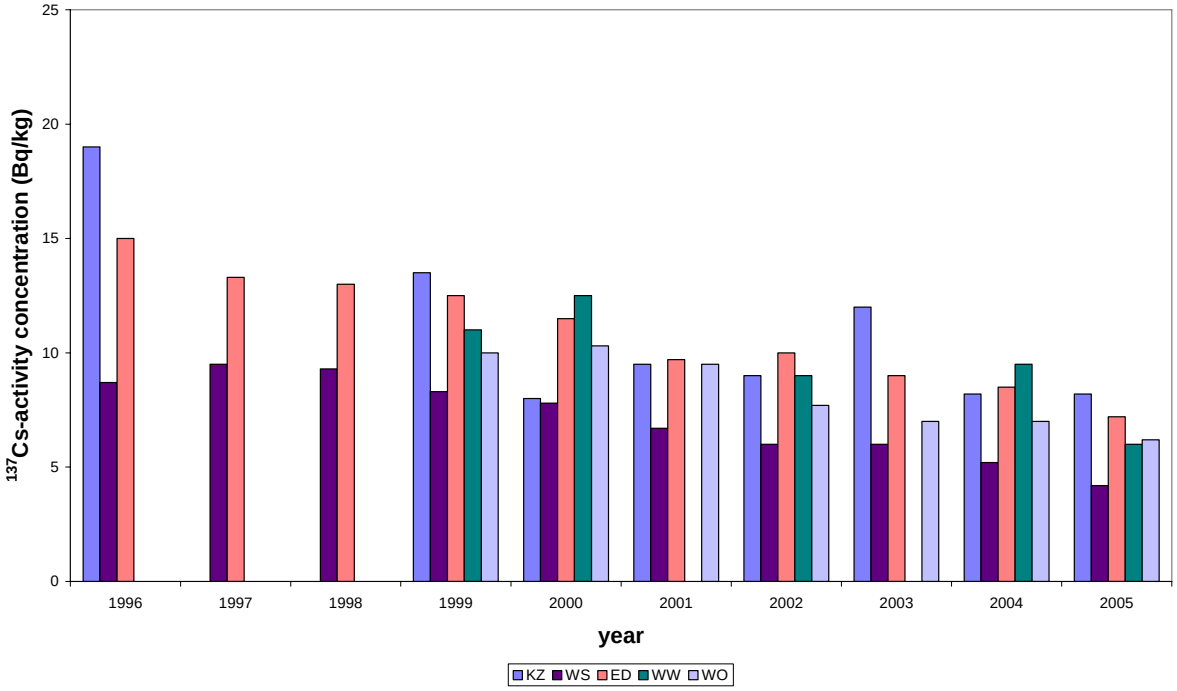


Figure 5.29: Yearly averaged ^{137}Cs-activity concentrations in suspended solids.

The yearly averaged concentrations of ^{137}Cs in 2005 are within the range of those in previous years. In 2001 and 2003 data were not available for Wadden Sea West due to insufficient amount of collected suspended solids.

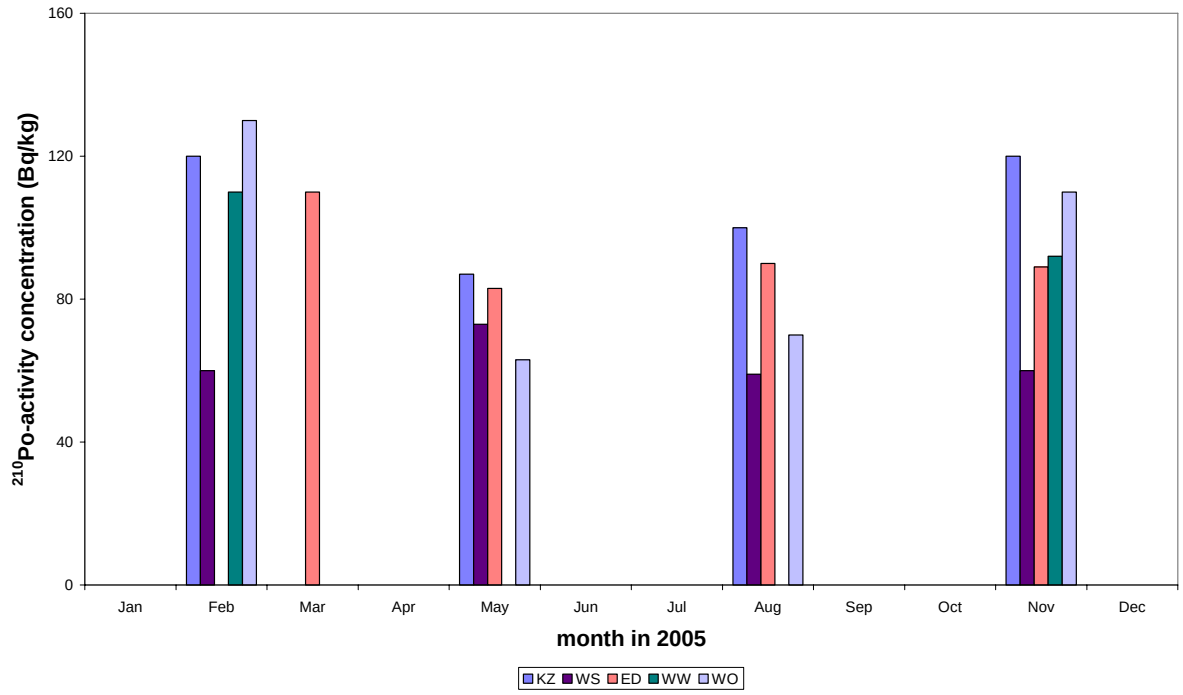


Figure 5.30: The ^{210}Po-activity concentration in suspended solids in seawater in 2005. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 107, 63, 93, 101 and 93 Bq·kg^{-1}, respectively. Data were not available for some samples taken due to insufficient amount of collected suspended solids (May and August for Wadden Sea West).

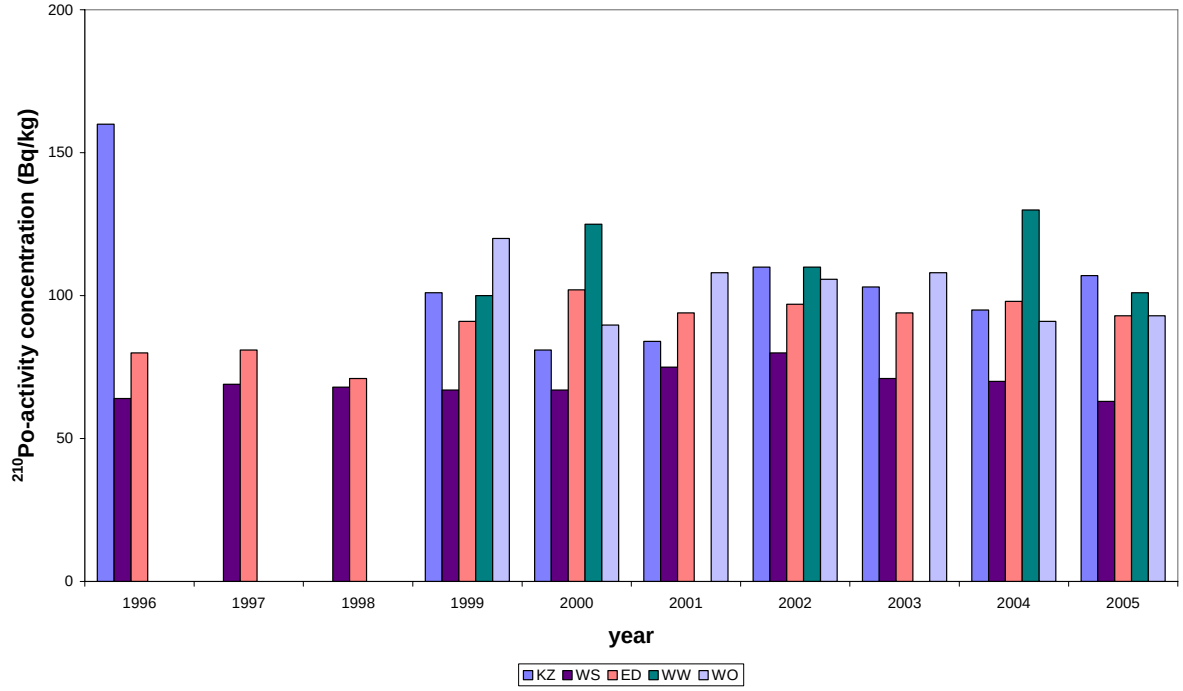


Figure 5.31: Yearly averaged ^{210}Po-activity concentrations in suspended solids.

The nuclide ^{210}Po originates from the uranium decay chain and is discharged by the phosphate processing industry and production platforms for oil and gas [38]. 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 2005 are within the range of those in previous years. In 2001 and 2003 data were not available for Wadden Sea West due to insufficient amount of collected suspended solids.

6 Water for human consumption

In the Netherlands, water pumping-stations monitor raw input water for ^{3}H-, gross β- and residual β-activity. The monitoring frequency is from once to 24 times per year depending on the volume of water produced. The results for 2005 are presented in Table 6.1.
For ^{3}H, gross β and residual β between six and seven hundred analyses were performed divided over about two hundred pumping stations.

Table 6.1 Analyses on drinking water in 2005.

Parameter	**^{3}H**	**Residual β**	**Gross β**
No. of analyses	682	594	669
No. of pumping stations	206	191	209
Average value	< 5 $Bq \cdot L^{-1}$	< 0.3 $Bq \cdot L^{-1}$	< 0.2 $Bq \cdot L^{-1}$
Maximum value (No.) [(1)]	< 14 $Bq \cdot L^{-1}$ (4)	< 0.3 $Bq \cdot L^{-1}$ (594)	0.33 $Bq \cdot L^{-1}$ (7)

(1) Number of results with the maximum value is given between brackets.

The results are within the range of those in previous years [30, 36,43]. Since there is almost no ^{40}K present, gross β- and residual β-activities are equal.

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 [44]. The average concentration found was 2.2 $Bq \cdot L^{-1}$ for drinking water produced from groundwater.

7 Milk

The Institute for Food Safety monitors radioactivity in milk on a weekly base via the National Monitoring Network Radioactivity in Food (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 26 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 2005 are presented in Table 7.1.

Table 7.1: Monthly averaged activity concentrations of ^{40}K,^{60}Co, ^{131}I, ^{134}Cs and ^{137}Cs ($Bq \cdot L^{-1}$) in milk in 2005.

Month	Number of samples	^{40}K $Bq \cdot L^{-1}$	^{60}Co $Bq \cdot L^{-1}$	^{131}I $Bq \cdot L^{-1}$	^{134}Cs $Bq \cdot L^{-1}$	^{137}Cs $Bq \cdot L^{-1}$
January	91	47 ± 8	< 4	< 2	< 2	< 2
February	83	48 ± 7	< 4	< 2	< 2	< 2
March	98	46 ± 8	< 4	< 2	< 2	< 2
April	82	46 ± 9	< 4	< 2	< 2	< 2
May	82	46 ± 8	< 4	< 2	< 2	< 2
June	77	45 ± 8	< 4	< 2	< 2	< 2
July	94	45 ± 9	< 4	< 2	< 2	< 2
August	89	45 ± 9	< 4	< 2	< 2	< 2
September	71	46 ± 8	< 4	< 2	< 2	< 2
October	85	45 ± 9	< 4	< 2	< 2	< 2
November	76	46 ± 9	< 4	< 2	< 2	< 2
December	84	46 ± 10	< 4	< 2	< 2	< 2
Average	1012 (1)	46 ± 8	< 4	< 2	< 2	< 2

(1) Yearly total.

The Institute for Food Safety analysed 27 milk samples for ^{90}Sr in the last quarter of 2005. The samples were taken across the Netherlands on 27 locations of which one was a farm. The ^{90}Sr-activity concentration was below 0.1 $Bq \cdot L^{-1}$ in all samples taken.

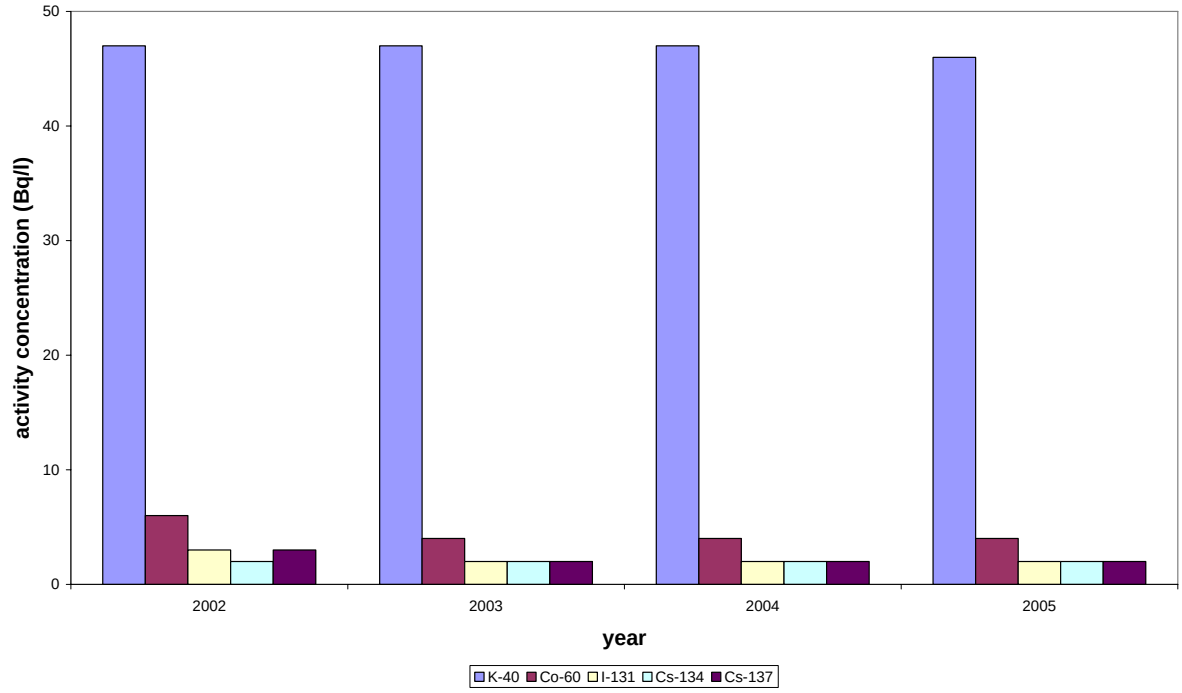


Figure 7.1: Yearly averaged activity concentrations of ^{40}K, ^{60}Co, ^{131}I, ^{134}Cs and ^{137}Cs in milk.

8 Food

The measurements are performed by the Food and Consumer Product Safety Authority. Measurements were carried out according to standard procedures [45, 46]. The results are presented in Table 8.1. None of the samples exceeded the set limit [47].

Since 2005 the Food and Consumer Product Safety Authority monitors activity concentrations in a mixed diet. The mixed diet is sampled as separate ingredients during two weeks in five different regions. In each region a standard sampling [48] is carried out which consists of 95 samples, of which 66 are taken from retail shops and 29 are taken from auctions and distribution centres. The samples are divided in the following product groups: grain (16), vegetables (24), fruit (5), milk and milk products (12), meat and meat products (16), game and poultry (8), salads (6) and oil and butter (8). Given between brackets are the amounts of samples per group.

Radioactivity is also measured in food suspected to contain more than the normal activity concentrations. In total 860 samples were analysed.

8.1 Honey

In total 275 samples of honey were analysed [49]. The activity (sum of ^{134}Cs and ^{137}Cs) was found to be below the set limit of 600 Bq·kg^{-1} [47]. Only thirteen samples of honey (all heather honey) contained ^{137}Cs. The activity varied from 15 up to 494 Bq·kg^{-1}.

8.2 Other products

Except for natural occurring ^{40}K, radioactivity was not detected in the other product categories.

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

Product	Number of samples	Number of positive samples	^{134}Cs Bq·kg^{-1}	^{137}Cs Bq·kg^{-1}
Grain	68	0	< 0.6	< 0.5
Vegetables	124	0	< 0.6	< 0.5
Fruit	47	0	< 0.6	< 0.5
Milk and milk products	60	0	< 0.6	< 0.5
Meat and meat products	70	0	< 0.6	< 0.5
Game and poultry	133	0	< 0.6	< 0.5
Salads	40	0	< 0.6	< 0.5
Oil and butter	35	0	< 0.6	< 0.5
Honey	275	13	< 0.6	15 - 494
Miscellaneous	8	0	< 0.6	< 0.5

9 Conclusions

The gross α-activity concentration in the Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse exceeded the target value (100 $mBq \cdot L^{-1}$) in three out of six, six out of thirteen, two out of thirteen, thirteen out of thirteen and one out of thirteen samples taken, respectively. The yearly averaged gross α-activity concentrations in the Nieuwe Waterweg and Scheldt (121 and 270 $mBq \cdot L^{-1}$, respectively) are above the target value, but within range of those in previous years.

The ^{3}H-activity concentration in the Meuse and Scheldt exceeded the target value (10 $Bq \cdot L^{-1}$) in five out of thirteen and three out of seven samples taken, respectively. The yearly averaged ^{3}H-activity concentrations in the Meuse and Scheldt (12.0 and 10.8 $Bq \cdot L^{-1}$, respectively) are above the target value, but within range of those in previous years.

The ^{226}Ra-activity concentration in the Nieuwe Waterweg, Rhine, Scheldt and Meuse exceeded the target value (5 $mBq \cdot L^{-1}$) in one out of seven, one out of six, seven out of seven and one out of six samples taken, respectively. The yearly averaged ^{226}Ra-activity concentration in the Scheldt (11 $mBq \cdot L^{-1}$) is above the target value, but within range of those in previous years.

The ^{60}Co-activity concentration in the Meuse exceeded the target value (10 $Bq \cdot kg^{-1}$) in twenty-six out of fifty-two samples taken. The yearly averaged ^{60}Co-activity concentration in the Meuse (12.5 $Bq \cdot kg^{-1}$) is above the target value.

The ^{131}I-activity concentration in the Noordzeekanaal and Meuse exceeded the target value (20 $Bq \cdot kg^{-1}$) in two out of six and thirty-seven out of fifty-two samples taken, respectively. The yearly averaged ^{131}I-activity concentration in the Meuse (31 $Bq \cdot kg^{-1}$) is above the target value, but within range of those in previous years.

The ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine and Meuse exceeded the target value (100 $Bq \cdot kg^{-1}$) in three out of seven, six out of six and six out of six samples taken, respectively. The yearly averaged ^{210}Pb-activity concentration in the Rhine and Meuse (120 and 185 $Bq \cdot kg^{-1}$, respectively) are above the target value, but within range of those in previous years.

The yearly averaged gross α-activity concentrations in seawater are higher in 2005 than in previous years. The yearly averaged ^{90}Sr-activity concentration of 2005 in the Delta Coastal Waters was the highest since 1999.

The results of all other radioactivity measurements are within range of previous years. Data on air dust and deposition were reanalysed from 1991 respectively 1993 onwards for presentation purposes. This can result in small differences between results presented in this report and in previous reports.

In 2005 the program was extended with measurements in milk and in mixed diet. Contrary to previous reports the Dutch monitoring program now complies with the recommendations of the European Union.

References

[1] EC, 2000. Recommendation of the Commission of the European Communities on the application of Article 36 of the Euratom Treaty. EC Brussels, 2000/473/Euratom.

[2] R.M.W. Overwater (ed), 1998. Monitoring of radiation in airdust, deposition and an overall country milk sample. Results in the Netherlands in 1996. RIVM Bilthoven, Report no. 610056043.

[3] S.T. van Tuinen (ed), 1996. Monitoring of radiation in the atmosphere and a food chain. Results in the Netherlands in 1995. RIVM Bilthoven, Report no. 610056029.

[4] R.B. Tax, P.J.M. Kwakman, A.P.P.A. van Lunenburg, M.H. Tijsmans, 1994. Development of a High Volume Air Sampler for the sensitive detection of γ-emitting radionuclides attached to aerosols. Results obtained in the test period 1991-1992. RIVM Bilthoven, Report no. 610056005.

[5] NEN, 2006. Radioactiviteitsmetingen - Bepaling van de kunstmatige totale alfa-activiteit, kunstmatige totale bèta-activiteit en gammaspectrometrie van luchtfilters en berekening van de volumieke activiteit van de bemonsterde lucht. NEN Delft, NEN 5636.

[6] S. Sugihara, N. Momoshima, Y. Maeda, S. Osaki, 2000. Variation of atmospheric ^{7}Be and ^{210}Pb depositions at Fukuoka, Japan. IRPA 10th congress, internetsite: www.irpa.net/irpa10/cdrom/00822.pdf (July 2003).

[7] C. Ródenas, J. Gómez, L.S. Quindós, P.L. Fernández, J. Soto, 1997. ^{7}Be concentrations in air, rain water and soil in Cantabria (Spain). Appl. Radiat. Isot. 48, 545-548.

[8] S. Talpos and V. Cuculeanu, 1997. A study of the vertical diffusion of ^{7}Be in the atmosphere. J. Environ. Radioactivity 36 (1), 93-106.

[9] K.N. Yu and L.Y.L. Lee, 2002. Measurements of atmospheric ^{7}Be properties using high-efficiency gamma spectroscopy. Appl. Radiat. Isotop. 57, 941-946.

[10] C. Papastefanou and A. Ioannidou, 1995. Aerodynamic size association of ^{7}Be in ambient aerosols. J. Environ. Radioactivity 26, 273-282.

[11] H.W. Feely, R.J. Larsen, C.G. Sanderson, 1989. Factors that cause seasonal variations in ^{7}Be concentrations in surface air. J. Environ. Radioactivity 9, 223-249.

[12] C.L. Fogh, J. Roed, K.G. Andersson, 1999. Radionuclide resuspension and mixed deposition at different heights. J. Environ. Radioactivity 46, 67-75.

[13] Solar Cycle Progression, August 2005. Internetsite: www.sec.noaa.gov/SolarCycle.

[14] R.C.G.M Smetsers and R.O. Blaauboer, 1997. A dynamic compensation method for natural ambient dose rate based on 6 years data from the Dutch Radioactivity Monitoring Network. Radiat. Prot. Dosim. 69 (1), 19-31.

[15] S. I. Dusha-Gudym, 1992. Forest fires on the areas contaminated by radionuclides from the Chernobyl nuclear power plant accident. International Forest Fire News 7. Internetsite: www.fire.uni-freiburg.de (July 2003).

[16] KNMI database, July 2003. Internetsite: www.knmi.nl.

[17] T. Hantke, F.J. Aldenkamp, R.M.W. Overwater, H. Slaper, 1998. De jacht op een ^{137}Cs-wolk in Zuid Europa – “aftermath” van een ongeval in Algeciras. NVS Nieuws 23 (4).

[18] UNSCEAR, 2000. Sources and effects of ionizing radiation. Volume 1: Sources.

[19] E.A. Bondietti, C. Papastefanou, C. Rangarajan, 1987. Aerodynamic size associations of natural radioactivity with ambient aerosols. In: Radon and its Decay Products: Occurrence, Properties and Health Effects, ACS Symp. Ser. No. 331, P.K. Hopke (Ed.), American Chemical Society, Washington DC, 377-397.

[20] T. Suzuki, Y. Maruyama, N. Nakayama, K. Yamada, K. Ohta, 1999. Measurement of $^{210}Po/^{210}Pb$ activity ratio in size fractionated aerosols from the coast of the Japan sea. Atmospheric Environ. 33, 2285-2288.

[21] T. Tokieda, K. Yamanaka, K. Harada, S. Tsunogai, 1996. Seasonal variations of residence time and upper atmospheric contribution of aerosols studied with Pb-210, Bi-210, Po-210 and Be-7. Tellus, 48B, 690-702.

[22] G. Lambert, P. Bristeau, G. Polian, 1976. Emission and enrichments of Radon daughters from Etna volcano magma. Geophys. Res. Lett. 3 (12), 724-726.

[23] J. Sato, T. Doi, T. Segawa, S. Sugawara, 1994. Seasonal variation of atmospheric concentrations of ^{210}Pb and ^{7}Be at Tsukuba, Japan, with a possible observation of ^{210}Pb originating from the 1991 eruption of Pinatubo volcano, Phillippines. Geochem. J. 28, 123-129.

[24] J.P. Beks, D. Eisma, J. van der Plicht, 1998. A record of atmospheric ^{210}Pb deposition in the Netherlands. Sci. Total Environ. 222, 35-44.

[25] J. Sato, 2003. Natural radionuclides in volcanic activity. Appl. Radiat. Isotop. 58, 393-399.

[26] G. Lambert, B. Ardouin, G. Polian, 1982. Volcanic ouput of long-lived Radon daughters. J. Geophys. Res. 87 (C13), 11103-11108.

[27] E.Y. Nho, B. Ardouin, M.F. Le Cloarec, M. Ramonet, 1996. Origins of ^{210}Po in the atmosphere at Lamto, Ivory Coast: biomass burning and Saharan dust. Atmospheric Environ. 30 (22), 3705-3714.

[28] M.A. Mélières, M. Pourchet, S. Richard, 2003. Surface air concentration and deposition of lead-210 in French Guiana: two years of continuous monitoring. J. Environ. Radioactivity 66, 261-269.

[29] P.G. Appleby, A.O. Koulikov, L. Camarero, M. Ventura, 2002. The input and transmission of fall-out radionuclides through Redó, a high mountain lake in the Spanish Pyrenees. Water, Air & Soil Pollution: Focus 2, 19-31.

[30] G.J. Knetsch (ed), 2003. Monitoring of radiation in the environment in the Netherlands. Results in 2002. RIVM Bilthoven, Report no. 861020005.

[31] C.J.W. Twenhöfel, et al, 2005. Operation of the Dutch 3rd Generation National Radioactivity Monitoring Netwerk. In: Automatic Mapping Algorithms for Routine and Emergency Monitoring Data, Spatial Interpolation Comparison 2004 by IES, G. Dubois (ed), European Committee, JRC, EUR 21595 2005, p. 19-31.

[32] R.O. Blaauboer and R.C.G.M. Smetsers, 1996. Variations in outdoor radiation levels in the Netherlands. Thesis University of Groningen, Groningen.

[33] C. de Hoog en R.B. Tax, 2003. Achtergronddocument bij NMR integrale rapportage 2002, intern document.

[34] R.C.G.M. Smetsers, L.J. de Vries, A.P.P.A. van Lunenburg, F.J. Aldenkamp, 1996. National radioactivity monitoring network (LMR): Data report 1993–1995. RIVM Bilthoven, Report no. 610056028.

[35] Office of Aerospace Medicine, November 2003. Internetsite: http://www.cami.jccbi.gov/AAM-600/Radiation/600radio.html.

[36] G.J. Knetsch (ed), 2004. Monitoring of radiation in the environment in the Netherlands. Results in 2003. RIVM Bilthoven, Report no. 861020010.

[37] RIZA and RIKZ, July 2005. Internetsite: www.watermarkt.nl.
[38] E.J. de Jong en O.C. Swertz, 2000. Radioactieve stoffen in de zoute wateren. RIKZ, Den Haag, Report no. RIKZ/2000.041.
[39] L.J. Gilde, K.H. Prins, C.A.M. van Helmond, 1999. Monitoring zoete rijkswateren. RIZA Lelystad, Report no. 99.004.
[40] E.J. de Jong, W. Lutthmer, B. Munster, 1995. Onderzoek naar radioactieve stoffen in Rijkswateren. Resultaten 1992. RIZA, Lelystad.
[41] Ministerie V&W, 1998. Vierde Nota waterhuishouding. Den Haag.
[42] J.E.M. Beurskens, C.G.C. Dekker, J. Jonkhoff, L. Pomstra, 1995. Microbial dechlorination of hexachlorobenzene in a sedimentation area of the Rhine river. In: Microbial transformation of chlorinated aromatics in sediments (dissertation), Wageningen.
[43] G.J. Knetsch (ed), 2005. Monitoring of radiation in the environment in the Netherlands. Results in 2004. RIVM Bilthoven, Report no. 861020011.
[44] F.M. Versteegh, F.W. van Gaalen, B.A. Baumann, E. Smit, L. Vaas, 1995. Resultaten van het meetprogramma drinkwater 1994 voor parameters uit het Waterleidingbesluit en enkele aanvullende parameters. RIVM Bilthoven, Report no. 731011009.
[45] Keuringsdienst van Waren Oost, 1998. Werkvoorschrift CHE01-OT802, Keuringsdienst van Waren Oost, Bepaling van de activiteit van gammastraling uitzendende nucliden in een telmonster met halfgeleiderspectrometrie. Nijmegen.
[46] Keuringsdienst van Waren Oost, 2003. Werkvoorschrift CHE01-WV143, Keuringsdienst van Waren Oost, Bepaling van de activiteit van gammastraling uitzendende nucliden in een telmonster met de LMRV voedselmonitor. Zutphen.
[47] EEC, 1990. Council Regulation on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power-station. EEC Brussels, No. 737/90.
[48] J.A.M. Geertsen, 2005. Van meting tot beleid. Voedsel en Waren Autoriteit/Keuringsdienst van Waren Oost. Zutphen.
[49] Voedsel en Waren Autoriteit/Keuringsdienst van Waren, 2006. Radiologisch jaarverslag 2005. Zutphen.
[50] J.E.M. Jacobs (ed), 2001. Monitoring of radiation in the Environment. Results in the Netherlands in 1999. RIVM Bilthoven, Report no. 610056046.
[51] Letter to the State Health Inspectorate of the Ministry of Housing, Spatial Planning and Environment, January 13th, 1997. Reference no. 23/97 LSO Le/Ald/jdk. Onderzoek naar de slechte resultaten in 1995 van de bepaling van ^{210}Po en ^{210}Pb in natte en droge depositie. RIVM Bilthoven.

Appendix A: Result tables

Table A1: Weekly averaged gross α- and gross β-activity concentrations in air dust sampled with a HVS at RIVM in 2005.

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	0.033	0.241	± 0.017	27	0.059	0.264	± 0.018
2	0.051	0.33	± 0.02	28	0.041	0.47	± 0.03
3 [2]	0.07	0.40	± 0.03	29	0.046	0.34	± 0.02
4 [2]	0.13	0.272	± 0.019	30 [2]	0.041	0.33	± 0.02
5	0.027	0.176	± 0.013	31	0.045	0.219	± 0.015
6 [2]	0.09	0.83	± 0.05	32	0.022	0.175	± 0.013
7	0.026	0.46	± 0.03	33	0.034	0.31	± 0.02
8	0.041	0.57	± 0.04	34	0.055	0.37	± 0.02
9	0.041	0.53	± 0.03	35	0.08	0.61	± 0.04
10	0.025	0.266	± 0.018	36	0.09	0.84	± 0.05
11	0.050	0.32	± 0.02	37	0.044	0.59	± 0.04
12	0.048	0.46	± 0.03	38	0.055	0.47	± 0.03
13	0.063	0.52	± 0.03	39	0.049	0.35	± 0.02
14	0.056	0.56	± 0.04	40 [2]	0.044	0.49	± 0.03
15	0.020	0.201	± 0.014	41 [2]	0.16	1.71	± 0.11
16	0.057	0.47	± 0.03	42	0.09	0.98	± 0.06
17	0.08	0.61	± 0.04	43	0.10	0.39	± 0.03
18	0.08	0.40	± 0.03	44	0.09	0.82	± 0.05
19	0.019	0.200	± 0.014	45	0.047	0.42	± 0.03
20	0.029	0.37	± 0.02	46	0.048	0.237	± 0.016
21	0.046	0.35	± 0.02	47 [2]	0.14	0.35	± 0.02
22	0.043	0.39	± 0.03	48	0.049	0.268	± 0.018
23	0.037	0.31	± 0.02	49	0.061	0.269	± 0.018
24	0.029	0.278	± 0.019	50 [2]	0.10	0.43	± 0.03
25	0.057	0.40	± 0.03	51	0.09	0.285	± 0.016
26	0.041	0.35	± 0.02	52	0.039	0.35	± 0.02
				Average	0.06 [3]	0.434	± 0.005 [4]
				SD [5]	0.03		0.2

[1] The precise sampling period is given in Table A3.

[2] Due to problems with or maintenance on the high volume sampler sampling occurred with a lower flow (about one third of regular flow) during 0.3 to 2 days of the week and in case of week 41 didn't occur at all during 2 days.

[3] 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 [5].

[4] The error in the yearly average is equal to the square root of the sum of the squared weekly errors divided by the number of weeks. Errors are given as 1σ.

[5] 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 2005. 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 [50] 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 2005. 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	31/12-07/01	2500	±	200		180	±	20
2	07/01-14/01	3600	±	300		300	±	30
3 (1)	14/01-21/01	3100	±	300		360	±	40
4 (1)	21/01-28/01	1870	±	160		300	±	30
5	28/01-04/02	1760	±	150		137	±	15
6 (1)	04/02-11/02	3400	±	300		890	±	80
7	11/02-18/02	2700	±	200		460	±	40
8	18/02-25/02	1700	±	150		610	±	60
9	25/02-04/03	3500	±	300		530	±	50
10	04/03-11/03	2300	±	200		230	±	20
11	11/03-18/03	3000	±	300		280	±	30
12	18/03-25/03	4900	±	400		430	±	40
13	25/03-01/04	3700	±	300		480	±	50
14	01/04-08/04	5600	±	500		560	±	50
15	08/04-15/04	2300	±	200		190	±	20
16	15/04-22/04	4200	±	400		420	±	40
17	22/04-29/04	6100	±	500		590	±	60
18	29/04-06/05	4400	±	400		440	±	40
19	06/05-13/05	2300	±	200		166	±	17
20	13/05-20/05	3900	±	300		310	±	30
21	20/05-27/05	4400	±	400		300	±	30
22	27/05-03/06	4600	±	400		330	±	30
23	03/06-10/06	3700	±	300		230	±	30
24	10/06-17/06	3600	±	300		220	±	20
25	17/06-24/06	3800	±	300		330	±	30
26	24/06-01/07	4100	±	400		280	±	30

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	01/07-08/07	3100	±	300		250	±	30
28	08/07-15/07	4900	±	400		450	±	40
29	15/07-22/07	3400	±	300		300	±	30
30 (1)	22/07-29/07	3400	±	300		330	±	30
31	29/07-05/08	2300	±	200		191	±	19
32	05/08-12/08	2090	±	180		160	±	20
33	12/08-19/08	2500	±	200		320	±	30
34	19/08-26/08	3300	±	300		380	±	40
35	26/08-02/09	4400	±	400		730	±	70
36	02/09-09/09	5000	±	400		900	±	80
37	09/09-16/09	3600	±	300		670	±	60
38	16/09-23/09	3400	±	300		470	±	40
39	23/09-30/09	2800	±	200		300	±	30
40 (1)	30/09-07/10	1720	±	150		540	±	50
41 (1)	07/10-14/10	3400	±	300		2020	±	180
42	14/10-21/10	3400	±	300		1000	±	90
43	21/10-28/10	2800	±	200		460	±	50
44	28/10-04/11	4300	±	400		720	±	60
45	04/11-11/11	3500	±	300		410	±	40
46	11/11-18/11	2800	±	200		220	±	30
47 (1)	18/11-24/11	1940	±	170		320	±	30
48	24/11-02/12	1340	±	120		250	±	20
49	02/12-09/12	1570	±	140		320	±	30
50 (1)	09/12-16/12	2600	±	200		460	±	50
51	16/12-23/12	2700	±	200		230	±	20
52	23/12-30/12	2600	±	200		360	±	30
	Average	3260	±	40 (2)		428	±	7 (2)
	SD (3)			1100				300

(1) Due to problems with or maintenance on the high volume sampler sampling occurred with a lower flow (about one third of regular flow) during 0.3 to 2 days of the week and in case of week 41 didn't occur at all during 2 days.
(2) The error in the yearly average is equal to the square root of the sum of the squared weekly errors divided by the number of weeks. Errors are given as 1σ.
(3) 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 2005.

Month	Precipitation mm	^{3}H [1] Bq·m^{-2}	Gross α Bq·m^{-2}	Gross β Bq·m^{-2}
January	64.0	< 104	1.02 ± 0.18	4.4 ± 0.4
February	81.3	< 127	1.6 ± 0.3	7.0 ± 0.6
March	38.0	< 62	1.3 ± 0.3	5.5 ± 0.4
April	72.8	< 138	1.5 ± 0.3	8.0 ± 0.6
May	53.1	< 101	1.9 ± 0.3	10.1 ± 0.8
June	70.4	< 134	2.1 ± 0.3	9.5 ± 0.7
July	81.4	< 133	1.2 ± 0.2	6.6 ± 0.5
August	133.3	< 219	1.6 ± 0.3	10.2 ± 0.8
September	60.3	< 99	1.7 ± 0.3	8.7 ± 0.7
October	59.4	< 121	1.1 ± 0.4	5.4 ± 0.4
November	96.0	< 196	1.6 ± 0.3	7.0 ± 0.5
December	46.1	< 94	1.0 ± 0.2	5.2 ± 0.4
Total	856	-	17.6 ± 1.0 [2]	88 ± 2 [2]
Lower limit [3]	-	0	-	-
Upper limit [3]	-	1530	-	-

[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 (1.6-2.0 Bq·l^{-1}).
[2] The error in the sum is equal to the square root of the sum of the squared monthly errors. Errors are given as 1σ.
[3] 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 1993-2005. Either the yearly total with uncertainty [1] or the lower and upper limits [2] of the 68% confidence range are given.

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

[1] Errors 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 2005.

Month	^{210}Po Bq·m^{-2}		
January	< 0.50		
February	0.80	±	0.18
March	0.53	±	0.09
April	0.55	±	0.11
May	1.17	±	0.14
June	0.93	±	0.12
July	0.74	±	0.11
August	0.81	±	0.14
September	0.86	±	0.16
October	0.74	±	0.06
November	1.37	±	0.09
December	0.78	±	0.09
Total	-		
Lower limit [2]	8.9		
Upper limit [2]	10.2		

[1] Measurements are carried out using α-spectroscopy. Errors are given as 1σ.
[2] 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 1993-2005. 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] Bq·m^{-2}			^{137}Cs [3] Bq·m^{-2}			^{210}Pb [3] Bq·m^{-2}			^{210}Pb [4] Bq·m^{-2}			^{210}Po [4] Bq·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

[1] Errors 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 [51].
[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 2005.

Week Number	Period	Precipitation mm	^{7}Be Bq·m^{-2}	^{137}Cs Bq·m^{-2}	^{210}Pb Bq·m^{-2}
1	31/12-07/01	10.8	18 ± 2	< 0.12	1.9 ± 0.7
2	07/01-14/01	3.3	11.4 ± 1.7	< 0.13	1.2 ± 0.4
3	14/01-21/01	33.0	30 ± 4	< 0.11	1.6 ± 0.5
4	21/01-28/01	7.0	12.8 ± 1.7	< 0.12	1.0 ± 0.4
5	28/01-04/02	10.0	10.9 ± 1.4	< 0.14	< 1.3
6	04/02-11/02	20.0	29 ± 3	< 0.14	2.7 ± 0.9
7	11/02-18/02	36.0	33 ± 4	< 0.13	2.5 ± 0.7
8	18/02-25/02	14.0	12.1 ± 1.5	< 0.12	2.2 ± 0.5
9	25/02-04/03	11.3	16 ± 2	< 0.11	< 1.4
10	04/03-11/03	8.5	12.7 ± 1.7	< 0.13	1.6 ± 0.6
11	11/03-18/03	8.3	12.8 ± 1.8	< 0.11	< 1.3
12	18/03-25/03	12.4	26 ± 3	< 0.11	3.9 ± 0.9
13	25/03-01/04	8.8	16 ± 2	< 0.11	1.4 ± 0.5
14	01/04-08/04	12.1	24 ± 3	< 0.13	3.4 ± 0.8
15	08/04-15/04	19.7	12.3 ± 1.6	< 0.09	< 1.5
16	15/04-22/04	21.5	41 ± 5	< 0.11	4.0 ± 0.7
17	22/04-29/04	19.5	41 ± 5	< 0.06	3.3 ± 0.6
18	29/04-06/05	9.3	42 ± 5	< 0.11	3.7 ± 0.8
19	06/05-13/05	11.0	18 ± 2	< 0.11	1.2 ± 0.4
20	13/05-20/05	12.9	25 ± 3	< 0.13	< 1.4
21	20/05-27/05	5.0	10.6 ± 1.7	< 0.11	< 1.2
22	27/05-03/06	14.9	78 ± 9	< 0.11	5.6 ± 1.0
23	03/06-10/06	19.0	0.36 ± 0.04	< 0.11	2.4 ± 0.5
24	10/06-17/06	8.4	23 ± 3	< 0.11	2.4 ± 0.8
25	17/06-24/06	1.0	5.5 ± 1.0	< 0.13	2.6 ± 0.5
26	24/06-01/07	42.0	79 ± 9	< 0.13	6.0 ± 1.0

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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	01/07-08/07	42.0	36 ± 4	< 0.13	3.4 ± 0.7
28	08/07-15/07	2.5	3.4 ± 0.6	< 0.14	< 1.3
29	15/07-22/07	12.4	32 ± 4	< 0.10	3.0 ± 0.7
30	22/07-29/07	24.5	27 ± 3	< 0.12	1.1 ± 0.5
31	29/07-05/08	55.4	81 ± 10	< 0.12	4.7 ± 0.8
32	05/08-12/08	36.5	41 ± 5	< 0.14	1.7 ± 0.7
33	12/08-19/08	23.6	32 ± 4	< 0.14	< 1.4
34	19/08-26/08	16.4	31 ± 4	< 0.07	< 1.6
35	26/08-02/09	1.4	8.6 ± 1.3	< 0.13	2.1 ± 0.7
36	02/09-09/09	1.1	4.0 ± 0.8	< 0.15	1.8 ± 0.5
37	09/09-16/09	42.5	79 ± 9	< 0.13	6.8 ± 1.1
38	16/09-23/09	3.1	9.0 ± 1.7	< 0.11	< 1.2
39	23/09-30/09	13.6	19 ± 2	< 0.13	1.2 ± 0.4
40	30/09-07/10	12.8	13.8 ± 1.9	< 0.14	< 1.5
41	07/10-14/10	1.3	2.9 ± 0.8	< 0.10	< 1.4
42	14/10-21/10	6.3	5.3 ± 0.8	< 0.15	< 1.3
43	21/10-28/10	33.0	36 ± 4	< 0.14	1.6 ± 0.4
44	28/10-04/11	6.0	8.7 ± 1.1	< 0.10	3.2 ± 0.6
45	04/11-11/11	5.0	15 ± 2	< 0.12	< 1.3
46	11/11-18/11	22.0	49 ± 6	< 0.09	1.2 ± 0.4
47	18/11-25/11	29.0	36 ± 4	< 0.10	1.4 ± 0.6
48	25/11-02/12	40.0	24 ± 3	< 0.13	1.1 ± 0.5
49	02/12-09/12	17.0	12 ± 2	< 0.09	< 1.2
50	09/12-16/12	13.0	34 ± 4	< 0.12	1.1 ± 0.4
51	16/12-23/12	12.0	36 ± 4	< 0.14	1.3 ± 0.6
52	23/12-30/12	4.1	4.3 ± 0.6	< 0.10	< 1.3
Total		856	1320 ± 30 [2]	-	-
Lower limit [3]		-	-	0.00	87
Upper limit [3]		-	-	6.09	117

[1] Measurements are carried out using γ-spectroscopy.
[2] The error in the sum is equal to the square root of the sum of the squared weekly errors. Errors 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 2005, as measured by the NMR stations equipped with aerosol monitors.

Station	No.	α-Activity concentration Bq.m^{-3}	Ambient dose equivalent rate nSv.h^{-1}
Kollumerwaard	972	3.3	81.5
Valthermond (1)	974	3.1	74.8
Vlaardingen	976	3.4	84.6
Braakman	978	3.3	75.4
Huijbergen	980	3.3	67.7
Houtakker	982	3.2	64.1
Wijnandsrade	984	6.1	67.8
Eibergen	986	4.0	71.5
De Zilk	988	2.6	66.6
Wieringerwerf	990	2.6	80.9
Vredepeel	992	4.0	70.6
Biddinghuizen	994	3.5	87.7
Wageningen	996	4.6	89.8
Bilthoven	998	2.8	68.9

(1) *The station formerly known as Witteveen.*

Table A10: The yearly averaged ambient dose equivalent rate for the NMR stations in 2005.

Station	No.	Ambient dose equivalent rate nSv.h^{-1}	Station	No.	Ambient dose equivalent rate nSv.h^{-1}
Den Burg	1001	76	Hooglanderveen	1046	73
Den Oever	1003	69	Harderwijk	1050	66
Julianadorp	1004	64	Wijk bij Duurstede	1056	80
Petten	1006	63	Rhenen	1061	77
Kolhorn	1007	81	Nieuwegein	1062	81
Egmond aan Zee	1009	66	Apeldoorn	1066	72
Heerhugowaard	1011	72	Heerenveen	1071	63
Haarlem-Noord	1014	73	Oosterwolde	1072	81
Nederhorst den Berg	1015	60	Bergum	1074	68
Enkhuizen	1018	77	Witmarsum	1076	88
Oosthuizen	1019	67	Sneek	1077	70
Zaandam	1021	68	St. Jacobiparochie	1081	76
Gouda	1024	74	Holwerd	1082	85
Dordrecht	1027	57	Leeuwarden	1085	67
Zuid-Beijerland	1028	74	Zwolle-Zuid	1087	73
Pijnacker	1032	84	Ommen	1093	64
Rotterdam Crooswijk	1033	73	Hardenberg	1095	65
Rotterdam Waalhaven	1034	70	Assen	1097	63
Maasvlakte (1)	1035	-	Rutten	1099	74
Maassluis	1037	87	Lelystad	1103	75
Hellevoetsluis	1038	97	Urk	1105	75
Ouddorp	1039	65	Eemshaven	1106	81
Wekerom	1041	72	Uithuizen	1107	82
Wageningen	1043	68	Wagenborgen	1109	74

To be continued on the next page.

Table A10: Continued.

Station	No.	Ambient dose equivalent rate nSv.h^{-1}	Station	No.	Ambient dose equivalent rate nSv.h^{-1}
Winschoten	1110	69	Reuver	1188	68
Ter Apel	1111	70	Nederweert	1189	71
Stadskanaal	1112	67	Heythuisen	1190	72
Nieuweschans	1113	71	Mariahoop	1191	66
Bellingwolde	1114	59	Stramproy	1192	64
Groningen	1116	74	Arnhem-Oosterbeek	1193	76
Leens	1117	80	Leiden	1196	77
Grijpskerk	1118	72	Hulst	1197	73
Meppel	1125	65	Terneuzen (1)	1199	-
Hoogeveen	1126	60	Sluis	1201	70
Steenwijksmoer	1129	64	Vlissingen	1202	77
Nieuw Amsterdam	1130	75	Halsteren	1204	64
Nw. Schoonebeek/ Weiteveen	1131	61	Oud-Gastel	1206	66
Emmen	1132	74	Goes	1207	76
Borne (1)	1135	-	Bruinisse	1209	74
Hengelo (Gld)	1136	71	Burgh-Haamstede	1211	60
Enschede	1139	66	Vrouwenpolder	1212	63
Losser	1140	61	Wemeldinge	1214	77
Oldenzaal	1141	64	Middelburg	1215	74
Westerhaar	1142	63	Westkapelle	1216	69
Rijssen	1143	68	Noordwijk-Binnen	1217	76
's Heerenberg	1144	62	Stein	1219	81
Dinxperlo	1145	78	Maastricht	1220	89
Varsseveld	1146	70	Ravensbos	1221	90
Groenlo	1147	82	Vaals	1222	86
Deventer	1148	75	Gulpen	1223	78
Etten-Leur	1154	68	Kerkrade	1224	89
Den Bosch	1157	67	Hoensbroek	1225	86
Raamsdonkveer	1159	87	Gennep	1228	73
Ulvenhout	1160	72	Elst (Gld)	1229	81
Baarle-Nassau	1161	99	Zevenaar	1230	71
Uden	1162	69	Nijmegen	1231	67
Mill	1163	63	Amstelveen	1233	80
Oss	1167	66	Amsterdam Oost	1234	71
Nuenen	1172	69	Aalsmeer	1236	81
Bergeyk	1174	92	Nispen (1)	1237	-
Waalre	1175	67	Groesbeek	1240	75
Someren (dorp)	1176	66	Tubbergen	1243	66
Oisterwijk	1178	73	Haaksbergen	1244	65
Riel	1179	67	Scheveningen	1247	74
Oostelbeers	1180	85	Zaltbommel	1251	71
Hilvarenbeek	1181	64	IJzendijke	1252	81
Venray	1183	62	Ritthem	1253	102
Nieuw-Bergen	1184	61	Vlissingen-Haven	1254	73
Sevenum (1)	1185	-	Nieuwdorp	1255	86

To be continued on the next page.

Table A10: Continued.

Station	No.	Ambient dose equivalent rate nSv.h^{-1}	Station	No.	Ambient dose equivalent rate nSv.h^{-1}
's Heerenhoek	1256	79	Rilland	1263	79
Driewegen	1257	88	Putte	1264	56
Arnemuiden	1258	72	Nieuw Namen	1265	83
Heinkeszand	1259	85	Denekamp	1272	78
Baarland	1260	86	Winterswijk	1278	65
Biervliet	1261	66	Bilthoven	1279	68
Slijkplaat (1)	1262	-	Maarheze/Gastel	1280	60

(1) *Station was not operational in 2005.*

Table A11: Gross α, residual β, ^{3}H-, ^{90}Sr and ^{226}Ra-activity concentrations (mBq·L^{-1}) in surface water in 2005 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**				
11/01/05	61	23			
08/02/05	33	2	4700		
08/03/05	52	16			
05/04/05	44	< 1	6000		
02/05/05	21	< 1			
31/05/05	13	11	2700		
28/06/05	30	18			
26/07/05	26	22	2400		
23/08/05	25	19			
20/09/05	11	< 1	3200		
18/10/05	38	40			
15/11/05	59	45	3400		
13/12/05	42	18			
Average	35	17	3700		
Location:	**Noordzeekanaal**				
24/02/05	58	19	3000		
21/04/05	74	24	5400		
16/06/05	74	24	2500		
11/08/05	130	22	2500		
06/10/05	130	68	4400		
01/12/05	110	18	1500		
Average	96	29	3200		
Location:	**Nieuwe Waterweg**				
26/01/05	100	63	7800	< 1	4
23/02/05	160	150			
23/03/05	100	30	7800	4	4
20/04/05	66	46			
18/05/05	98	16	4000	3	3
15/06/05	73	27			
13/07/05	91	24	2000	4	4
10/08/05	120	42			
07/09/05	100	44	2700	4	4
05/10/05	150	49			
02/11/05	260	26	4700	< 1	7
30/11/05	140	55			
28/12/05	110	40	10000	< 1	5
Average	121	47	5600	2.4	4.4

To be continued on the next page.

Table A11: Continued.

Date	Gross α $mBq \cdot L^{-1}$	Residual β $mBq \cdot L^{-1}$	^{3}H $mBq \cdot L^{-1}$	^{90}Sr $mBq \cdot L^{-1}$	^{226}Ra $mBq \cdot L^{-1}$
Location:	**Rhine**				
19/01/05	53	5	8200		
16/02/05	150	130	5100	1	7
16/03/05	52	14	5800		
13/04/05	78	31	7200	3	3
11/05/05	57	35	1600		
08/06/05	99	83	4100	2	3
06/07/05	51	43	4000		
03/08/05	60	49	3000	5	3
31/08/05	130	120	1600		
28/09/05	59	62	6000	1	4
26/10/05	41	29	4800		
22/11/05	59	34	2600	< 1	4
21/12/05	53	8	9000		
Average	72	49	4800	2.1	4
Location:	**Scheldt**				
12/01/05	320	69	12000		7
09/02/05	230	100			
07/03/05	180	110	9500		9
04/04/05	160	23			
02/05/05	150	83	10000		11
30/05/05	150	63			
27/06/05	250	90	12000		12
25/07/05	260	69			
23/08/05	150	97	9600		13
21/09/05	390	79			
19/10/05	270	140	8400		16
15/11/05	450	160			
12/12/05	490	65	14000		12
Average	270	88	10800		11
Location:	**Meuse**				
18/01/05	42	16	7400		
15/02/05	150	150	9200	< 1	7
15/03/05	41	27	15000		
12/04/05	38	11	3300	5	2
10/05/05	24	1	1100		
07/06/05	49	16	32000	7	3
05/07/05	21	30	28000		
02/08/05	58	36	2200	< 1	4
30/08/05	46	5	2400		
27/09/05	25	19	10000	2	4
25/10/05	22	18	22000		
22/11/05	29	1	2600	4	5
20/12/05	34	23	20000		
Average	45	27	12000	3.2	4.2

Table A12: ^{60}Co-, ^{131}I-, ^{137}Cs- and ^{210}Pb-activity concentrations in suspended solids (Bq·kg^{-1}) in surface water in 2005 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**			
11/01/05	< 1	< 1	10	
08/02/05	< 1	< 1	12	
08/03/05	< 1	< 1	11	
05/04/05	< 1	< 1	5	
02/05/05	< 1	< 1	2	
31/05/05	< 1	< 1	3	
28/06/05	< 1	< 1	6	
26/07/05	< 1	< 1	3	
23/08/05	< 1	< 1	1	
20/09/05	< 1	< 1	3	
18/10/05	< 1	< 1	7	
15/11/05	< 1	< 1	6	
13/12/05	< 1	< 1	7	
Average	< 1	< 1	6	
Location:	**Ketelmeer**			
06/01/05	< 1	3	19	
03/03/05	< 1	7	18	
28/04/05	< 1	3	18	
23/06/05	< 1	< 1	13	
18/08/05	< 1	< 1	18	
12/10/05	< 1	< 1	16	
08/12/05	< 1	3	17	
Average	< 1	3	17	
Location:	**Noordzeekanaal**			
22/02/05	< 1	4	13	
19/04/05	< 1	49	9	
14/06/05	< 1	7	1	
10/08/05	< 1	3	8	
04/10/05	< 1	37	9	
28/11/05	< 1	15	18	
Average	< 1	19	10	
Location:	**Nieuwe Waterweg**			
26/01/05	< 1	4	13	110
23/02/05	< 1	5	16	
23/03/05	< 1	7	11	95
20/04/05	< 1	3	12	
18/05/05	< 1	5	13	110
15/06/05	< 1	< 1	12	
13/07/05	< 1	1	11	91
10/08/05	< 1	< 1	11	
07/09/05	< 1	1	12	86
05/10/05	< 1	< 1	12	
02/11/05	< 1	< 1	8	90
30/11/05	< 1	< 1	10	
28/12/05	< 1	< 1	13	120
Average	< 1	2.2	12	100

To be continued on the next page.

Table A12: Continued.

Date	^{60}Co Bq·kg^{-1}	^{131}I Bq·kg^{-1}	^{137}Cs Bq·kg^{-1}	^{210}Pb Bq·kg^{-1}
Location:	**Rhine**			
19/01/05	< 1	18	21	
16/02/05	< 1	10	17	120
16/03/05	< 1	12	14	
13/04/05	< 1	4	16	120
11/05/05	< 1	13	17	
08/06/05	< 1	4	15	120
06/07/05	< 1	8	15	
03/08/05	< 1	< 1	15	120
31/08/05	< 1	< 1	11	
29/09/05	< 1	< 1	17	110
26/10/05	< 1	< 1	13	
22/11/05	< 1	< 1	14	130
21/12/05	< 1	13	17	
Average	< 1	6.5	16	120
Location:	**Scheldt**			
12/01/05	< 1	< 1	12	100
09/02/05	2	4	9	
07/03/05	< 1	6	9	100
04/04/05	< 1	4	13	
02/05/05	2	< 1	10	100
30/05/05	3	2	9	
27/06/05	< 1	< 1	6	84
25/07/05	1	2	8	
23/08/05	1	< 1	8	92
21/09/05	< 1	< 1	8	
19/10/05	< 1	< 1	8	89
15/11/05	< 1	< 1	8	
12/12/05	< 1	5	7	100
Average	< 1	< 2	9	95
Location:	**Meuse**			
04/01/05	50	9	21	
11/01/05	14	8	16	
18/01/05	6	13	13	
25/01/05	3	11	17	
01/02/05	4	22	19	
09/02/05	22	33	14	
15/02/05	2	7	14	140
22/02/05	7	8	12	
01/03/05	5	21	16	
08/03/05	< 1	47	12	
15/03/05	6	20	13	
22/03/05	6	38	15	
29/03/05	7	28	13	

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**			
05/04/05	26	39	23	
13/04/05	13	21	15	180
19/04/05	10	20	11	
26/04/05	2	19	13	
03/05/05	30	21	13	
10/05/05	10	19	17	
17/05/05	9	25	14	
24/05/05	17	30	13	
31/05/05	18	39	10	
07/06/05	20	31	14	180
14/06/05	9	28	11	
21/06/05	< 1	< 1	1	
29/06/05	7	36	9	
05/07/05	17	65	11	
12/07/05	16	28	9	
19/07/05	8	21	8	
26/07/05	12	13	9	
02/08/05	18	60	14	210
09/08/05	9	44	11	
17/08/05	14	23	14	
23/08/05	15	94	13	
30/08/05	13	25	11	
06/09/05	6	56	6	
13/09/05	5	47	11	
20/09/05	10	29	12	
27/09/05	8	35	11	170
04/10/05	11	24	11	
11/10/05	9	50	13	
18/10/05	9	53	9	
25/10/05	9	47	13	
01/11/05	12	96	15	
08/11/05	15	34	19	
15/11/05	13	59	22	
22/11/05	11	34	15	230
29/11/05	12	24	12	
06/12/05	26	20	15	
13/12/05	32	32	14	
20/12/05	18	18	16	
27/12/05	16	11	14	
Average	12.5	31	13	185

Table A13: Gross α-, residual β-, ^{3}H- and ^{90}Sr-activity concentrations ($mBq \cdot L^{-1}$) in seawater in 2005 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**			
18/02/05	210	60	7700	
25/05/05	340	40	4500	
19/08/05	520	59	5000	
01/12/05	370	83	5600	
Average	360	60	5700	
Location:	**Southern North Sea**			
22/02/05	180	68	4500	2
25/05/05	360	36	2300	< 1
17/08/05	600	50	3100	< 1
14/11/05	410	50	6800	< 1
Average	390	51	4200	< 1
Location:	**Central North Sea**			
14/02/05	400	33	1500	5
01/06/05	770	43	350	< 1
16/08/05	710	48	450	1
14/11/05	750	45	< 100	< 1
Average	660	42	600	1.8
Location:	**Delta Coastal Waters**			
27/01/05	550	120		
21/02/05	200	77	7200	6
16/03/05	410	66		
20/04/05	750	29		
24/05/05	330	26	2100	< 1
16/06/05	560	43		
13/07/05	550	41		
18/08/05	1020	32	5100	3
19/09/05	410	71		
17/10/05	510	84		
14/11/05	690	70	6400	6
13/12/05	350	96		
	530	63	5200	3.9
Location:	**Westerscheldt**			
11/01/05	620	75	7100	1
10/02/05	670	79	7900	< 1
09/03/05	760	84	7100	< 1
05/04/05	400	46	7600	< 1
03/05/05	220	80	6700	2
30/05/05	910	28	6100	< 1
28/06/05	810	29	5200	2
26/07/05	700	45	9100	2
24/08/05	230	100	9400	3
20/09/05	730	56	9200	< 1
18/10/05	730	61	9400	1
15/11/05	770	93	9900	< 1
13/12/05	640	93	9500	3
Average	640	68	6200	1.3

To be continued on the next page.

Table A13: Continued.

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:	**Eems-Dollard**			
21/02/05	610	48	5500	
19/05/05	430	32	4800	
16/08/05	580	42	3500	
14/11/05	390	34	3200	
Average	500	39	4200	
Location:	**Wadden Sea West**			
09/02/05	270	41	5100	
09/05/05	550	51	4700	
17/08/05	840	48	4400	
15/11/05	950	75	5100	
Average	650	54	4820	
Location:	**Wadden Sea East**			
16/02/05	570	250	6600	
11/05/05	270	160	5200	
22/08/05	510	69	4300	
11/11/05	890	130	4300	
Average	560	150	5100	

Table A14: ^{137}Cs- and ^{210}Po-activity concentrations in suspended solids (Bq·kg^{-1}) in seawater in 2005 as measured by RIZA.

Date	**^{137}Cs**	**^{210}Po**
	Bq·kg^{-1}	**Bq·kg^{-1}**
Location:	**Coastal area**	
14/02/05	10	120
17/05/05	7	87
15/08/05	6	100
14/11/05	10	120
Average	8.2	107
Location:	**Westerscheldt**	
08/02/05	5	60
03/05/05	5	73
24/08/05	3	59
15/11/05	4	60
Average	4.2	63
Location:	**Eems-Dollard**	
22/03/05	9	110
20/05/05	7	83
10/08/05	6	90
08/11/05	7	89
Average	7.2	93
Location:	**Wadden Sea West**	
08/02/05	7	110
04/05/05	n/a	n/a
18/08/05	n/a	n/a
16/11/05	5	92
Average	6	101
Location:	**Wadden Sea East**	
16/02/05	9	130
11/05/05	3	63
15/08/05	5	70
11/11/05	8	110
Average	6.2	93

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

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 a range (lower and upper limit) is given instead of a total with an uncertainty. In both cases the data is presented with a 68% confidence level.

The lower limit is defined as the sum of the real data minus the uncertainty in the sum (square root of the sum of the squared weekly or monthly errors). The upper limit is defined as the sum of the real data plus the uncertainty in the sum plus the detection limits.
The detection limits are omitted in the calculation of the averages. If no data are reported (e.g. no sample is analysed) the period is not taken into account for the calculation of the sum or average.

B.3 Calculation of errors

The errors given in Tables A1 to A8 are a combination of the statistical error and estimations of the experimental errors. In the yearly total the error is the square root of the sum of the squared weekly or monthly errors. In the yearly average the error is the square root of the sum of the squared weekly errors 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.
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.