National Institute
for Public Health
and the Environment

Report 610791001/2007

G.J. Knetsch (ed.)

Environmental radioactivity in the Netherlands

Results in 2006

RIVM report 610791001/2007

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Dit rapport bevat een erratum d.d. 27-10-2010

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This report was commissioned by the Ministry of Housing, Spatial Planning and the Environment within the framework of project 610791: environmental monitoring of radioactivity and radiation.

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Rapport in het kort

Radioactiviteit in het Nederlandse milieu

Resultaten in 2006

Volgens het EURATOM-verdrag uit 1957 moeten alle lidstaten van de Europese Unie jaarlijks de hoeveelheid radioactiviteit in het milieu meten. Ook in 2006 heeft Nederland aan deze verplichting voldaan. Sinds 2000 kent EURATOM aanbevelingen om de metingen volgens een bepaald stramien uit te voeren, lidstaten zijn echter niet verplicht deze na te leven. Om beter te voldoen aan de EU-aanbevelingen van 2000 werd het meetprogramma voor drinkwater in 2006 uitgebreid met een extra meetparameter, namelijk de totale hoeveelheid aan alfastralers. Nederland voldeed in 2006 aan alle Europese aanbevelingen, met uitzondering van de bepaling van strontium-90 in melk en voedsel.

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

In het oppervlaktewater is op een aantal locaties voor sommige radioactieve stoffen de streefwaarde overschreden. Deze overschrijdingen zijn echter zodanig dat ze niet schadelijk zijn voor de volksgezondheid. Streefwaarden zijn waarden die bij voorkeur niet overschreden mogen worden, maar het zijn geen limieten.

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

Abstract

Environmental radioactivity in the Netherlands
Results in 2006

The Member States of the European Union have the obligation to measure radioactivity in the environment yearly, as stated in the Euratom Treaty of 1957. The Netherlands fulfilled this obligation also in 2006. In 2000 Euratom made recommendations to perform the measurements according to a certain outline, however Member States are not obliged to comply with these recommendations. To comply even further to the Euratom recommendations the monitoring program in drinking water was extended in 2006 with an additional parameter, namely the total amount of alpha-emitters. In 2006 the Netherlands complied to the Euratom recommendations except for the determination of strontium-90 in milk and mixed diet.

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

The target values in fresh water were exceeded for some radionuclides and locations, however these exceedings do not pose a threat to the public health. Target values are values that should preferably not be exceeded, however they are not limits.

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.
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The Food and Consumer Product Safety Authority
Voedsel en Waren Autoriteit (VWA)
Data on foodstuff.
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RIKILT - Institute of Food Safety
RIKILT - Instituut voor Voedselveiligheid
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 2006. 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 en vallen binnen het bereik van voorgaande jaren.

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 3,7 $Bq \cdot m^{-3}$. Het jaargemiddelde voor de berekende kunstmatige β-activiteitsconcentratie in luchtstof week niet significant af van nul. Met het NMR werd daarnaast het omgevingsdosisequivalenttempo bepaald, de jaargemiddelde meetwaarde was 73,6 $nSv \cdot h^{-1}$. Gebaseerd op eerder onderzoek wordt aangenomen dat deze waarde een overschatting is met 5 tot 10 $nSv \cdot h^{-1}$.

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 en de Schelde overschreed de streefwaarde (100 $mBq \cdot L^{-1}$) in respectievelijk zeven van de zeven, negen van de dertien, één van de dertien en dertien van de dertien genomen monsters. De jaargemiddelde totaal α-activiteitsconcentraties in het Noordzeekanaal, de Nieuwe Waterweg en de Schelde (respectievelijk 220, 133 en 350 $mBq \cdot L^{-1}$) zijn boven de streefwaarde, maar vallen binnen het bereik van voorgaande jaren.

De ^{3}H-activiteitsconcentratie in de Schelde en de Maas overschreed de streefwaarde (10 $Bq \cdot L^{-1}$) in respectievelijk drie van de zes en acht van de dertien genomen monsters. De jaargemiddelde ^{3}H-activiteitsconcentraties in de Schelde en de Maas (respectievelijk 11,9 en 15,0 $Bq \cdot L^{-1}$) zijn boven de streefwaarde, maar vallen binnen het bereik van voorgaande jaren.

De ^{226}Ra-activiteitsconcentratie in de Nieuwe Waterweg en de Schelde overschreed de streefwaarde (5 mBq·L^{-1}) in respectievelijk één van de zes en zes van de zes genomen monsters. De jaargemiddelde ^{226}Ra-activiteitsconcentratie in de Schelde (11,2 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 éénenvijftig genomen monsters. De jaargemiddelde ^{60}Co-activiteitsconcentratie in de Maas (18 Bq·kg^{-1}) is boven de streefwaarde, maar valt binnen het bereik van voorgaande jaren.

De ^{131}I-activiteitsconcentratie in het Noordzeekanaal en de Maas overschreed de streefwaarde (20 Bq·kg^{-1}) in respectievelijk twee van de zes en drieëndertig van de tweeënvijftig genomen monsters. De jaargemiddelde ^{131}I-activiteitsconcentratie in de Maas (36 Bq·kg^{-1}) is boven de streefwaarde, maar valt binnen het bereik van voorgaande jaren.

De ^{137}Cs-activiteitsconcentratie in de Maas overschreed de streefwaarde (40 Bq·kg^{-1}) in vier van de tweeënvijftig genomen monsters. De jaargemiddelde ^{137}Cs-activiteitsconcentraties zijn beneden de streefwaarde.

De ^{210}Pb-activiteitsconcentratie in de Nieuwe Waterweg, de Rijn, de Schelde en de Maas overschreed de streefwaarde (100 Bq·kg^{-1}) in respectievelijk vier van de zes, vijf van de zeven, twee van de zes en zeven van de zeven genomen monsters. De jaargemiddelde ^{210}Pb-activiteitsconcentraties in de Nieuwe Waterweg, de Rijn, de Schelde en de Maas (respectievelijk 109, 117, 102 en 141 Bq·kg^{-1}) zijn boven de streefwaarde, maar vallen binnen het bereik van voorgaande jaren.

De jaargemiddelde totaal α- en ^{3}H-activiteitsconcentraties in zeewater zijn voor sommige gebieden hoger in 2006 dan in voorgaande jaren. De jaargemiddelde activiteitsconcentraties van de overige nucliden (^{90}Sr, ^{137}Cs en ^{210}Po) vallen binnen het bereik van voorgaande jaren.

Het meetprogramma van drinkwater is vanaf 2006 uitgebreid met de bepaling van de totaal α- activiteitsconcentratie. Gangbare waarden die in ruw water voor de drinkwaterproductie gevonden worden, zijn weergegeven in Tabel S1. In dit water is weinig kalium, en dus ^{40}K, aanwezig. De totaal α-activiteitsconcentratie gemiddeld per pompstation overschreed 0,1 Bq·L^{-1} bij één van de 137 pompstations. Deze waarde is niet grondig onderzocht. Toekomstige waarden boven 0,1 Bq·L^{-1} worden nader onderzocht.

De resultaten van het meetprogramma voor melk en voedsel zijn weergegeven in Tabel S1. Nederland voldeed in 2006 aan alle Europese aanbevelingen, met uitzondering van de bepaling van strontium-90 in melk en voedsel.

Summary

The Dutch government is obligated to measure radioactivity in air, water and soil under the terms of the Euratom Treaty of 1957. In 2000 the European Union specified this treaty by means of recommendations describing the matrices to be measured (air dust, ambient dose 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 2006. 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 and are within the range of those in previous years.

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 3.7 $Bq·m^{-3}$. The yearly average of the calculated artificial β-activity concentration did not deviate significantly from zero. The NMR was also used to determine the ambient dose equivalent rate, the yearly averaged measured value was 73.6 $nSv·h^{-1}$. 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 and Scheldt exceeds the target value (100 $mBq·L^{-1}$) in seven out of seven, nine out of thirteen, one out of thirteen and thirteen out of thirteen samples taken, respectively. The yearly averaged gross α-activity concentrations in the Noordzeekanaal, Nieuwe Waterweg and Scheldt (220, 133 and 350 $mBq·L^{-1}$, respectively) are above the target value, but within the range of those in previous years.

The ^{3}H-activity concentration in the Scheldt and the Meuse exceeds the target value (10 $Bq·L^{-1}$) in three out of six and eight out of thirteen samples taken, respectively. The yearly averaged ^{3}H-activity concentrations in the Scheldt and the Meuse (11.9 and 15.0 $Bq·L^{-1}$, respectively) are above the target value, but within the range of those in previous years.

The ^{226}Ra-activity concentration in the Nieuwe Waterweg and the Scheldt exceeds the target value (5 mBq·L^{-1}) in one out of six and six out of six samples taken, respectively. The yearly averaged ^{226}Ra-activity concentration in the Scheldt (11.2 mBq·L^{-1}) is above the target value, but within the range of those in previous years.

The ^{60}Co-activity concentration in the Meuse exceeds the target value (10 Bq·kg^{-1}) in twenty-six out of fifty-one samples taken. The yearly averaged ^{60}Co-activity concentration in the Meuse (18 Bq·kg^{-1}) is above the target value, but within the range of those in previous years.

The ^{131}I-activity concentration in the Noordzeekanaal and Meuse exceeds the target value (20 Bq·kg^{-1}) in two out of six and thirty-three out of fifty-two samples taken, respectively. The yearly averaged ^{131}I-activity concentration in the Meuse (36 Bq·kg^{-1}) is above the target value, but within the range of those in previous years.

The ^{137}Cs-activity concentration in the Meuse exceeds the target value (40 Bq·kg^{-1}) in four out of fifty-two samples taken. The yearly averaged ^{137}Cs-activity concentrations are below the target value.

The ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine, Scheldt and Meuse exceeds the target value (100 Bq·kg^{-1}) in four out of six, five out of seven, two out of six and seven out of seven samples taken, respectively. The yearly averaged ^{210}Pb-activity concentrations in the Nieuwe Waterweg, Rhine, Scheldt and Meuse (109, 117, 102 and 141 Bq·kg^{-1}, respectively) are above the target value, but within the range of those in previous years.

For some areas the yearly averaged gross α- and ^{3}H-activity concentrations in seawater are higher in 2006 than those in previous years. The yearly averaged activity concentration of the other nuclides (^{90}Sr, ^{137}Cs and ^{210}Po) are within the range of those in previous years.

In 2006 gross α-activity concentrations in drinking water are reported for the first time. 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. At one of the 137 pumping stations the gross α-activity concentration averaged per pumping station exceeds 0.1 Bq·L^{-1}. This value was not thoroughly investigated. Future values above 0.1 Bq·L^{-1} for the gross α-activity concentration will be investigated.

The results of the monitoring program in milk and mixed diet are presented in Table S1.
In 2006 the Netherlands complied to the Euratom recommendations except for the determination of strontium-90 in milk and mixed diet.

Tabel S1: Overzicht van de resultaten in 2006.
Table S1: Summary of the results in 2006.

Matrix	Parameter	Locations	Values	Frequency (per year)
Air dust (1)	Gross α	1	0.05 mBq·m^{-3}	52
	Gross β	1	0.489 mBq·m^{-3}	52
	^{7}Be	1	3.800 mBq·m^{-3}	52
	^{137}Cs	1	0.0049 mBq·m^{-3} (2)	52
	^{210}Pb	1	0.473 mBq·m^{-3}	52
Deposition (3)	Gross α	1	25.7 Bq·m^{-2}	12
	Gross β	1	98 Bq·m^{-2}	12
	^{3}H	1	280 - 1820 Bq·m^{-2} (4)	12
	^{7}Be	1	1400 Bq·m^{-2}	52
	^{137}Cs	1	0.06 - 7.47 Bq·m^{-2} (4)	52
	^{210}Pb	1	66 - 103 Bq·m^{-2} (4)	52
	^{210}Po	1	14.1 - 15.6 Bq·m^{-2} (4)	12
Surface water (1)	Gross α	6	38 - 350 mBq·L^{-1}	7 or 13 (5)
	Residual β	6	34 - 84 mBq·L^{-1}	7 or 13 (5)
	^{3}H	6	3700 - 15000 mBq·L^{-1}	6, 7 or 13 (5)
	^{90}Sr	3	1.5 - 4.2 mBq·L^{-1}	6 or 7 (5)
	^{226}Ra	4	3.0 - 11.2 mBq·L^{-1}	6 or 7 (5)
	^{60}Co	7	<1 - 18 Bq·kg^{-1}	6, 7, 13 or 51 (5)
	^{131}I	7	<1 - 36 Bq·kg^{-1}	6, 7, 13 or 52 (5)
	^{137}Cs	7	4.2 - 23.3 Bq·kg^{-1}	6, 7, 13 or 52 (5)
	^{210}Pb	4	102 - 141 Bq·kg^{-1}	6 or 7 (5)
Seawater (1)	Gross α	8	340 - 800 mBq·L^{-1}	4, 12 or 13 (5)
	Residual β	8	42 - 130 mBq·L^{-1}	4, 12 or 13 (5)
	^{3}H	8	600 - 6600 mBq·L^{-1}	4 or 13 (5)
	^{90}Sr	4	<1.1 - 4 mBq·L^{-1}	4 or 13 (5)
	^{137}Cs	4	4.5 - 8.3 Bq·kg^{-1}	3 or 4 (5)
	^{210}Po	4	70 - 102 Bq·kg^{-1}	3 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 α	137	<0.1 $Bq \cdot L^{-1}$	360
	Gross β	207	<0.2 $Bq \cdot L^{-1}$	714
	Residual β	189	<0.2 $Bq \cdot L^{-1}$	636
	^{3}H	139	<3.2 $Bq \cdot L^{-1}$	410
Milk (1)	^{40}K	24	49 $Bq \cdot L^{-1}$	915
	^{60}Co	24	<1.4 $Bq \cdot L^{-1}$	915
	^{131}I	24	<0.6 $Bq \cdot L^{-1}$	915
	^{134}Cs	24	<0.6 $Bq \cdot L^{-1}$	915
	^{137}Cs	24	<0.5 $Bq \cdot L^{-1}$	915
Food (6, 7)				
Grain	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	78 (0) (8)
Vegetables	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	83 (0) (8)
Fruit	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	58 (0) (8)
Milk and milk products	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	44 (0) (8)
Meat and meat products	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	75 (0) (8)
Game and poultry	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	45 (0) (8)
Salads	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	27(0) (8)
Oil and butter	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	39 (0) (8)
Honey	^{137}Cs	-	7 - 408 $Bq \cdot kg^{-1}$	120 (19) (8)
Ready-to-eat meals	^{137}Cs	-	< 3.0 $Bq \cdot kg^{-1}$	22 (0) (8)

(1) = Yearly average is shown.
(2) = Only one measurement was above the detection limit.
(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 below the detection limit.
(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 2006. 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. General conclusions are presented in Chapter 9.

2 Airborne particles

The 2006 monitoring program for determining radioactive nuclides in air dust is given in Table 2.1. The sampling was done on the RIVM premises in Bilthoven. Air dust samples for the measurement of gross α, gross β and γ-emitters were collected weekly with a High Volume Sampler (HVS). A detailed description of sampling, sample treatment and the analytical method is given in previous reports [2, 3, 4]. The data from 1991 to 2004 were reanalysed to determine the yearly averages by the method described in Appendix B [5]. This can result in small differences between results presented in this report and reports on data prior to 2005.

Table 2.1: Monitoring program in 2006 for the determination of radioactive nuclides in air dust.

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

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

2.1 Long-lived α- and β-activity

The weekly results of gross α- and β-activity concentrations in air dust are given in Figure 2.1 and Table A1 (see Appendix A). Due to large uncertainties caused by variations in dust thickness on the filters, gross α-activity concentrations in air dust should be regarded as indicative values [6]. The period between sampling and analysis is five to ten days, which is long compared to the decay time of the short-lived decay products of ^{222}Rn and ^{220}Rn. This is to ensure that these naturally occurring decay-products do not contribute to the measured α- and β-activity concentrations. The frequency distributions of gross α-activity and gross β-activity concentrations in air dust are given in Figures 2.2 and 2.3, respectively.

The yearly averages of the gross α- and β-activity concentrations of long-lived nuclides in 2006 are within the range of the results from the period 1992-2005 as is illustrated in Figure 2.4.

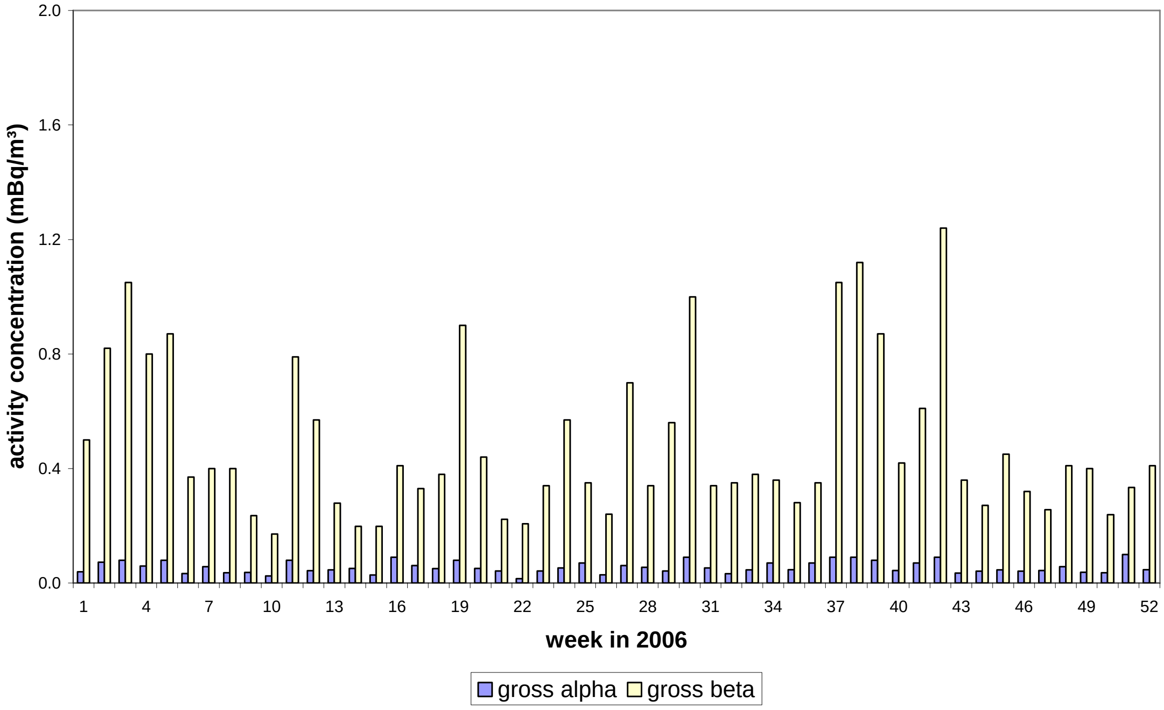


Figure 2.1: Weekly averaged gross α- and β-activity concentrations of long-lived nuclides in air dust sampled at RIVM in 2006.

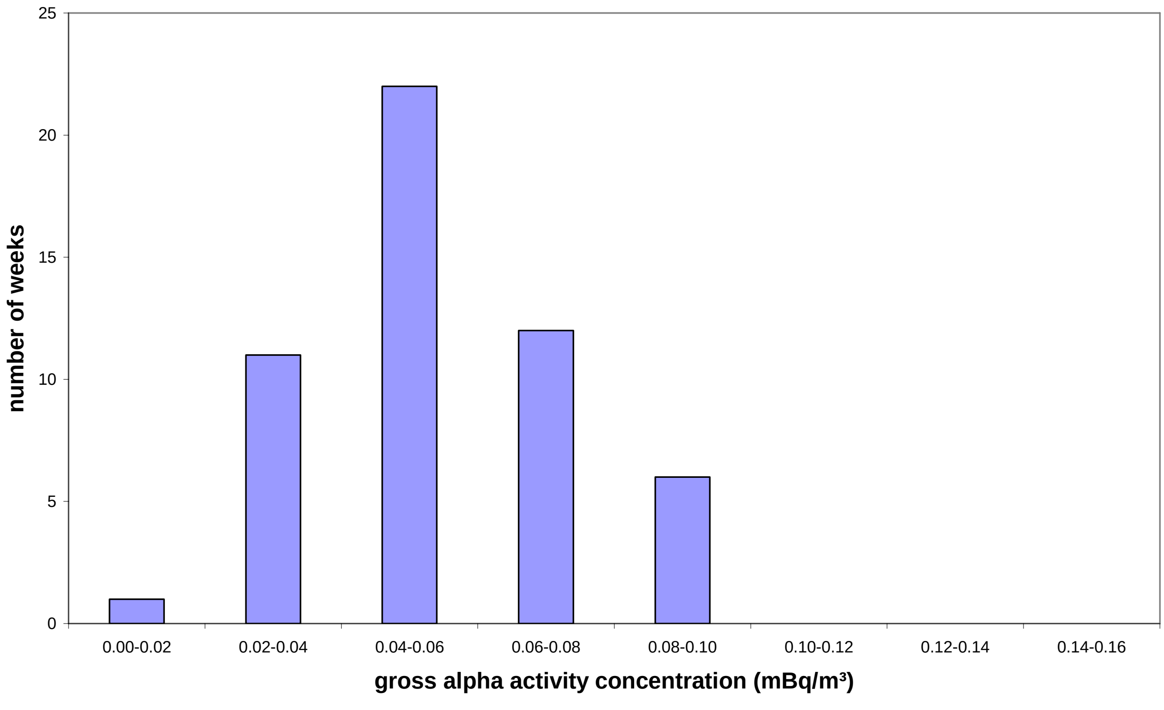


Figure 2.2: Frequency distribution of gross α-activity concentration of long-lived nuclides in air dust collected weekly in 2006. The yearly average is 0.05 (SD=0.02) mBq·m^{-3}. SD is the standard deviation and illustrates the variation in weekly averages during the year.

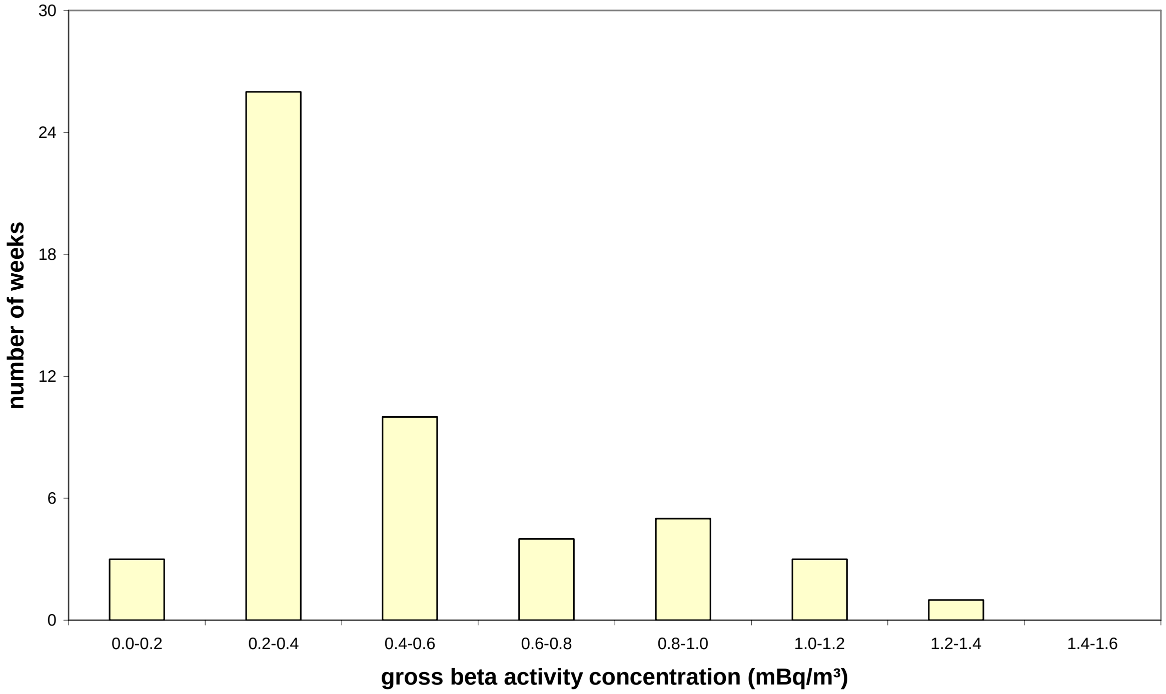


Figure 2.3: Frequency distribution of gross β-activity concentration of long-lived nuclides in air dust collected weekly in 2006. The yearly average is 0.489 ± 0.005 (SD=0.3) mBq·m^{-3}.

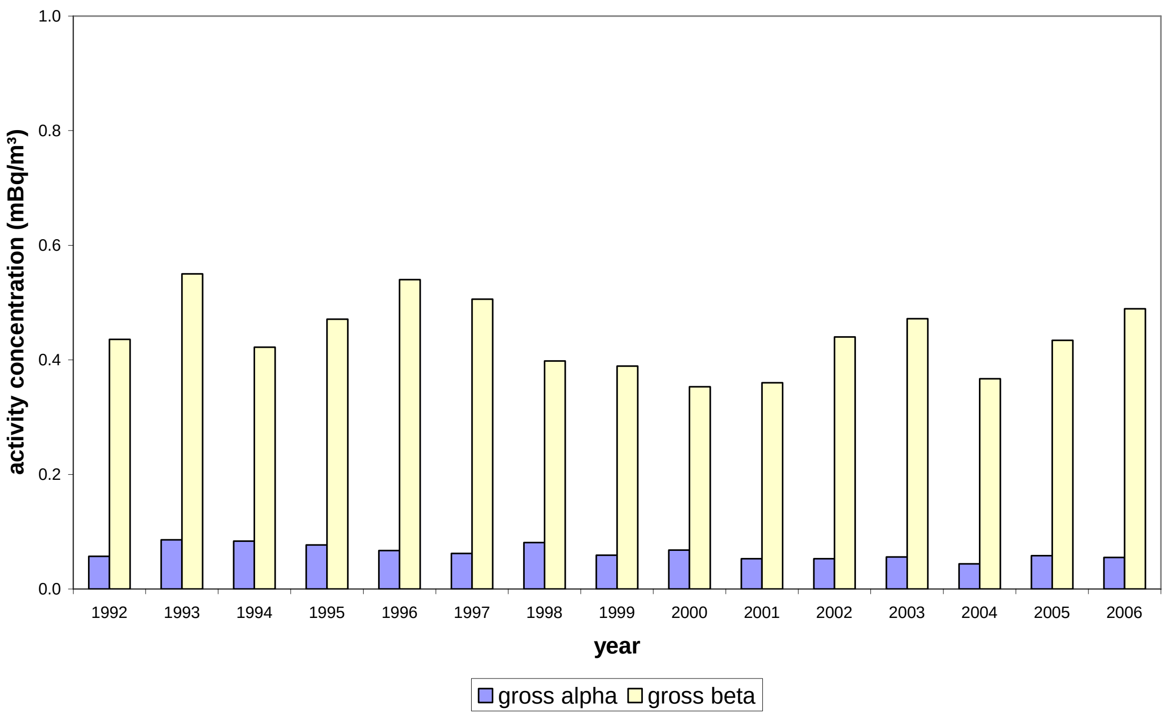


Figure 2.4: Yearly averaged gross α- and gross β-activity concentrations of long-lived nuclides in air dust at RIVM in 1992-2006.

2.2 γ-emitting nuclides

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

The behaviour of ^{7}Be in the atmosphere has been studied world-wide [8, 9, 10, 11, 12, 13, 14]. Natural ^{7}Be (half-life 53.3 days) is formed by spallation reactions of cosmogenic radiation with atmospheric nuclei, such as carbon, nitrogen and oxygen resulting in the formation of BeO or $Be(OH)_2$ molecules. Approximately 70% of ^{7}Be is produced in the stratosphere, with the remaining 30% being produced in the troposphere. A residence time is estimated at about one year in the stratosphere and about six weeks in the troposphere. Most of the ^{7}Be produced in the stratosphere does not reach the troposphere except during spring when seasonal thinning of the tropopause takes place at midlatitudes, resulting in air exchange between stratosphere and troposphere. In the troposphere ^{7}Be rapidly associates mainly with submicron-sized aerosol particles. Gravitational settling and precipitation processes accomplish transfer to the earth's surface. Seasonal variations in the concentration of ^{7}Be in surface air is influenced by the following main atmospheric processes: wet and dry deposition, mass exchange between stratosphere and troposphere, vertical transport in the troposphere and horizontal transport of air masses from the subtropics and midlatitudes into the tropics and polar regions.

The red line in Figure 2.5 shows the seasonal variation of the ^{7}Be-activity concentration, with peaks during the spring and summer periods, reflecting the seasonal variations in the transport rate of air from stratosphere to troposphere. Figure 2.5 further shows the influence of the solar cycle. The maximum at 1997 and the minimum at 2000-2002 are consistent with the solar minimum (measured by radio flux and sunspot count) of 1996-1997 and the solar maximum of 2000-2002 [15]. In the summer of 1991 two severe geomagnetic storms caused a significant world-wide disturbance of earth's geomagnetic field. This resulted in a considerable decrease in cosmogenic radiation, unprecedented in at least the previous four decades [16]. The absence of a 1991 summer peak in the ^{7}Be-activity concentration can be explained by the decrease in cosmogenic radiation. The concentrations found for ^{7}Be in 2006 fit in the pattern described above.

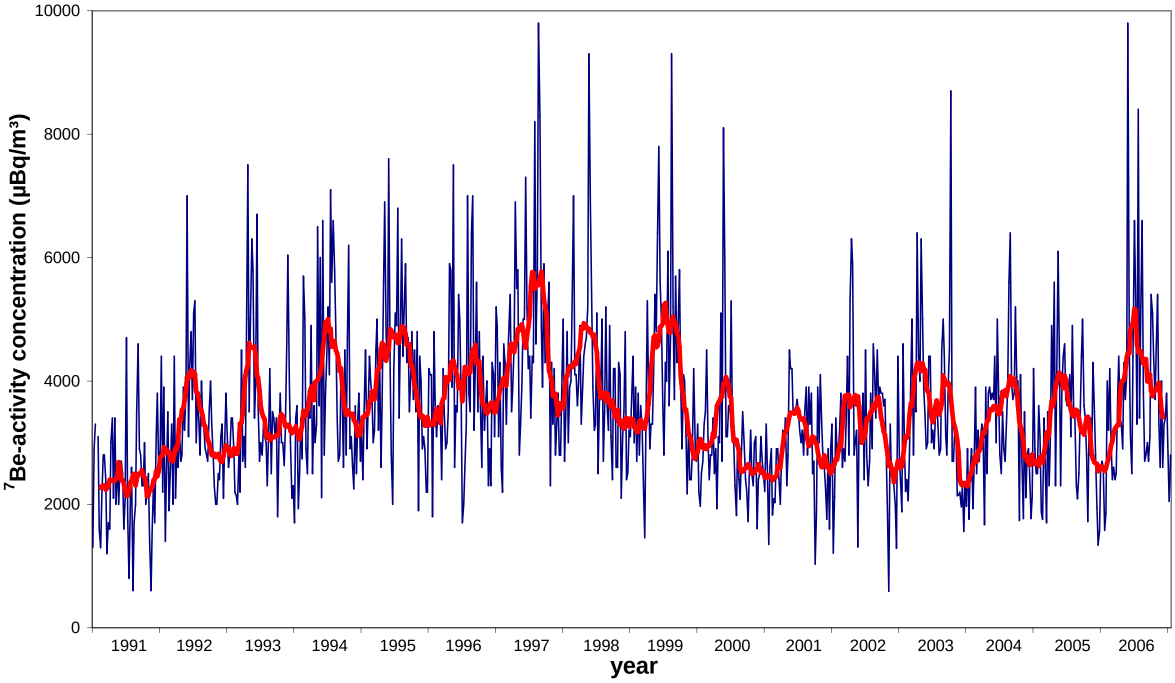


Figure 2.5: Weekly averaged ^{7}Be-activity concentrations (blue) in air dust at RIVM in 1991-2006. The red line is a moving average of 13 weeks. The yearly average for 2006 is 3800 ± 50 (SD=1500) μBq·m^{-3}.

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

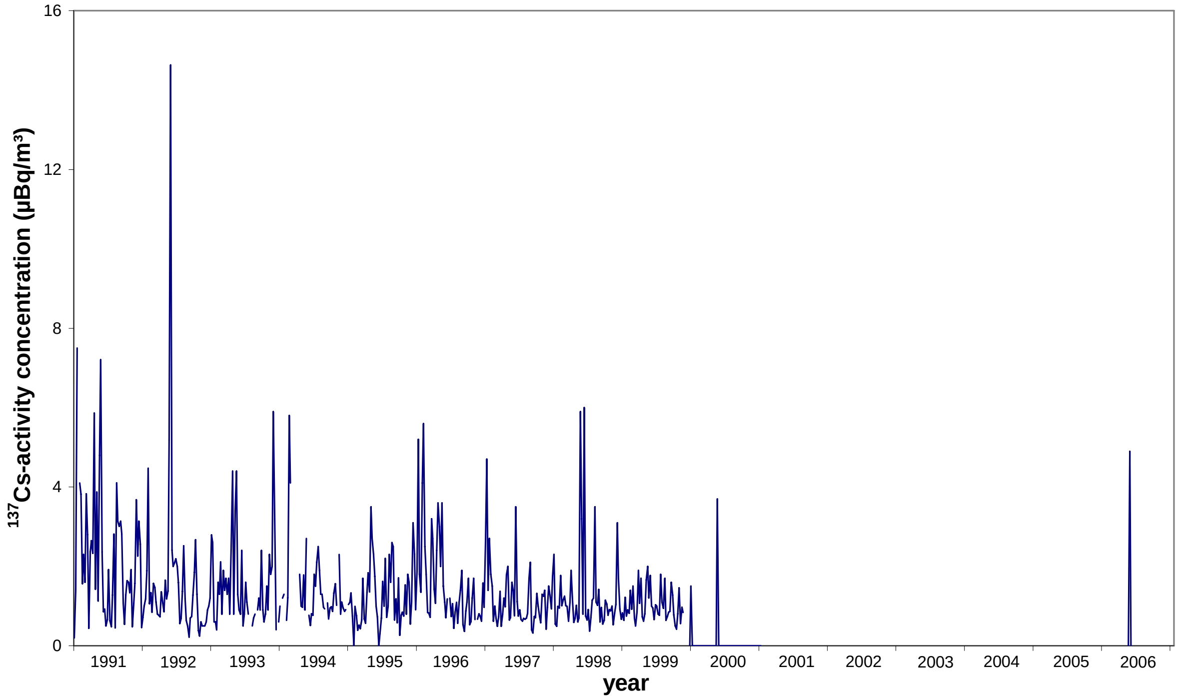


Figure 2.6: Weekly averaged ^{137}Cs-activity concentrations in air dust at RIVM in 1991-2006. In 2006 all but one measurement were below the detection limit. From 2000 onwards the detection limit was higher than during 1991-1999, due to a different detector set-up.

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

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

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

Except for week 45 in 2002 there is a good correlation between activity concentrations of ^{210}Pb and activity concentrations of gross β, as is the case in 2006 (Figure 2.8).

The weekly averaged activity concentrations of ^{210}Pb in 2006 are within range of those found in previous years.

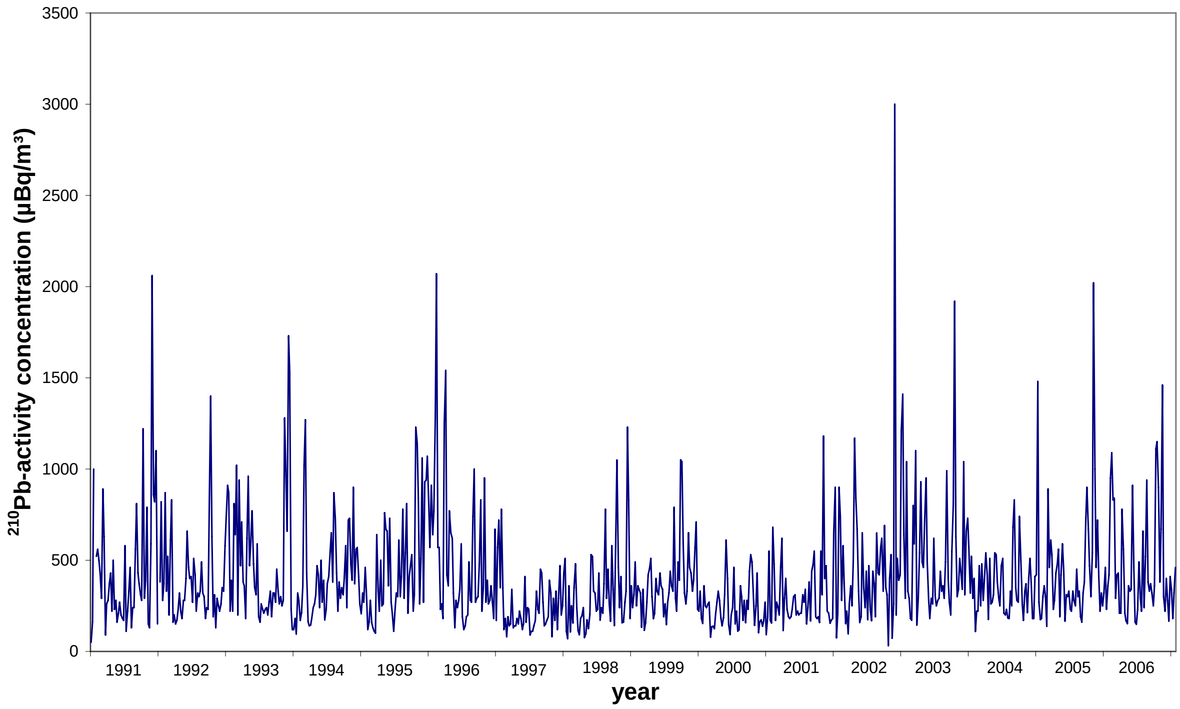


Figure 2.7: Weekly averaged ^{210}Pb-activity concentrations in air dust at RIVM in 1991-2006. The yearly average for 2006 is 473 ± 7 (SD=300) µBq·m^{-3}.

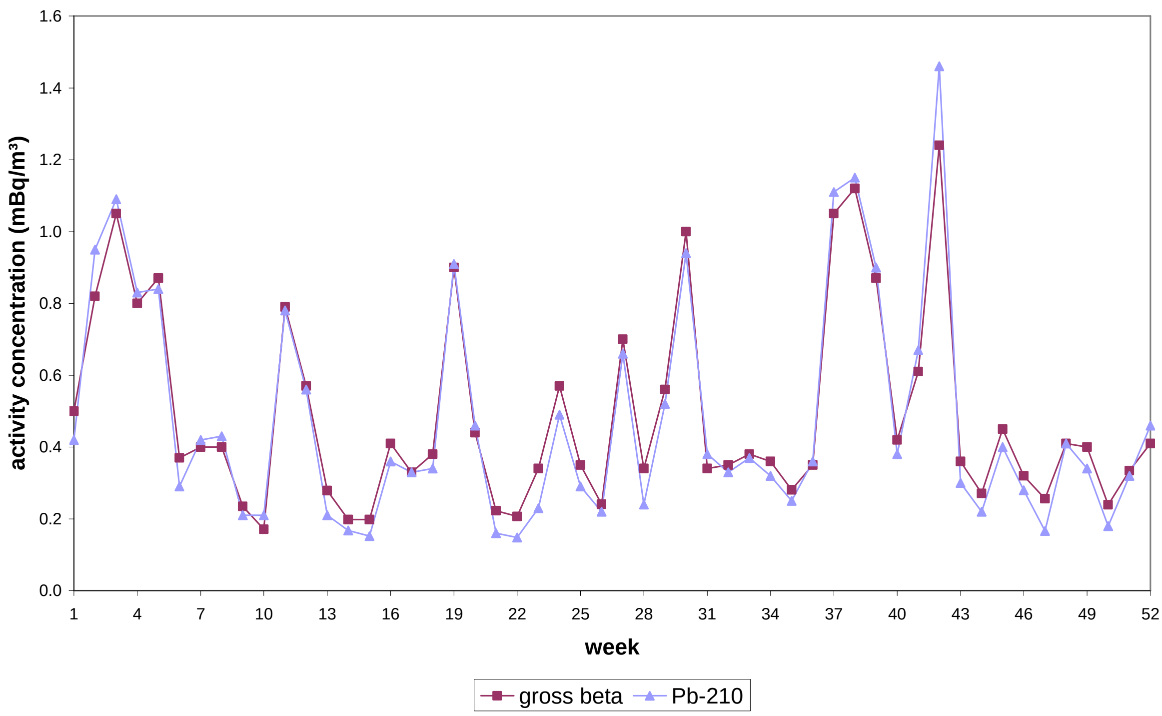


Figure 2.8: Correlation between weekly averaged gross β- and ^{210}Pb-activity concentrations in air dust at RIVM in 2006.

3 Deposition

The 2006 monitoring program for determining radioactive nuclides in deposition is given in Table 3.1. Sampling was done on the RIVM premises in Bilthoven. Samples were collected weekly for γ-emitters and monthly in case of gross α, gross β, ^{3}H and ^{210}Po. The data from 1993 to 2004 were reanalysed to determine the yearly totals by the method described in Appendix B [5]. This can result in small differences between results presented in this report and reports on data prior to 2005.

Table 3.1: The 2006 monitoring program for the determination of radioactive nuclides in deposition.

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

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

3.1 Long-lived α- and β-activity

The monthly deposited gross α- and gross β-activities of long-lived nuclides are given in Figure 3.1, Figure 3.3 and Table A4. The yearly total deposition of gross α and gross β was 25.7 ± 1.5 and 98 ± 3 $Bq{\cdot}m^{-2}$, respectively. These values are within range of those from previous years, as illustrated in Figure 3.2, Figure 3.4 and Table A5.

The monthly deposition of ^{3}H is given in Table A4. In 2006 the yearly total deposition of ^{3}H ranged between 280 and 1820 $Bq{\cdot}m^{-2}$ (68% confidence level). Eight out of twelve measurements were below the detection limit. Therefore detection limits were used for the contribution to the yearly total. This range does not differ significantly from those measured since 1993, as illustrated in Figure 3.5 and Table A5. Until 1998 samples were electrolytic enriched before counting, which resulted in a much lower detection limit than that after 1997.

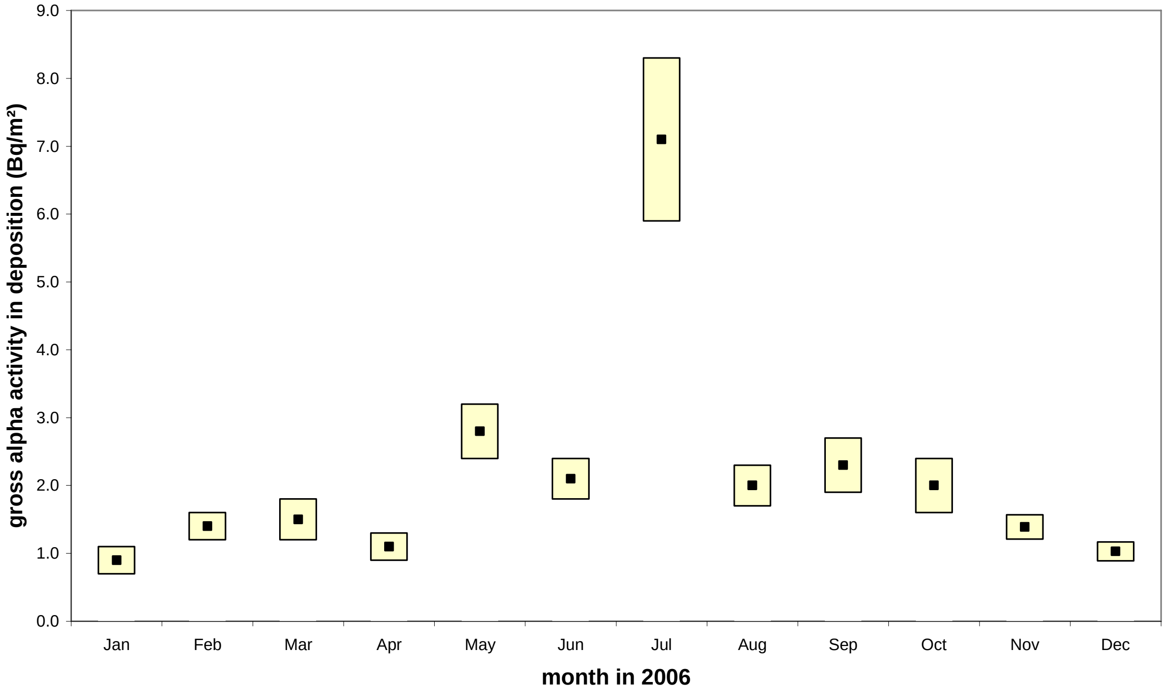


Figure 3.1: Monthly deposited gross α-activity of long-lived nuclides at RIVM in 2006. Given are monthly averages (black dot) with a 68% confidence range (colored bar).

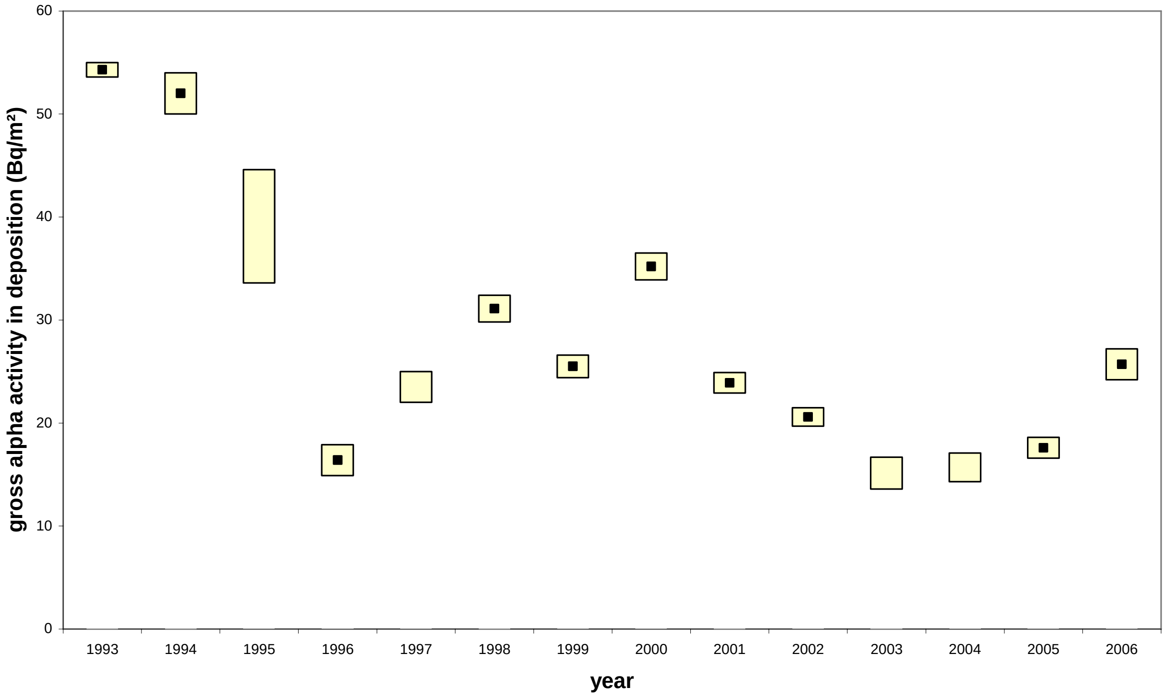


Figure 3.2: Yearly gross α-activity of long-lived nuclides deposited at RIVM from 1993 to 2006. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

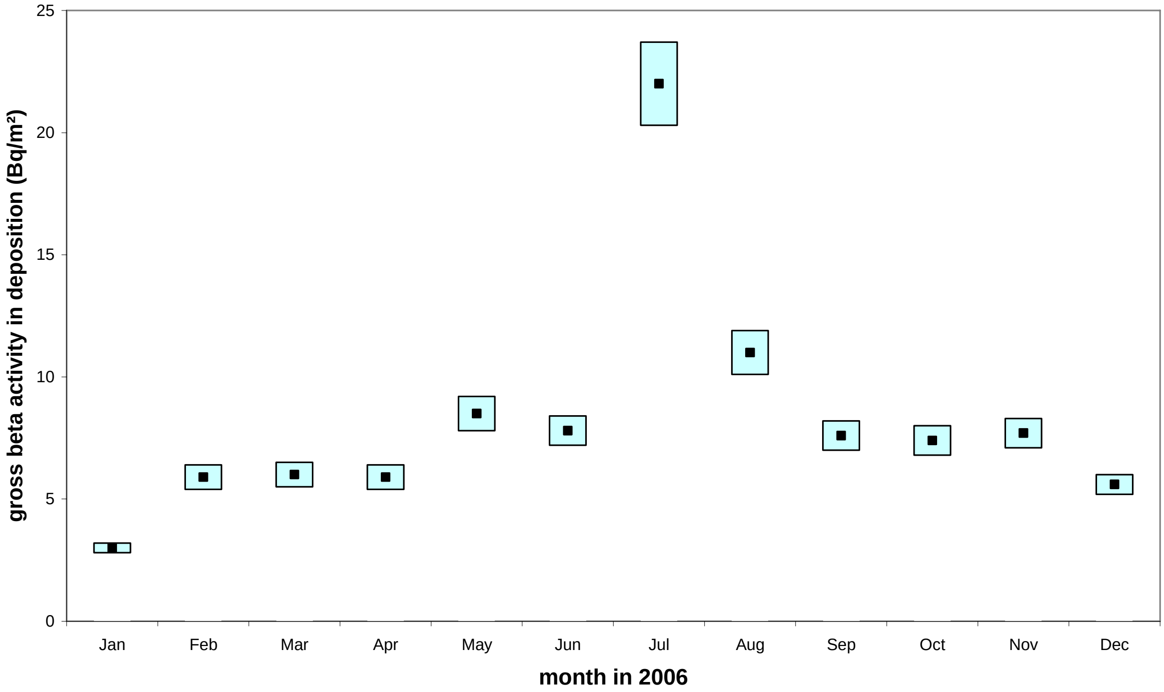


Figure 3.3: Monthly deposited gross β-activity of long-lived nuclides at RIVM in 2006. Given are monthly averages (black dot) with a 68% confidence range (colored bar).

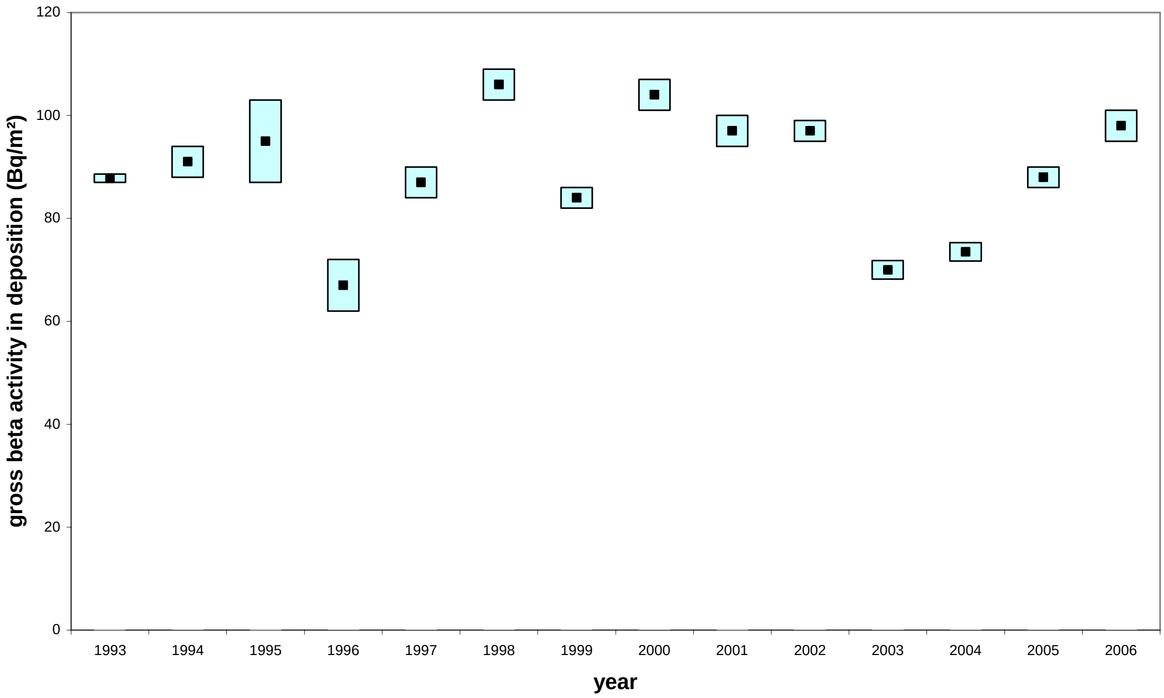


Figure 3.4: Yearly gross β-activity of long-lived nuclides deposited at RIVM from 1993 to 2006. Given are yearly averages (black dot) with a 68% confidence range (colored bar).

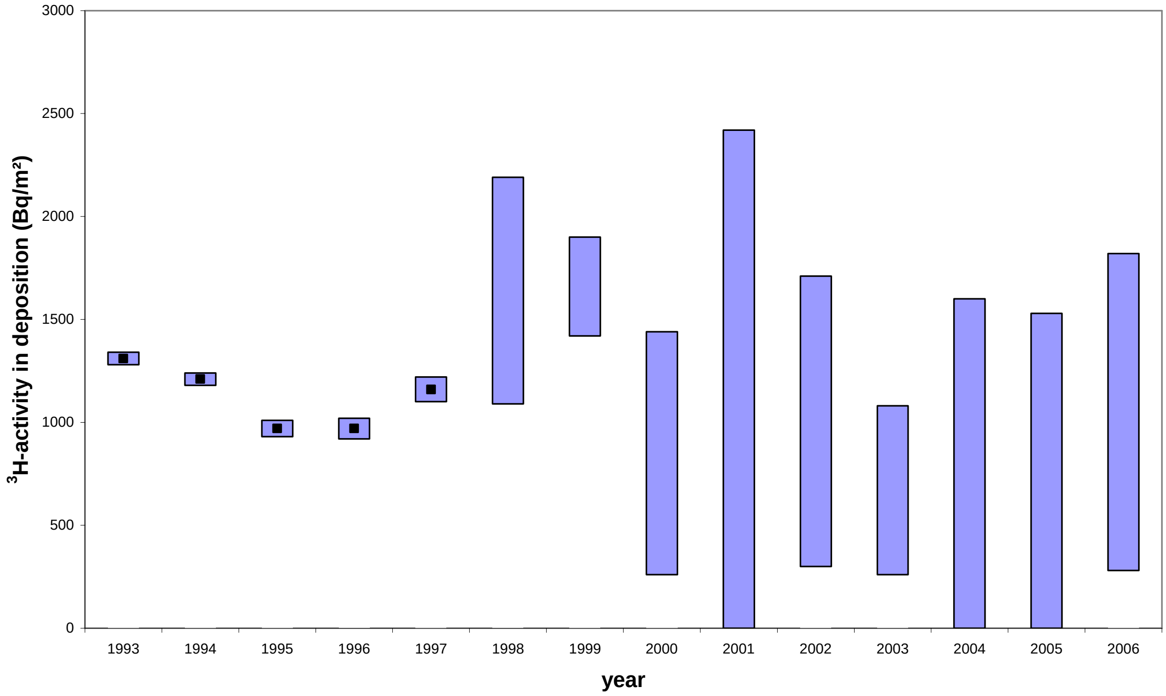


Figure 3.5: Yearly deposition of ^{3}H at RIVM from 1993 to 2006. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

The monthly α-spectroscopy results for ^{210}Po are given in Figure 3.6 and Table A6. The results for previous years are given in Figure 3.7 and Table A7. The amount of ^{210}Po deposited in 2006 ranged between 14.1 and 15.6 Bq·m^{-2} (68% confidence level). ^{210}Po was not detected in the sample from June. Therefore the detection limit was used for the contribution to the yearly total.

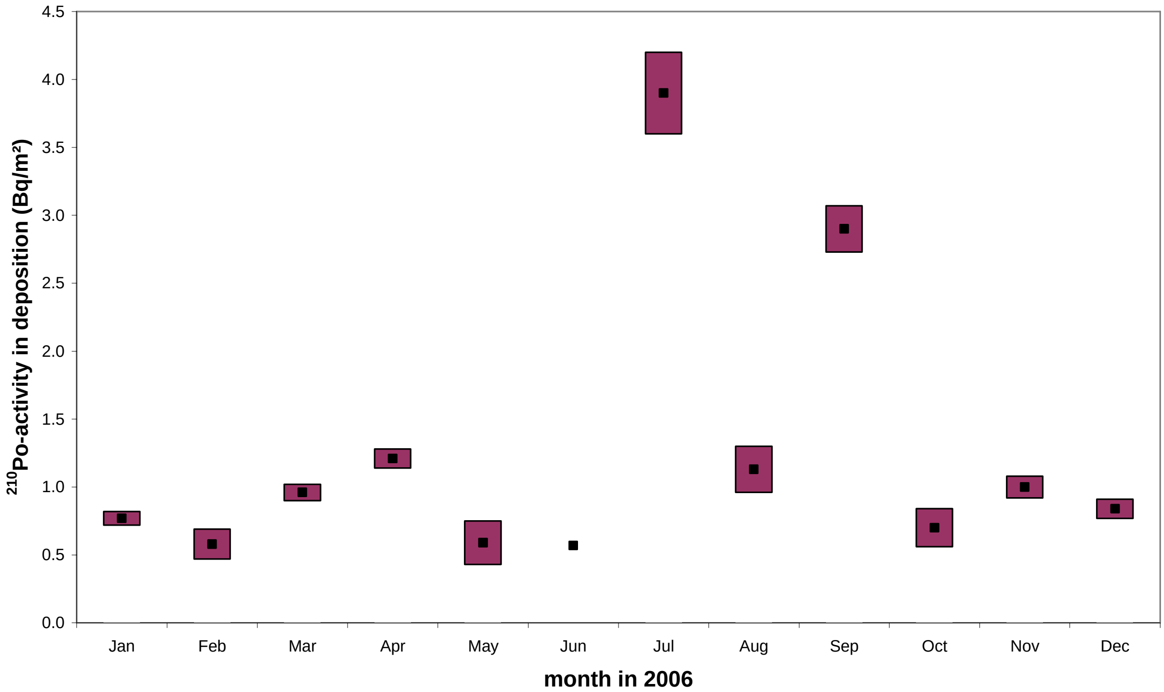


Figure 3.6: Monthly deposited ^{210}Po-activity at RIVM in 2006. Given are monthly averages (black dot) with a 68% confidence range (colored bar). Solely a black dot is given if the result is a detection limit.

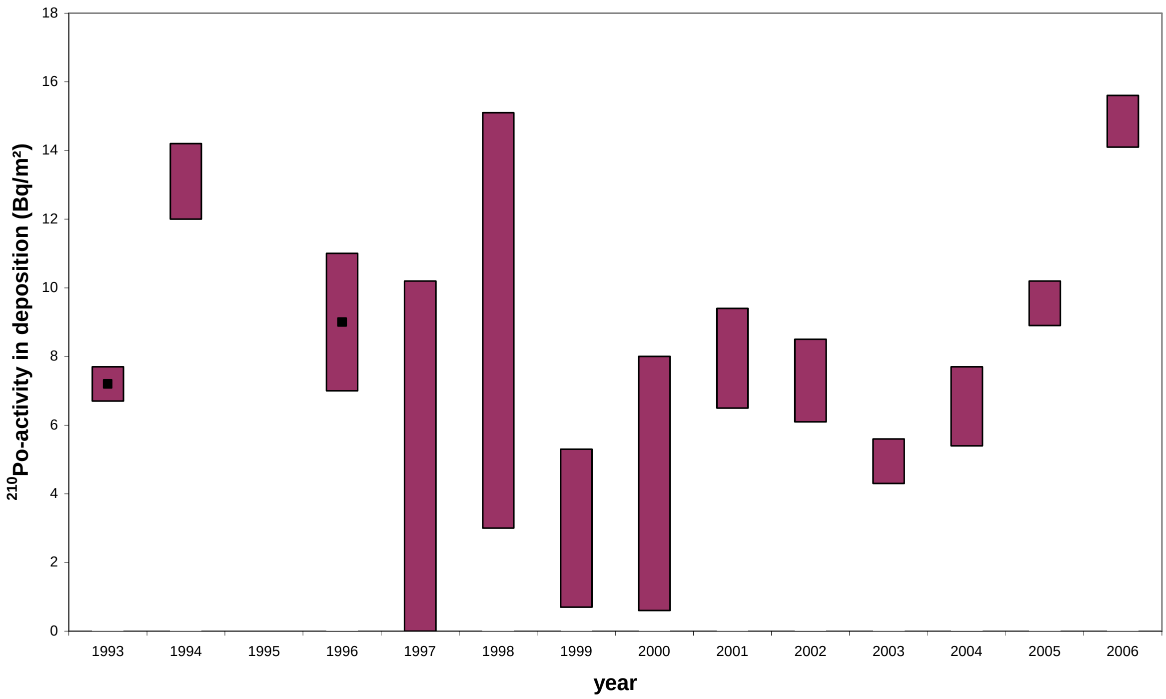


Figure 3.7: Yearly ^{210}Po-activity deposited at RIVM from 1993 to 2006. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

3.2 γ-emitting nuclides

Detectable quantities of the naturally occurring nuclides ^{7}Be and ^{210}Pb were found in 52 and respectively 30 out of 52 samples. The yearly total deposition of ^{7}Be is 1400 ± 30 Bq·m^{-2}. The yearly total deposition of ^{210}Pb ranged between 66 and 103 Bq·m^{-2} (68% confidence level). The nuclide ^{137}Cs was detected in 1 out of 52 samples (detection limit is about 0.1 Bq·m^{-2}). The yearly total deposition of ^{137}Cs ranged between 0.06 and 7.47 Bq·m^{-2} (68% confidence level). The weekly results for deposition of ^{7}Be, ^{137}Cs and ^{210}Pb are given in Table A8 and Figures 3.8 and 3.11. The results for previous years are given in Table A7, Figure 3.9, 3.10 and 3.12.

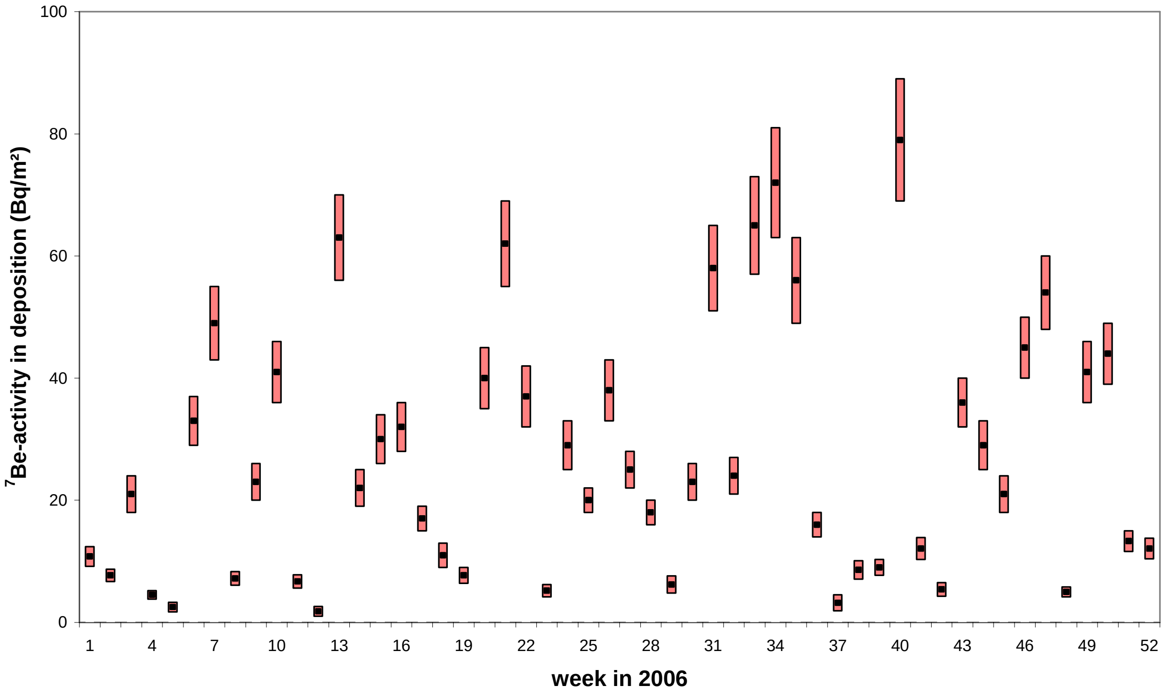


Figure 3.8: Weekly deposited ^{7}Be-activity at RIVM in 2006. Given are weekly averages (black dot) with a 68% confidence range (colored bar).

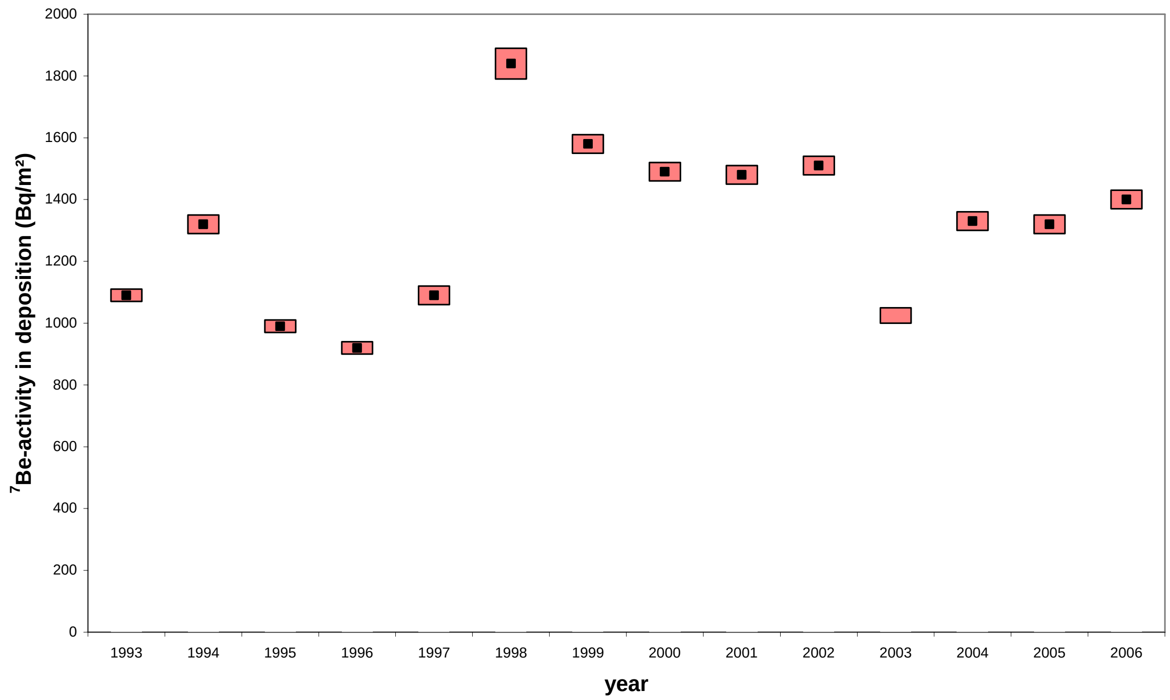


Figure 3.9: Yearly ^{7}Be-activity deposited at RIVM from 1993 to 2006. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

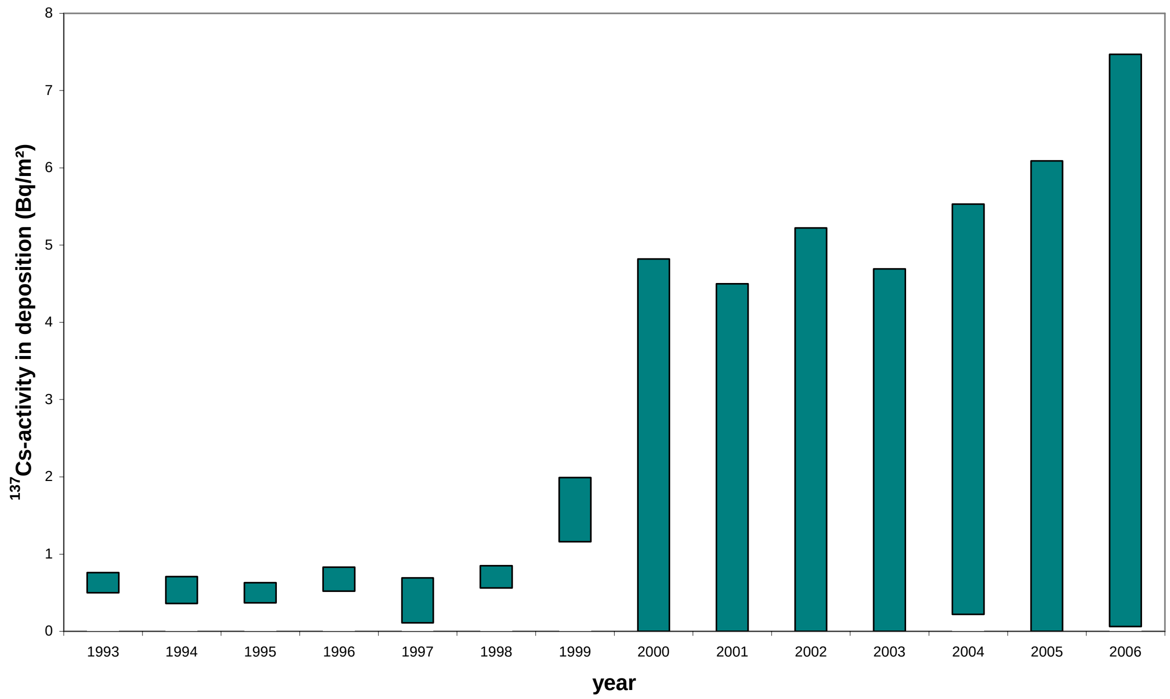


Figure 3.10: Yearly ^{137}Cs-activity deposited at RIVM from 1993 to 2006. Given are yearly averages, solely a 68% confidence range is given since the yearly result is made up of at least one detection limit. Since 2000 the detection limit is higher than during 1993-1999, due to a different detector set-up.

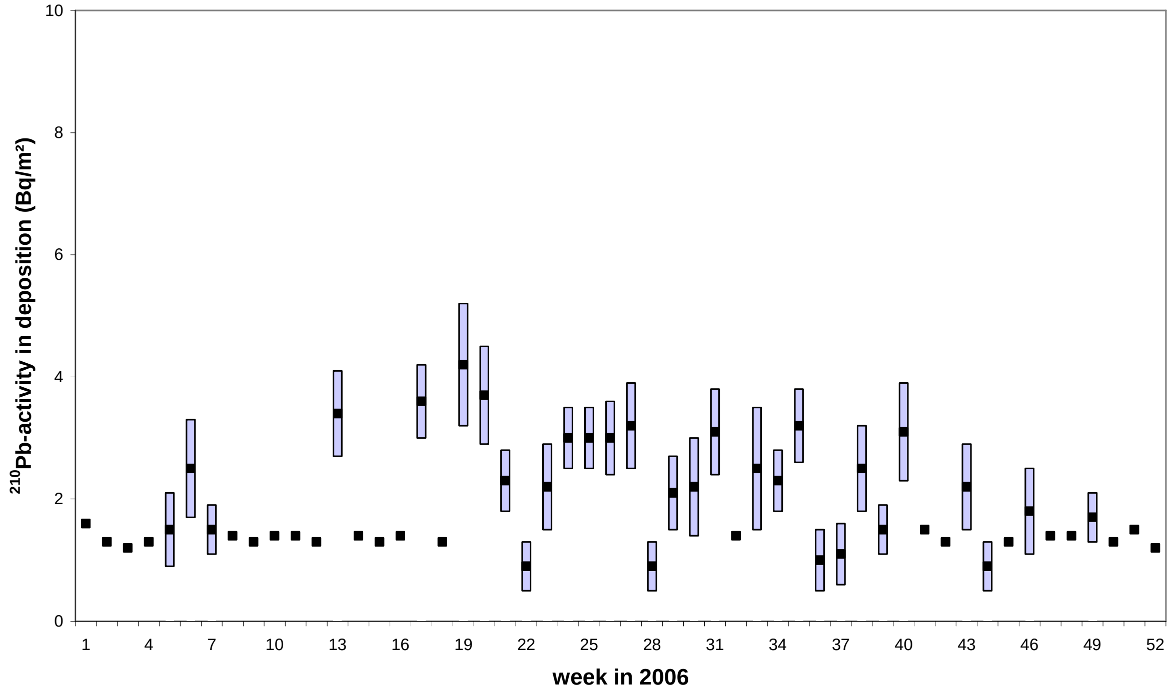


Figure 3.11: Weekly deposited ^{210}Pb-activity at RIVM in 2006. Given are weekly averages (black dot) with a 68% confidence range (colored bar). Solely a black dot is given if the result is a detection limit.

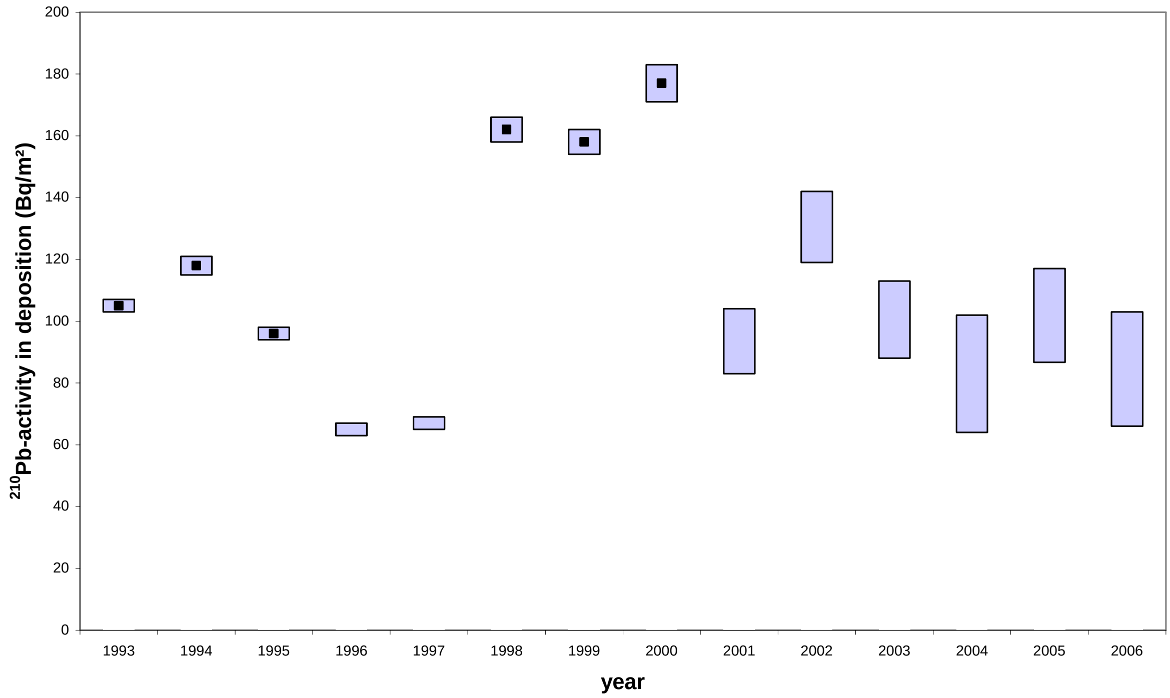


Figure 3.12: Yearly ^{210}Pb-activity deposited at RIVM from 1993 to 2006. Given are yearly averages (black dot) with a 68% confidence range (colored bar). Solely a 68% confidence range is given if the yearly result is made up of at least one detection limit.

4 National Radioactivity Monitoring Network

This chapter presents data on gross α- and artificial β-activity concentrations in air dust and ambient dose equivalent rates as measured by the National Radioactivity Monitoring Network (Nationaal Meetnet Radioactiviteit, NMR). The data on gross α and artificial β differ in sample size, sampling frequency and analytical procedures from those given in the previous chapter. The difference between the NMR data and those mentioned in the previous chapter is due to the contribution of short-lived natural radionuclides (radon daughters).

The NMR consists of 14 aerosol monitors for determining gross α- and artificial β-activity concentrations and 153 ambient dose equivalent rate monitors [33]. The 14 sites with an aerosol monitor are also equipped with a dose equivalent rate monitor. These 14 dose equivalent rate monitors are differently placed from the 153 dose equivalent rate monitors with regard to height (3.5 meter versus 1 meter above ground level) and surface covering. Therefore, results can differ between the two types of monitors [34]. Hence, these 14 dose equivalent rate monitors are not taken into account for calculating the yearly averaged ambient dose equivalent. The reported artificial β-activity concentrations are calculated from the difference between the measured gross β-activity concentration and the natural gross β-activity derived from the measured gross α-activity concentration.

During the second half of 2002 the 14 aerosol FAG FHT59S monitors were gradually replaced by 14 new Berthold BAI 9128 monitors. Due to differences in detection method, filter transport, calibration nuclides and algorithms the results for the activity concentrations are not exactly the same. By running both monitors simultaneously at the same location, the measured gross α-activity concentration was compared. On average the Berthold monitor systematically reports about 20% higher values than the FAG monitor [35]. The estimated random uncertainty for both types of monitor is about 20%. No correction is applied for the difference in the gross α-activity concentration between the Berthold and FAG monitor.

The data presented in this chapter are based on ten-minute measurements. Averages over the year are calculated per location using daily averages from the ten-minute measurements (Tables A9 and A10). The data on external radiation, expressed in ambient dose equivalent, contain a systematic error because of an overestimation of the cosmogenic dose rate and an underestimation of the terrestrial dose rate. Based upon earlier research [34, 36] it is assumed that the ambient dose equivalent rate is overestimated by 5 to 10 $nSv.h^{-1}$. However, NMR data are not corrected for these response 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 2006, while Figure 4.4 presents the yearly averages of ambient dose equivalent rate from 1996 to 2006. In 2006 the yearly averaged gross α-activity concentration in air dust was 3.7 $Bq{\cdot}m^{-3}$ (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 3.1 $Bq{\cdot}m^{-3}$. 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 2006 is calculated using 150 stations. The remaining 3 stations were not operational.

For the ambient dose equivalent rate the yearly averaged measured value was 73.6 $nSv.h^{-1}$. It is assumed that this value is an overestimate of 5 to 10 $nSv.h^{-1}$. Figure 4.5 shows the influence of the 11-year solar cycle on the cosmogenic contribution to the effective dose rate, which is related to the ambient dose equivalent rate. The decrease in the ambient dose equivalent rate (as given by the NMR) during 1996 to 2003 (Figure 4.4) might be related to the decrease in the cosmogenic contribution. However the correlation between the increase in the cosmogenic contribution since 2004 and the measured ambient dose equivalent rate is less evident (Figure 4.4).

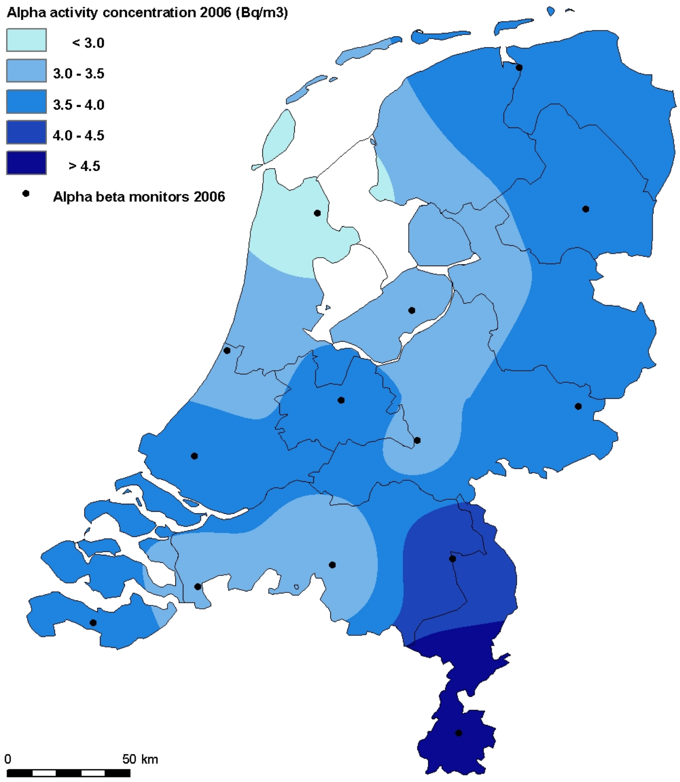


Figure 4.1: Spatial variation in the average gross α-activity concentration of (mainly) short-lived nuclides in air dust in 2006. The dots represent the locations of the aerosol monitors.

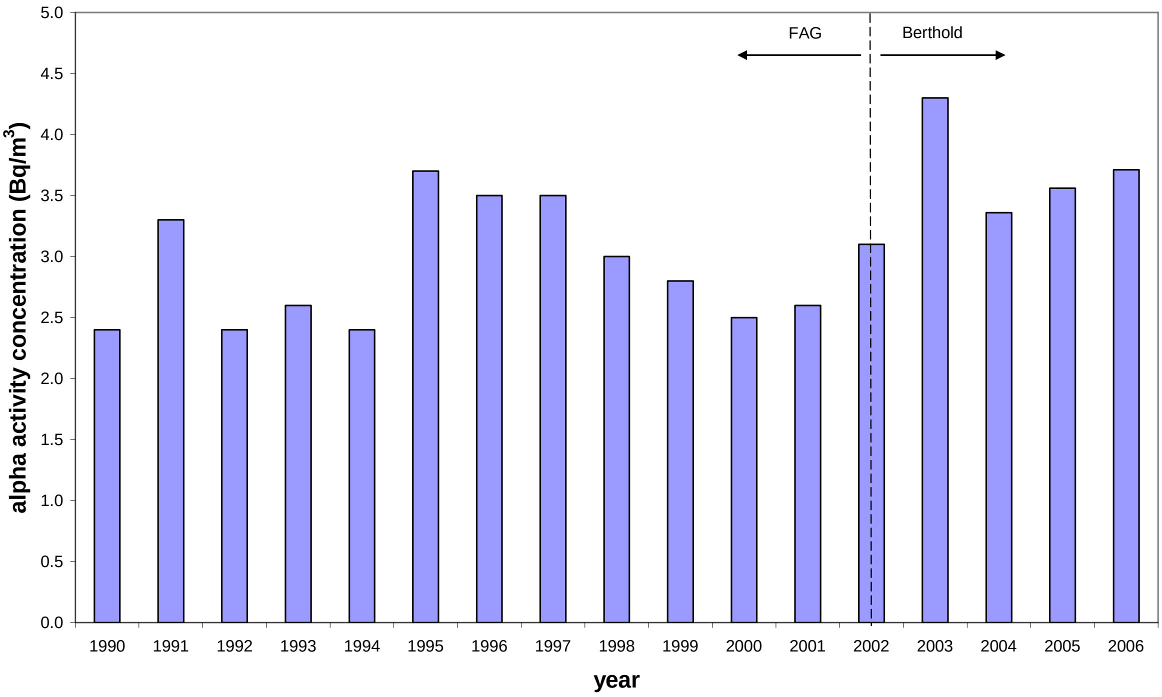


Figure 4.2: Yearly averaged gross α-activity concentration of (mainly) short-lived nuclides in air dust. During the second half of 2002 the FAG monitors were gradually replaced by the Berthold monitors. The Berthold monitor reports about 20% higher values than the FAG monitor. No correction is applied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

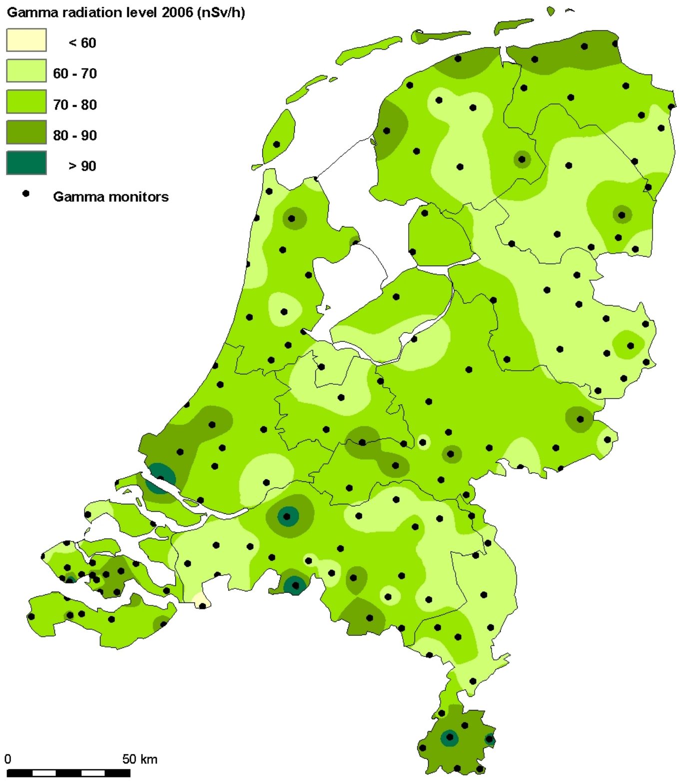


Figure 4.3: Spatial variation in the average ambient dose equivalent rate in 2006. The dots represent the locations of the dose equivalent rate monitors.

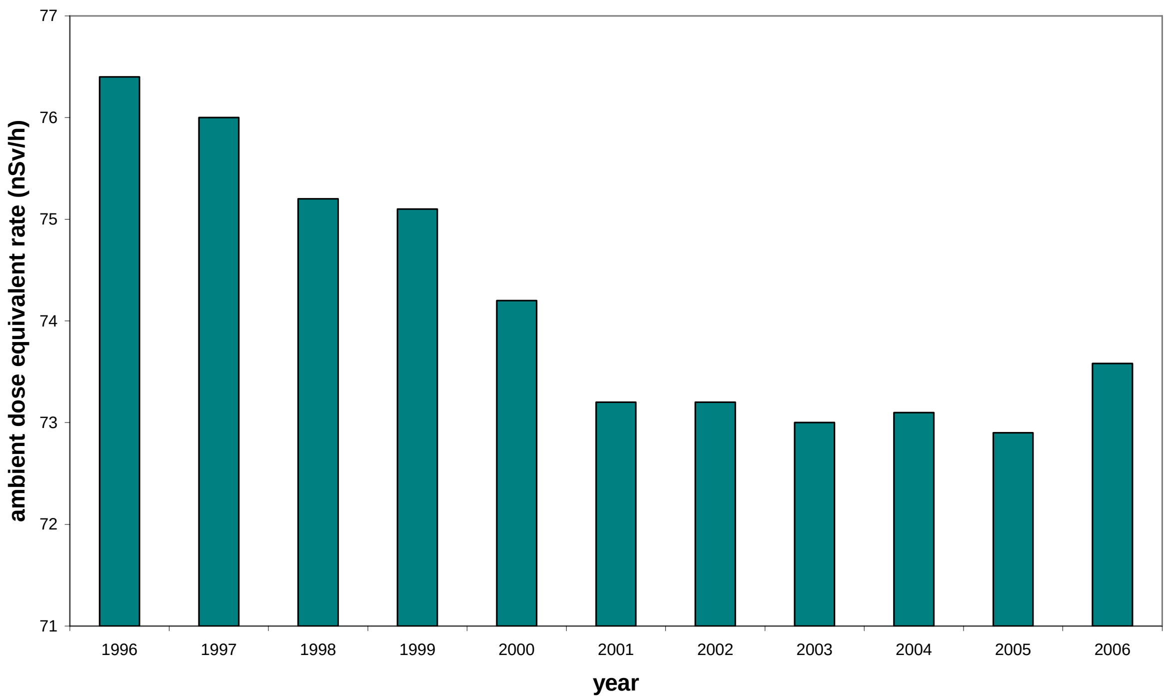


Figure 4.4: The yearly averaged ambient dose equivalent rate.

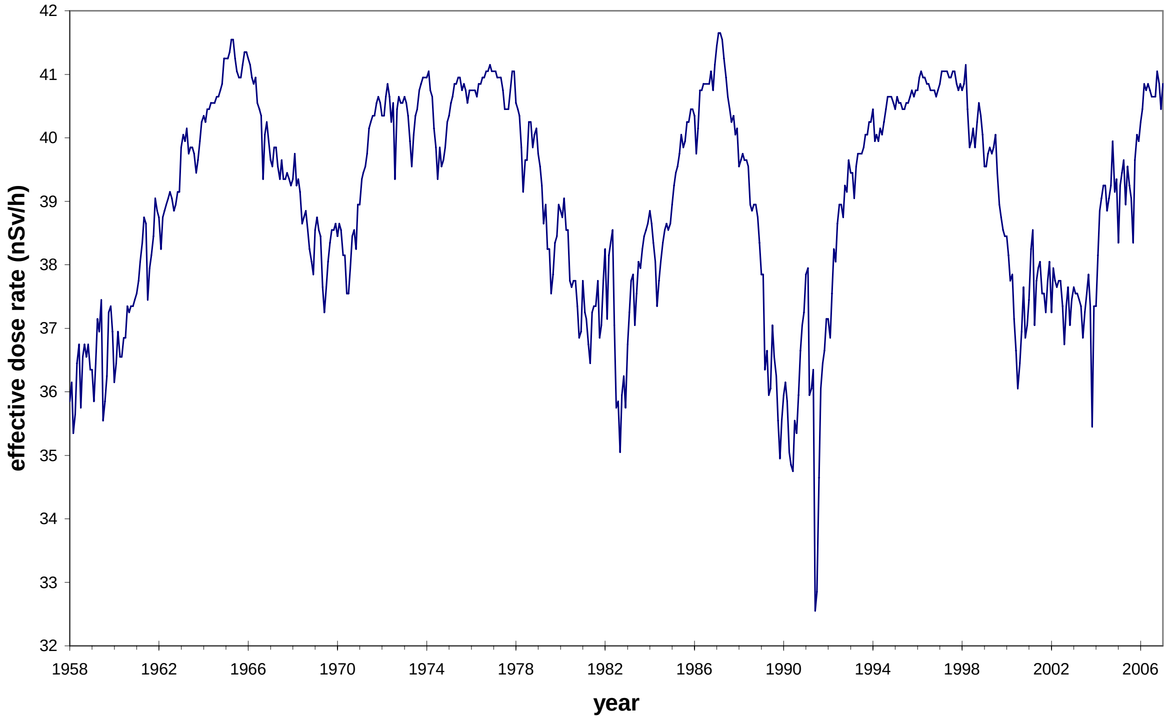


Figure 4.5: Cosmogenic contribution to the effective dose rate (at sea level), influenced by the solar cycle. Location 51° 26' north latitude and 3° 43' eastern longitude (in the south-west of the Netherlands), air pressure 1019 hPa. Figure derived from data supplied by Federal Aviation Administration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

5 Surface water and seawater

5.1 Introduction

The 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 [39, 40, 41].

The locations presented in this report have been chosen to represent the major inland waters and seawater. The 2006 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 2006.

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

To be continued on the next page

Table 5.1: Continued.

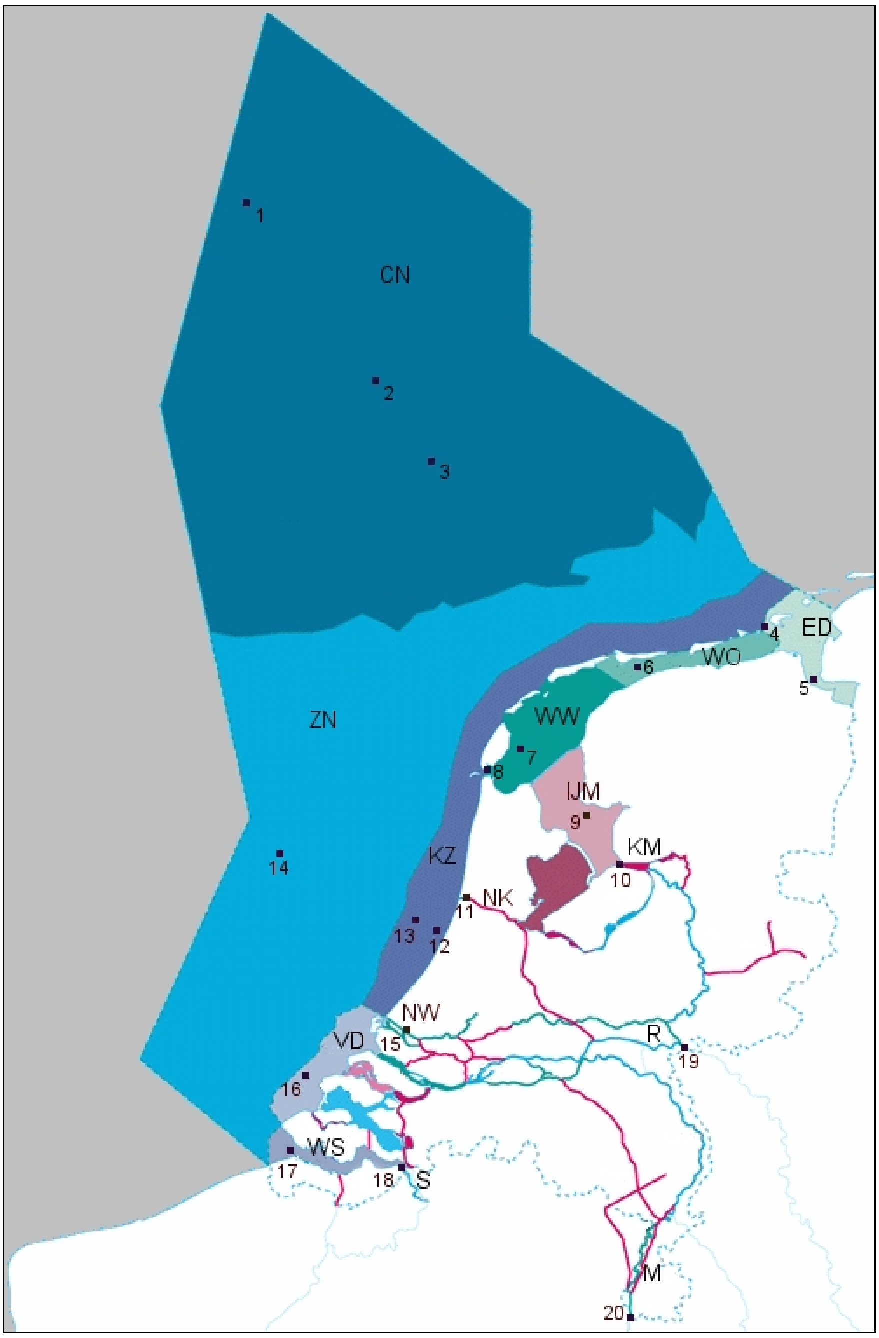
Location	Parameter	Compartment	Monitoring frequency (per year)
Rhine	Gross α	Water	13
(Lobith)	Residual β	Water	13
	^{3}H	Water	13
	^{90}Sr	Water	7
	^{226}Ra	Water	7
	^{60}Co	Suspended solids	13
	^{131}I	Suspended solids	13
	^{137}Cs	Suspended solids	12
	^{210}Pb	Suspended solids	7
Scheldt	Gross α	Water	13
(Schaar van Ouden Doel)	Residual β	Water	13
	^{3}H	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
Meuse	Gross α	Water	13
(Eijsden)	Residual β	Water	13
	^{3}H	Water	13
	^{90}Sr	Water	7
	^{226}Ra	Water	7
	^{60}Co	Suspended solids	51
	^{131}I	Suspended solids	52
	^{137}Cs	Suspended solids	52
	^{210}Pb	Suspended solids	7

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

Table 5.2: Monitoring program for the determination of radioactive nuclides in seawater in 2006.

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	3 (2)
		^{210}Po	Suspended solids	3 (2)
Southern North Sea (ZN)	Noordwijk 70 (1)	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{90}Sr	Water	4
Central North Sea (CN)	Terschelling 235 (1)	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{90}Sr	Water	4
Delta Coastal Waters (VD)	Schouwen 10 (1)	Gross α	Water	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 (3) (WW)	Marsdiep Noord	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
Wadden Sea East (WO)	Dantziggat	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{137}Cs	Suspended solids	4
		^{210}Po	Suspended solids	4

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



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

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

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

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 [40]. Doove Balg West was the monitoring location for radionuclides in suspended solids for the Wadden Sea West during 1996-2005.

5.2 The results for surface water

The general monitoring strategy for surface water is to monitor the inland and border crossing waters of the Netherlands. Therefore the locations mentioned in Table 5.1 are used for monitoring as they represent the major inland, incoming and outgoing waters of the Netherlands. The results for surface water are presented in Tables A11 and A12 and in Figures 5.2 to 5.19.

Gross α and residual β are indicative parameters. The yearly averaged activity concentrations of gross α and residual β in 2006 are within the range of those in previous years.
The gross α-activity concentration in the Noordzeekanaal, Nieuwe Waterweg, Rhine and Scheldt exceeds the target value (100 $mBq \cdot L^{-1}$) in 7 out of 7, 9 out of 13, 1 out of 13 and 13 out of 13 samples taken, respectively. In 2006 the yearly averaged gross α-activity concentration in the Noordzeekanaal, Nieuwe Waterweg and Scheldt (220, 133 and 350 $mBq \cdot L^{-1}$, 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 [40]. Therefore, no change in trend is shown for the IJsselmeer, Rhine and Meuse.

The ^{3}H-activity concentration in the Scheldt and Meuse exceeds the target value (10 $Bq \cdot L^{-1}$) in 3 out of 6 and 8 out of 13 samples taken, respectively. The elevated levels of ^{3}H in the Meuse (Figure 5.6) could originate from the nuclear power plants at Tihange (Belgium) or Chooz (France). The elevated levels of ^{3}H in the Scheldt could originate from the nuclear power plant at Doel (Belgium). The yearly averaged ^{3}H-activity concentrations in 2006 are within the range of those in previous years. In 2006 the yearly averaged ^{3}H-activity concentration in the Scheldt and Meuse (11.9 and 15.0 $Bq \cdot L^{-1}$, respectively) are above the target value of 10 $Bq \cdot L^{-1}$.

The nuclide ^{90}Sr is released into the environment by nuclear power plants and nuclear reprocessing plants. The yearly averaged ^{90}Sr-activity concentrations in 2006 are within the range of those in previous years. The yearly averaged ^{90}Sr-activity concentrations are below the target value of 10 $mBq \cdot L^{-1}$.

The nuclide ^{226}Ra is released into the environment by the ore processing industry.
The ^{226}Ra-activity concentration in the Nieuwe Waterweg and Scheldt exceeds the target value (5 $mBq \cdot L^{-1}$) in 1 out of 6 and 6 out of 6 samples taken, respectively. The yearly averaged ^{226}Ra-activity concentrations in 2006 are within the range of those in previous years. In 2006 the yearly averaged ^{226}Ra-activity concentration in the Scheldt (11.2 $mBq \cdot L^{-1}$) is above the target value of 5 $mBq \cdot L^{-1}$.

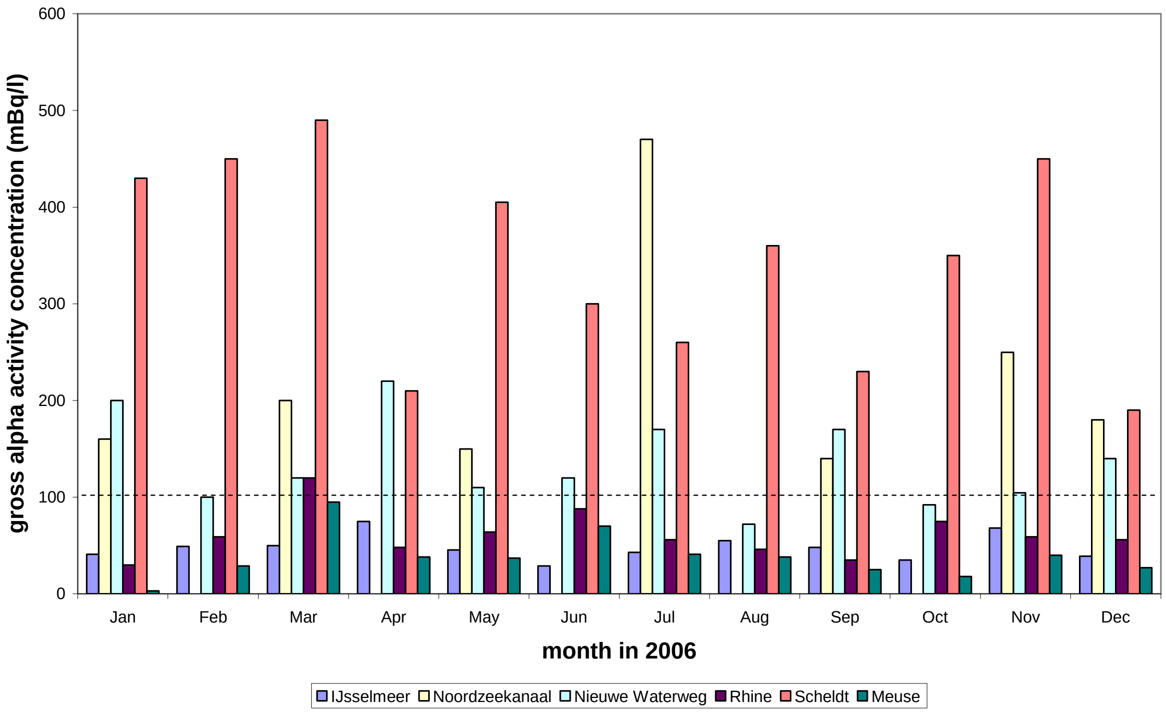


Figure 5.2: The gross α-activity concentration in 2006 for the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 48, 220, 133, 60, 350 and 38 mBq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 100 mBq·L^{-1} [43].

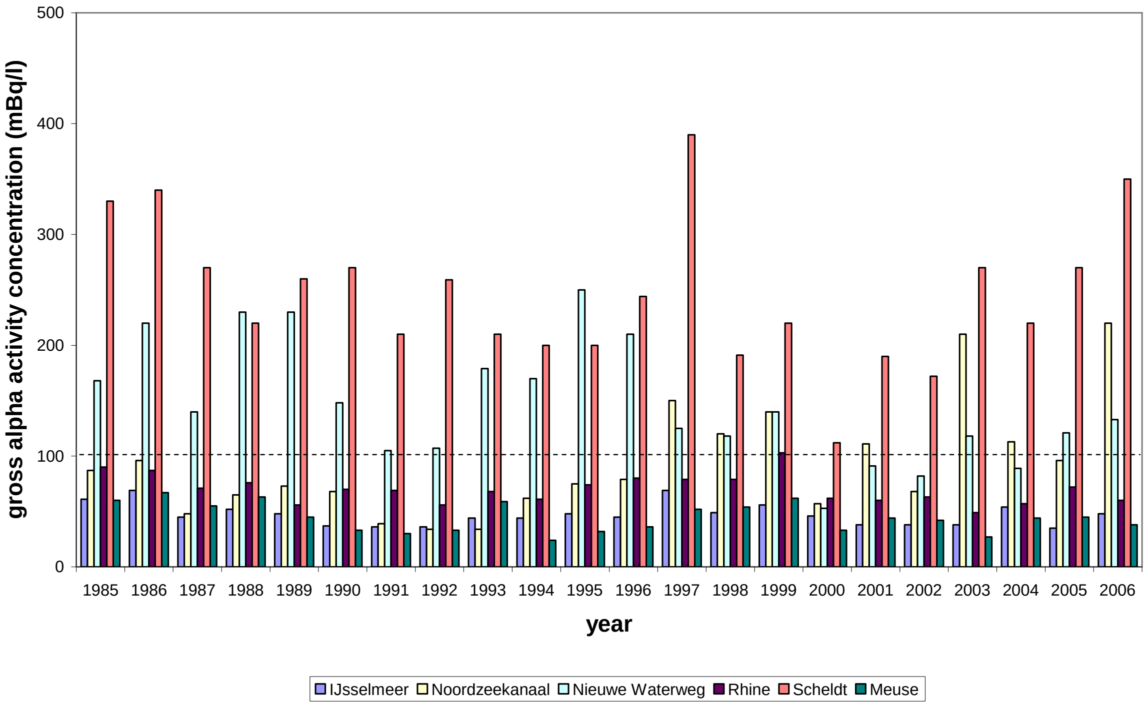


Figure 5.3: Yearly averaged gross α-activity concentrations.

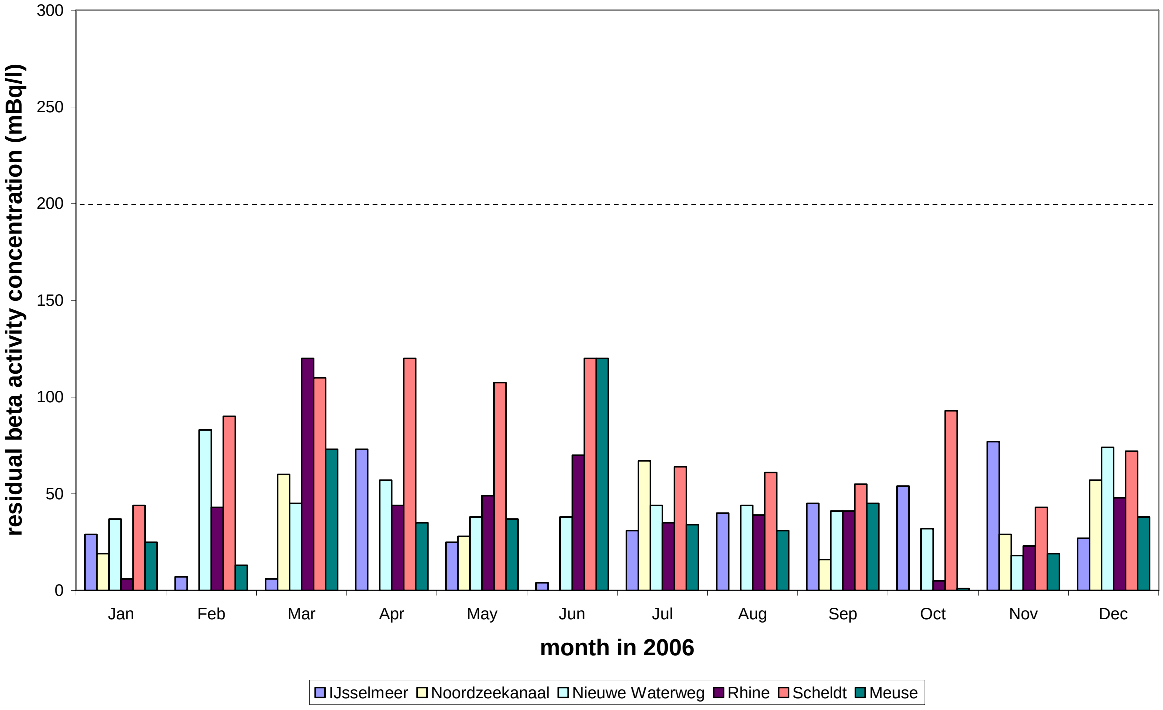


Figure 5.4: The residual β-activity concentration in 2006 for the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 34, 39, 44, 43, 84 and 39 mBq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 200 mBq·L^{-1} [43].

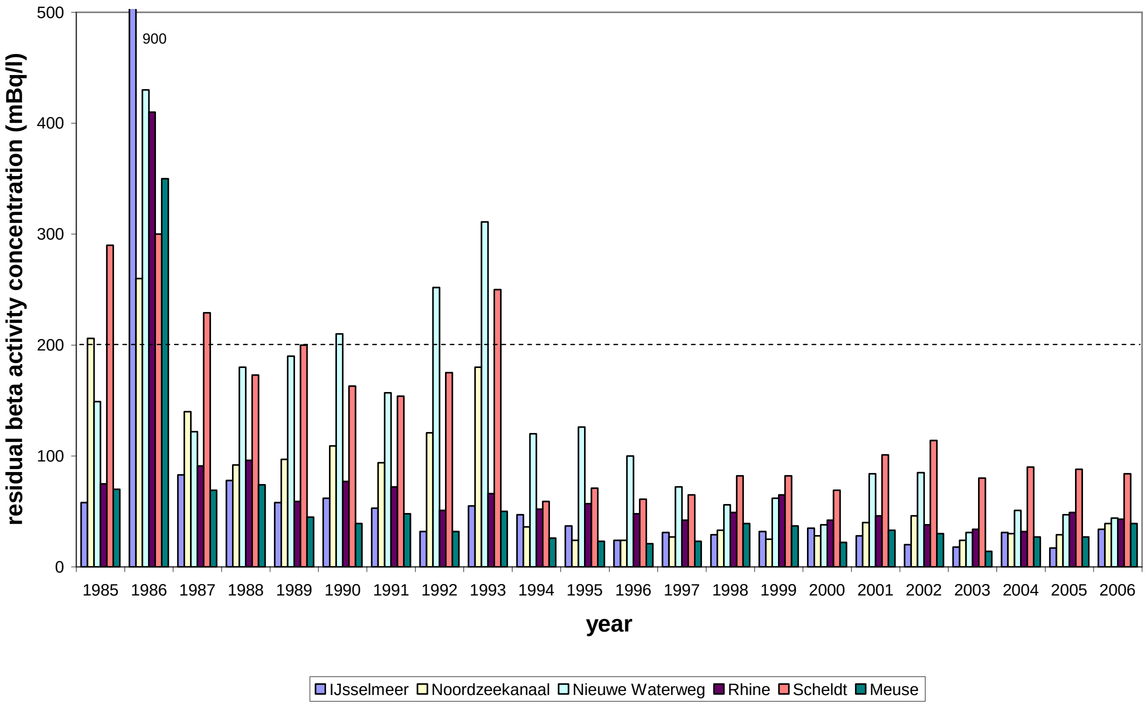


Figure 5.5: Yearly averaged residual β-activity concentrations.

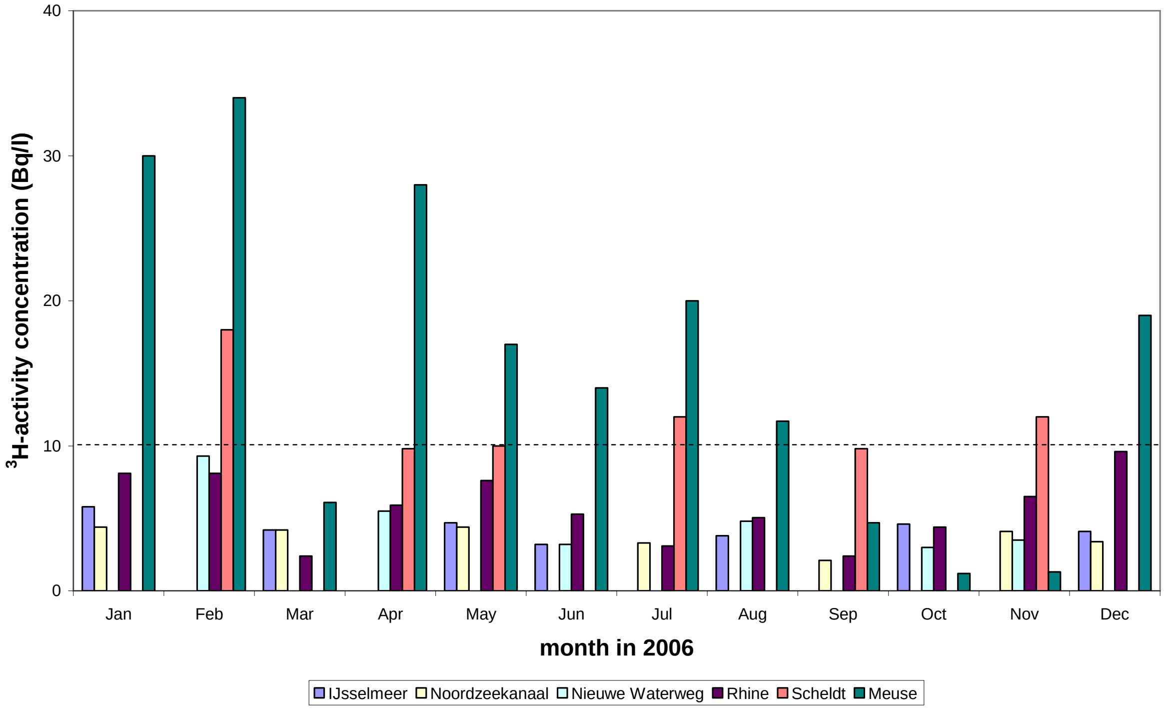


Figure 5.6: The ^{3}H-activity concentration in 2006 for the IJsselmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 4.3, 3.7, 4.9, 5.7, 11.9 and 15.0 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 10 Bq·L^{-1} [43].

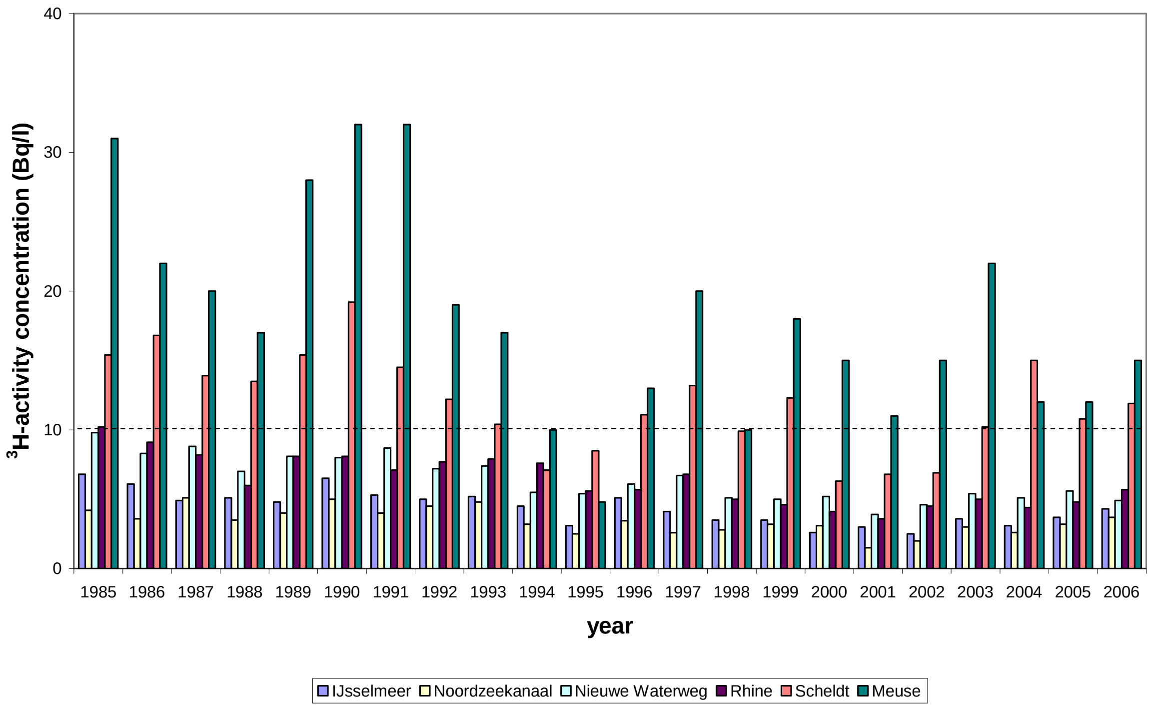


Figure 5.7: Yearly averaged ^{3}H-activity concentrations.

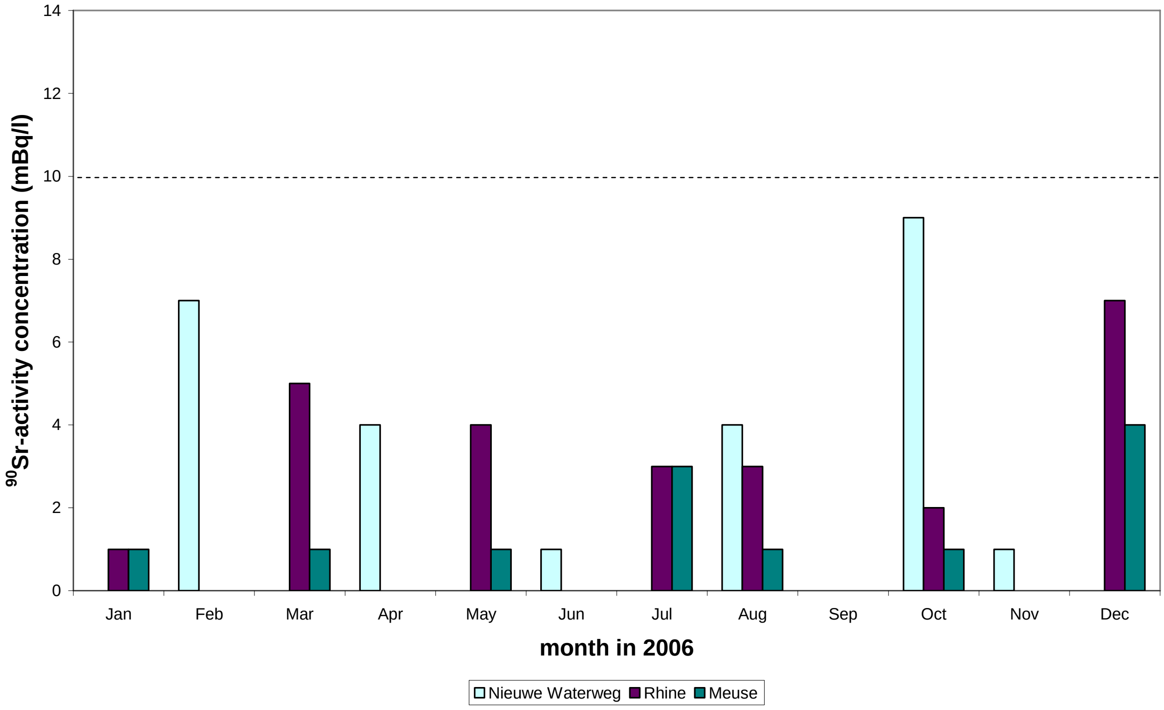


Figure 5.8: The ^{90}Sr-activity concentration in 2006 for the Nieuwe Waterweg, Rhine and Meuse, with yearly averages of 4.2, 3.5 and 1.5 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 10 mBq·L^{-1} [43].

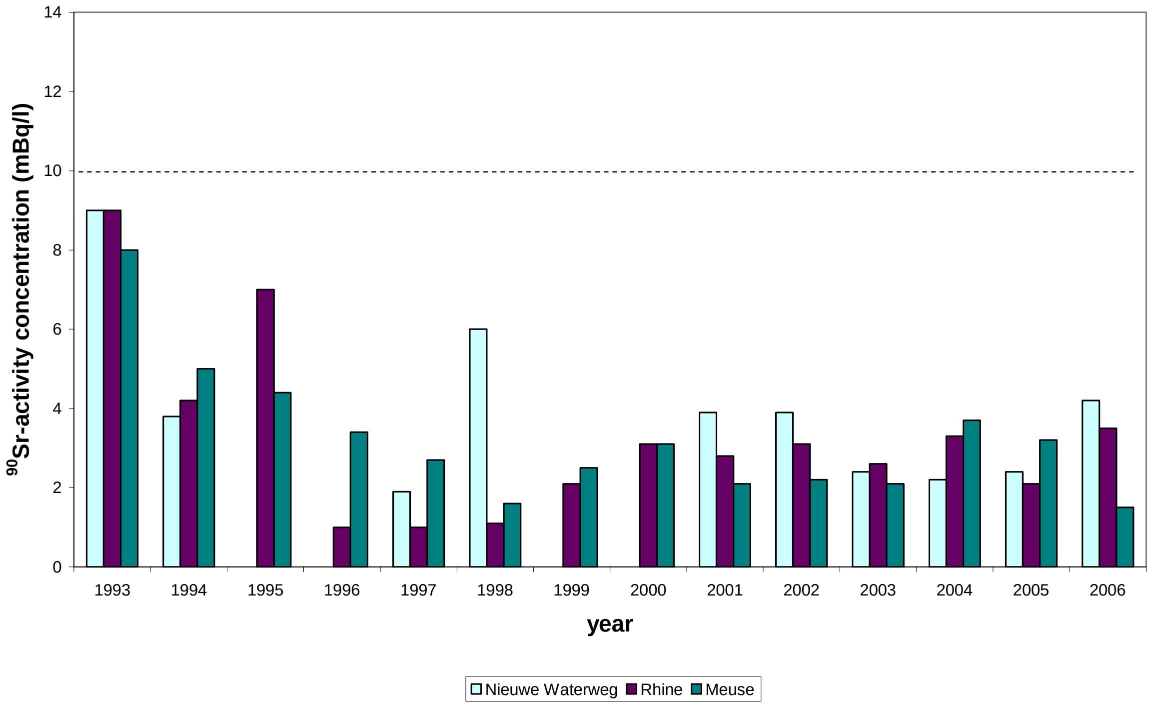


Figure 5.9: Yearly averaged ^{90}Sr-activity concentrations. Data is not available for the Nieuwe Waterweg in 1995, 1996, 1999 and 2000.

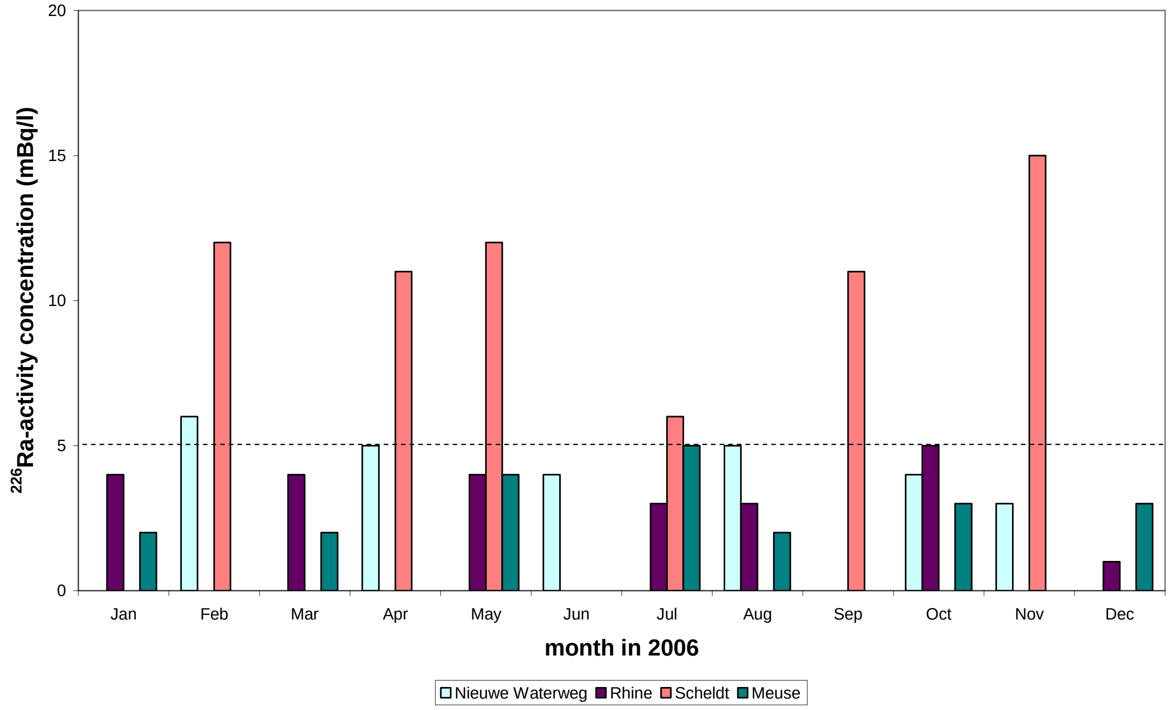


Figure 5.10: The ^{226}Ra-activity concentration in 2006 for the Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 4.5, 3.4, 11.2 and 3.0 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 5 mBq·L^{-1} [43].

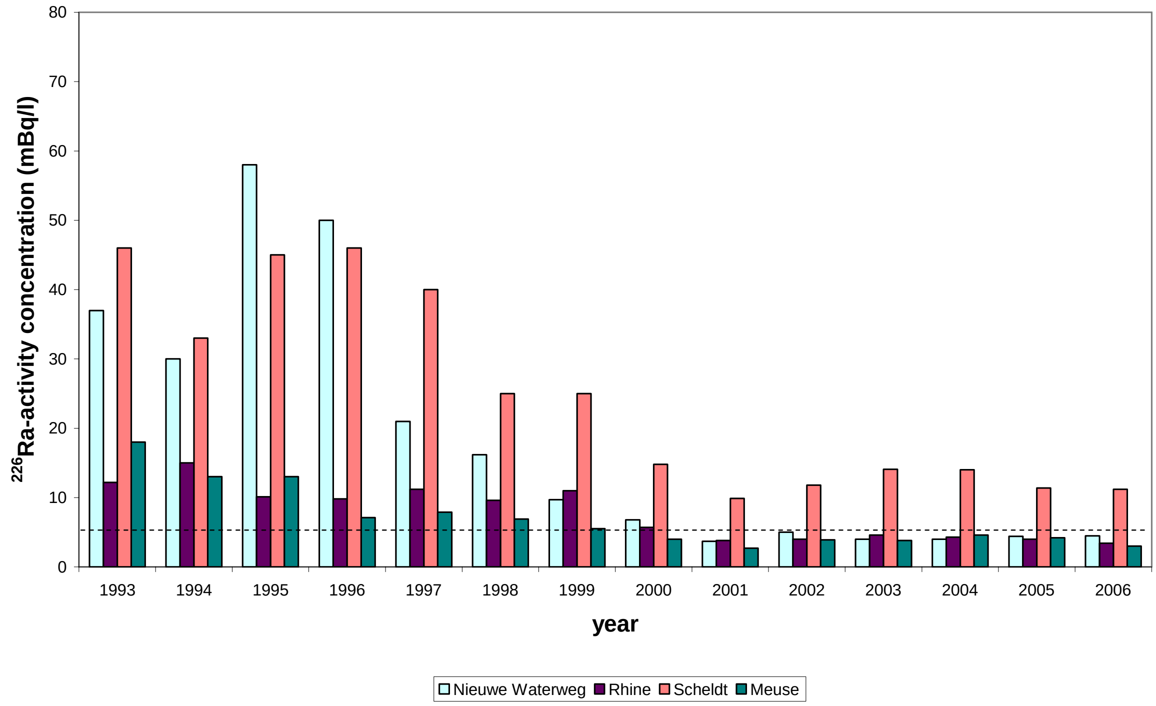


Figure 5.11: Yearly averaged ^{226}Ra-activity concentrations.

The nuclide ^{60}Co is a known corrosion product of nuclear power plants. The ^{60}Co-activity concentration in the Meuse exceeds the target value (10 Bq·kg^{-1}) in 26 out of 51 samples taken. In 2006 the yearly averaged ^{60}Co-activity concentration in the Meuse (18 Bq·kg^{-1}) is above the target value of 10 Bq·kg^{-1}, but within range of those in previous years.

The nuclide ^{131}I is released into the environment by medical facilities. The ^{131}I-activity concentration in the Noordzeekanaal and Meuse exceeds the target value (20 Bq·kg^{-1}) in 2 out of 6 and 33 out of 52 samples taken, respectively. In 2006 the yearly averaged ^{131}I-activity concentration in the Meuse (36 Bq·kg^{-1}) is above the target value of 20 Bq·kg^{-1}, but within range of those in previous years.

The yearly averaged concentrations of ^{137}Cs in 2006 are within the range of those in previous years. The ^{137}Cs-activity concentration in the Meuse exceeds the target value (40 Bq·kg^{-1}) in 4 out of 52 samples taken. 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 (Figure 5.17). This indicates an extra contribution besides the one currently originating from the Rhine, which can be explained by the following. The Ketelmeer serves as a sink for Rhine sediment and thus contains a large amount of sediment deposited in previous years. A considerable amount of sediment, containing ^{137}Cs originating from the Chernobyl accident, resuspends in the relatively shallow Ketelmeer due to wind influences [44].

In suspended solids ^{210}Po is 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 released by the phosphate processing industry. The ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine, Scheldt and Meuse exceeds the target value (100 Bq·kg^{-1}) in 4 out of 6, 5 out of 7, 2 out of 6 and 7 out of 7 samples taken, respectively. In 2006 the yearly averaged ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine, Scheldt and Meuse (109, 117, 102 and 141 Bq·kg^{-1}, respectively) are above the target value of 100 Bq·kg^{-1}, but within range of those in previous years.

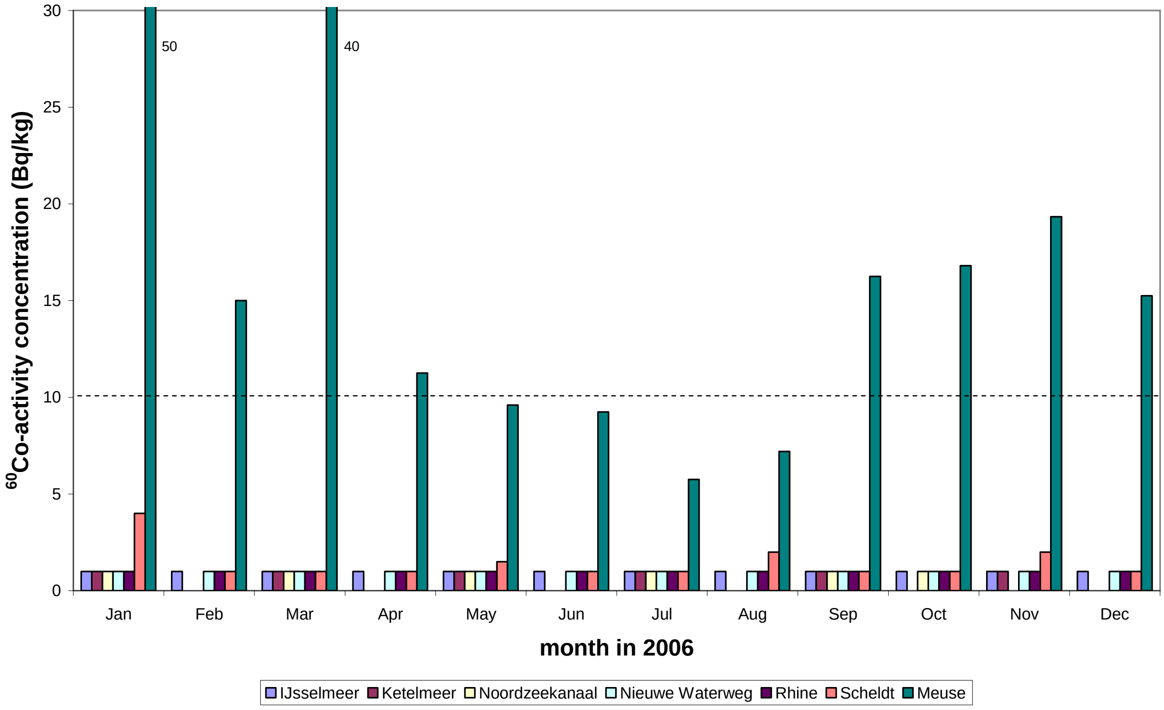


Figure 5.12: The ^{60}Co-activity concentration in suspended solids in 2006 for the IJsselmeer, Ketelmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse. The yearly averages of all except for the Meuse (18 Bq·kg^{-1}) and Scheldt (1.2 Bq·kg^{-1}) are < 1 Bq·kg^{-1}. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 10 Bq·kg^{-1} [43].

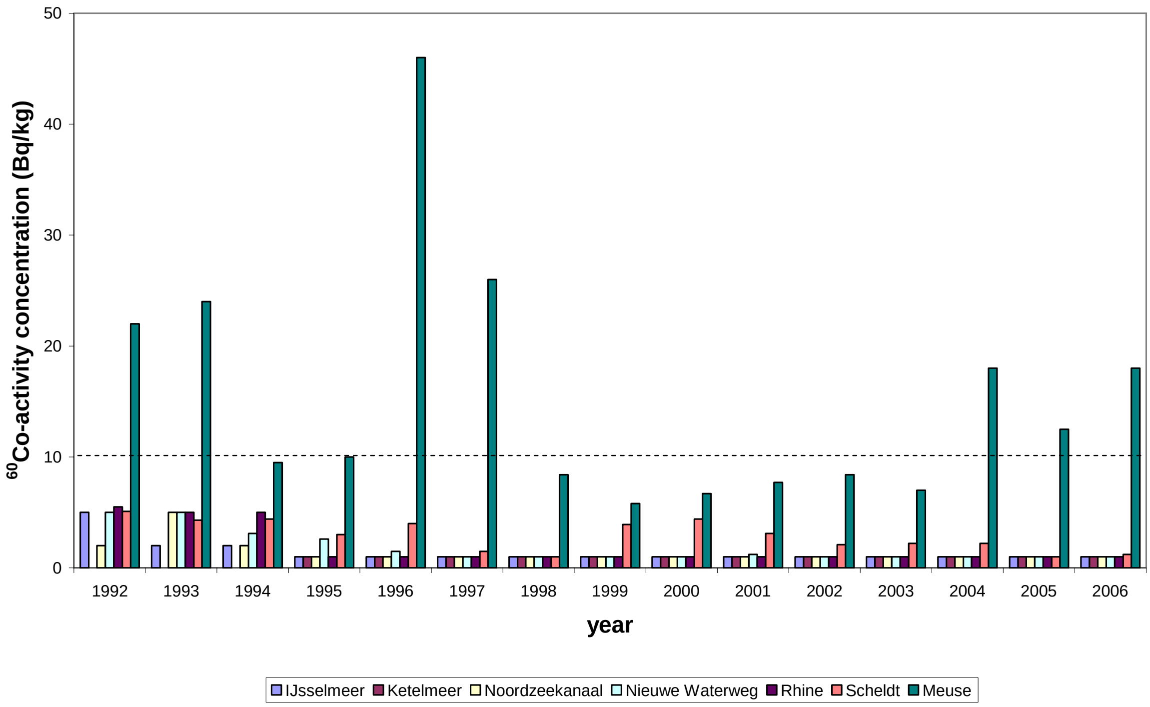


Figure 5.13: Yearly averaged ^{60}Co-activity concentrations in suspended solids. Data on Ketelmeer are available since 1995.

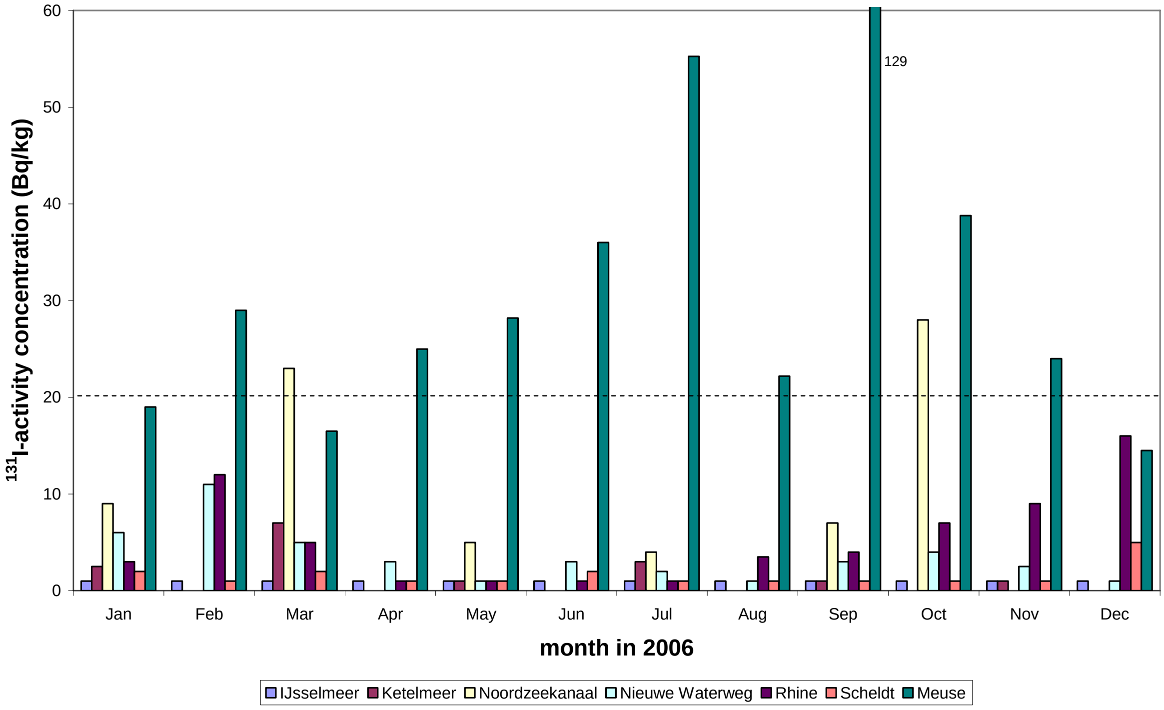


Figure 5.14: The ^{131}I-activity concentration in suspended solids in 2006 for the IJsselmeer, Ketelmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of < 1, < 2.3, 13, 3.3, 5.0, < 1.2, and 36 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 20 Bq·kg^{-1} [43].

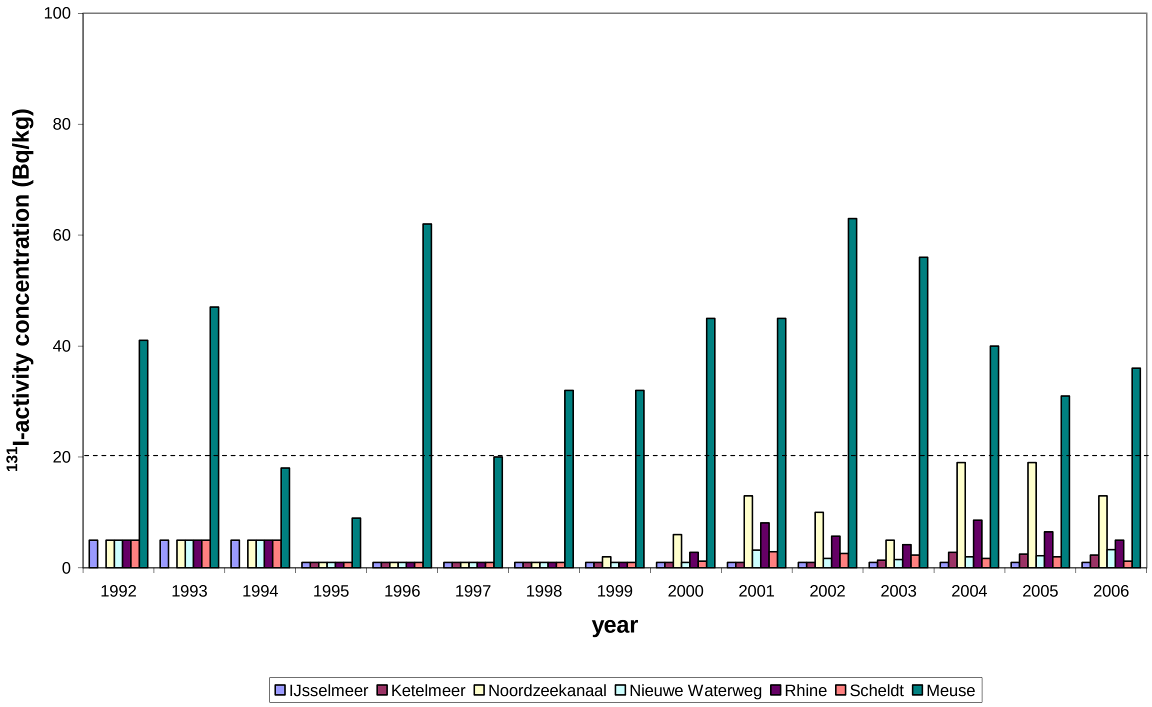


Figure 5.15: Yearly averaged ^{131}I-activity concentrations in suspended solids. Data on Ketelmeer are available since 1995.

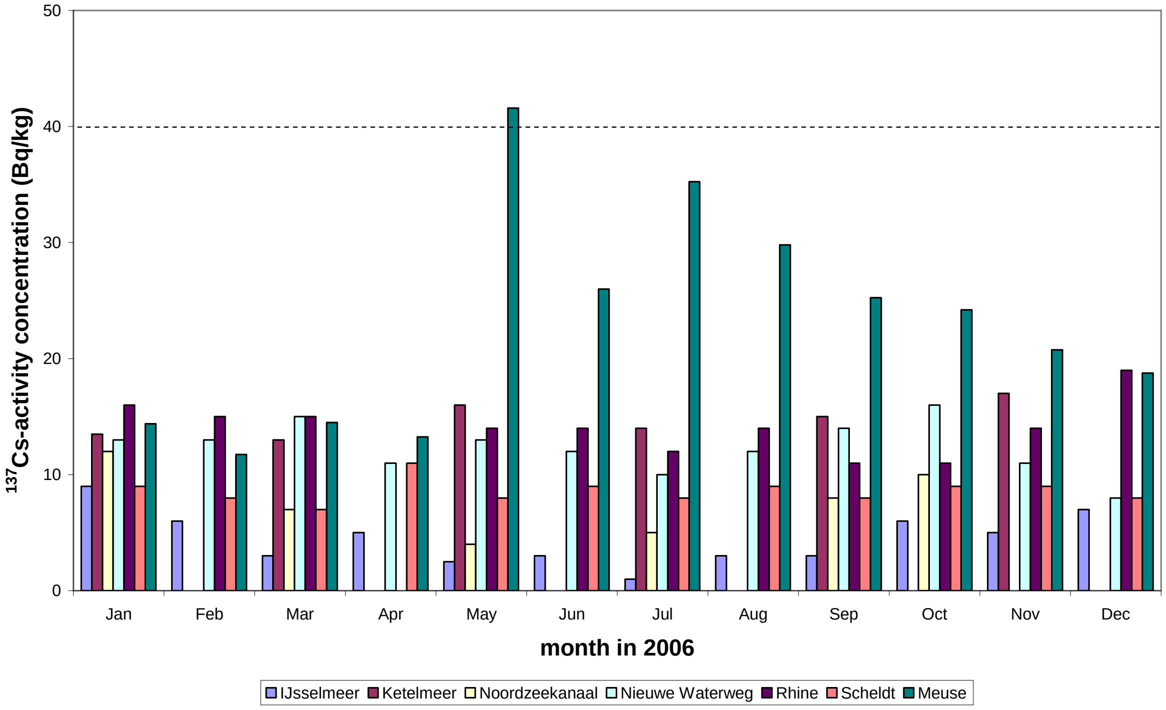


Figure 5.16: The ^{137}Cs-activity concentration in suspended solids in 2006 for the IJsselmeer, Ketelmeer, Noordzeekanaal, Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 4.2, 14.6, 7.7, 12.2, 14.1, 8.5, and 23.3 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 40 Bq·kg^{-1} [43].

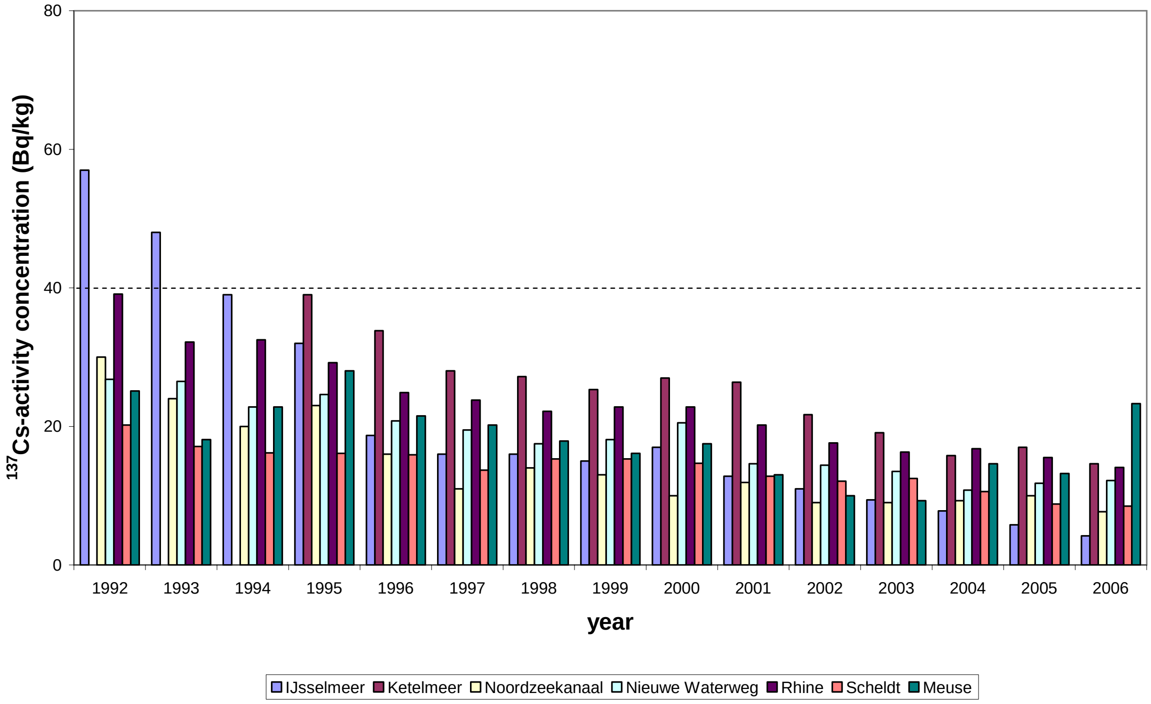


Figure 5.17: Yearly averaged ^{137}Cs-activity concentrations in suspended solids. Data on Ketelmeer are available since 1995.

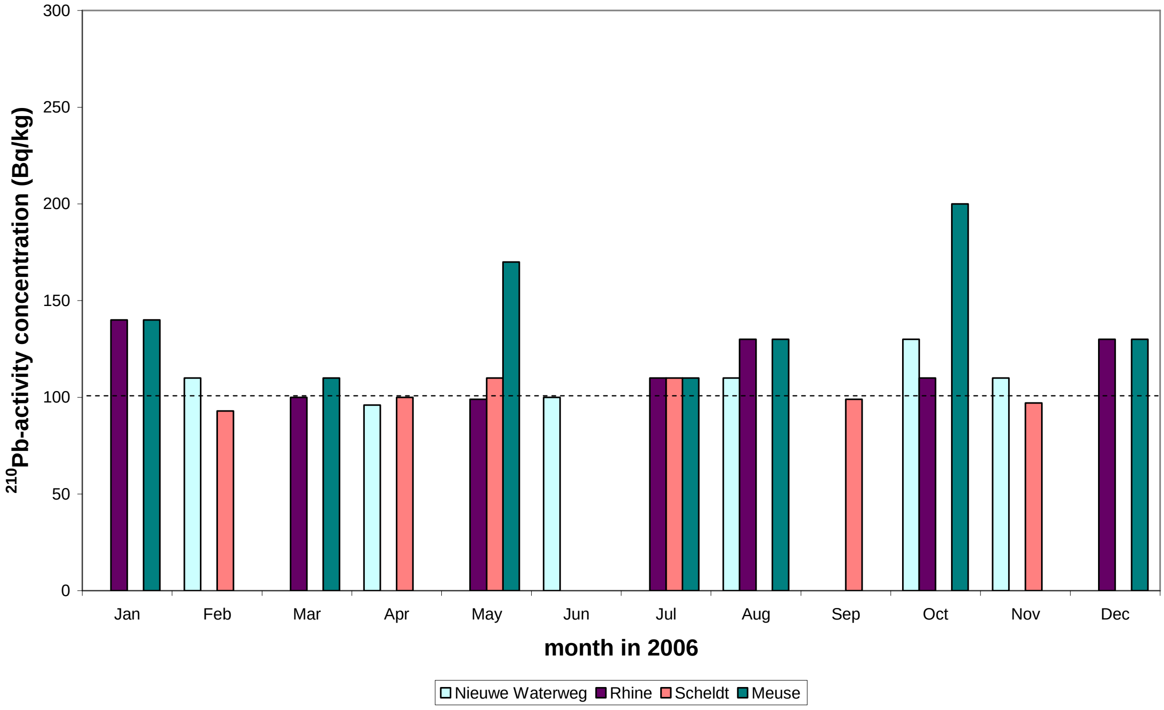


Figure 5.18: The ^{210}Pb-activity concentration in suspended solids in 2006 for the Nieuwe Waterweg, Rhine, Scheldt and Meuse, with yearly averages of 109, 117, 102, and 141 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value of 100 Bq·kg^{-1} [43].

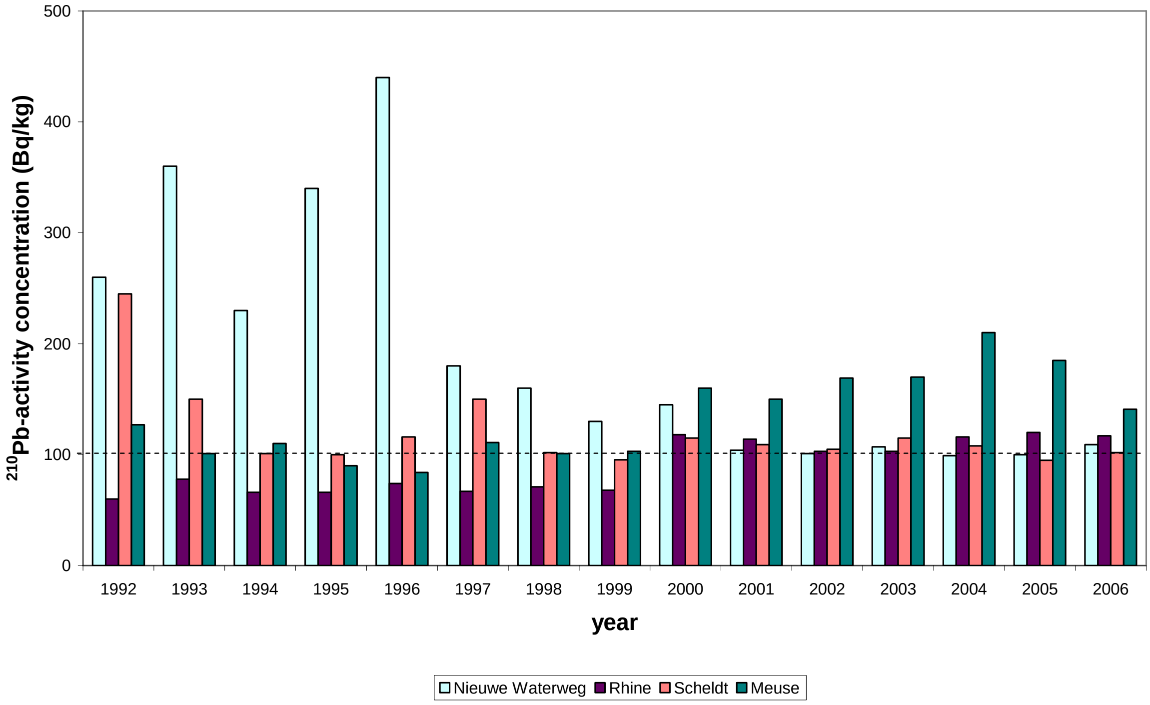


Figure 5.19: Yearly averaged ^{210}Pb-activity concentrations in suspended solids.

5.3 The results for seawater

The results for seawater are presented in Tables A13 and A14 and in Figures 5.20 to 5.31. Gross α and residual β are indicative parameters [40]. In the first half of 2000 the background of the measuring equipment was unstable and higher than usual, which resulted in lower results. Therefore yearly averaged concentrations of gross α in 2000 are based on data starting from the end of July 2000. Changes in the trend of gross α in the period 1985-1997 are explained elsewhere [40]. In some areas the yearly averaged gross α concentrations of 2006 are higher than those in previous years (Figure 5.21).

Residual β shows an apparent change in the trend since 1994 (Figure 5.23). This is caused by a change in measuring technique, which only applies to salt and brackish water [40]. The yearly averaged residual β concentrations in 2006 are within the range of those in the period 1994-2005.

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

In some areas the yearly averaged ^{3}H- concentrations in 2006 are higher than those in previous years (Figure 5.25). The yearly averaged ^{90}Sr-concentrations in 2006 are within the range of those in previous years (Figure 5.27).

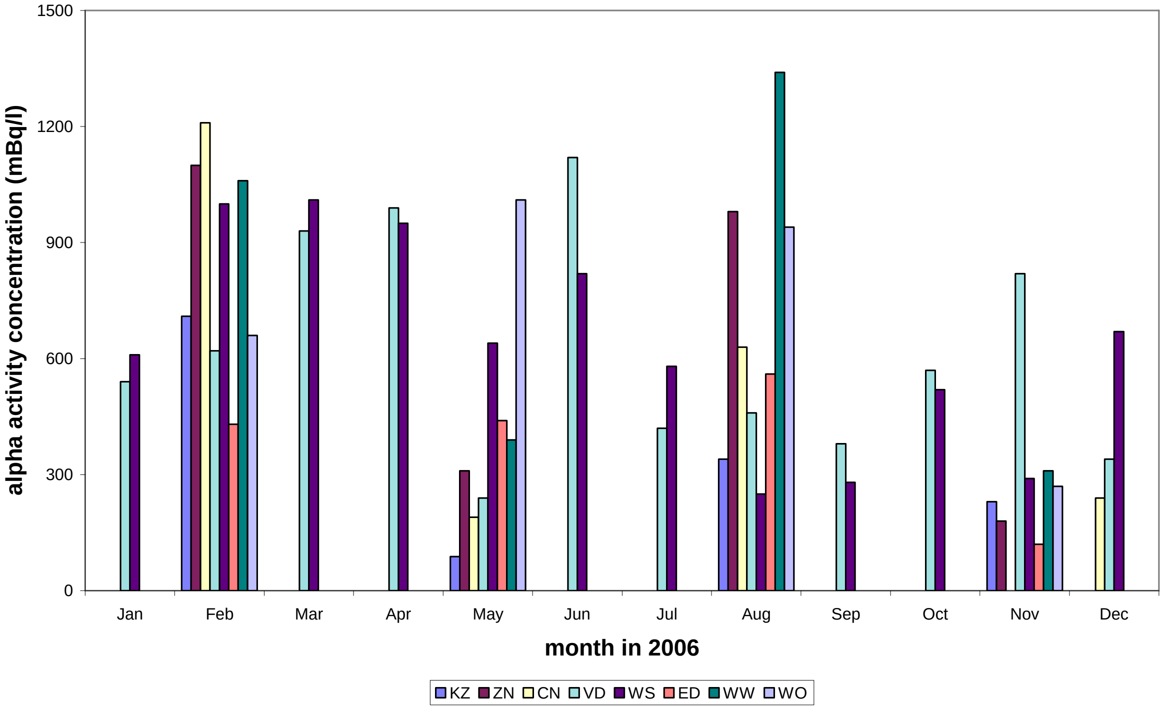


Figure 5.20: The gross α-activity concentration in seawater in 2006. The yearly averages for the Coastal area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Westerscheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO) are 340, 600, 600, 620, 640, 390, 800 and 720 mBq·L^{-1}, respectively.

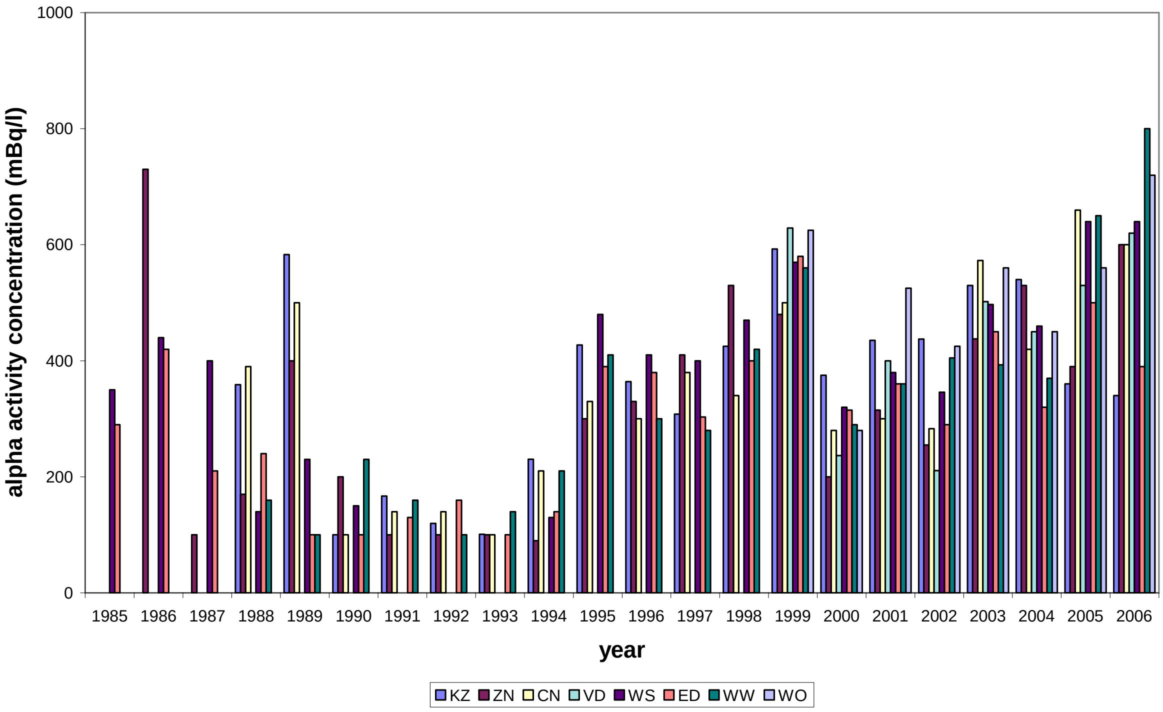


Figure 5.21: Yearly averaged gross α-activity concentrations.

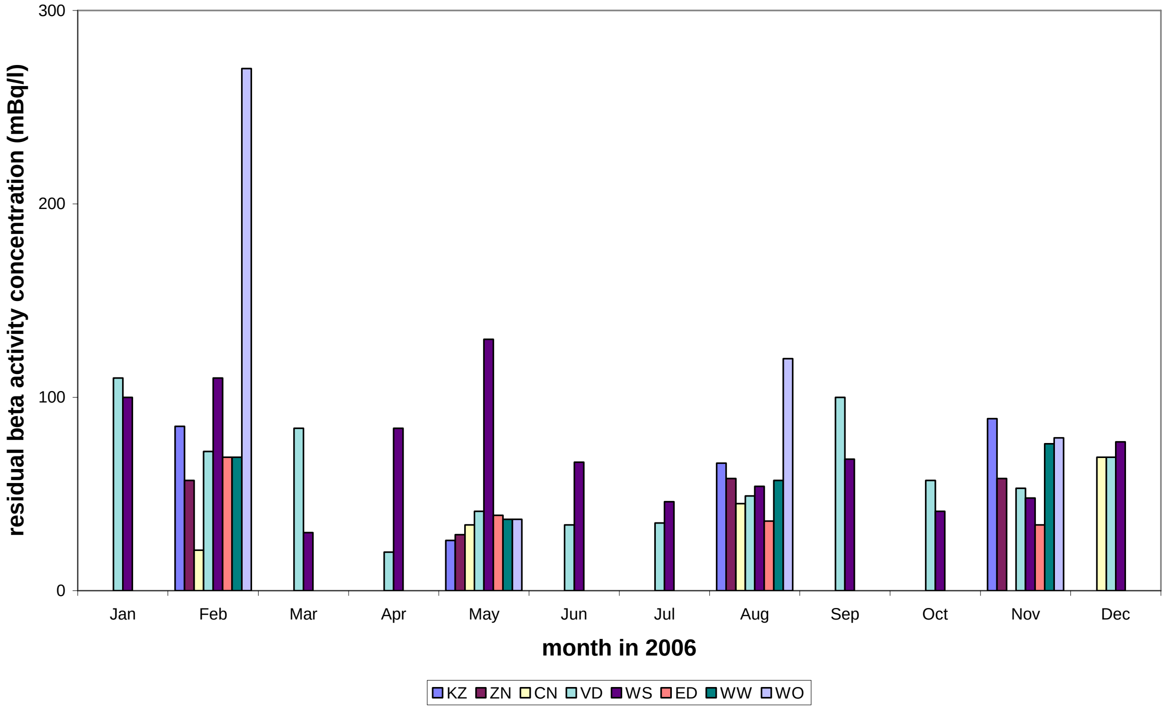


Figure 5.22: The residual β-activity concentration in seawater in 2006. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 66, 50, 42, 60, 71, 44, 60 and 130 mBq·L^{-1}, respectively.

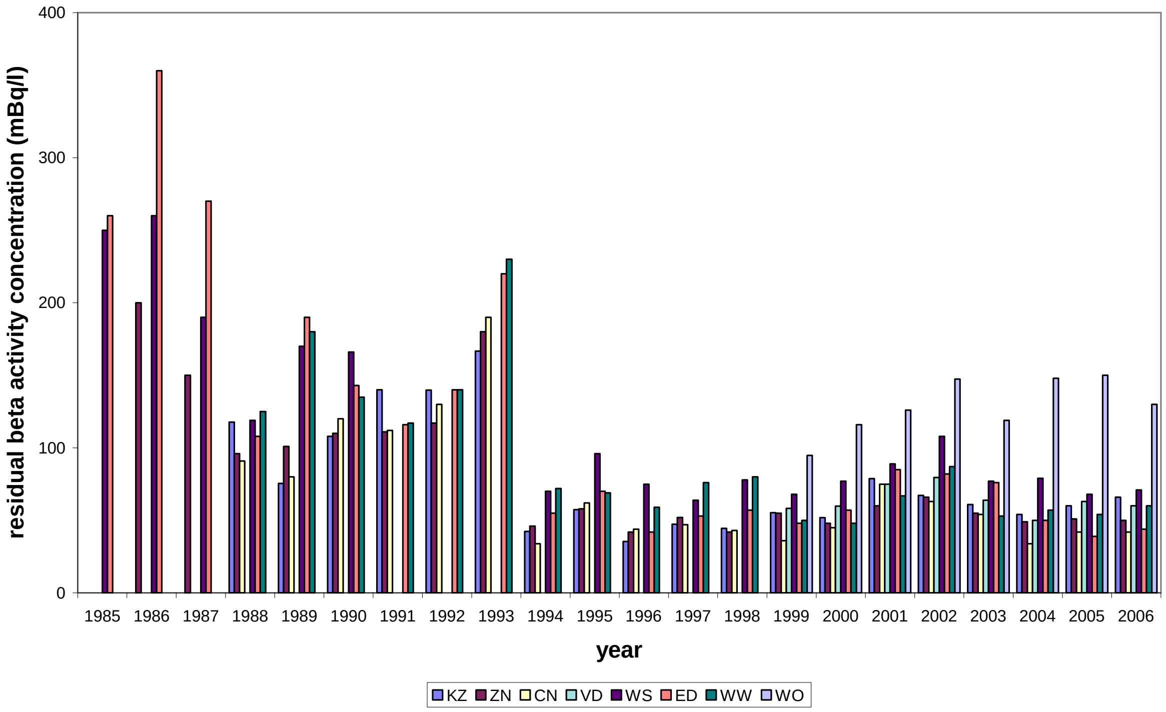


Figure 5.23: Yearly averaged residual β-activity concentrations.

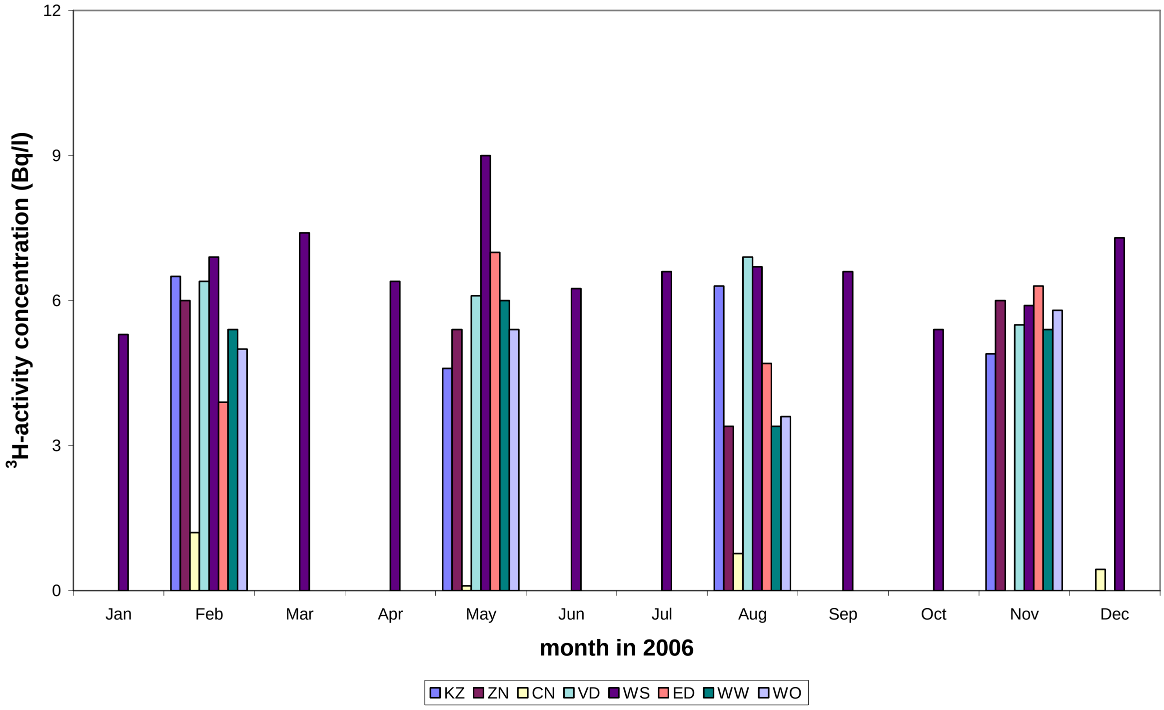


Figure 5.24: The ^{3}H-activity concentration in seawater in 2006. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 5.6, 5.2, 0.6, 6.2, 6.6, 5.5, 5.0 and 5.0 Bq·L^{-1}, respectively.

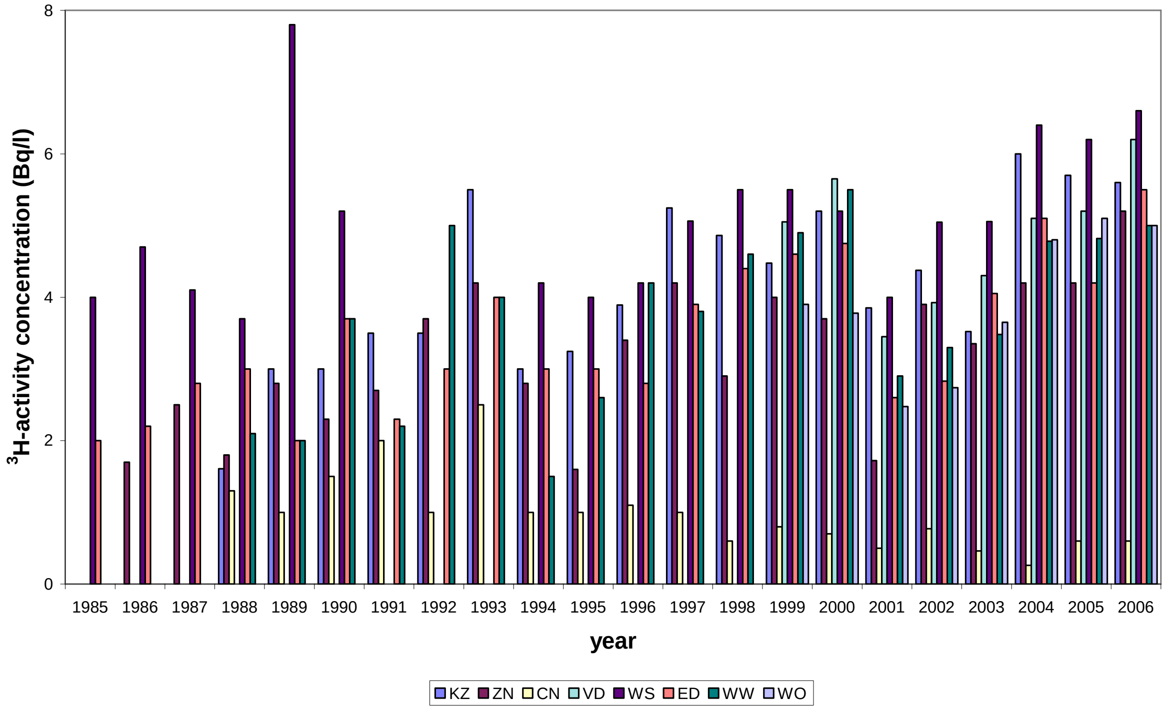


Figure 5.25: Yearly averaged ^{3}H-activity concentrations.

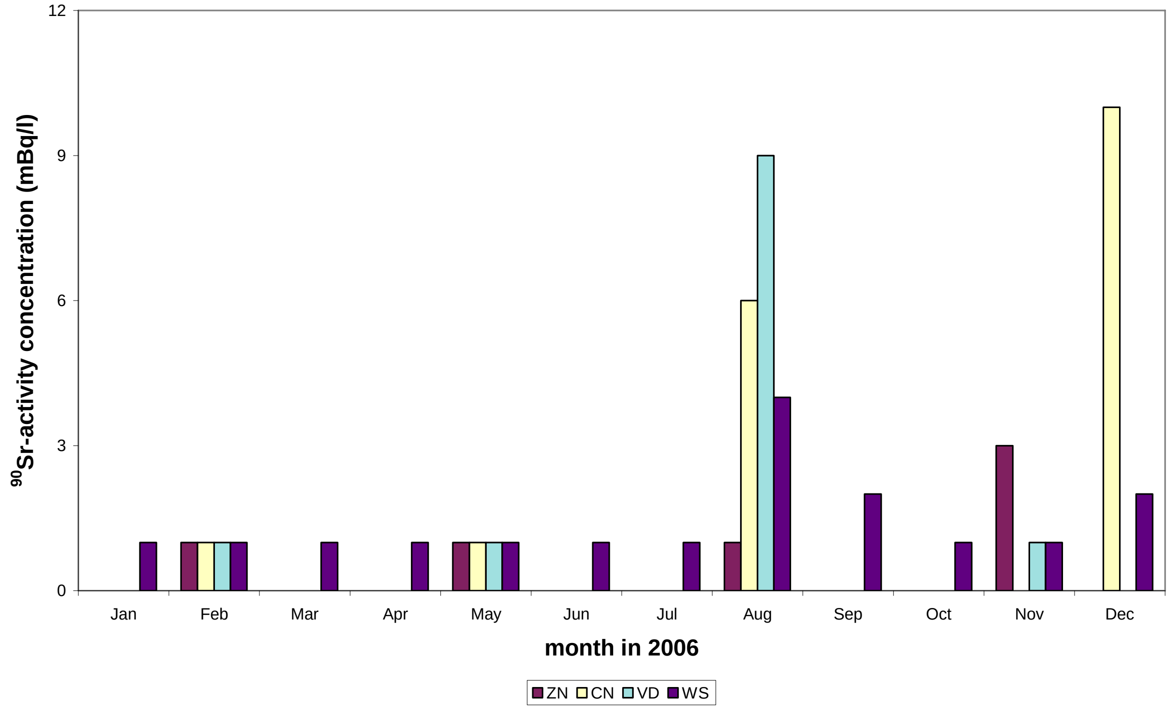


Figure 5.26: The ^{90}Sr-activity concentration in seawater in 2006. The yearly averages for the Southern North Sea, Central North Sea, Delta Coastal Waters and Westerscheldt are < 1.1, 4, < 3 and 1.2 mBq·L^{-1}, respectively.

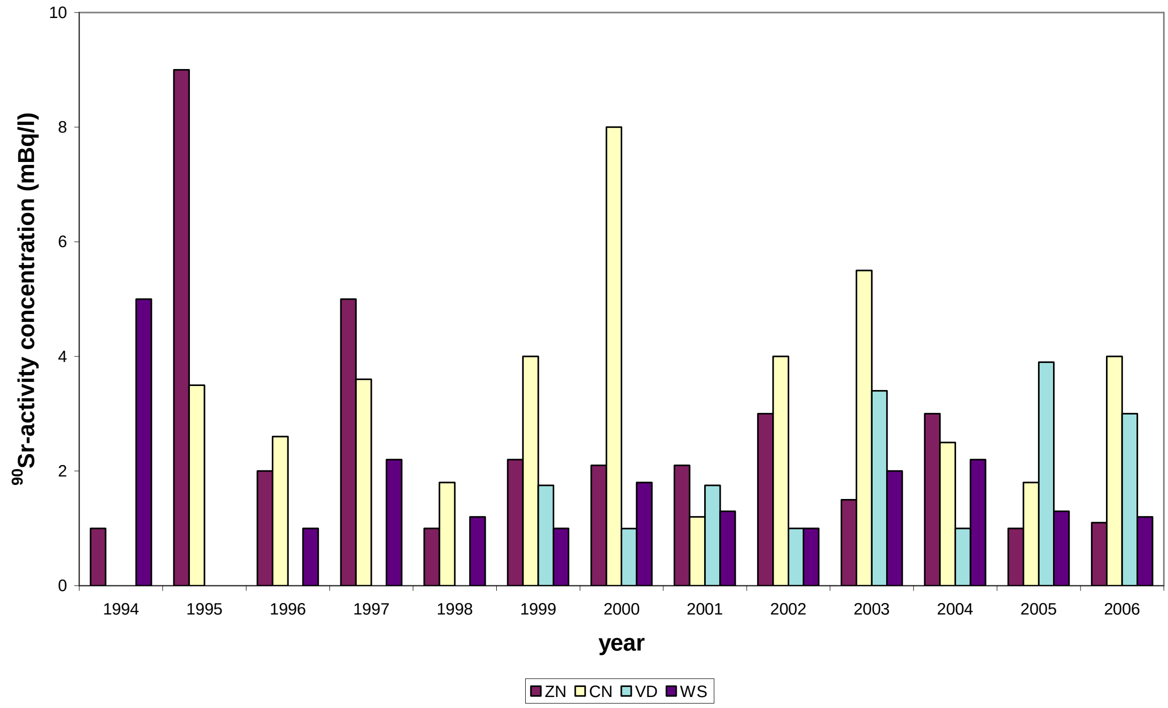


Figure 5.27: Yearly averaged ^{90}Sr-activity concentrations.

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

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

The yearly averaged concentrations of ^{210}Po in 2006 are within the range of those in previous years (Figure 5.31). In 2001 and 2003 data were not available for Wadden Sea West due to insufficient amount of collected suspended solids. Since 2006 ^{210}Po is not longer determined at Wadden Sea West due to repeatedly insufficient amount of collected suspended solids in previous years.

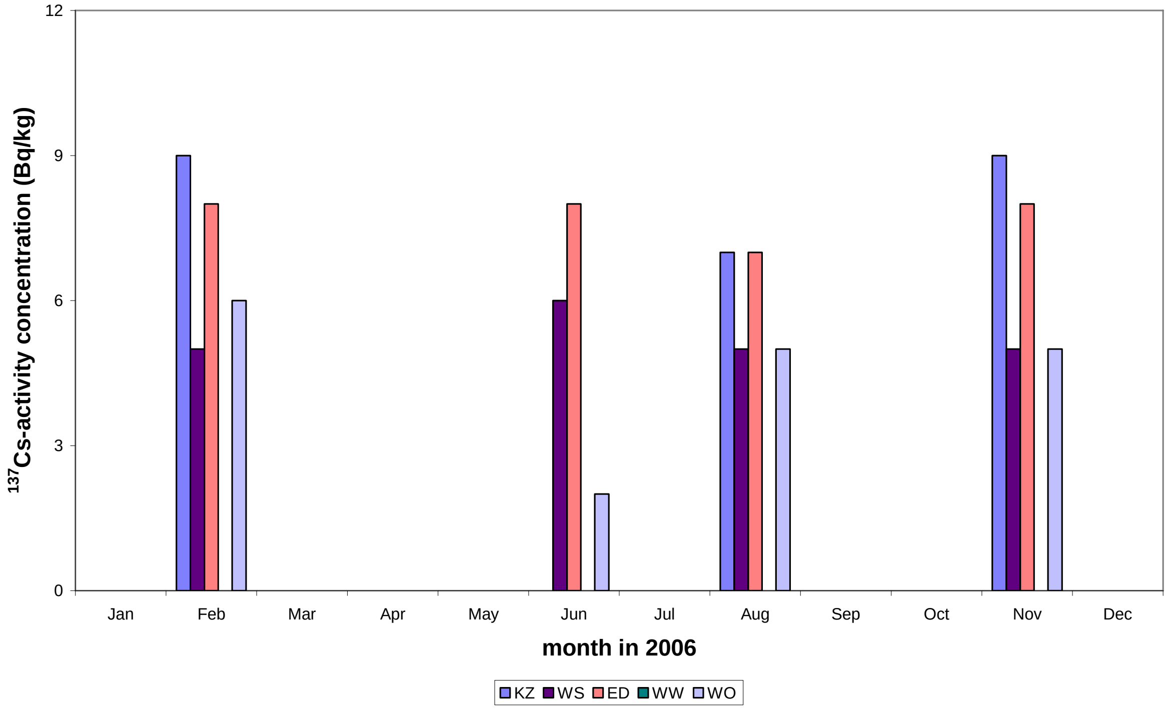


Figure 5.28: The ^{137}Cs-activity concentration in suspended solids in seawater in 2006. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard and Wadden Sea East are 8.3, 5.2, 7.8 and 4.5 Bq·kg^{-1}, respectively. Since 2006 ^{137}Cs is not longer determined at Wadden Sea West due to repeatedly insufficient amount of collected suspended solids in previous years.

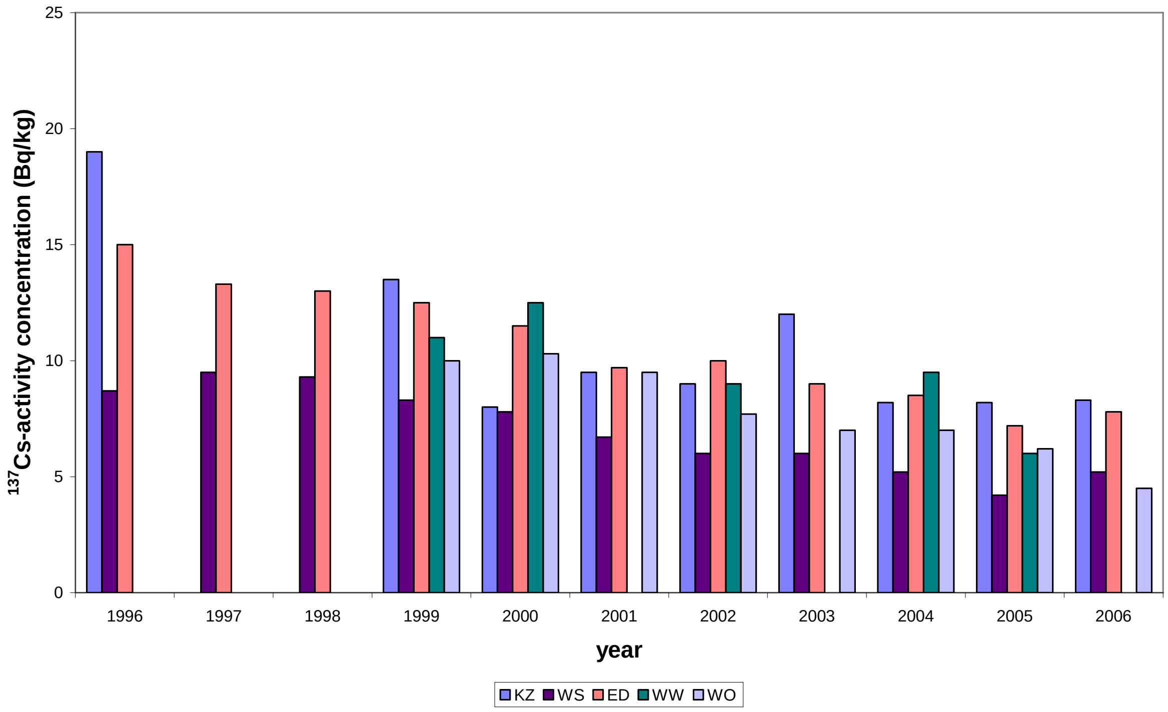


Figure 5.29: Yearly averaged ^{137}Cs-activity concentrations in suspended solids.

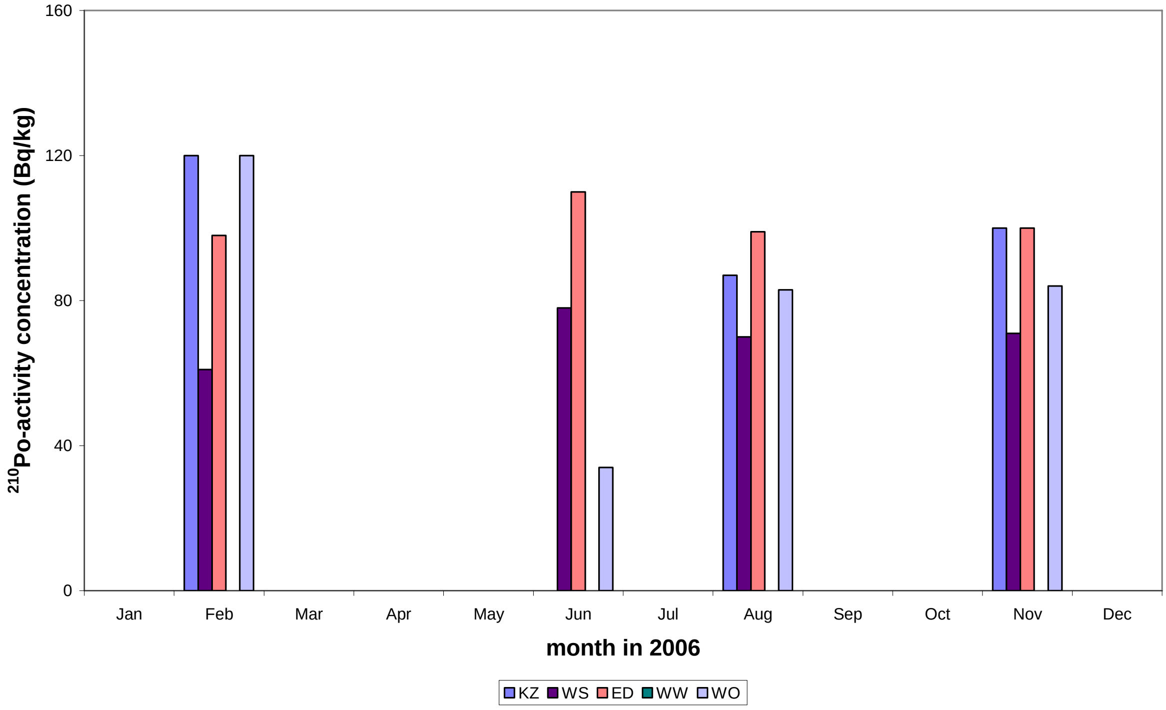


Figure 5.30: The ^{210}Po-activity concentration in suspended solids in seawater in 2006. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard and Wadden Sea East are 102, 70, 102 and 80 Bq·kg^{-1}, respectively. Since 2006 ^{210}Pb is not longer determined at Wadden Sea West due to repeatedly insufficient amount of collected suspended solids in previous years.

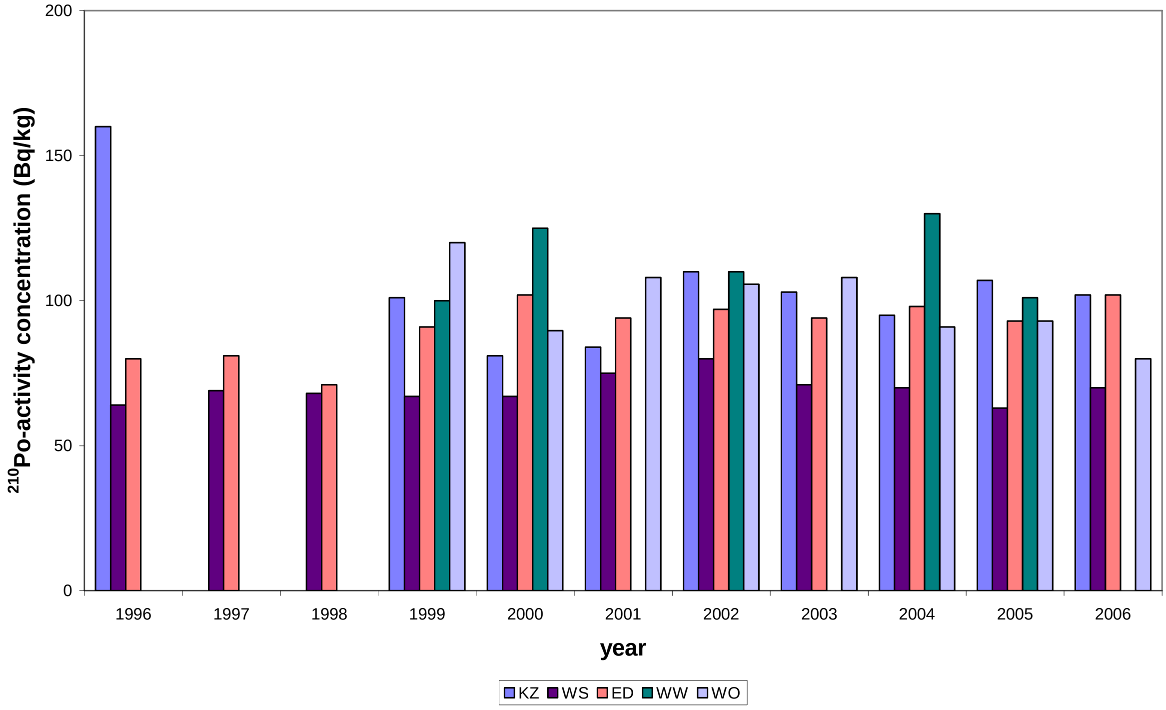


Figure 5.31: Yearly averaged ^{210}Po-activity concentrations in suspended solids.

6 Water for human consumption

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

In the Netherlands, water pumping-stations monitor raw input water for ^{3}H-, gross α-, gross β- and residual β-activity concentrations. The monitoring frequency per location ranges from once to 27 times per year depending on the volume of water produced. The activity concentrations are averaged per pumping station.

The results for 2006 are presented in Table 6.1. For gross α, ^{3}H, gross β and residual β several hundred analyses were performed divided over 100 to 200 pumping stations.

Table 6.1: Analyses on drinking water in 2006.

Parameter	Gross α	^{3}H	Residual β	Gross β
Average value (1)	< 0.1 $Bq \cdot L^{-1}$	< 3.2 $Bq \cdot L^{-1}$	< 0.2 $Bq \cdot L^{-1}$	< 0.2 $Bq \cdot L^{-1}$
No. of all pumping stations	137	139	189	207
No. of all analyses	360	410	636	714
Maximum value (2)	0.23 $Bq \cdot L^{-1}$	16 $Bq \cdot L^{-1}$	< 0.4 $Bq \cdot L^{-1}$	< 0.4 $Bq \cdot L^{-1}$
No. of pumping stations (3)	1	1	60	60
No. of analyses (4)	4	4	1 - 9	1 - 9

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

In 2006 gross α-activity concentrations are reported for the first time. At one of the 137 pumping stations the gross α-activity concentration averaged per pumping station exceeds 0.1 $Bq \cdot L^{-1}$. This value was not thoroughly investigated. Future values above 0.1 $Bq \cdot L^{-1}$ for the gross α-activity concentration will be investigated.

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

The activity of natural nuclides, such as ^{226}Ra and ^{222}Rn, in Dutch drinking water is very low. In 1994 a survey was carried out to determine the radon activity of Dutch water [48]. The average concentration found was 2.2 $Bq \cdot L^{-1}$ for drinking water produced from groundwater. The difference between this value and those mentioned in Table 6.1 is due to the contribution of short-lived and volatile natural radionuclides (radon daughters), which are not included in the gross α-, gross β- and residual β-activity concentrations.

7 Milk

The Institute of Food Safety monitors radioactivity in milk on a weekly base via the National Monitoring Network Radioactivity in Food (Landelijk Meetnet Radioactiviteit in Voedsel, LMRV). The LMRV is a monitoring network that in principal is set up as an emergency network for monitoring relatively high contamination levels. The LMRV consists of 70 NaI-monitors of which 24 are stationed at dairy factories. The weekly samples of all locations are combined into a monthly average for the whole country. The monthly averages for 2006 are presented in Table 7.1.

Table 7.1: Monthly averaged activity concentrations in milk in 2006.

Month	**Number of samples**	**^{40}K Bq·L^{-1}**	**^{60}Co Bq·L^{-1}**	**^{131}I Bq·L^{-1}**	**^{134}Cs Bq·L^{-1}**	**^{137}Cs Bq·L^{-1}**
January	70	49 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
February	74	49 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
March	73	50 ± 4	< 1.4	< 0.6	< 0.6	< 0.5
April	79	50 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
May	86	49 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
June	73	49 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
July	95	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
August	86	50 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
September	73	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
October	78	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
November	71	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
December	57	48 ± 5	< 1.4	< 0.6	< 0.6	< 0.5
Average	915 (1)	49 ± 5	< 1.4	< 0.6	< 0.6	< 0.5

(1) Yearly total.

The detection limits for ^{60}Co, ^{131}I, ^{134}Cs and ^{137}Cs are lower in 2006 then in previous years. In 2006 analyses were not performed on ^{90}Sr in milk.

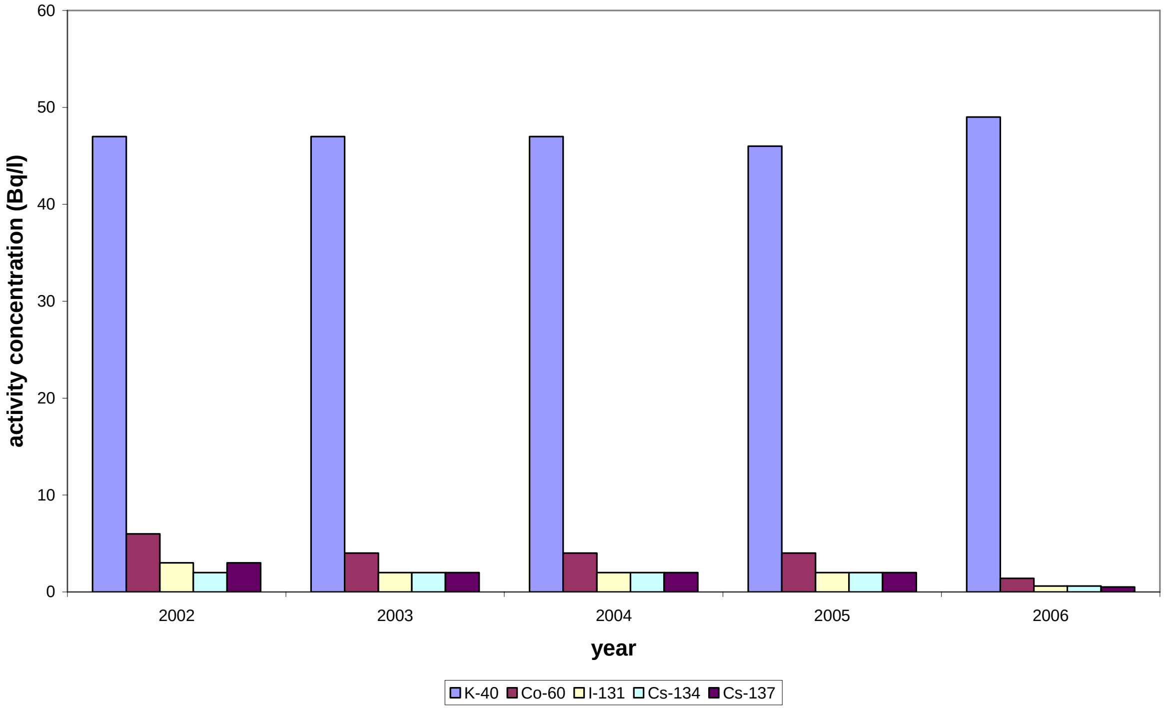


Figure 7.1: Yearly averaged activity concentrations of ^{40}K, ^{60}Co, ^{131}I, ^{134}Cs and ^{137}Cs in milk.

8 Food

The measurements are performed by the Food and Consumer Product Safety Authority. Measurements were carried out according to standard procedures [49, 50]. The results are presented in Table 8.1, in total 591 samples were analysed. None of the samples exceed the set limit of 600 $Bq \cdot kg^{-1}$ [51].

Since 2005 the Food and Consumer Product Safety Authority monitors activity concentrations in a mixed diet. In 2006 the mixed diet was sampled mainly as separate ingredients but also as some complete meals. During two weeks in five different regions a standard sampling was carried out which consisted of 471 samples, which were taken from retail shops, auctions and distribution centres [52]. The separate ingredients were divided in the following product groups: grain, vegetables, fruit, milk and dairy products, meat and meat products, game and poultry, salads and oil and butter.

Radioactivity is also measured in food suspected to contain more than the normal activity concentrations, in this case honey. In 2006 analyses were not performed on ^{90}Sr in mixed diet.

8.1 Honey

In total 120 samples of honey were analysed [52]. The activity (sum of ^{134}Cs and ^{137}Cs) was found to be below the set limit of 600 $Bq \cdot kg^{-1}$ [51]. Only 19 samples of honey (all heather honey) contained ^{137}Cs. The activity varied from 7 up to 408 $Bq \cdot kg^{-1}$.

8.2 Other products

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

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

Product	Number of samples	Number of positive samples	^{134}Cs $Bq \cdot kg^{-1}$	^{137}Cs $Bq \cdot kg^{-1}$
Grain	78	0	< 3.8	< 3.0
Vegetables	83	0	< 3.8	< 3.0
Fruit	58	0	< 3.8	< 3.0
Milk and milk products	44	0	< 3.8	< 3.0
Meat and meat products	75	0	< 3.8	< 3.0
Game and poultry	45	0	< 3.8	< 3.0
Salads	27	0	< 3.8	< 3.0
Oil and butter	39	0	< 3.8	< 3.0
Honey	120	19	< 3.8	7 - 408
Ready-to-eat meals	22	0	< 3.8	< 3.0

9 Conclusions

The gross α-activity concentration in the Noordzeekanaal, Nieuwe Waterweg, Rhine and Scheldt exceeds the target value (100 $mBq \cdot L^{-1}$) in seven out of seven, nine out of thirteen, one out of thirteen and thirteen out of thirteen samples taken, respectively. The yearly averaged gross α-activity concentrations in the Noordzeekanaal, Nieuwe Waterweg and Scheldt (220, 133 and 350 $mBq \cdot L^{-1}$, respectively) are above the target value, but within the range of those in previous years.

The ^{3}H-activity concentration in the Scheldt and Meuse exceeds the target value (10 $Bq \cdot L^{-1}$) in three out of six and eight out of thirteen samples taken, respectively. The yearly averaged ^{3}H-activity concentrations in the Scheldt and Meuse (11.9 and 15.0 $Bq \cdot L^{-1}$, respectively) are above the target value, but within the range of those in previous years.

The ^{226}Ra-activity concentration in the Nieuwe Waterweg and the Scheldt exceeds the target value (5 $mBq \cdot L^{-1}$) in one out of six and six out of six samples taken, respectively. The yearly averaged ^{226}Ra-activity concentration in the Scheldt (11.2 $mBq \cdot L^{-1}$) is above the target value, but within the range of those in previous years.

The ^{60}Co-activity concentration in the Meuse exceeds the target value (10 $Bq \cdot kg^{-1}$) in twenty-six out of fifty-one samples taken. The yearly averaged ^{60}Co-activity concentration in the Meuse (18 $Bq \cdot kg^{-1}$) is above the target value.

The ^{131}I-activity concentration in the Noordzeekanaal and Meuse exceeds the target value (20 $Bq \cdot kg^{-1}$) in two out of six and thirty-three out of fifty-two samples taken, respectively. The yearly averaged ^{131}I-activity concentration in the Meuse (36 $Bq \cdot kg^{-1}$) is above the target value, but within the range of those in previous years.

The ^{137}Cs-activity concentration in the Meuse exceeds the target value (40 $Bq \cdot kg^{-1}$) in four out of fifty-two samples taken. The yearly averaged ^{137}Cs-activity concentrations are below the target value.

The ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine, Scheldt and Meuse exceeds the target value (100 $Bq \cdot kg^{-1}$) in four out of six, five out of seven, two out of six and seven out of seven samples taken, respectively. The yearly averaged ^{210}Pb-activity concentration in the Nieuwe Waterweg, Rhine, Scheldt and Meuse (109, 117, 102 and 141 $Bq \cdot kg^{-1}$, respectively) are above the target value, but within the range of those in previous years.

For some areas the yearly averaged gross α- and ^{3}H-activity concentrations in seawater are higher in 2006 than those in previous years.

In 2006 gross α-activity concentrations in drinking water are reported for the first time. At one of the 137 pumping stations the gross α-activity concentration averaged per pumping station exceeds 0.1 $Bq \cdot L^{-1}$. This value was not thoroughly investigated. Future values above 0.1 $Bq \cdot L^{-1}$ for the gross α-activity concentration will be investigated.

The results of all other radioactivity measurements are within the range of those in previous years. In 2006 the Netherlands complied to the Euratom recommendations except for the determination of strontium-90 in milk and mixed diet.

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] G.J. Knetsch (ed), 2006. Environmental radioactivity in the Netherlands. Results in 2005. RIVM Bilthoven, Report no. 861020013.

[6] 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.

[7] J.E.M. Jacobs (ed), 2001. Monitoring of radiation in the Environment. Results in the Netherlands in 1999. RIVM Bilthoven, Report no. 610056046.

[8] 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 (September 2007).

[9] 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.

[10] 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.

[11] 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.

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

[13] 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.

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

[15] Solar Cycle Progression, September 2007. Internetsite: www.sec.noaa.gov/SolarCycle.

[16] 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.

[17] 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 (September 2007).

[18] KNMI database, September 2007. Internetsite: www.knmi.nl/klimatologie/.

[19] 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).

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

[21] 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.

[22] 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.

[23] 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.

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

[25] 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.

[26] 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.

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

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

[29] 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.

[30] 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.

[31] 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.

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

[33] 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.

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

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

[36] 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.
[37] Federal Aviation Administration, September 2007. Internetsite: http://www.faa.gov/education_research/research/med_humanfacs/aeromedical/radiobiology.
[38] G.J. Knetsch (ed), 2004. Monitoring of radiation in the environment in the Netherlands. Results in 2003. RIVM Bilthoven, Report no. 861020010.
[39] RIZA and RIKZ, September 2007. Internetsite: www.watermarkt.nl.
[40] E.J. de Jong en O.C. Swertz, 2000. Radioactieve stoffen in de zoute wateren. RIKZ, Den Haag, Report no. RIKZ/2000.041.
[41] L.J. Gilde, K.H. Prins, C.A.M. van Helmond, 1999. Monitoring zoete rijkswateren. RIZA Lelystad, Report no. 99.004.
[42] E.J. de Jong, W. Lutthmer, B. Munster, 1995. Onderzoek naar radioactieve stoffen in Rijkswateren. Resultaten 1992. RIZA, Lelystad.
[43] Ministerie V&W, 1998. Vierde Nota waterhuishouding. Den Haag.
[44] 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.
[45] EC, 1998. Council directive on the quality of water intended for human consumption. EC Brussels, 98/83/EC.
[46] H.A.J.M. Reinen, C. de Hoog, F. Wetsteyn, J.G.M.M. Smeenk, H.A.M. Ketelaars, A.D. Hulsmann, J.M. van Steenwijk, A.J. Stortenbeek, 2003. Meetstrategie drinkwater bij kernongevallen. VROM-Inspectie Den Haag, Report No. 15060/177.
[47] G.J. Knetsch (ed), 2005. Monitoring of radiation in the environment in the Netherlands. Results in 2004. RIVM Bilthoven, Report no. 861020011.
[48] J.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.
[49] 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.
[50] 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.
[51] 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.
[52] Voedsel en Waren Autoriteit, 2007. VWA-resultaten Nationaal Plan Kernongevallen 2006. Zutphen.
[53] 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 High Volume Sampler at RIVM in 2006.

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 [(2)]	0.039	0.50	±	0.02	27	0.061	0.70	±	0.05
2 [(2)]	0.073	0.82	±	0.05	28	0.055	0.34	±	0.02
3	0.08	1.05	±	0.06	29	0.042	0.56	±	0.04
4	0.059	0.80	±	0.05	30	0.09	1.00	±	0.06
5	0.08	0.87	±	0.05	31	0.053	0.34	±	0.02
6	0.033	0.37	±	0.02	32	0.032	0.35	±	0.02
7	0.057	0.40	±	0.03	33	0.046	0.38	±	0.03
8	0.036	0.40	±	0.03	34	0.07	0.36	±	0.02
9	0.037	0.235	±	0.016	35	0.047	0.281	±	0.019
10 [(2)]	0.025	0.171	±	0.013	36	0.07	0.35	±	0.02
11	0.08	0.79	±	0.05	37	0.09	1.05	±	0.07
12	0.043	0.57	±	0.04	38	0.09	1.12	±	0.07
13	0.046	0.279	±	0.019	39	0.08	0.87	±	0.06
14	0.051	0.198	±	0.014	40	0.044	0.42	±	0.03
15	0.028	0.198	±	0.014	41	0.07	0.61	±	0.04
16	0.09	0.41	±	0.03	42	0.09	1.24	±	0.08
17	0.061	0.33	±	0.02	43	0.035	0.36	±	0.02
18	0.050	0.38	±	0.03	44	0.041	0.271	±	0.019
19	0.08	0.90	±	0.06	45	0.046	0.45	±	0.03
20	0.051	0.44	±	0.03	46	0.041	0.32	±	0.02
21	0.042	0.223	±	0.016	47	0.044	0.256	±	0.018
22	0.015	0.207	±	0.015	48	0.057	0.41	±	0.03
23	0.042	0.34	±	0.02	49	0.038	0.40	±	0.03
24	0.053	0.57	±	0.04	50	0.036	0.239	±	0.017
25	0.07	0.35	±	0.02	51 [(2)]	0.10	0.334	±	0.019
26	0.029	0.241	±	0.017	52	0.047	0.41	±	0.03
					Average	0.05 [(3)]	0.489	±	0.005 [(4)]
					SD [(5)]	0.02			0.3

[(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 1.1 days of the week. In case of week 10 sampling did not occur at all during 0.3 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 [6].

[(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 2006. Measurements were carried out on a coaxial detector with a ten days delay between sampling and start of measurement, a counting time of 100,000 seconds and a sample volume of about 50,000 m^3. The detection limits are higher than before 2000 [7] due to a different detector set-up.

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

(1) Due to the relatively short half-life of ^{24}Na and the long delay between the sampling and the measurement this nuclide cannot be determined in the residue measurement on the coaxial detector. Therefore, the detection limit for the filter measurement on the coaxial detector is given (3 days delay time, 100,000 seconds counting time).
(2) Due to the sample preparation procedure the volatile nuclide ^{131}I cannot be determined in the residue measurement on the coaxial detector. Therefore, the detection limit for the filter measurement on the coaxial detector is given (3 days delay time, 100,000 seconds counting time).

Table A3: Weekly averaged ^{7}Be-, ^{137}Cs- and ^{210}Pb-activity concentrations in air dust sampled with a HVS at RIVM in 2006. 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 (1)	30/12-06/01	1580	±	140				420	±	40
2 (1)	06/01-13/01	1860	±	160				950	±	90
3	13/01-20/01	4000	±	400				1090	±	120
4	20/01-27/01	3200	±	300				830	±	70
5	27/01-03/02	4200	±	400				840	±	90
6	03/02-10/02	3000	±	300				290	±	30
7	10/02-17/02	2400	±	200				420	±	40
8	17/02-24/02	2600	±	200				430	±	40
9	24/02-03/03	2400	±	200				210	±	20
10 (1)	03/03-10/03	2500	±	200				210	±	30
11	10/03-17/03	3700	±	300				780	±	70
12	17/03-24/03	4400	±	400				560	±	60
13	24/03-31/03	3400	±	300				210	±	20
14	31/03-07/04	3300	±	300				168	±	16
15	07/04-14/04	2900	±	200				152	±	14
16	14/04-21/04	4300	±	400				360	±	30
17	21/04-28/04	3700	±	300				330	±	30
18	28/04-04/05	4100	±	400				340	±	30
19	04/05-12/05	9800	±	900	4.9	±	0.8	910	±	80
20	12/05-19/05	4500	±	400				460	±	40
21	19/05-26/05	3100	±	300				160	±	20
22	26/05-02/06	2500	±	200				148	±	14
23	02/06-09/06	4400	±	400				230	±	20
24	09/06-16/06	6600	±	600				490	±	50
25	16/06-23/06	5300	±	500				290	±	30
26	23/06-30/06	3300	±	300				220	±	20

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	30/06-07/07	8400	±	700				660	±	60
28	07/07-14/07	3400	±	300				240	±	30
29	14/07-21/07	5200	±	500				520	±	50
30	21/07-28/07	6600	±	600				940	±	80
31	28/07-04/08	3800	±	300				380	±	40
32	04/08-11/08	2700	±	200				330	±	40
33	11/08-18/08	2800	±	200				370	±	30
34	18/08-25/08	3000	±	300				320	±	30
35	25/08-01/09	2700	±	200				250	±	30
36	01/09-08/09	3100	±	300				360	±	40
37	08/09-15/09	5400	±	500				1110	±	100
38	15/09-22/09	5100	±	400				1150	±	100
39	22/09-29/09	4400	±	400				900	±	80
40	29/09-06/10	3700	±	300				380	±	40
41	06/10-13/10	4600	±	400				670	±	60
42	13/10-20/10	5400	±	500				1460	±	130
43	20/10-27/10	3300	±	300				300	±	30
44	27/10-03/11	2600	±	200				220	±	20
45	03/11-10/11	4000	±	400				400	±	40
46	10/11-17/11	2600	±	200				280	±	30
47	17/11-24/11	3300	±	300				166	±	16
48	24/11-01/12	3400	±	300				410	±	40
49	01/12-08/12	3800	±	300				340	±	40
50	08/12-15/12	2800	±	200				180	±	20
51 (1)	15/12-22/12	2050	±	180				320	±	30
52	22/12-29/12	2800	±	200				460	±	40
	Average	3800	±	50 (2)	4.9	±	0.8 (2)	473	±	7 (2)
	SD (3)			1500			-			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 1.1 days of the week and in case of week 10 didn't occur at all during 0.3 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 2006.

Month	Precipitation mm	^{3}H [(1)] Bq·m^{-2}				Gross α Bq·m^{-2}			Gross β Bq·m^{-2}		
January	30.4		70	±	20	0.9	±	0.2	3.0	±	0.2
February	64.3		180	±	40	1.4	±	0.2	5.9	±	0.5
March	92.5	<	181			1.5	±	0.3	6.0	±	0.5
April	37.4	<	70			1.1	±	0.2	5.9	±	0.5
May	88.5	<	167			2.8	±	0.4	8.5	±	0.7
June	17.5		63	±	12	2.1	±	0.3	7.8	±	0.6
July	9.6	<	20			7.1	±	1.2	22.0	±	1.7
August	218.1	<	446			2.0	±	0.3	11.0	±	0.9
September	9.3		22	±	6	2.3	±	0.4	7.6	±	0.6
October	127.0	<	249			2.0	±	0.4	7.4	±	0.6
November	81.4	<	159			1.39	±	0.18	7.7	±	0.6
December	78.6	<	154			1.03	±	0.14	5.6	±	0.4
Total	854	-				25.7	±	1.5 [(2)]	98	±	3 [(2)]
Lower limit [(3)]	-		280			-			-		
Upper limit [(3)]	-		1820			-			-		

[(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 (1.9-2.0 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 1993-2006. Either the yearly total with uncertainty [(1)] or the lower and upper limits [(2)] of the 68% confidence range are given.

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

[(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 2006.

Month		**^{210}Po Bq·m^{-2}**		
January		0.77	±	0.05
February		0.58	±	0.11
March		0.96	±	0.06
April		1.21	±	0.07
May		0.59	±	0.16
June	<	0.57		
July		3.9	±	0.3
August		1.13	±	0.17
September		2.90	±	0.17
October		0.70	±	0.14
November		1.00	±	0.08
December		0.84	±	0.07
Total		-		
Lower limit [(2)]		14.1		
Upper limit [(2)]		15.6		

[(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 1993-2006. 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
2006	1400	±	30	0.06	-	7.47	66	-	103	-			14.1	-	15.6

[(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 [53].
[(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 2006.

Week Number	Period	Precipitation mm	^{7}Be Bq·m^{-2}			^{137}Cs Bq·m^{-2}		^{210}Pb Bq·m^{-2}			
1	30/12-06/01	11.1	10.8	±	1.6	<	0.13	<	1.6		
2	06/01-13/01	5.4	7.7	±	1.0	<	0.14	<	1.3		
3	13/01-20/01	10.3	21	±	3	<	0.12	<	1.2		
4	20/01-27/01	3.6	4.5	±	0.7	<	0.12	<	1.3		
5	27/01-03/02	0.0	2.5	±	0.8	<	0.13		1.5	±	0.6
6	03/02-10/02	13.8	33	±	4	<	0.11		2.5	±	0.8
7	10/02-17/02	29.5	49	±	6	<	0.12		1.5	±	0.4
8	17/02-24/02	5.0	7.2	±	1.1	<	0.08	<	1.4		
9	24/02-03/03	16.0	23	±	3	<	0.23	<	1.3		
10	03/03-10/03	36.5	41	±	5	<	0.13	<	1.4		
11	10/03-17/03	3.5	6.7	±	1.1	<	0.24	<	1.4		
12	17/03-24/03	0.0	1.8	±	0.8	<	0.11	<	1.3		
13	24/03-31/03	52.5	63	±	7	<	0.20		3.4	±	0.7
14	31/03-07/04	10.8	22	±	3	<	0.10	<	1.4		
15	07/04-14/04	13.7	30	±	4	<	0.11	<	1.3		
16	14/04-21/04	10.0	32	±	4	<	0.12	<	1.4		
17	21/04-28/04	2.9	17	±	2	<	0.14		3.6	±	0.6
18	28/04-04/05	5.1	11	±	2	<	0.11	<	1.3		
19	04/05-12/05	0.0	7.7	±	1.3	<	0.22		4.2	±	1.0
20	12/05-19/05	21.6	40	±	5	<	0.32		3.7	±	0.8
21	19/05-26/05	36.3	62	±	7	<	0.12		2.3	±	0.5
22	26/05-02/06	25.5	37	±	5	<	0.14		0.9	±	0.4
23	02/06-09/06	0.0	5.2	±	1.0	<	0.14		2.2	±	0.7
24	09/06-16/06	5.6	29	±	4	<	0.13		3.0	±	0.5
25	16/06-23/06	2.3	20	±	2	<	0.12		3.0	±	0.5
26	23/06-30/06	9.7	38	±	5	<	0.10		3.0	±	0.6

To be continued on the next page.

(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 A8: Continued.

Week Number	**Period**	**Precipitation mm**	**^{7}Be Bq·m^{-2}**			**^{137}Cs Bq·m^{-2}**				**^{210}Pb Bq·m^{-2}**			
27	30/06-07/07	2.8	25	±	3	<	0.11				3.2	±	0.7
28	07/07-14/07	4.9	18	±	2	<	0.12				0.9	±	0.4
29	14/07-21/07	0.0	6.2	±	1.4	<	0.11				2.1	±	0.6
30	21/07-28/07	1.9	23	±	3	<	0.14				2.2	±	0.8
31	28/07-04/08	52.0	58	±	7	<	0.10				3.1	±	0.7
32	04/08-11/08	14.0	24	±	3	<	0.15			<	1.4		
33	11/08-18/08	67.0	65	±	8	<	0.12				2.5	±	1.0
34	18/08-25/08	46.2	72	±	9	<	0.13				2.3	±	0.5
35	25/08-01/09	38.9	56	±	7	<	0.13				3.2	±	0.6
36	01/09-08/09	5.9	16	±	2	<	0.12				1.0	±	0.5
37	08/09-15/09	0.0	3.2	±	1.3	<	0.12				1.1	±	0.5
38	15/09-22/09	2.8	8.6	±	1.5	<	0.12				2.5	±	0.7
39	22/09-29/09	0.6	9.0	±	1.3	<	0.13				1.5	±	0.4
40	29/09-06/10	70.0	79	±	10	<	0.14				3.1	±	0.8
41	06/10-13/10	10.0	12.1	±	1.8		0.10	±	0.05	<	1.5		
42	13/10-20/10	3.0	5.4	±	1.1	<	0.11			<	1.3		
43	20/10-27/10	34.0	36	±	4	<	0.11				2.2	±	0.7
44	27/10-03/11	10.0	29	±	4	<	0.10				0.9	±	0.4
45	03/11-10/11	4.9	21	±	3	<	0.13			<	1.3		
46	10/11-17/11	36.5	45	±	5	<	0.11				1.8	±	0.7
47	17/11-24/11	35.5	54	±	6	<	0.11			<	1.4		
48	24/11-01/12	4.5	5.0	±	0.8	<	0.07			<	1.4		
49	01/12-08/12	43.8	41	±	5	<	0.10				1.7	±	0.4
50	08/12-15/12	23.5	44	±	5	<	0.13			<	1.3		
51	15/12-22/12	9.0	13.3	±	1.7	<	0.23			<	1.5		
52	22/12-29/12	2.3	12.1	±	1.7	<	0.70			<	1.2		
Total (2)		854	1400	±	30		-				-		
Lower limit (3)		-	-				0.06				66		
Upper limit (3)		-	-				7.47				103		

(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 2006 as measured by the NMR stations equipped with aerosol monitors.

Station	**No.**	**α-Activity concentration** $Bq.m^{-3}$	**Ambient dose equivalent rate** [(1)] $nSv.h^{-1}$
Arnhem [(2)]	970	4.2	67
Kollumerwaard	972	3.8	71
Valthermond [(3)]	974	3.6	62
Vlaardingen	976	3.8	71
Braakman	978	3.6	67
Huijbergen	980	3.4	58
Houtakker	982	3.3	63
Wijnandsrade	984	6.2	72
Eibergen	986	4.0	62
De Zilk	988	3.1	65
Wieringerwerf	990	2.8	70
Vredepeel [(4)]	992	4.3	70
Biddinghuizen [(4)]	994	3.0	77
Wageningen [(2)]	996	3.5	82
Bilthoven	998	3.7	62

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

Table A10: The yearly averaged ambient dose equivalent rate for the NMR stations in 2006.

Station	**No.**	**Ambient dose equivalent rate** $nSv.h^{-1}$	**Station**	**No.**	**Ambient dose equivalent rate** $nSv.h^{-1}$
Den Burg	1001	77	Wekerom	1041	73
Den Oever	1003	69	Wageningen	1043	69
Julianadorp	1004	65	Hooglanderveen	1046	71
Petten	1006	63	Harderwijk	1050	65
Kolhorn	1007	82	Wijk bij Duurstede	1056	83
Egmond aan Zee	1009	67	Rhenen	1061	77
Heerhugowaard	1011	73	Nieuwegein	1062	80
Haarlem-Noord	1014	74	Apeldoorn	1066	70
Nederhorst den Berg	1015	60	Heerenveen	1071	63
Enkhuizen	1018	80	Oosterwolde	1072	80
Oosthuizen	1019	78	Bergum	1074	68
Zaandam	1021	67	Witmarsum	1076	88
Gouda	1024	72	Sneek	1077	71
Dordrecht	1027	61	St. Jacobiparochie	1081	78
Zuid-Beijerland	1028	73	Holwerd	1082	89
Pijnacker	1032	88	Leeuwarden	1085	68
Rotterdam Crooswijk	1033	73	Zwolle-Zuid	1087	73
Rotterdam Waalhaven	1034	71	Ommen	1093	64
Maasvlakte [(1)]	1035	-	Hardenberg	1095	66
Maassluis	1037	84	Assen	1097	65
Hellevoetsluis	1038	95	Rutten	1099	75
Ouddorp	1039	73	Lelystad	1103	77

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}
Urk	1105	77	Nieuw-Bergen	1184	62
Eemshaven	1106	84	Sevenum	1185	68
Uithuizen	1107	83	Reuver	1188	64
Wagenborgen	1109	76	Nederweert	1189	72
Winschoten	1110	70	Heythuisen	1190	74
Ter Apel	1111	72	Mariahoop	1191	68
Stadskanaal	1112	65	Stramproy	1192	64
Nieuweschans	1113	72	Arnhem-Oosterbeek	1193	76
Bellingwolde	1114	60	Leiden	1196	73
Groningen	1116	75	Hulst (1)	1197	-
Leens	1117	85	Terneuzen	1199	71
Grijpskerk	1118	72	Sluis	1201	74
Meppel	1125	67	Vlissingen	1202	77
Hoogeveen	1126	61	Halsteren	1204	64
Steenwijksmoer	1129	65	Oud-Gastel	1206	66
Nieuw Amsterdam	1130	79	Goes	1207	84
Nw. Schoonebeek/ Weiteveen	1131	61	Bruinisse	1209	73
Emmen	1132	81	Burgh-Haamstede	1211	62
Hengelo (Ov) (2)	1135	70	Vrouwenpolder	1212	64
Hengelo (Gld) (1)	1136	-	Wemeldinge	1214	76
Enschede	1139	63	Middelburg	1215	77
Losser	1140	63	Westkapelle	1216	68
Oldenzaal	1141	76	Noordwijk-Binnen	1217	76
Westerhaar	1142	63	Stein	1219	80
Rijssen	1143	66	Maastricht	1220	89
's Heerenberg	1144	62	Ravensbos	1221	92
Dinxperlo	1145	78	Vaals	1222	84
Varsseveld	1146	72	Gulpen	1223	80
Groenlo	1147	83	Kerkrade	1224	90
Deventer	1148	78	Hoensbroek	1225	83
Etten-Leur	1154	69	Gennep	1228	79
Den Bosch	1157	69	Elst (Gld)	1229	82
Raamsdonkveer	1159	92	Zevenaar	1230	72
Ulvenhout	1160	73	Nijmegen	1231	74
Baarle-Nassau	1161	93	Amstelveen	1233	73
Uden	1162	71	Amsterdam Oost	1234	72
Mill	1163	64	Aalsmeer	1236	72
Oss	1167	66	Nispen	1237	63
Nuenen	1172	71	Groesbeek	1240	77
Bergeyk	1174	88	Tubbergen	1243	66
Waalre	1175	69	Haaksbergen	1244	67
Someren (dorp)	1176	69	Scheveningen	1247	77
Oisterwijk	1178	73	Zaltbommel	1251	71
Riel	1179	70	IJzendijke	1252	80
Oostelbeers	1180	83	Ritthem	1253	100
Hilvarenbeek	1181	65	Vlissingen-Haven	1254	72
Venray	1183	62	Nieuwdorp	1255	85

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	74	Putte	1264	56
Driewegen	1257	82	Nieuw Namen	1265	81
Arnemuiden	1258	72	Beneden Leeuwen	1272	84
Heinkeszand	1259	84	Denekamp	1278	64
Baarland	1260	86	Winterswijk/Kotten	1279	69
Biervliet	1261	76	Bilthoven	1280	61
Nummer Één (3)	1262	76	Maarheze/Gastel	1281	74
Rilland	1263	79			

(1) Station was not operational in 2006.
(2) In 2006 the station has been moved from Borne to Hengelo (Ov).
(3) In 2006 the station has been moved from Slijkplaat to Nummer Één.

Table A11: Gross α, residual β, ^{3}H-, ^{90}Sr and ^{226}Ra-activity concentrations (mBq·L^{-1}) in surface water in 2006 as measured by RIZA.

Date	**Gross α mBq·L^{-1}**	**Residual β mBq·L^{-1}**	**^{3}H mBq·L^{-1}**	**^{90}Sr mBq·L^{-1}**	**^{226}Ra mBq·L^{-1}**
Location:	**IJsselmeer**				
10/01/06	41	29	5800		
07/02/06	49	7			
07/03/06	50	6	4200		
04/04/06	75	73			
02/05/06	44	34	4700		
30/05/06	47	16			
27/06/06	29	4	3200		
25/07/06	43	31			
22/08/06	55	40	3800		
19/09/06	48	45			
17/10/06	35	54	4600		
14/11/06	68	77			
12/12/06	39	27	4100		
Average	48	34	4300		
Location:	**Noordzeekanaal**				
26/01/06	160	19	4400		
23/03/06	200	60	4200		
18/05/06	150	28	4400		
13/07/06	470	67	3300		
07/09/06	140	16	2100		
02/11/06	250	29	4100		
28/12/06	180	57	3400		
Average	220	39	3700		
Location:	**Nieuwe Waterweg**				
25/01/06	200	37			
22/02/06	100	83	9300	7	6
22/03/06	120	45			
19/04/06	220	57	5500	4	5
17/05/06	110	38			
14/06/06	120	38	3200	< 1	4
12/07/06	170	44			
09/08/06	72	44	4800	4	5
06/09/06	170	41			
04/10/06	92	32	3000	9	4
02/11/06	130	16			
29/11/06	79	20	3500	< 1	3
27/12/06	140	74			
Average	133	44	4900	4.2	4.5

To be continued on the next page.

Table A11: Continued.

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:	**Rhine**				
18/01/06	30	6	8100	< 1	4
15/02/06	59	43	8100		
15/03/06	120	120	2400	5	4
12/04/06	48	44	5900		
10/05/06	64	49	7600	4	4
07/06/06	88	70	5300		
05/07/06	56	35	3100	3	3
02/08/06	59	48	4200		
30/08/06	33	30	5900	3	3
27/09/06	35	41	2400		
25/10/06	75	5	4400	2	5
22/11/06	59	23	6500		
20/12/06	56	48	9600	7	1
Average	60	43	5700	3.5	3.4
Location:	**Scheldt**				
10/01/06	430	44			
08/02/06	450	90	18000		12
06/03/06	490	110			
03/04/06	210	120	9800		11
01/05/06	350	120			
30/05/06	460	95	10000		12
27/06/06	300	120			
26/07/06	260	64	12000		6
23/08/06	360	61			
18/09/06	230	55	9800		11
16/10/06	350	93			
13/11/06	450	43	12000		15
11/12/06	190	72			
Average	350	84	11900		11.2
Location:	**Meuse**				
17/01/06	3	25	30000	1	2
14/02/06	29	13	34000		
14/03/06	95	73	6100	< 1	2
11/04/06	38	35	28000		
09/05/06	37	37	17000	< 1	4
06/06/06	70	120	14000		
04/07/06	41	34	20000	3	5
01/08/06	41	33	15000		
29/08/06	35	29	8400	< 1	2
26/09/06	25	45	4700		
24/10/06	18	< 1	1200	1	3
21/11/06	40	19	1300		
19/12/06	27	38	19000	4	3
Average	38	39	15000	1.5	3.0

Table A12: ^{60}Co-, ^{131}I-, ^{137}Cs- and ^{210}Pb-activity concentrations in suspended solids (Bq·kg^{-1}) in surface water in 2006 as measured by RIZA.

Date	^{60}Co Bq·kg^{-1}	^{131}I Bq·kg^{-1}	^{137}Cs Bq·kg^{-1}	^{210}Pb Bq·kg^{-1}
Location:	**IJsselmeer**			
10/01/06	< 1	< 1	9	
07/02/06	< 1	< 1	6	
07/03/06	< 1	< 1	3	
04/04/06	< 1	< 1	5	
02/05/06	< 1	< 1	< 1	
30/05/06	< 1	< 1	4	
27/06/06	< 1	< 1	3	
25/07/06	< 1	< 1	< 1	
22/08/06	< 1	< 1	3	
19/09/06	< 1	< 1	3	
17/10/06	< 1	< 1	6	
14/11/06	< 1	< 1	5	
12/12/06	< 1	< 1	7	
Average	< 1	< 1	4.2	
Location:	**Ketelmeer**			
04/01/06	< 1	< 1	14	
31/01/06	< 1	4	13	
30/03/06	< 1	7	13	
29/05/06	< 1	< 1	16	
20/07/06	< 1	3	14	
14/09/06	< 1	< 1	15	
09/11/06	< 1	< 1	17	
Average	< 1	< 2.3	14.6	
Location:	**Noordzeekanaal**			
23/01/06	< 1	9	12	
20/03/06	< 1	23	7	
15/05/06	< 1	5	4	
10/07/06	< 1	4	5	
04/09/06	< 1	7	8	
30/10/06	< 1	28	10	
27/12/06	n/a	n/a	n/a	
Average	< 1	13	7.7	
Location:	**Nieuwe Waterweg**			
25/01/06	< 1	6	13	
22/02/06	< 1	11	13	110
22/03/06	< 1	5	15	
19/04/06	< 1	3	11	96
17/05/06	< 1	< 1	13	
14/06/06	1	3	12	100
12/07/06	< 1	2	10	
09/08/06	< 1	< 1	12	110
06/09/06	< 1	3	14	
04/10/06	< 1	4	16	130
02/11/06	< 1	< 1	10	
29/11/06	< 1	4	12	110
27/12/06	< 1	< 1	8	
Average	< 1	3.3	12.2	109

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**				
04/01/06	<	1		3	16	140
15/02/06	<	1		12	15	
15/03/06	<	1		5	15	100
12/04/06	<	1		1	n/a	
10/05/06	<	1	<	1	14	99
07/06/06	<	1	<	1	14	
05/07/06	<	1	<	1	12	110
02/08/06	<	1		6	16	
30/08/06	<	1	<	1	12	130
28/09/06	<	1		4	11	
27/10/06	<	1		7	11	110
23/11/06	<	1		9	14	
20/12/06	<	1		16	19	130
Average	<	1		5.0	14.1	117
Location:		**Scheldt**				
10/01/06		4		2	9	
06/02/06		1	<	1	8	93
06/03/06	<	1		2	7	
03/04/06	<	1	<	1	11	100
01/05/06	<	1	<	1	8	
29/05/06		2	<	1	8	110
27/06/06		1		2	9	
26/07/06	<	1	<	1	8	110
23/08/06		2		1	9	
18/09/06		1	<	1	8	99
16/10/06	<	1	<	1	9	
13/11/06		2	<	1	9	97
11/12/06	<	1		5	8	
Average		1.2	<	1.2	8.5	102
Location:		**Meuse**				
03/01/06		25		10	13	
10/01/06		10	<	1	11	
18/01/06		50		34	19	140
24/01/06		16		16	13	
31/01/06		150		34	16	
07/02/06		21		43	11	
14/02/06		25		37	11	
21/02/06		4		22	12	
28/02/06		10		14	13	
07/03/06		130		24	15	
14/03/06		7		7	15	110
22/03/06		11		13	14	
28/03/06		10		22	14	

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:	**Meuse**			
04/04/06	7	8	15	
11/04/06	9	21	14	
18/04/06	25	17	12	
25/04/06	4	54	12	
02/05/06	23	34	89	
09/05/06	5	58	56	170
16/05/06	10	24	27	
23/05/06	8	15	20	
30/05/06	2	10	16	
06/06/06	7	24	34	
13/06/06	8	24	24	
20/06/06	3	47	20	
27/06/06	19	49	26	
04/07/06	7	23	14	110
11/07/06	8	51	50	
18/07/06	4	37	50	
25/07/06	4	110	27	
01/08/06	6	27	31	
08/08/06	8	19	35	
15/08/06	6	18	26	
22/08/06	9	37	33	
29/08/06	7	10	24	130
05/09/06	19	44	28	
12/09/06	19	140	26	
19/09/06	15	50	27	
25/09/06	12	280	20	
03/10/06	12	73	23	
10/10/06	20	27	25	
17/10/06	17	29	25	
24/10/06	15	47	24	200
31/10/06	20	18	24	
07/11/06	25	32	25	
14/11/06	n/a	29	18	
21/11/06	21	19	20	
28/11/06	12	16	20	
05/12/06	17	21	20	
12/12/06	3	< 1	13	
19/12/06	27	20	20	130
27/12/06	14	16	22	
Average	18	36	23.3	141

n/a = data not available

Table A13: Gross α-, residual β-, ^{3}H- and ^{90}Sr-activity concentrations ($mBq{\cdot}L^{-1}$) in seawater in 2006 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**			
20/02/06	710	85	6500	
11/05/06	88	26	4600	
08/08/06	340	66	6300	
16/11/06	230	89	4900	
Average	340	66	5600	
Location:	**Southern North Sea**			
20/02/06	1100	57	6000	< 1
17/05/06	310	29	5400	< 1
14/08/06	980	58	3400	< 1
13/11/06	180	58	6000	3
Average	600	50	5200	< 1.1
Location:	**Central North Sea**			
21/02/06	1210	21	1200	< 1
15/05/06	190	34	100	< 1
24/08/06	630	45	770	6
19/12/06	240	69	440	10
Average	600	42	600	4
Location:	**Delta Coastal Waters**			
05/01/06	540	110		
23/02/06	620	72	6400	< 1
17/03/06	930	84		
27/04/06	990	20		
15/05/06	240	41	6100	< 1
13/06/06	1120	34		
20/07/06	420	35		
14/08/06	460	49	6900	9
18/09/06	380	100		
11/10/06	570	57		
15/11/06	820	53	5500	< 1
20/12/06	340	69		
Average	620	60	6200	< 3
Location:	**Westerscheldt**			
11/01/06	610	100	5300	< 1
06/02/06	1000	110	6900	< 1
09/03/06	1010	30	7400	< 1
06/04/06	950	84	6400	< 1
01/05/06	640	130	9000	< 1
01/06/06	1190	53	6200	< 1
28/06/06	450	80	6300	1
25/07/06	580	46	6600	1
21/08/06	250	54	6700	4
19/09/06	280	68	6600	2
17/10/06	520	41	5400	< 1
13/11/06	290	48	5900	1
13/12/06	670	77	7300	2
Average	640	71	6600	1.2

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**			
07/02/06	430	69	3900	
10/05/06	440	39	7000	
17/08/06	560	36	4700	
17/11/06	120	34	6300	
Average	390	44	5500	
Location:	**Wadden Sea West**			
13/02/06	1060	69	5400	
09/05/06	390	37	6000	
09/08/06	1340	57	3400	
21/11/06	310	76	5400	
Average	800	60	5000	
Location:	**Wadden Sea East**			
09/02/06	660	270	5000	
12/05/06	1010	37	5400	
30/08/06	940	120	3600	
15/11/06	270	79	5800	
Average	720	130	5000	

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

Date	**^{137}Cs $Bq{\cdot}kg^{-1}$**	**^{210}Po $Bq{\cdot}kg^{-1}$**
Location:	**Coastal area**	
13/02/06	9	120
15/05/06	n/a	n/a
14/08/06	7	87
13/11/06	9	100
Average	8.3	102
Location:	**Westerscheldt**	
07/02/06	5	61
14/06/06	6	78
21/08/06	5	70
14/11/06	5	71
Average	5.2	70
Location:	**Eems-Dollard**	
06/02/06	8	98
14/06/06	8	110
01/08/06	7	99
02/11/06	8	100
Average	7.8	102
Location:	**Wadden Sea East**	
10/02/06	6	120
14/06/06	2	34
21/08/06	5	83
15/11/06	5	84
Average	4.5	80

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 solely a range (lower and upper limit) is given instead of a total with an uncertainty. Both range and total with an uncertainty are presented with a 68% confidence level.

The lower and upper limits are calculated as follows:

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

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

where

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

The detection limits are omitted in the calculation of the averages. If no data are reported (e.g. no sample is analysed) the sampling period is not taken into account for the calculation of the sum or average.

B.3 Calculation of 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.

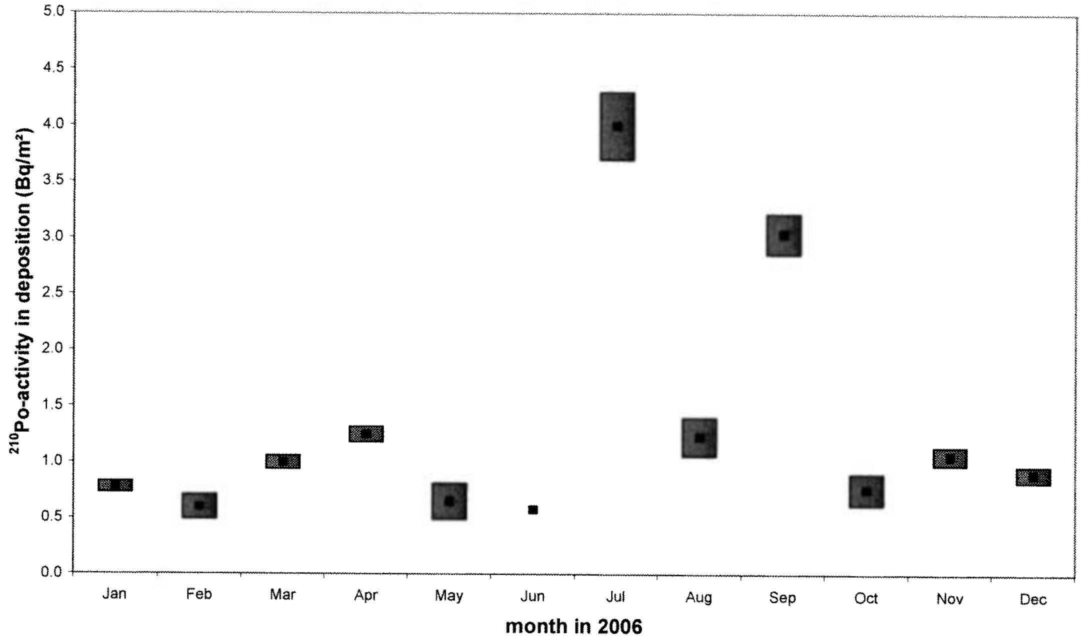
Erratum report 610791001/2007

The ^{210}Po results for 2006 have been revised. Due to an increasing influence of a ^{209}Po impurity in the ^{208}Po tracer (used in the analysis of ^{210}Po) a correction has been applied. As a result the underlying results have changed to:

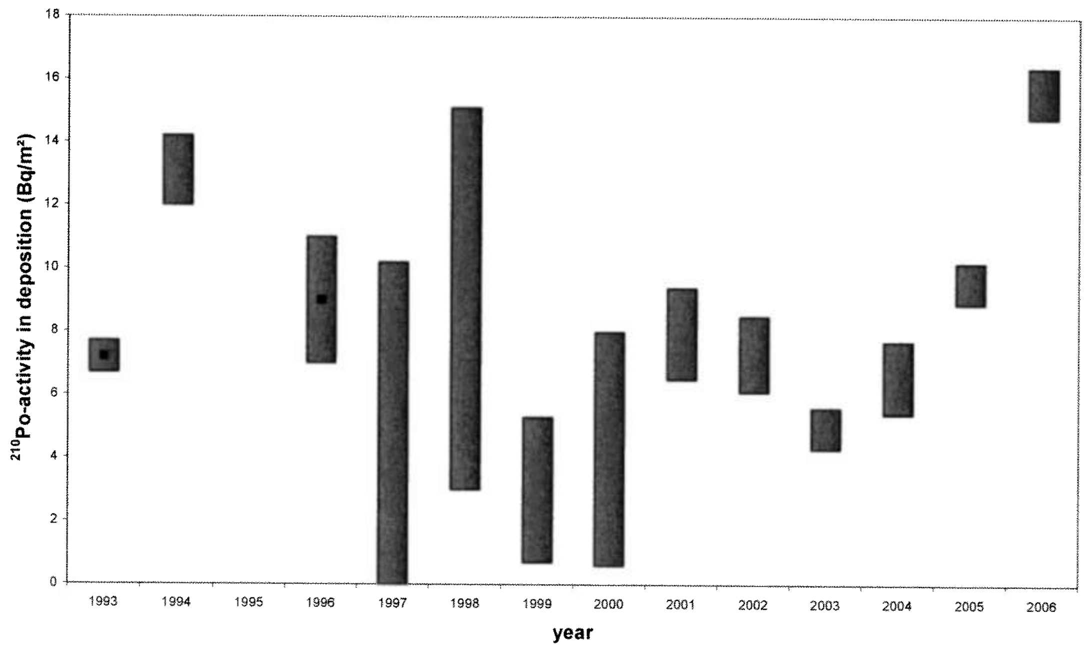
p.11 Table S1; in the column Values 14.8 – 16.4 Bq·m^{-2} for ^{210}Po in deposition.

p.26 3rd line; "…in 2006 ranged between 14.8 – 16.4 Bq·m^{-2} (68% confidence level)."

p.27 Figure 3.6;



p.27 Figure 3.7;



p.78 Table A6;

Month		^{210}Po Bq·m^{-2}		
January		0.78	±	0.05
February		0.60	±	0.11
March		1.00	±	0.06
April		1.25	±	0.07
May		0.65	±	0.16
June	<	0.58		
July		4.0	±	0.3
August		1.23	±	0.17
September		3.04	±	0.18
October		0.76	±	0.14
November		1.06	±	0.08
December		0.90	±	0.07
Total		-		
Lower limit (2)		14.8		
Upper limit (2)		16.4		

p.78 Table A7; in the column ^{210}Po in deposition 14.8 – 16.4 Bq·m^{-2} for 2006.

Ter akkoord

Paraaf Projectleider: [signature]

Datum: 27-10-2010

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