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Monitoring of radiation in the environment in the Netherlands
Results in 2003

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Rapport in het kort

Monitoring van straling in het milieu in Nederland
Resultaten in 2003

Dit rapport presenteert de resultaten van radioactiviteitsmetingen in het Nederlandse milieu in 2003. Radioactiviteit werd gemeten in belangrijke onderdelen van het leefmilieu van de mens zoals luchtstof, depositie, oppervlaktewater, zeewater, drinkwater, melk en voedsel. In het kader van het Euratom Verdrag uit 1957 is de Nederlandse overheid verplicht om radioactiviteitsgehaltes te meten in de compartimenten lucht, water en bodem. De resultaten van de radioactiviteitsmetingen liggen in het bereik van voorgaande jaren. Vergeleken met de aanbevelingen van de Europese Unie blijkt dat het Nederlandse meetprogramma op een aantal punten tekortschiet, met name voor wat betreft controle van drinkwater, melk en overige voedingsmiddelen.

Trefwoorden: radioactiviteit, milieu, luchtstof, water, voedsel

Abstract

Monitoring of radiation in the environment in the Netherlands
Results in 2003

This report presents the results of radioactivity measurements in the Dutch environment in 2003. Radioactivity measurements were carried out on important compartments of the environment like airborne particles, deposition, surface water, seawater, drinking water, milk and food. The Dutch government is compelled to measure radioactivity in the environment under terms of the Euratom Treaty of 1957.
The results of the radioactivity measurements are within range of previous years. The Dutch monitoring program does not fully comply with the recommendations of the European Union, mainly concerning the measurement of drinking water, milk and food.

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

Preface

The following institutes have contributed to the report:

The National Institute for Public Health and the Environment (RIVM)
Data on air dust, deposition, ambient dose rates and drinking water.
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The National Institute for Coastal and Marine Management (RIKZ)
Data on seawater.
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The Food and Consumer Product Safety Authority -
The Inspectorate for Health Protection and Veterinary Public Health (VWA/KvW)
Data on foodstuff.
ing. J.A.M. Geertsen.

Contents

Samenvatting

In het kader van het Euratom Verdrag uit 1957 is de Nederlandse overheid verplicht om radioactiviteitsgehaltes 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 radioactiviteitsmetingen in het Nederlandse milieu in 2003. De metingen zijn verricht door RIVM, RIZA, RIKZ en de Voedsel en Waren Autoriteit.

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, ^{134}Cs, ^{137}Cs, ^{210}Pb en ^{210}Po. Totaal-α respectievelijk totaal-β is de totale activiteit aan α- dan wel β-straling uitzendende nucliden. De resultaten zijn weergegeven in *Tabel S1*.

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

In oppervlaktewater werd de jaargemiddelde activiteitsconcentratie bepaald van ^{3}H en rest-β (totaal-β minus het van nature aanwezige ^{40}K). Daarnaast werd in oppervlaktewater de jaargemiddelde activiteitsconcentratie bepaald van ^{137}Cs 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 ^{3}H-activiteitsconcentratie overschreed in de Maas in acht van de dertien genomen monsters de streefwaarde van 10 Bq·L^{-1}. Het jaargemiddelde (22,1 Bq·L^{-1}) ligt in het bereik van voorgaande jaren. De ^{3}H-activiteitsconcentratie in de Schelde overschreed in twee van de zeven genomen monsters de streefwaarde. Het jaargemiddelde (10,2 Bq·L^{-1}) ligt in het bereik van voorgaande jaren.

Gangbare waarden die in ruw water voor de drinkwaterproductie gevonden worden, zijn weergegeven in *Tabel S1*. In dit water is weinig kalium, en dus ^{40}K, aanwezig.
In 2003 zijn radioactiviteitsmetingen verricht aan melk, melkpoeder en een aantal voedingsproducten. De resultaten zijn weergegeven in *Tabel S1*.

Vergeleken met de aanbevelingen van de Europese Unie blijkt dat het Nederlandse meetprogramma op een aantal punten tekortschiet, met name voor wat betreft controle van drinkwater, melk en overige voedingsmiddelen.

Summary

The Dutch government is compelled to measure radioactivity in air, water and soil under the terms of the Euratom Treaty of 1957. In 2000 the European Union specified this treaty by means of recommendations, in which is described the matrices to be measured (air dust, ambient dose equivalent rate, surface water, drinking water, milk and food) and the frequency of the measurements. The results should be published yearly. This report presents the results of radioactivity measurements in the Dutch environment in 2003. The measurements were carried out by RIVM, RIZA, RIKZ and the Food and Consumer Product Safety Authority.

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, ^{134}Cs, ^{137}Cs, ^{210}Pb and ^{210}Po. Gross α respectively gross β is the total activity of nuclides emitting α- respectively β-radiation. The results are presented in *Table S1*.

The National Radioactivity Monitoring Network (NMR) was used to determine the activity concentrations in air of gross α and artificial β (β-radiation emitted by man-made nuclides). The difference between the NMR data and those mentioned above is mainly due to the contribution of short-lived natural radionuclides (radon daughters). The yearly averaged gross α-activity concentration in air dust was 4.3 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 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 ^{3}H and residual β (gross β minus naturally occurring ^{40}K) were determined in surface water. The yearly averaged activity concentration of ^{137}Cs was determined in suspended solids in surface water. In seawater the yearly averaged activity concentration was 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 ^{3}H-activity concentration in the Meuse exceeded the target value (10 Bq·L^{-1}) in eight out of thirteen samples taken. However the yearly average (22.1 Bq·L^{-1}) is within range of previous years. The ^{3}H-activity concentration in the Scheldt exceeded the target value in two out of seven samples taken. The yearly average (10.2 Bq·L^{-1}) is within range of previous years.

Typical activities found in raw input water for drinking water production are presented in *Table S1*. There is little potassium, and thus ^{40}K, present in this water.
In 2003 radioactivity measurements were performed on milk, powdered milk and food products. The results are presented in *Table S1*.

The Dutch monitoring program does not fully comply with the recommendations of the European Union, mainly concerning the measurement of drinking water, milk and food.

Tabel S1: Overzicht van de resultaten in 2003.
Table S1: Summary of the results in 2003.

Matrix	Parameter	Location	Values	Frequency (per year)
Air dust [1]	Gross α	1	0.06 mBq·m^{-3}	52
	Gross β	1	0.467 mBq·m^{-3}	52
	^{7}Be	1	3.460 mBq·m^{-3}	52
	^{137}Cs	1	<0.002 mBq·m^{-3} [2]	52
	^{210}Pb	1	0.506 mBq·m^{-3}	52
Deposition [3]	Gross α	1	15.8 Bq·m^{-2}	12
	Gross β	1	70 Bq·m^{-2}	12
	^{3}H	1	<1020 Bq·m^{-2} [4]	12
	^{7}Be	1	1020 Bq·m^{-2}	52
	^{134}Cs	1	<0.1 Bq·m^{-2} [2]	52
	^{137}Cs	1	<0.1 Bq·m^{-2} [2]	52
	^{210}Pb	1	93 Bq·m^{-2}	52
	^{210}Po	1	5.1 Bq·m^{-2}	12
Surface water [1]	Residual β	3	0.014-0.080 Bq·L^{-1}	13
	^{3}H	3	5.0-22.1 Bq·L^{-1}	7 or 13 [5]
	^{137}Cs	4	9-19 Bq·kg^{-1}	7, 13 or 52 [5]
Seawater [1]	Gross α	8	393-573 mBq·L^{-1}	4, 12 or 13 [5]
	Residual β	8	53-119 mBq·L^{-1}	4, 12 or 13 [5]
	^{3}H	8	460-5100 mBq·L^{-1}	4 or 13 [5]
	^{90}Sr	4	1.5-5.5 mBq·L^{-1}	4 or 13 [5]
	^{137}Cs	5	6-12 Bq·kg^{-1}	2, 3 or 4 [5]
	^{210}Po	5	71-108 Bq·kg^{-1}	2, 3 or 4 [5]
Drinking water [2]	Gross β	175	<0.3 Bq·L^{-1}	706
	Residual β	144	<0.3 Bq·L^{-1}	602
	^{3}H	8	<5 Bq·L^{-1}	99
Milk [6, 7]	^{137}Cs	-	n.d.	23 (0) [8]
Powdered milk	^{137}Cs	-	24-50 Bq·kg^{-1}	62 (8) [8]
Food [6, 7]				
Various kinds of honey	^{137}Cs	-	12-462 Bq·kg^{-1}	169 (15) [8]
Game and poultry	^{137}Cs	-	25, 198, 283 Bq·kg^{-1}	29 (3) [8]
Fish	^{137}Cs	-	24-46 Bq·kg^{-1}	24 (5) [8]
Dried mushrooms	^{137}Cs	-	85 and 297 Bq·kg^{-1}	61 (2) [8]
Fruit	^{137}Cs	-	152 Bq·kg^{-1}	3 (1) [8]
Nuts and seeds	^{137}Cs	-	9 Bq·kg^{-1}	7 (1) [8]

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

1. Introduction

Levels of radioactive nuclides of natural origin, such as ^{40}K and daughters from the uranium and thorium series may be enhanced as a result of human activities, e.g. emissions from factories processing ores. Man-made radionuclides are found in the environment due to, for example, nuclear weapons tests or discharges from nuclear installations. It is advisable to monitor radiation in the environment to provide knowledge of levels of radiation under normal circumstances and to look out 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 2003. 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 the Chapters the results will, in general, be presented in graphs and tables. More detailed tables are presented in Appendix A.
Chapters 2 to 8 have been subdivided according to the structure of the Recommendation on the Application of Article 36 of the Euratom Treaty [1], and give the results of measurements for various environmental compartments. In chapter 9 general conclusions are presented.

2. Airborne particles

The 2003 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].

Table 2.1: Monitoring program in 2003 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 Gross α- and β-activity

The weekly results of gross α- and β-activity concentrations in air dust are given in *Figure 2.1* and *Table A1* (see Appendix A). Due to large uncertainties caused by variations in dust thickness on the filters, gross α-activity concentrations in air dust should be regarded as indicative values [5]. The period between sampling and analysis is 5 to 10 days, which is long compared to the decay time of the short-lived decay products of ^{222}Rn and ^{220}Rn. This is to ensure that these naturally occurring decay-products do not contribute to the measured α- and β-activity concentrations. Usually there is a good correlation between high activity concentrations of gross β and high activity concentrations of ^{210}Pb (*Figure 2.7*) as is the case in week 38 of 2003.

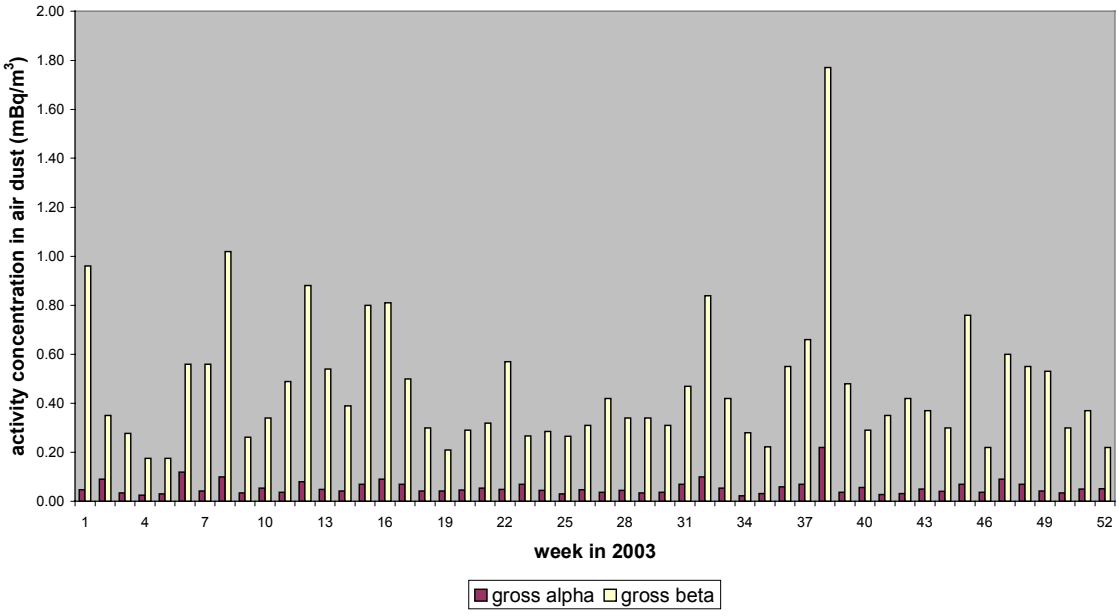


Figure 2.1: Weekly results of gross α- and β-activity concentrations of long-lived nuclides in air dust sampled at RIVM in 2003.

The frequency distributions of gross α-activity and gross β-activity concentrations in air dust are given in *Figures 2.2* and *2.3*, respectively.

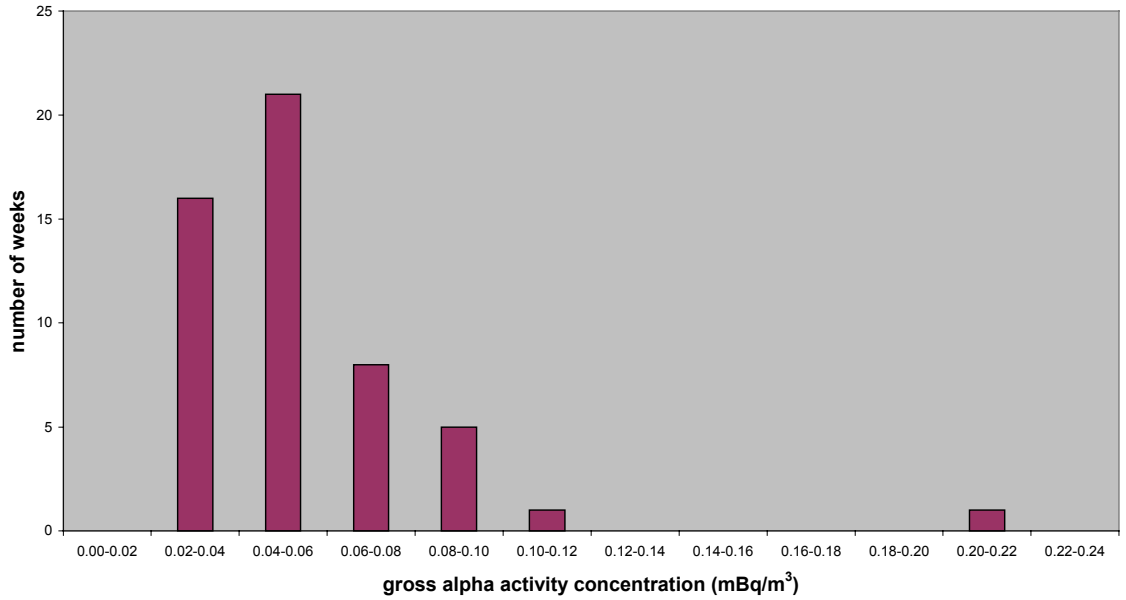


Figure 2.2: Frequency distribution of gross α-activity concentration of long-lived nuclides in air dust collected weekly at RIVM in 2003. The yearly average is 0.06 (SD=0.03) mBq·m^{-3}. SD is the standard deviation and illustrates the variation in weekly averages during the year.

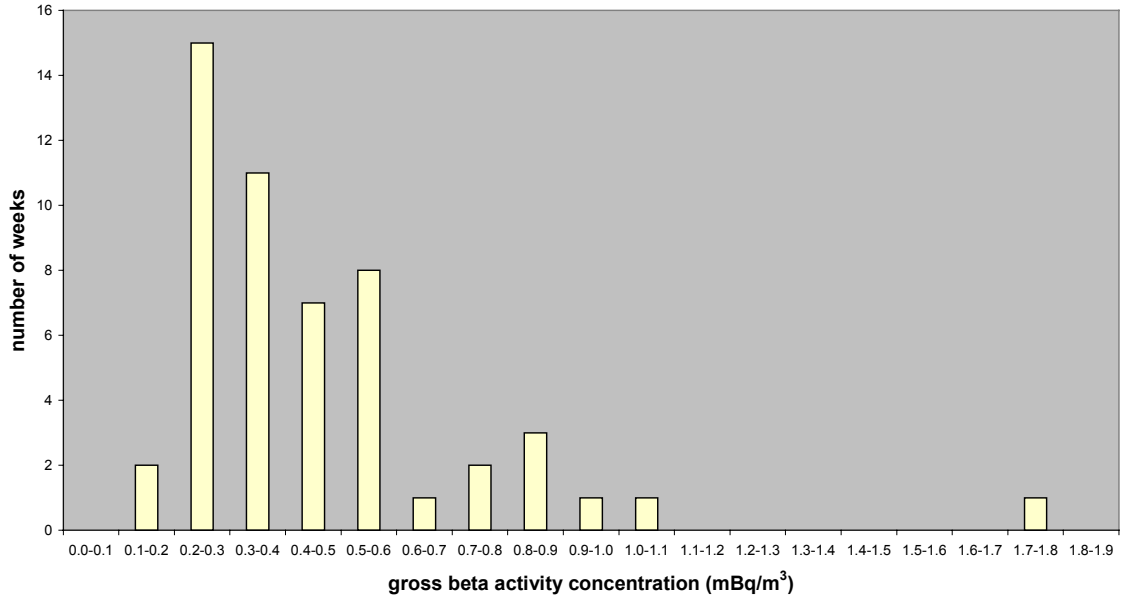


Figure 2.3: Frequency distribution of gross β-activity concentration of long-lived nuclides in air dust collected weekly at RIVM in 2003. The yearly average is 0.467 ± 0.005 (SD=0.3) mBq·m^{-3}.

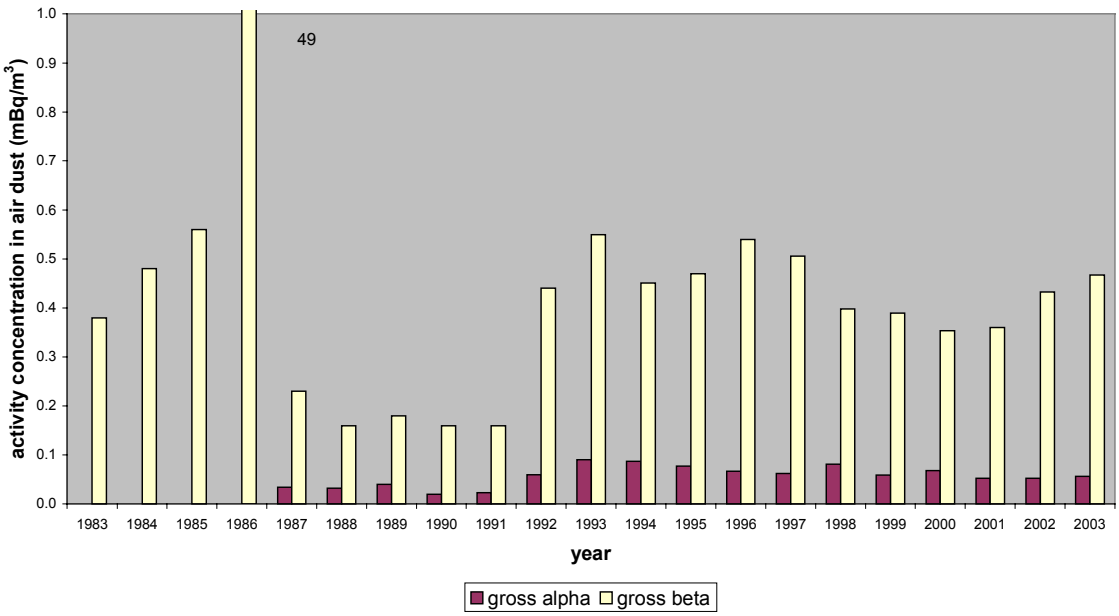


Figure 2.4: Yearly averages of gross α- and gross β-activity concentration of long-lived nuclides in air dust from the outset of the respective monitoring campaigns. The high level in 1986 was caused by the accident at the Chernobyl nuclear power plant.

The yearly averages of the gross α- and β-activity concentrations of long-lived nuclides in 2003 are within the range of the results from the period 1992-2002 [6].
Figure 2.4 shows an apparent change in the activity concentrations in 1987. This is caused by an alteration in the measuring technique since mid 1986 [7]. Due to this alteration in measuring technique gross α data came available. The year 1992 was the start of yet a different sampling procedure (sampling of air dust with a High Volume Sampler) and sample treatment which resulted in another change in the measurement results [8]. The results between mid 1986 and 1992 are underestimates due to the different sampling procedure and sample treatment.

2.2 γ-Emitting nuclides

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

The behaviour of ^{7}Be in the atmosphere has been studied world-wide [9, 10, 11, 12, 13, 14, 15]. Natural ^{7}Be (half-life 53.3 days) is formed by spallation reactions of cosmogenic radiation with atmospheric nuclei, such as carbon, nitrogen and oxygen resulting in the formation of BeO or $Be(OH)_2$ molecules. Approximately 70% of ^{7}Be is produced in the stratosphere, with the remaining 30% being produced in the troposphere. A residence time is estimated at about one year in the stratosphere and about six weeks in the troposphere. Most of the ^{7}Be produced in the stratosphere does not reach the troposphere except during spring when seasonal thinning of the tropopause takes place at midlatitudes, resulting in air exchange between stratosphere and troposphere. In the troposphere ^{7}Be rapidly associates

mainly with submicron-sized aerosol particles. Gravitational settling and precipitation processes accomplish transfer to earth's surface. Seasonal variations in the concentration of ^{7}Be in surface air is influenced by the following main atmospheric processes: wet and dry deposition, mass exchange between stratosphere and troposphere, vertical transport in the troposphere and horizontal transport of air masses from the subtropics and midlatitudes into the tropics and polar regions.

The red line in *Figure 2.5* shows the seasonal variation of the ^{7}Be-activity concentration, with peaks during the spring and summer periods, reflecting the seasonal variations in the transport rate of air from stratosphere to troposphere. *Figure 2.5* further shows the influence of the solar cycle. The maximum at 1997 and the minimum at 2000-2002 are consistent with the solar minimum (measured by radio flux and sunspot count) of 1996-1997 and the solar maximum of 2000-2002 [16]. Geomagnetic storms, a result of solar activities, are affected by the 11-year solar cycle. In the summer of 1991 two severe geomagnetic storms caused a significant world-wide disturbance of earth's geomagnetic field. This resulted in a considerable decrease in cosmogenic radiation, unprecedented in at least the previous four decades [17]. The absence of a 1991 summer peak in the ^{7}Be-activity concentration can be explained by the decrease in cosmogenic radiation.

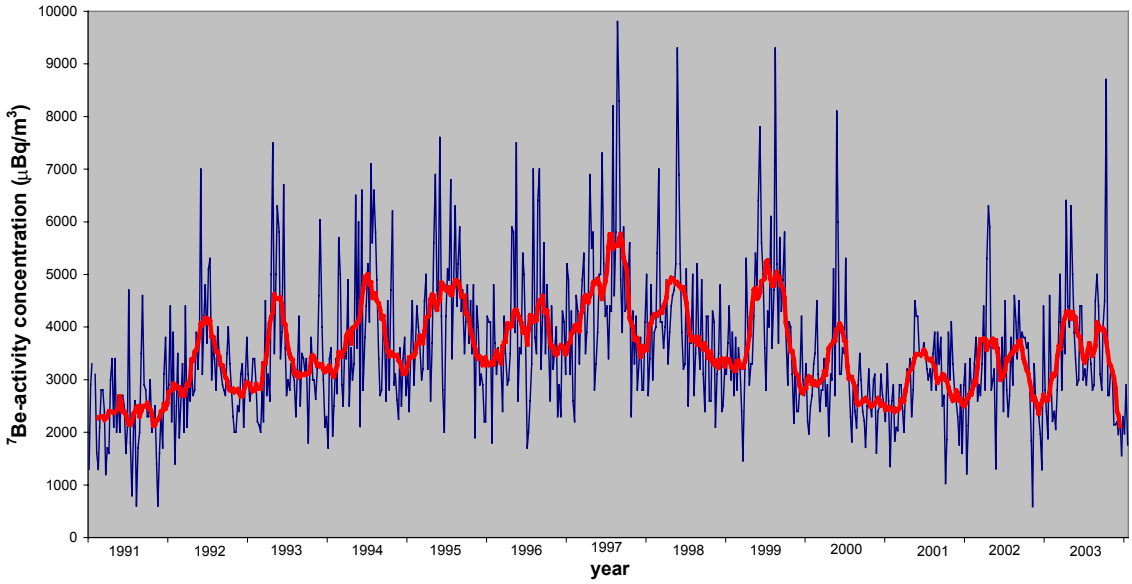


Figure 2.5: Weekly averaged activity concentrations (blue) of ^{7}Be in air dust at RIVM in 1991-2003. The red line represents a moving average of 13 weeks. Yearly average for 2003 is 3460 ± 50 (SD=1300) μBq·m^{-3}.

The concentrations found for ^{7}Be in 2003 fit in the pattern described above.

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 [18]. 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 [19]. On the 29th of May 1998 an incident occurred at Algeciras (Spain), an iron foundry melted a ^{137}Cs-source concealed in scrap metal [20]. 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 [20].

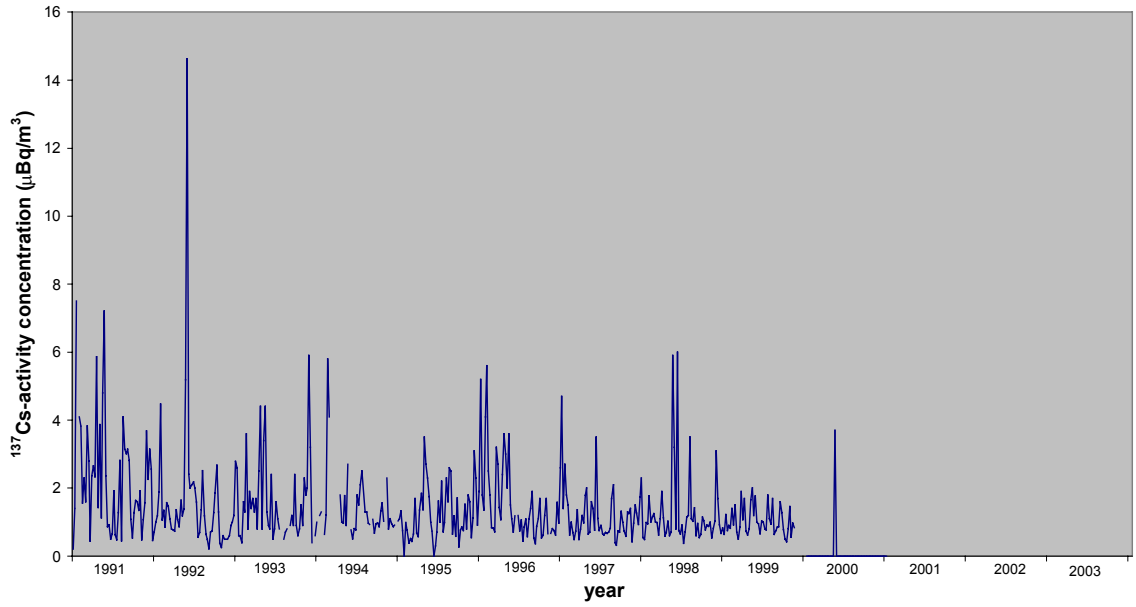


Figure 2.6: Weekly averaged activity concentrations of ^{137}Cs in air dust at RIVM in 1991-2003. In 2003 all measurements were below the detection limit. The detection limit was higher than during 1991-1999, due to a different detector set-up.

The primary source of atmospheric ^{210}Pb (half-life 22.3 years) is the decay of ^{222}Rn exhaled from continental surfaces. Therefore the atmospheric concentration of ^{210}Pb over the continental areas is in general higher than that over the oceanic ones (^{222}Rn exhalation from the ocean is 1000 times less than that from the continents). The reported reference value of ^{210}Pb in air dust is 500 µBq·m^{-3} [21]. In the atmosphere this radionuclide is predominantly associated with submicron-sized aerosols [22, 23]. The mean aerosol (carrying ^{210}Pb) residence time in the troposphere is approximately 5 days [24].

Other sources of ^{210}Pb in air dust are volcanic activity and industrial emissions [25, 26, 27, 28, 29]. 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 [27]. Volcanic eruptions bring U-decay products in the atmosphere like ^{226}Ra, ^{222}Rn, ^{210}Pb and ^{210}Po. Beks et al. [27] estimate that volcanoes contribute 60 TBq·year^{-1} to the atmospheric ^{210}Pb stock. If the volcanic deposition is evenly distributed world-wide, the contribution to the yearly total ^{210}Pb deposition would be negligible.

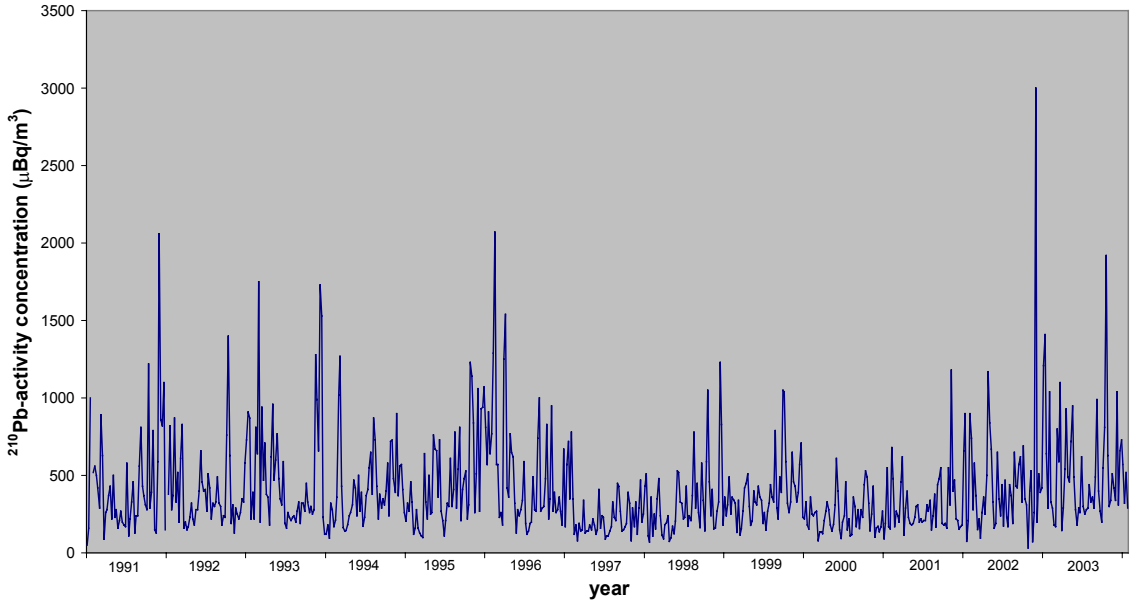


Figure 2.7: Weekly averaged activity concentrations of ^{210}Pb in air dust at RIVM in 1991-2003. Yearly average for 2003 is 506 ± 8 (SD=300) μBq·m^{-3}.

Unusual values might be explained by natural phenomena like an explosive volcanic eruption, Saharan dust [30, 31, 32] 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 [6]. Except for this sample there is a good correlation between high activity concentrations of ^{210}Pb and high activity concentrations of gross β, as is the case in week 38 of 2003 (1920 ± 170 μBq·m^{-3}).

The weekly averaged activity concentrations of ^{210}Pb in 2003 are within range of those found in previous years.

3. Deposition

The 2003 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.

Table 3.1: The 2003 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 Gross α- and β-activity

The monthly deposited gross α- and gross β-activities of long-lived nuclides are given in *Figure 3.1* and *Table A4*. The yearly total deposition of gross α and gross β was 15.8 ± 0.9 and 70 ± 2 $Bq \cdot m^{-2}$, respectively. These values do not differ significantly from those measured since 1983, as illustrated in *Figure 3.2* and *Table A5*. For gross α two out of twelve measurements were below the detection limit. The measuring technique for gross α and gross β was changed around mid 1986 [33], which makes it difficult to compare data before 1986 with data after 1986 [34].

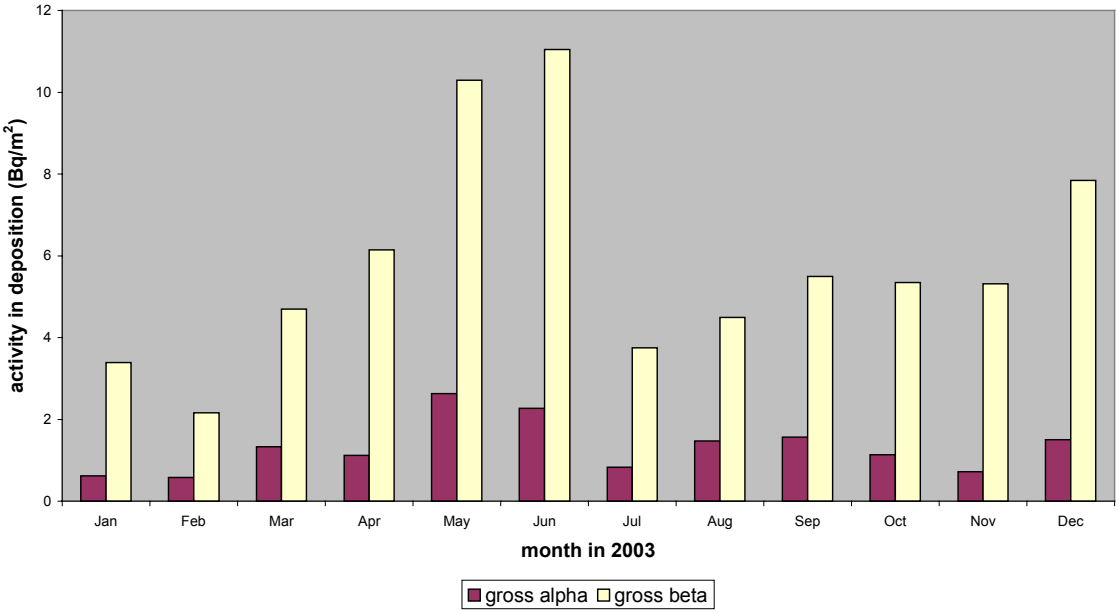


Figure 3.1: Monthly deposited gross α- and gross β-activity of long-lived nuclides at RIVM in 2003.

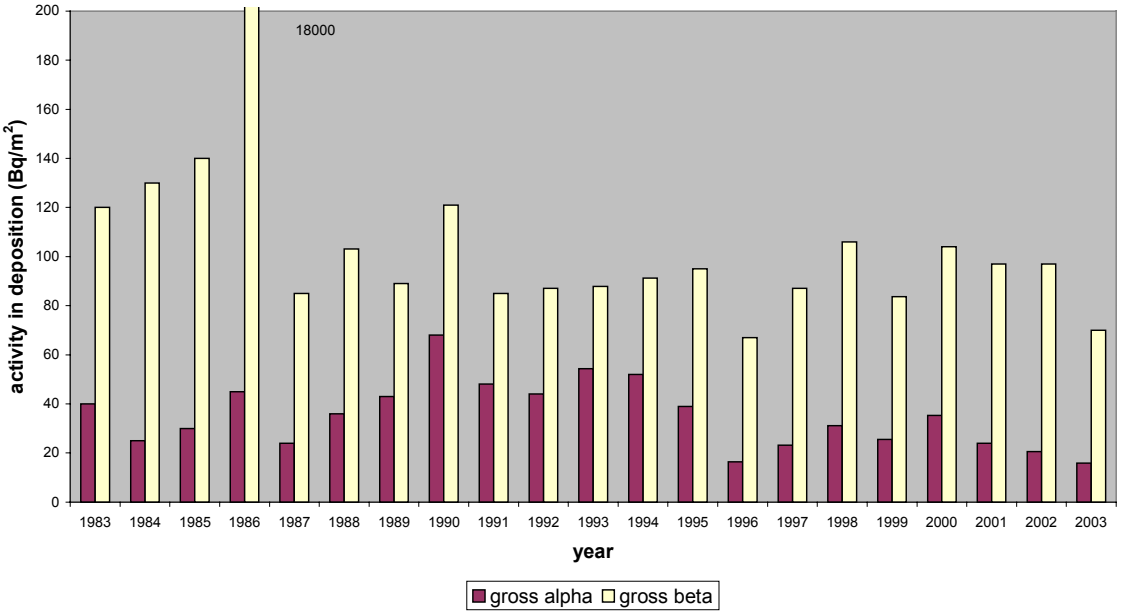


Figure 3.2: Yearly gross α- and gross β-activity of long-lived nuclides deposited at RIVM from 1983 to 2003 (see Table A5). The 1986 level resulted from the accident at the Chernobyl nuclear power plant.

The monthly deposition of ^{3}H is given in *Table A4*. In 2003 less than 1020 $Bq \cdot m^{-2}$ of ^{3}H was deposited. Eight out of twelve measurements were below the detection limit. Therefore detection limits were used for the calculation of the yearly total. From 2001 onward single analyses are carried out instead of duplicate. Together with a less stable background this resulted in a higher detection limit for ^{3}H in 2001 than in previous years. From 2002 onward measurements are carried out on a new Liquid Scintillation Counter. *Figure 3.3* shows the decay of ^{3}H after the end of the atmospheric nuclear weapons tests in the seventies.

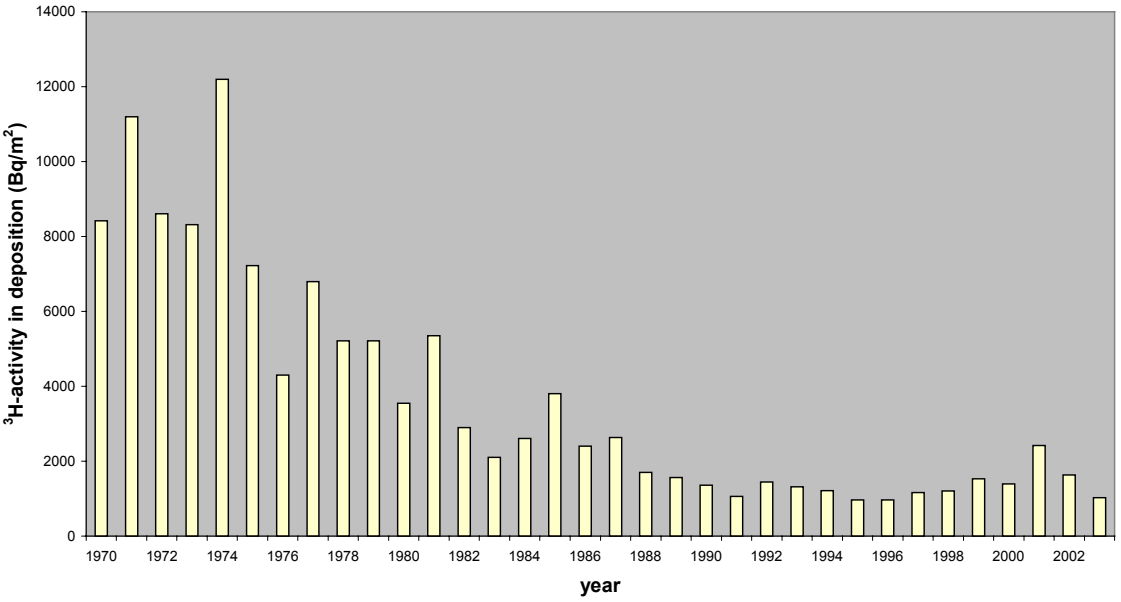


Figure 3.3: Yearly deposition of ^{3}H at RIVM in the period 1970-2003.

The monthly α-spectroscopy results for ^{210}Po are given in *Table A6*. The results for previous years are given in *Table A7*. In 2003 5.1 ± 0.6 Bq·m^{-2} of ^{210}Po was deposited. Because no ^{210}Po was detected in the August deposition, the detection limit was used for the August contribution to the year total.

3.2 γ-Emitting nuclides

Detectable quantities of the naturally occurring nuclides ^{7}Be and ^{210}Pb were found, with yearly total depositions of 1020 ± 20 and 93 ± 4 Bq·m^{-2}, respectively. The nuclides ^{134}Cs and ^{137}Cs were not found (detection limit is 0.1 Bq·m^{-2} for both nuclides). The weekly results for deposition of ^{7}Be and ^{210}Pb are given in *Table A8*. The results for previous years are given in *Table A7*. The correlation between the amount of precipitation and the deposition of ^{7}Be (*Figure 3.4)* is less clear than in previous years [35].

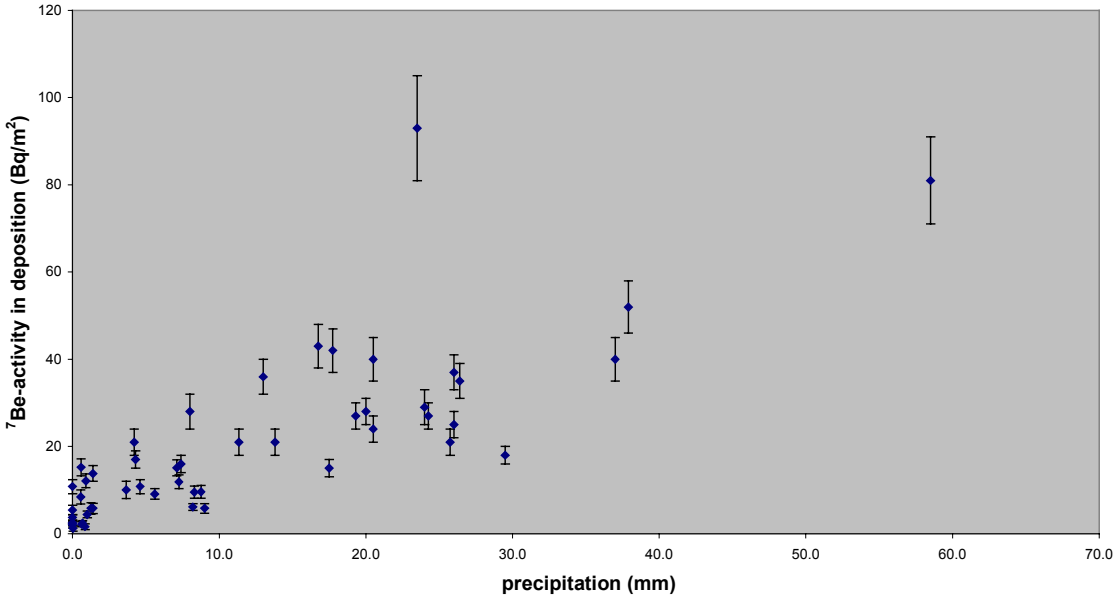


Figure 3.4: The weekly deposition of ^{7}Be at RIVM in 2003 versus precipitation.

The correlation between the amount of precipitation and the deposition of ^{210}Pb is even less clear (see *Figure 3.5*).

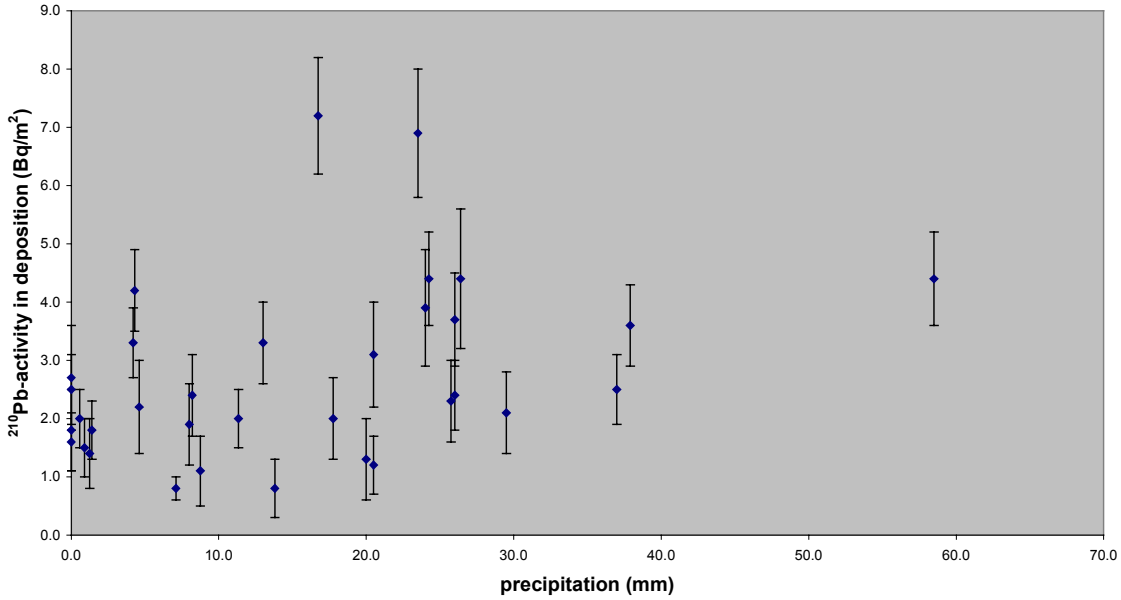


Figure 3.5: The weekly deposition of ^{210}Pb at RIVM in 2003 versus precipitation.

4. National Radioactivity Monitoring Network

This chapter presents data on gross α-activity concentrations, artificial β-activity concentrations in air and ambient dose equivalent rates as measured by the National Radioactivity Monitoring Network (Nationaal Meetnet Radioactiviteit). The data on gross α and artificial β differ in sample size, sampling frequency and analytical procedures from those given in the previous chapter. The difference between the NMR data and those mentioned in the previous chapter is mainly 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 163 ambient dose equivalent rate monitors [36]. 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 163 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 [37]. 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 [38]. 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 [37, 39] 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). A non-linear interpolation algorithm (and extrapolation using a grid) was applied to calculate values in between the NMR stations.

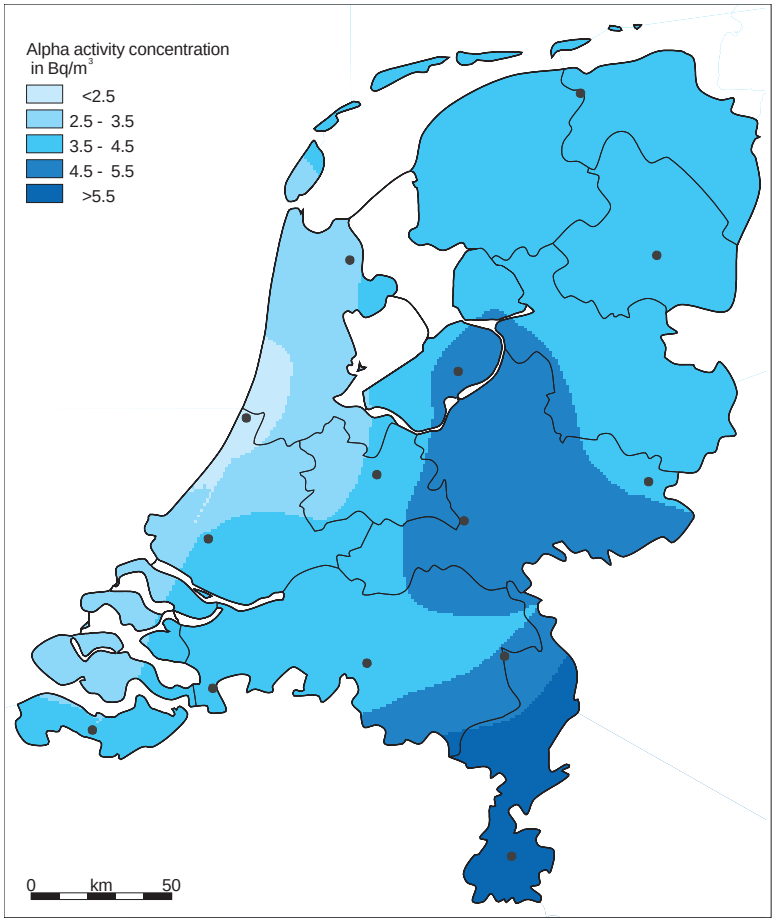


Figure 4.1: Spatial variation in the average gross α-activity concentration in air dust in 2003. The dots represent the locations of the aerosol monitors.

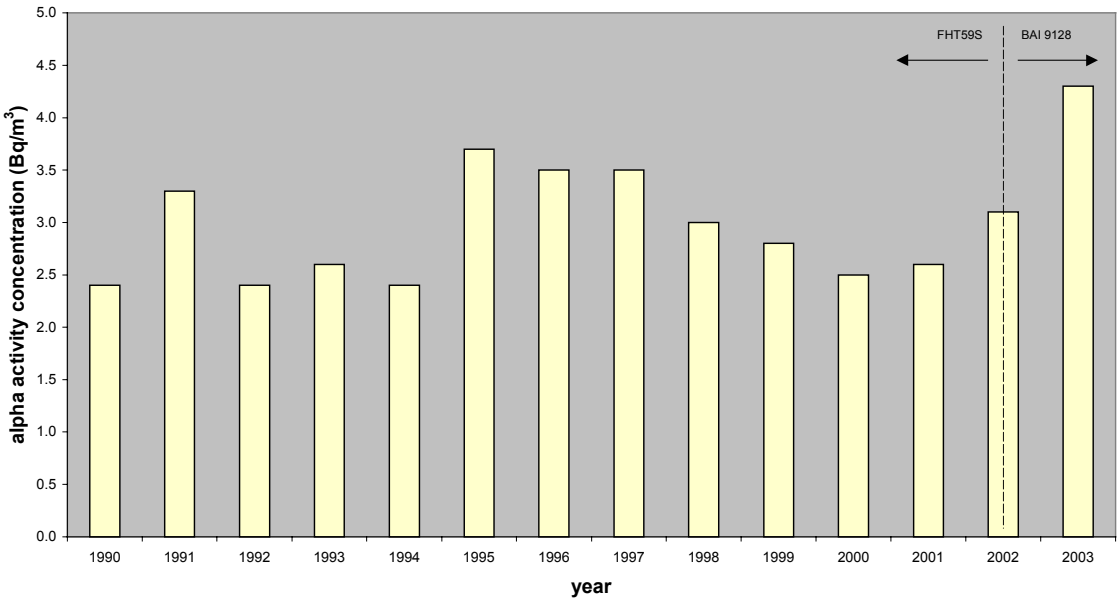


Figure 4.2: Yearly averages for gross α-activity concentration. During the second half of 2002 the FAG FHT59S monitors were gradually replaced by the Berthold BAI 9128 monitors. The Berthold monitor reports about 20% higher values than the FAG monitor. No correction is applied for the difference between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

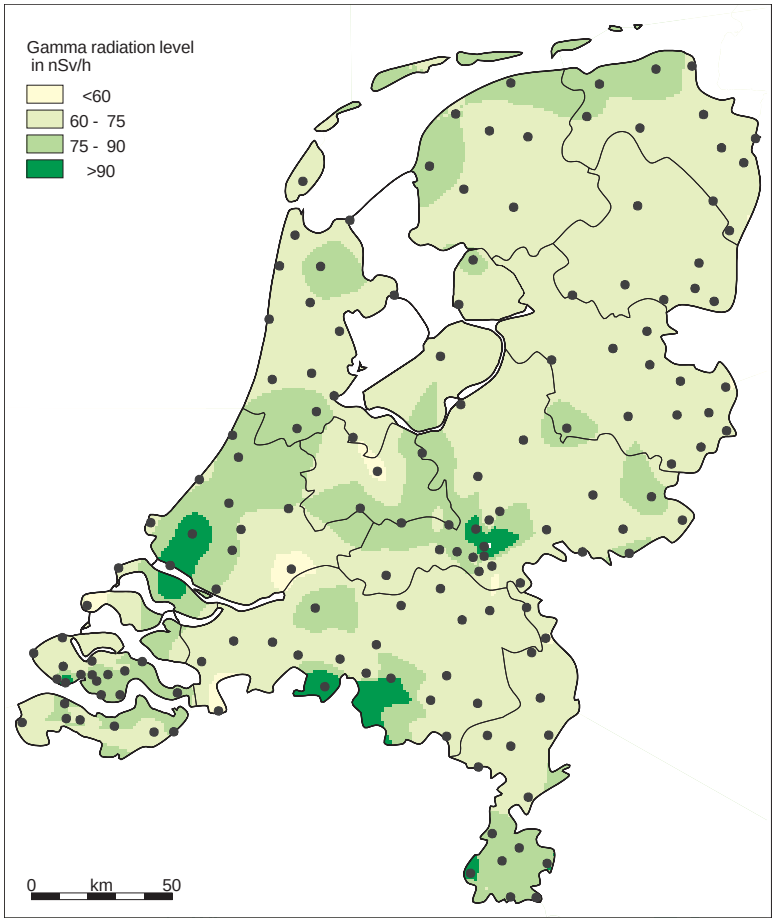


Figure 4.3: Spatial variation in the average ambient dose equivalent rate in 2003. The dots represent the locations of the dose equivalent rate monitors.

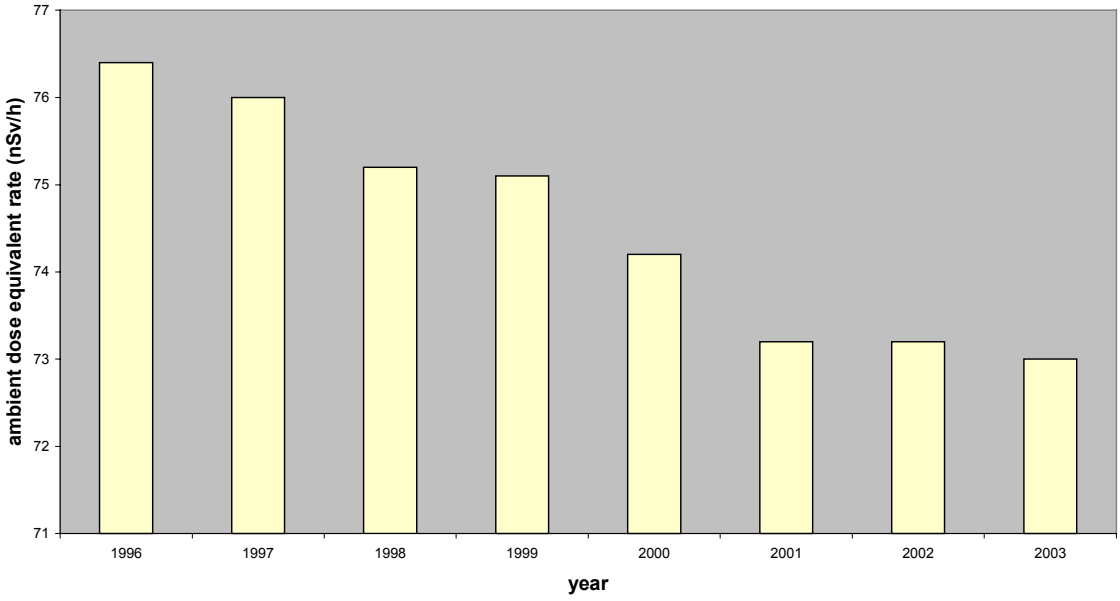


Figure 4.4: Yearly averages of the ambient dose equivalent rate.

Figures 4.2 and *4.4* present the yearly averages of gross α-activity concentration and ambient dose equivalent rate from 1990 to 2003, respectively. The yearly averaged gross α-activity concentration in air dust was 4.3 $Bq \cdot m^{-3}$ (based on the yearly averages of the 14 measurement locations). To compare with previous years (except 2002) it should be noted that the Berthold values are 20% higher than FAG values, and the value can be corrected to 3.6 $Bq \cdot m^{-3}$. 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.

Since 1996 the analysis of the ambient dose equivalent rate has been based on the set of 163 stations. The yearly averaged ambient dose equivalent rate in 2003 is calculated using 154 stations. The remaining 9 stations were not operational. Some of these stations are part of the so-called ring around the nuclear powerplant Dodewaard. The powerplant stopped operation in March 1997. The last of the nuclear fuel was removed in April 2003. Therefore these stations are dismantled or will be dismantled in the near future.

For the ambient dose equivalent rate the yearly averaged measured value was 73 $nSv.h^{-1}$. 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 ambient dose equivalent rate. The decrease in the ambient dose rate equivalent (as given by the NMR) during 1996 to 2003 (*Figure 4.4*) might be related to the decrease in the cosmogenic contribution.

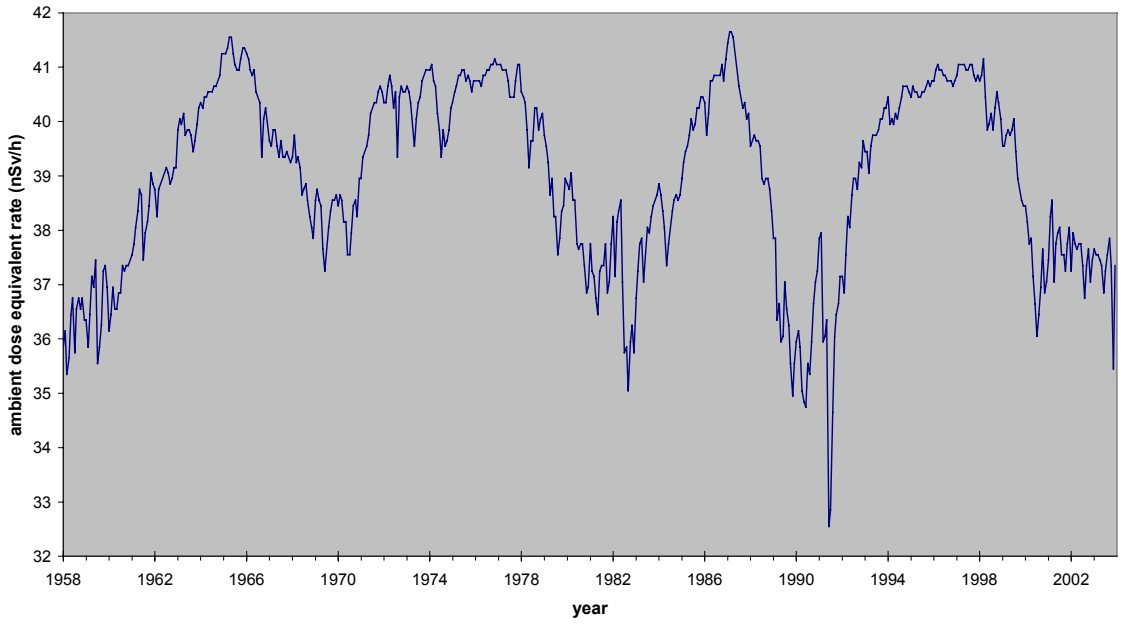


Figure 4.5: Cosmogenic contribution to the ambient dose equivalent rate (at sea level), influenced by the solar cycle. Location 51° 26' north latitude and 3° 43' eastern longitude, air pressure 1019 hPa. Figure derived from data supplied by Office of Aerospace Medicine [40]. In May 2004 the Office of Aerospace Medicine introduced a new algorithm to calculate the heliocentric potential, this results in a difference of ± 1 $nSv.h^{-1}$ compared to the data used in the previous report [6]. The new algorithm causes a greater change at the maxima than at the minima. The change in algorithm causes the average from 1958-2002 to change from 38.5 to 39.0 $nSv.h^{-1}$.

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 [41, 42, 43].

The locations presented in this report have been chosen to represent the major inland waters and seawater. The 2003 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 random times.

Table 5.1: Monitoring program for the determination of radioactive nuclides in surface water in 2003.

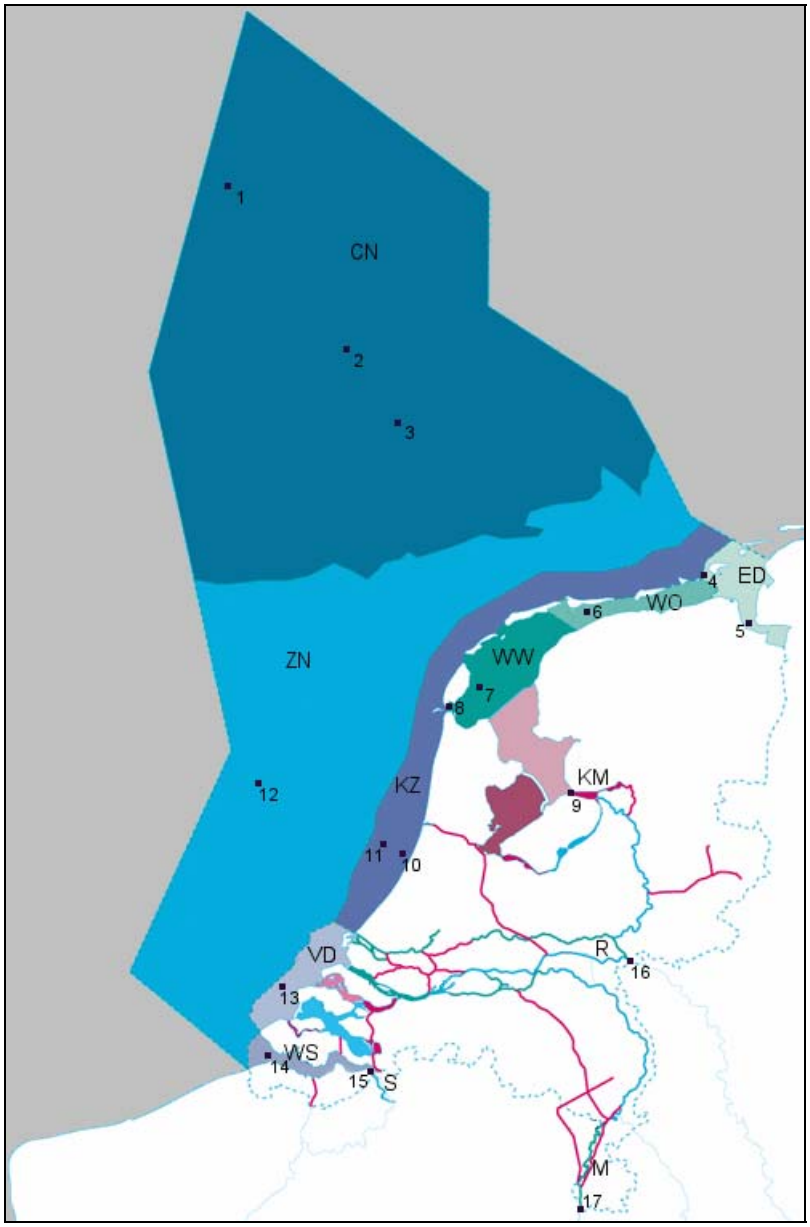
Location	Parameter	Compartment	Monitoring frequency (per year)
Meuse	Residual β	Water	13
(Eijsden)	^{3}H	Water	13
	^{137}Cs	Suspended solids	52
Rhine	Residual β	Water	13
(Lobith)	^{3}H	Water	13
	^{137}Cs	Suspended solids	14
Scheldt	Residual β	Water	13
(Schaar van Ouden Doel)	^{3}H	Water	7
	^{137}Cs	Suspended solids	13
Ketelmeer West	^{137}Cs	Suspended solids	7

The results for surface water are presented in *Tables A11* and *A12* and in *Figures 5.2 to 5.7*. The results for seawater are presented in *Tables A13* and *A14* and in *Figures 5.8* to *5.19*.
The samples were analysed at the RIZA laboratory in Lelystad. The radioactive nuclides were determined according to standard procedures [42] and [44]. 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") [45]. The yearly averages are compared with these target values.

Table 5.2: Monitoring program for the determination of radioactive nuclides in seawater in 2003.

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	2 (2)
		^{210}Po	Suspended solids	2 (2)
Southern North Sea (ZN)	Noordwijk 70 (1)	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{90}Sr	Water	4
Central North Sea (CN)	Terschelling 235 (1)	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{90}Sr	Water	4
Delta Coastal Waters (VD)	Schouwen 10 (1)	Gross α	Water	12
		Residual β	Water	12
		^{3}H	Water	4
		^{90}Sr	Water	4
Westerscheldt (WS)	Vlissingen Boei	Gross α	Water	13 (3)
		Residual β	Water	13 (3)
		^{3}H	Water	13 (3)
		^{90}Sr	Water	13 (3)
		^{137}Cs	Suspended solids	3 (2)
		^{210}Po	Suspended solids	3 (2)
Eems-Dollard (ED)	Huibergat Oost	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
	Bocht van Watum	^{137}Cs	Suspended solids	4
		^{210}Po	Suspended solids	4
Wadden Sea West (WW)	Marsdiep Noord	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
	Doove Balg West	^{137}Cs	Suspended solids	- (2)
		^{210}Po	Suspended solids	- (2)
Wadden Sea East (WO)	Dantziggat	Gross α	Water	4
		Residual β	Water	4
		^{3}H	Water	4
		^{137}Cs	Suspended solids	3 (2)
		^{210}Po	Suspended solids	3 (2)

(1) Number indicates distance from shore. For example Noordwijk 2 means Noordwijk 2 km offshore.
(2) Normally 4 times per year. Not all measurements could be performed due to insufficient amount of collected suspended solids.
(3) Normally 12 times per year.



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:
KM = Ketelmeer
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 = Ketelmeer West
10 = Noordwijk 2
11 = Noordwijk 10
12 = Noordwijk 70
13 = Schouwen 10
14 = Vlissingen Boei
15 = Schaar van Ouden Doel
16 = Lobith
17 = 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 [42].

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 Meuse, Rhine and Scheldt are monitored at Eijsden, Lobith and Schaar van Ouden Doel, respectively.

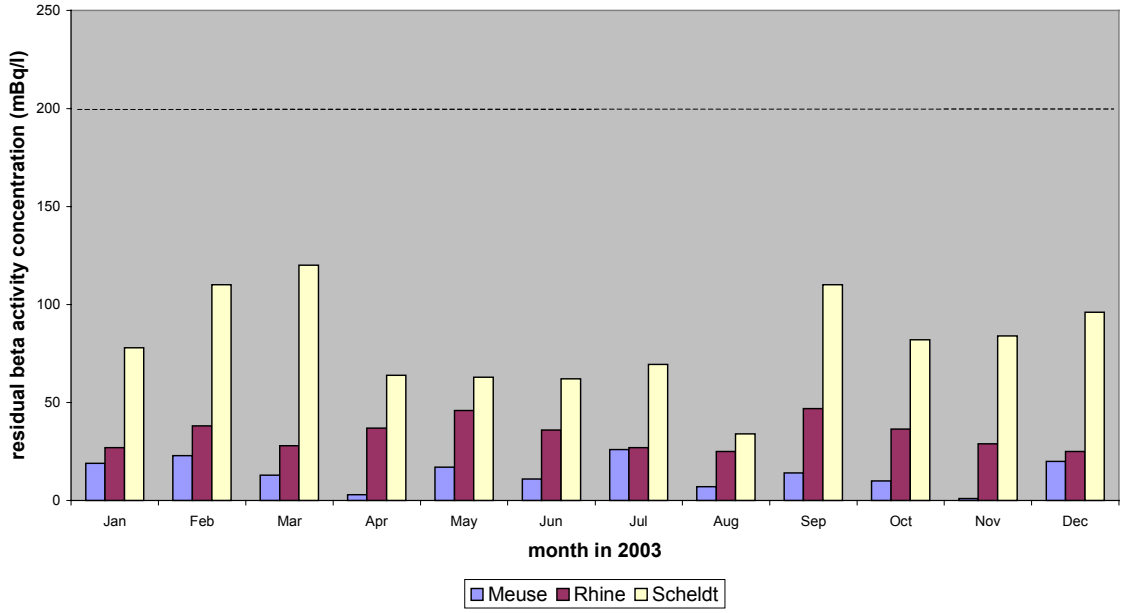


Figure 5.2: The residual β-activity concentration in 2003 for the Meuse, Rhine and Scheldt, with yearly averages of 14, 34 and 80 mBq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value [45].

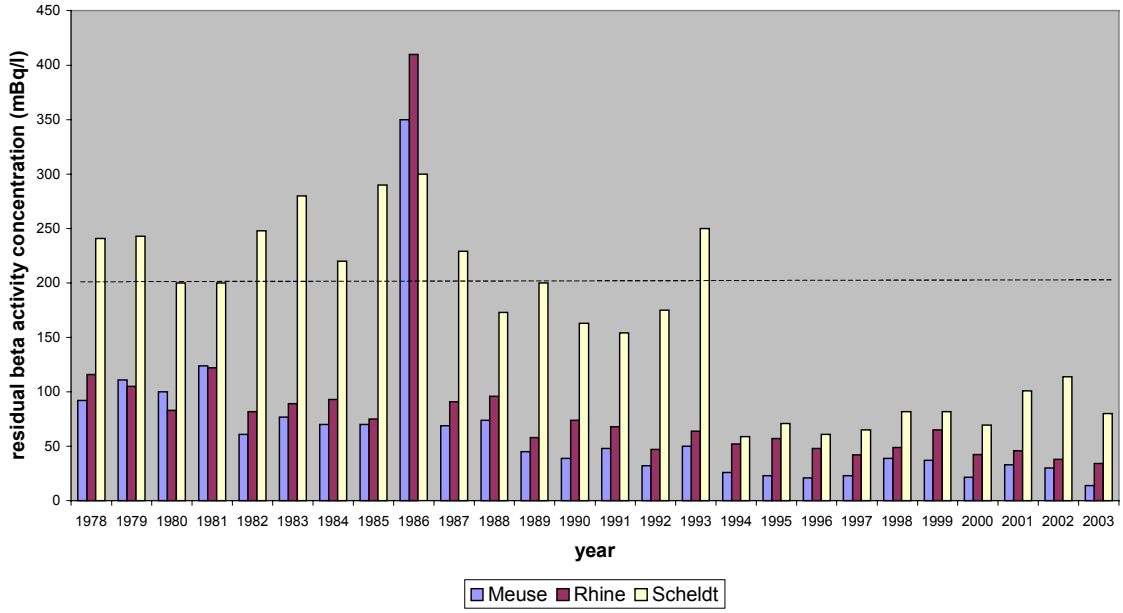


Figure 5.3: Yearly averaged residual β-activity concentrations.

The yearly averaged concentrations of residual β in 2003 are within the range of those in previous years. The averaged residual β-concentrations are below the target value of 200 mBq·L^{-1}. Residual β in the 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 [42]. Therefore, no change in trend is shown for the Meuse and the Rhine.

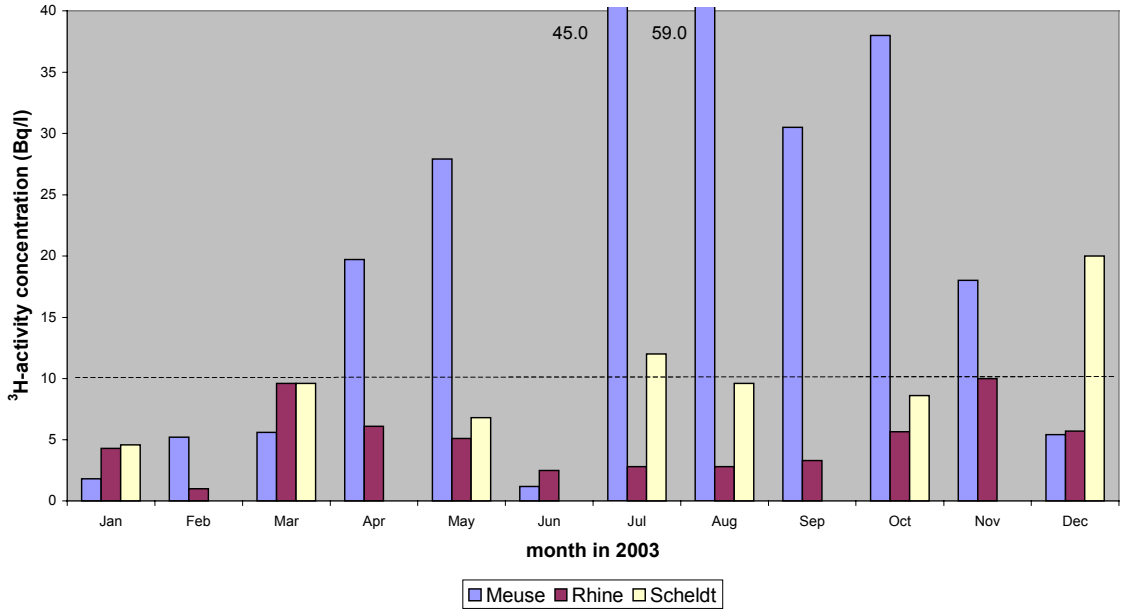


Figure 5.4: The ^{3}H-activity concentration in 2003 for Meuse, Rhine and Scheldt, with yearly averages of 22.1, 5.0 and 10.2 Bq·L^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value [45].

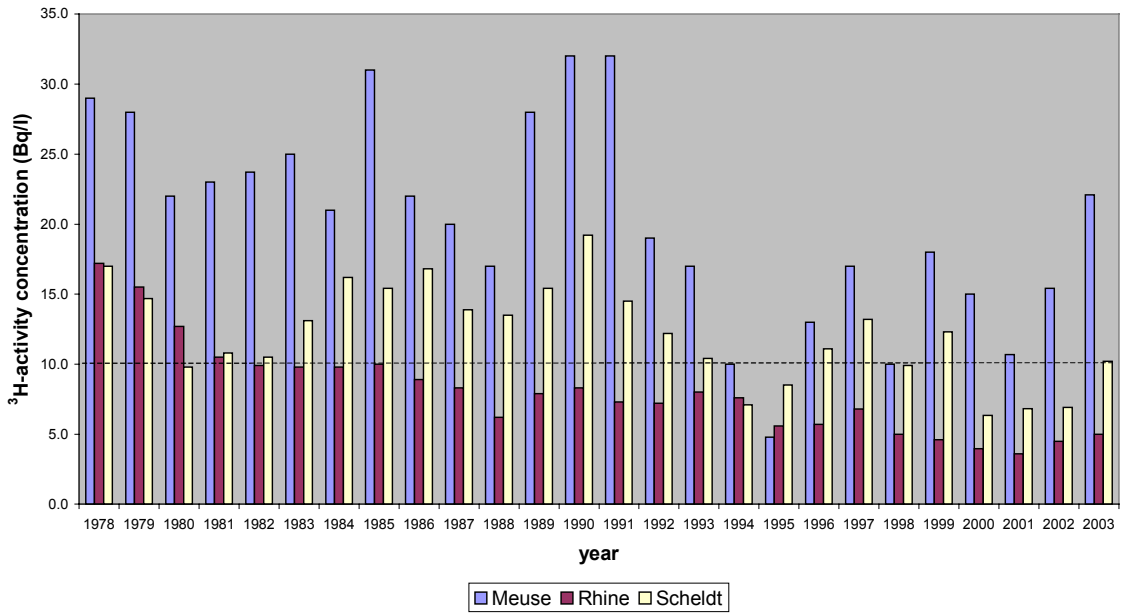


Figure 5.5: Yearly averaged ^{3}H-activity concentrations.

The ^{3}H-activity in the Meuse and the Scheldt exceeded the target value (10 Bq·L^{-1}) 8 out 13, respectively 2 out of 7 times. The elevated levels of ^{3}H in the Meuse (*Figure 5.4*) 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). For the Rhine and the Scheldt the yearly averaged ^{3}H-concentrations in 2003 are within the range of those in previous years. In 2003 the yearly averaged ^{3}H-concentration in the Meuse (22.1 Bq·L^{-1}) is above the target value of 10 Bq·L^{-1}.

The yearly averaged concentrations of ^{137}Cs in 2003 are within the range of those in previous years. The yearly averaged ^{137}Cs-concentrations are below the target value of 40 Bq·kg^{-1}.

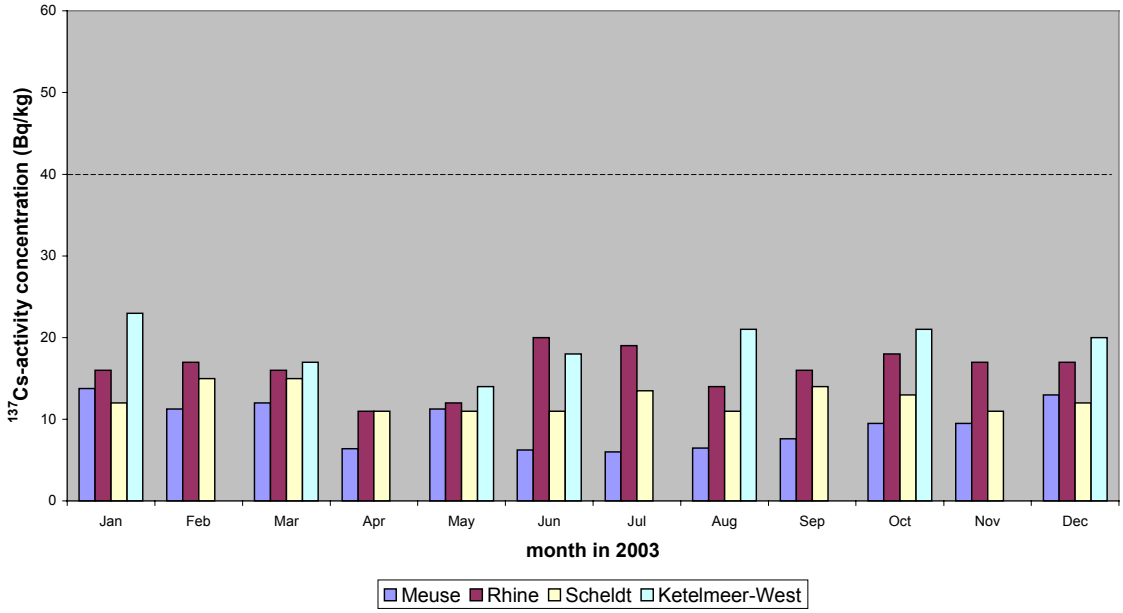


Figure 5.6: The ^{137}Cs-activity concentration in suspended solids in 2003 for the Meuse, Rhine, Scheldt and Ketelmeer-West with yearly averages of 9, 16, 13 and 19 Bq·kg^{-1}, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value [45].

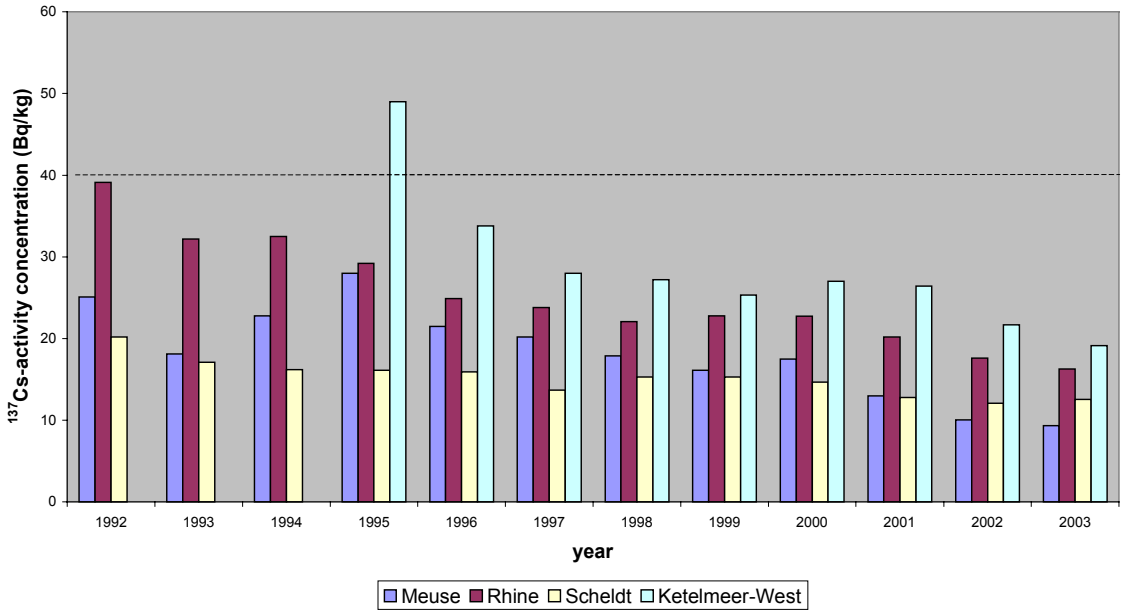


Figure 5.7: Yearly averaged ^{137}Cs-activity concentrations in suspended solids. Data on Ketelmeer-West are available since 1995.

The yearly averaged concentration of ^{137}Cs is consistently higher at Ketelmeer-West compared to that at Lobith. This indicates an extra contribution besides the one currently originating from the Rhine, which can be explained by the following. 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 [46].

5.3 The results for seawater

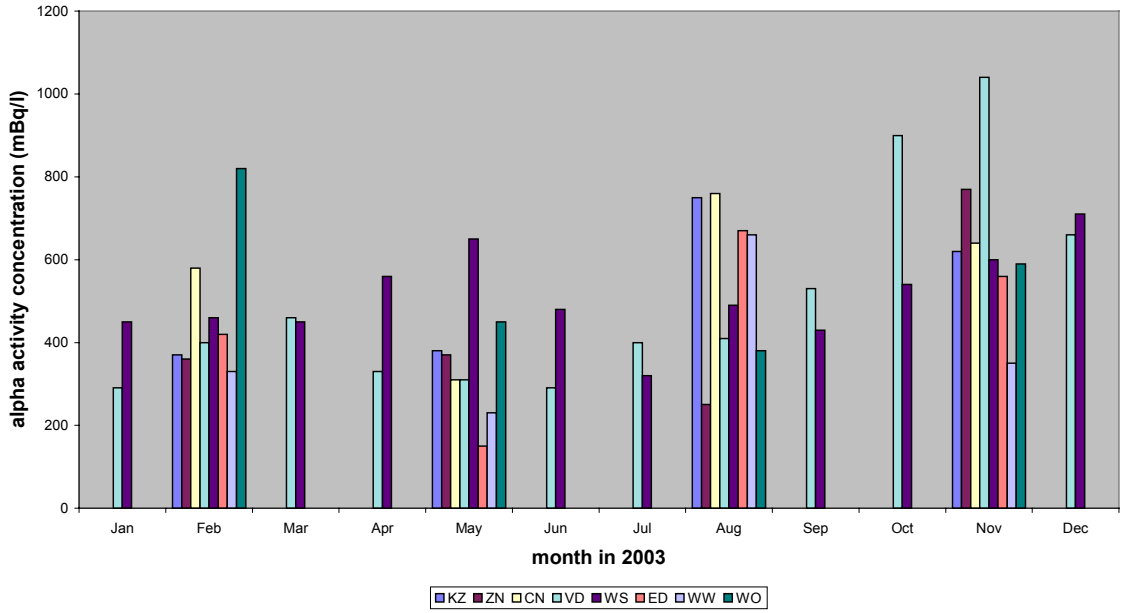


Figure 5.8: The gross α-activity concentration in seawater in 2003. The yearly averages for the Coastal area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Westerscheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO) are 530, 438, 573, 502, 497, 450, 393 and 560 mBq·L^{-1}, respectively.

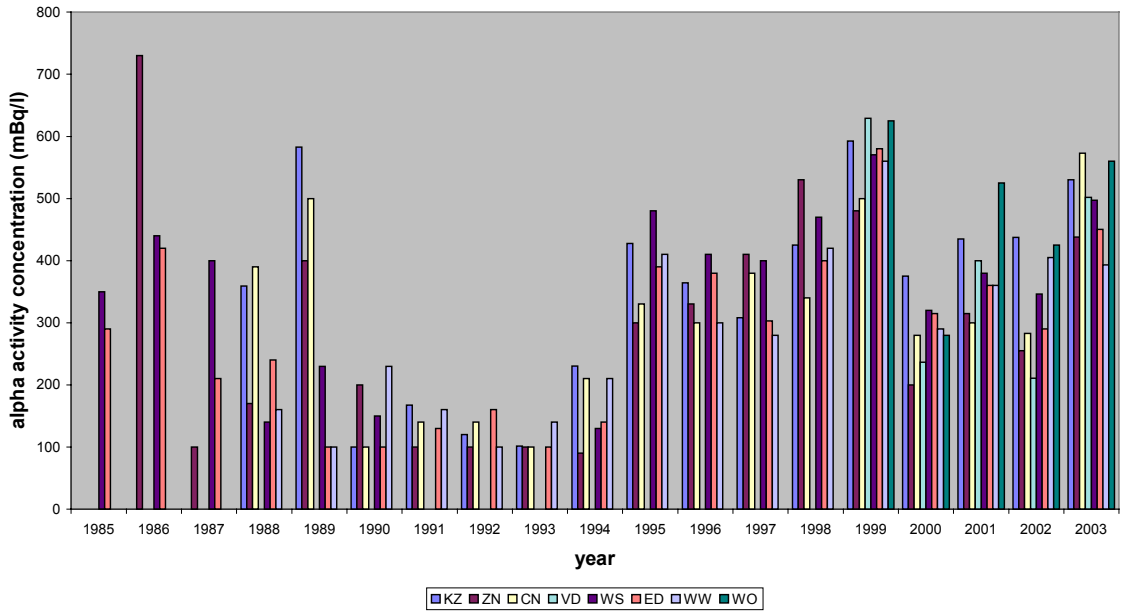


Figure 5.9: Yearly averaged gross α-activity concentrations.

Gross α and residual β are indicative parameters [42]. In the first half of 2000 the background of the measuring equipment was unstable and higher than usual, which resulted in lower results. Therefore yearly averaged concentrations of gross α in 2000 are based on data starting from the end of July 2000. Changes in the trend in the period 1985-1997 are explained elsewhere [42]. The results of 2003 are within the range of those in the period 1995-2002.

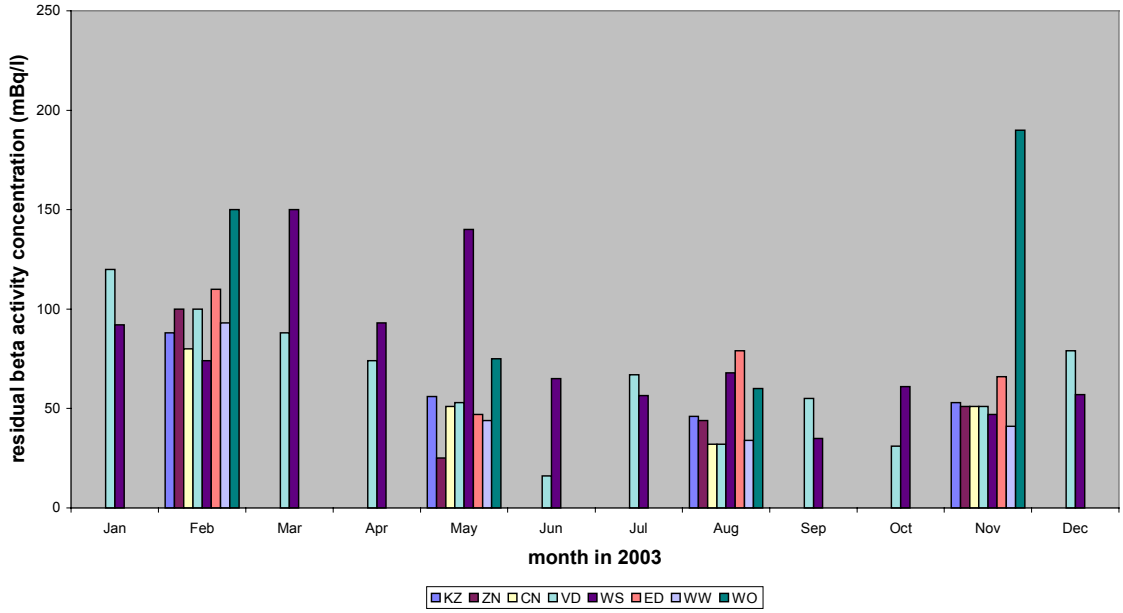


Figure 5.10: The residual β-activity concentration in seawater in 2003. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 61, 55, 54, 64, 77, 76, 53 and 119 mBq·L^{-1}, respectively.

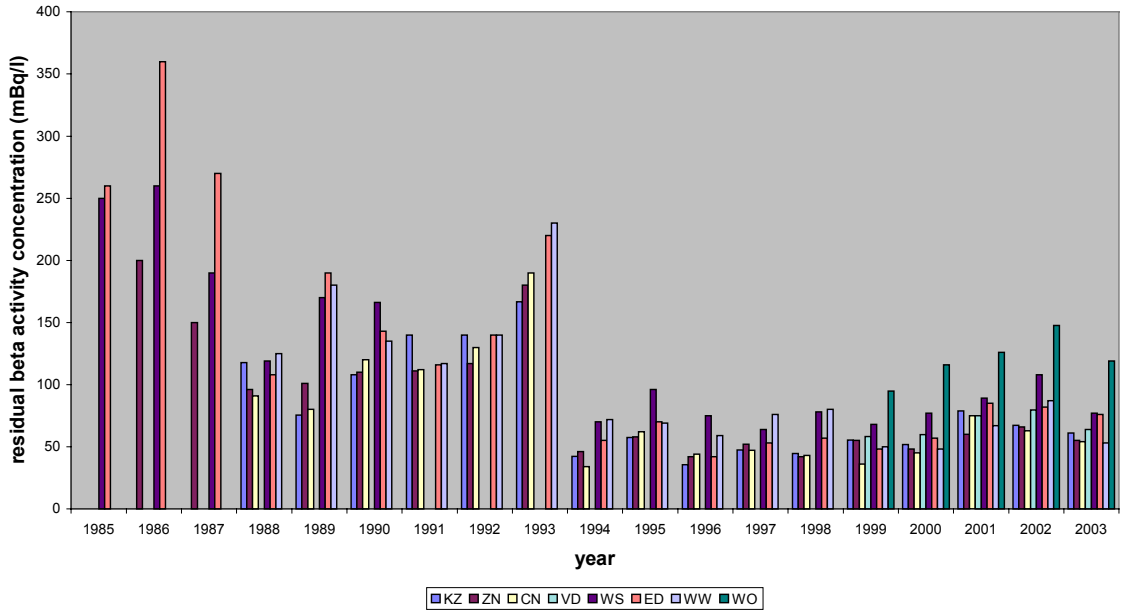


Figure 5.11: Yearly averaged residual β-activity concentrations.

Residual β shows a change in the trend since 1994. This is caused by a change in measuring technique, which only applies to salt and brackish water [42]. The yearly averaged concentrations of residual β in 2003 are within the range of those in the period 1994-2002.

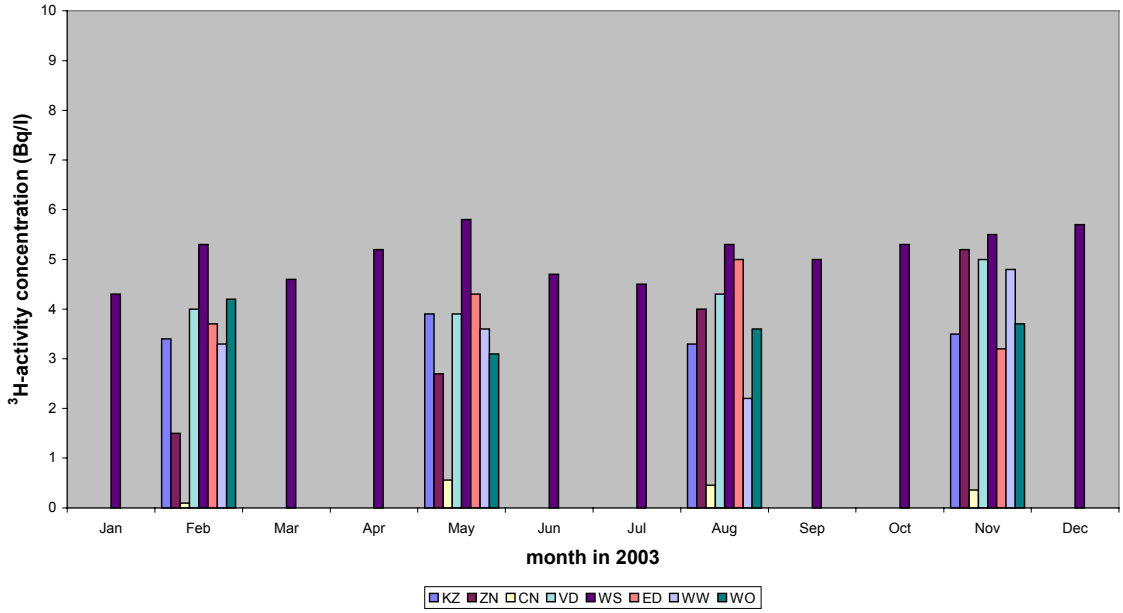


Figure 5.12: The ^{3}H-activity concentration in seawater in 2003. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 3.5, 3.4, 0.5, 4.3, 5.1, 4.1, 3.5 and 3.7 Bq·L^{-1}, respectively.

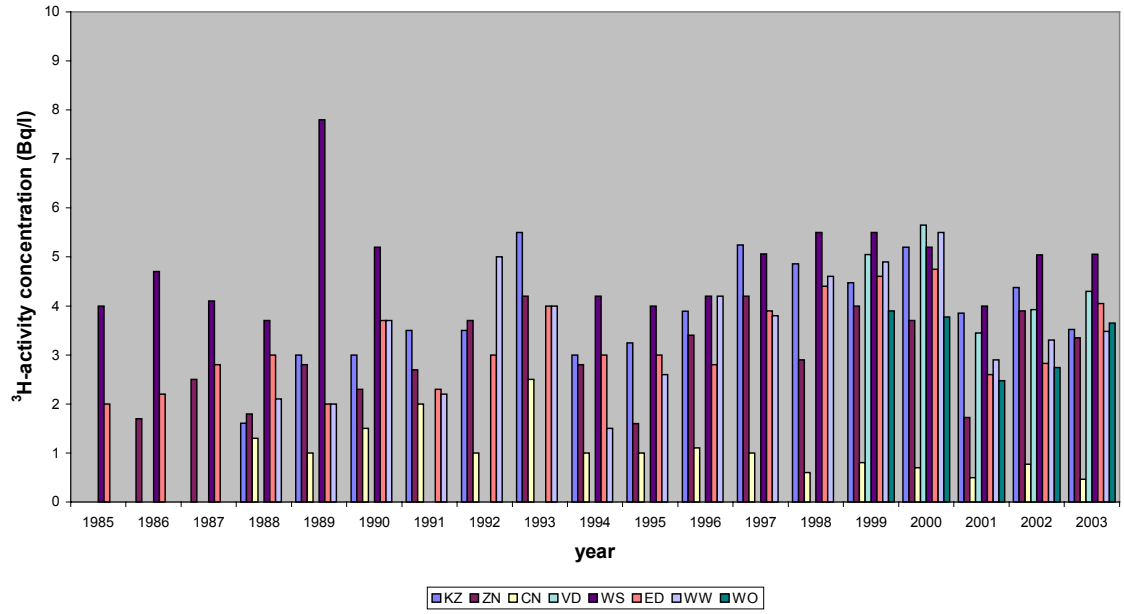


Figure 5.13: Yearly averaged ^{3}H-activity concentrations.

Nuclear power plants discharge the nuclides ^{3}H and ^{137}Cs. Nuclear fuel reprocessing plants discharge the nuclides ^{3}H and ^{90}Sr. Discharges by the research centre at Doel (Belgium) and the nuclear power plants at Doel and Borssele (the Netherlands) are monitored in the Westerscheldt (WS). The impact of reprocessing plants at Sellafield (England) and Le Havre (France) is monitored in the Central North Sea (CN) and Southern North Sea (ZN), respectively [42]. The impact of both sources (nuclear power and reprocessing plants) is monitored indirectly in the Delta Coastal Waters (VD). The yearly averaged concentrations of ^{3}H in 2003 are within the range of those in previous years.

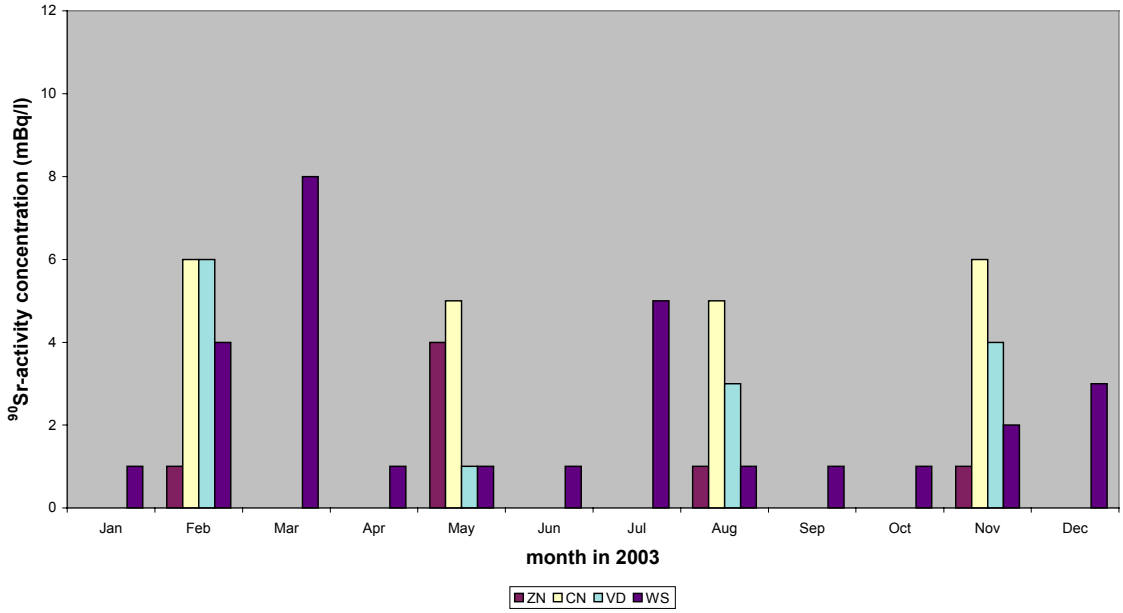


Figure 5.14: The ^{90}Sr-activity concentration in seawater in 2003. The yearly averages for the Southern North Sea, Central North Sea, Delta Coastal Waters and Westerscheldt are 1.5, 5.5, 3.4 and 2.0 mBq·L^{-1}, respectively.

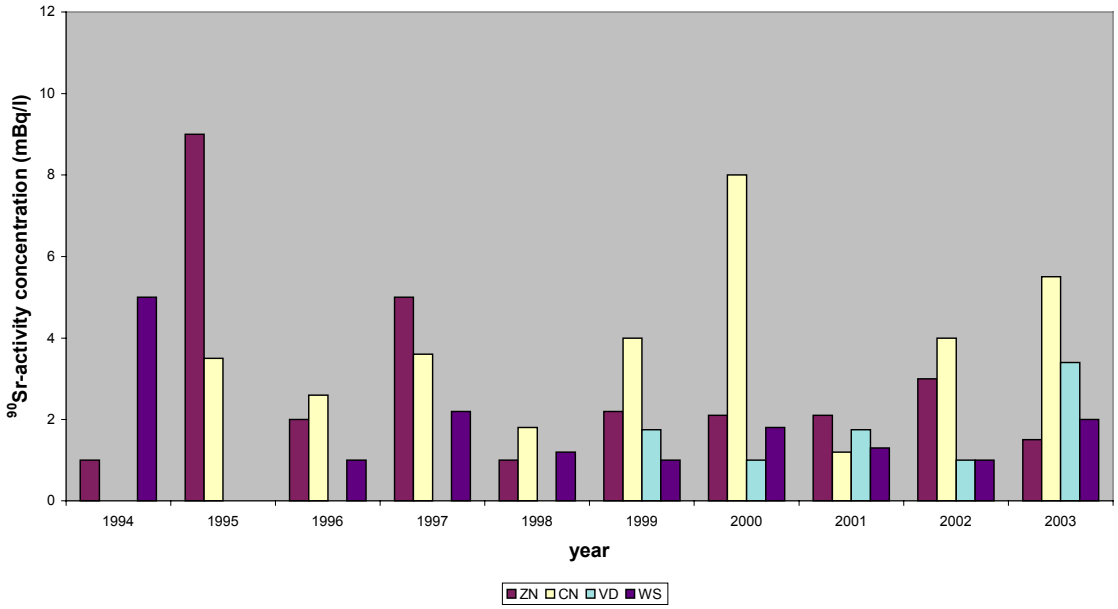


Figure 5.15: Yearly averaged ^{90}Sr-activity concentrations.

The yearly averaged concentrations of ^{90}Sr in 2003 are within the range of those in previous years.

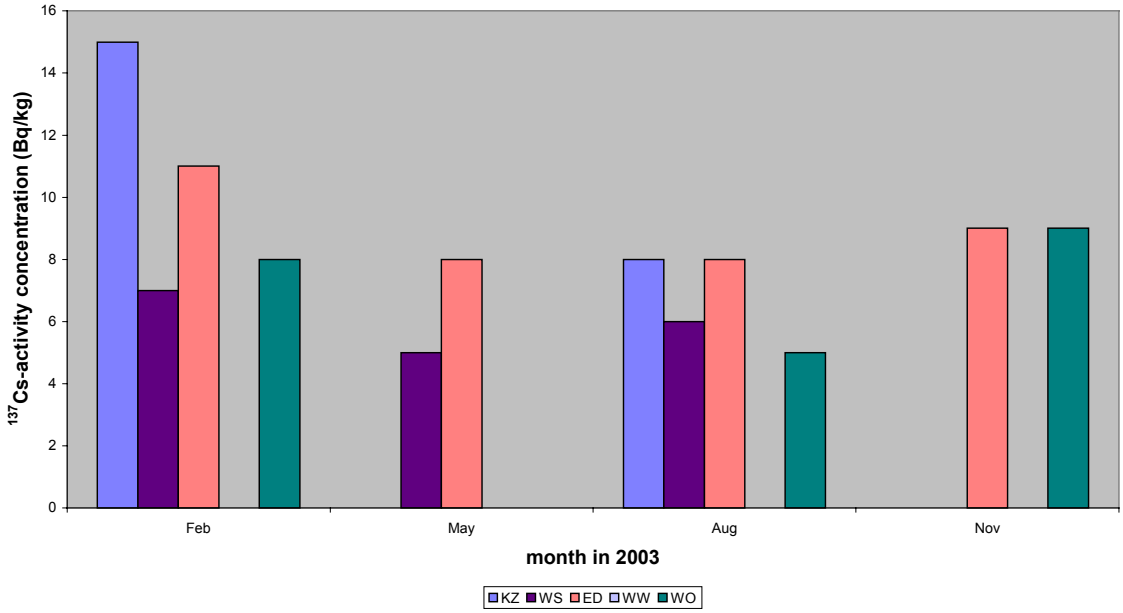


Figure 5.16: The ^{137}Cs-activity concentration in suspended solids in seawater in 2003. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard and Wadden Sea East are 12, 6, 9 and 7 Bq·kg^{-1}, respectively. Data were not available for some samples taken due to insufficient amount of collected suspended solids. Due to this cause no data were available for Wadden Sea West.

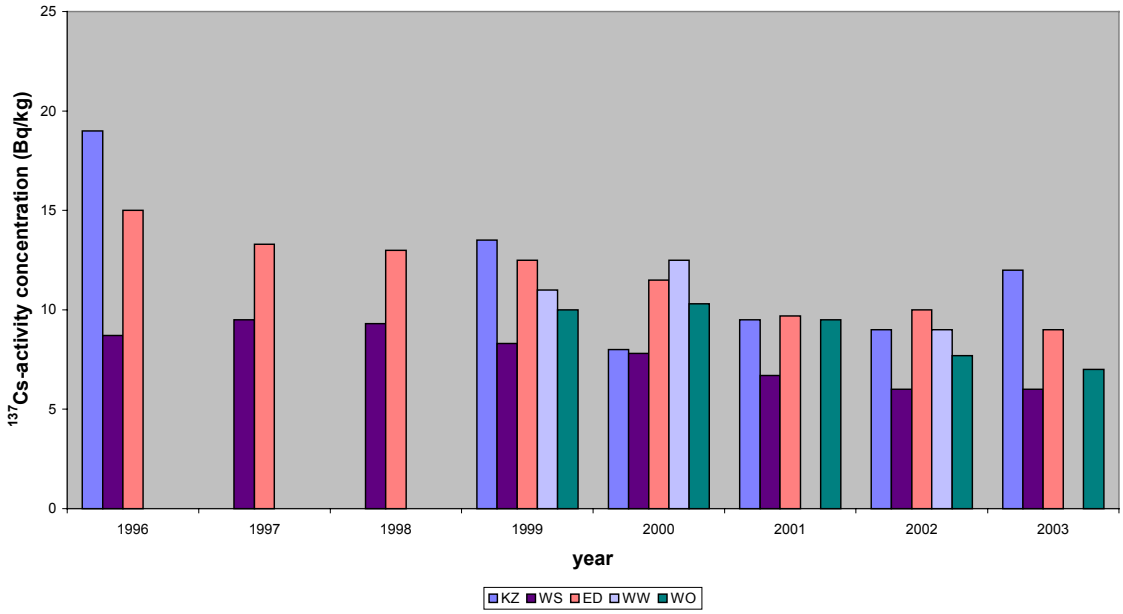


Figure 5.17: Yearly averaged ^{137}Cs-activity concentrations in suspended solids.

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

The nuclide ^{210}Po originates from the uranium decay chain and is discharged by the phosphate processing industry and production platforms for oil and gas [42]. 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.

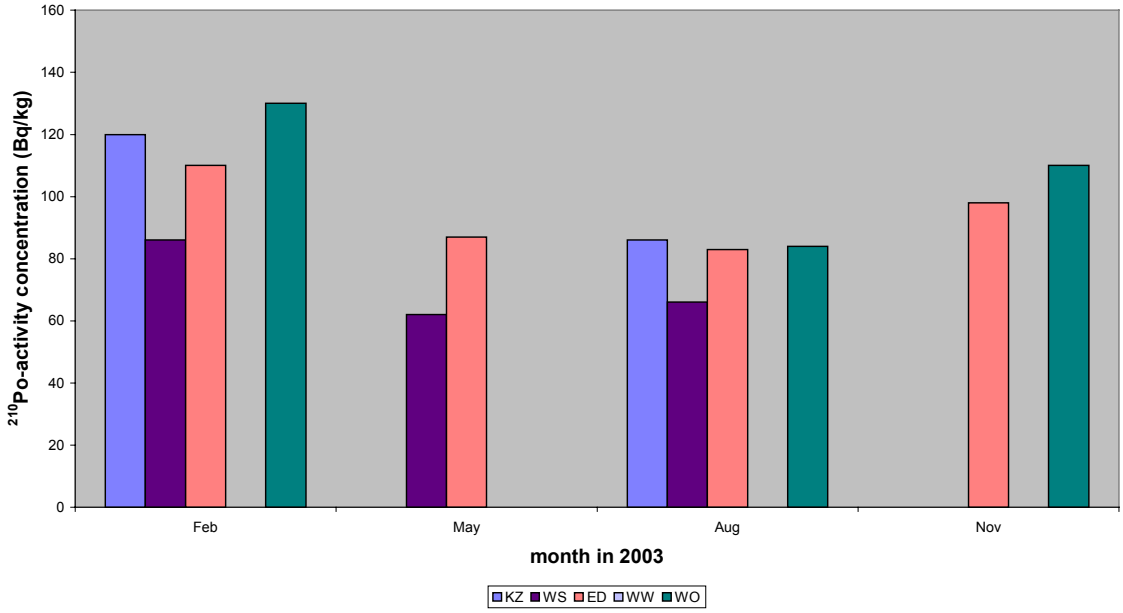


Figure 5.18: The ^{210}Po-activity concentration in suspended solids in seawater in 2003. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard and Wadden Sea East are 103, 71, 94 and 108 Bq·kg^{-1}, respectively. Data were not available for some samples taken due to insufficient amount of collected suspended solids. Due to this cause no data were available for Wadden Sea West.

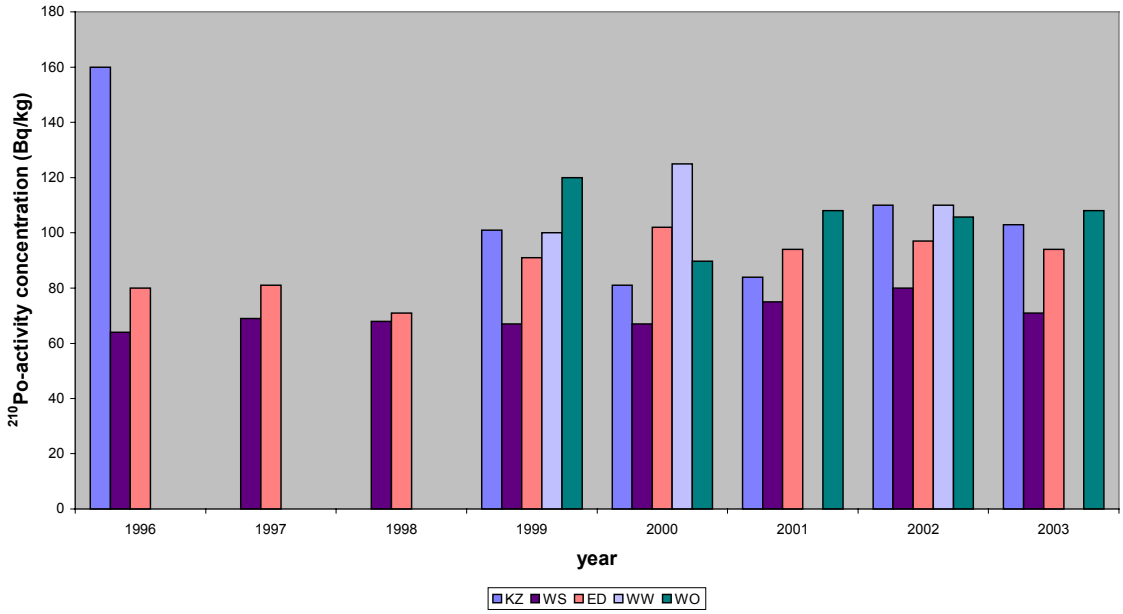


Figure 5.19: Yearly averaged ^{210}Po-activity concentrations in suspended solids.

The yearly averaged concentrations of ^{210}Po in 2003 are within the range of those in previous years. In 2001 and 2003 data were not available for Wadden Sea West due to insufficient amount of collected suspended solids.

6. Water for human consumption

In the Netherlands, water pumping-stations monitor raw input water for ^{3}H-, gross β- and residual β-activity. The monitoring frequency is from once to 26 times per year depending on the volume of water produced. The results for 2003 are presented in *Table 6.1*. For ^{3}H almost a hundred analyses were performed divided over 8 pumping stations. For residual and gross β hunderds of analyses were performed divided over a much larger number of pumping stations.

Table 6.1 Analyses on drinking water in 2003.

Parameter	^{3}H	Residual β	Gross β
No. of analyses	99	602	706
No. of pumping stations	8	144	175
Average value	< 5 Bq·L^{-1}	< 0.3 Bq·L^{-1}	< 0.3 Bq·L^{-1}
Maximum value (No.)	8 Bq·L^{-1} (13)	0.3 Bq·L^{-1} (4)	0.4 Bq·L^{-1} (3)

Figure 6.1 presents the results for the past few years. Since there is almost no ^{40}K present, gross β- and residual β-activities are equal.

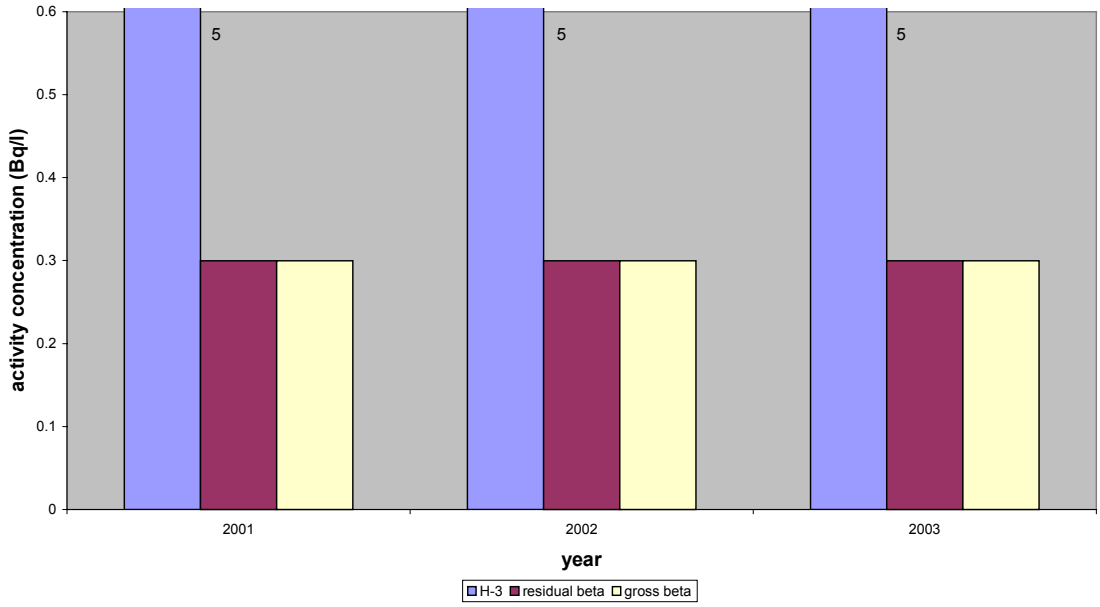


Figure 6.1 Yearly averaged ^{3}H-, residual β- and gross β-activity concentrations. All reported values are detection limits.

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 [47]. The average concentration found was 2.2 Bq·L^{-1} for drinking water produced from groundwater.

7. Milk

Until 1997 RIVM monitored radioactivity in milk under authority of the Chief Veterinary Inspectorate for Public Health of the Ministry of Health, Welfare and Sport.
Because of the low levels of radioactivity found in the milk samples, the Chief Veterinary Inspectorate for Public Health of the Ministry of Health, Welfare and Sport decided to stop the monitoring program in 1998.

In 2003 the Food and Consumer Product Safety Authority analysed samples of milk and milkpowder for ^{134}Cs and ^{137}Cs. The measurements on milk were carried out on an ad hoc basis as part of an intralaboratory validation project. This is not in compliance with the Euratom recommendation [1], in which it is recommended to monitor gamma emitters and ^{90}Sr in milk samples taken from dairies.

Measurements were carried out according to standard procedures [48, 49]. Via the import team 62 samples of powdered milk were offered for analysis [50]. The samples originated from Eastern Europe. Measurable quantities of activity were found in 8 samples, varying from 24 up to 50 Bq·kg^{-1}. The samples containing activity originated from Poland. The activity found was below the limit of 370 Bq·kg^{-1} [51].
Radioactivity was not detected in the samples of milk, which originated from the Netherlands.

Table 7.1 Results of analysis of milk and powdered milk for ^{134}Cs and ^{137}Cs.

Product	**Number of samples**	**Number of positive samples**	**^{134}Cs (Bq·kg^{-1})**	**^{137}Cs (Bq·kg^{-1})**
Milk	23	0	n.d.	n.d.
Powdered milk	62	8	n.d.	24 - 50

n.d. = not detectable

8. Food

Radioactivity is measured in food suspected to contain more than the normal activity concentrations. This is not in compliance with the Euratom recommendation [1], in which it is recommended to monitor gamma emitters and ^{90}Sr in mixed diets.

The measurements are performed by the Food and Consumer Product Safety Authority. Measurements were carried out according to standard procedures [48, 49]. The results are presented in *Table 8.1*. None of the samples exceeded the set limit [51].

8.1 Honey

In total 169 samples of honey were analysed [50]. The activity (sum of ^{134}Cs and ^{137}Cs) was found to be below the set limit of 600 $Bq \cdot kg^{-1}$ [51]. All samples of heather honey contained ^{137}Cs and originated from the Netherlands. The activity varied from 12 up to 462 $Bq \cdot kg^{-1}$.

8.2 Game and poultry

In total 29 samples of game and poultry were analysed. Measurable quantities of activity were found in 3 samples of game and poultry. A sample of boar contained 25 $Bq \cdot kg^{-1}$, a sample of plover 198 $Bq \cdot kg^{-1}$ and a sample of deer contained 283 $Bq \cdot kg^{-1}$.

8.3 Fish

In 2003 measurements were performed on 24 samples of carnivorous fish orginating from third countries, like Russia and Estonia. Measurable quantities of activity were found in 5 samples of fish, varying from 24 up to 46 $Bq \cdot kg^{-1}$.

8.4 Other products

Radioactivity was detected in some other products, amongst which blueberry (152 $Bq \cdot kg^{-1}$), hazelnut (9 $Bq \cdot kg^{-1}$) and mushrooms (85 and 297 $Bq \cdot kg^{-1}$).

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 ($Bq \cdot kg^{-1}$)
Honey	169	15	n.d.	12 - 462
Game and poultry	29	3	n.d.	25, 198, 283
Fish	24	5	n.d.	24 - 46
Dried mushrooms	61	2	n.d.	85, 297
Fruit	3	1	n.d.	152
Nuts and seeds	7	1	n.d.	9

n.d. = not detectable

9. Conclusions

The ^{3}H-activity concentration in the Meuse exceeded the target value (10 Bq·L^{-1}) in eight out of thirteen samples taken. The yearly average (22.1 Bq·L^{-1}) is within range of previous years. The ^{3}H-activity concentration in the Scheldt exceeded the target value in two out of seven samples taken. The yearly average (10.2 Bq·L^{-1}) is within range of previous years. The results of all other radioactivity measurements are within range of previous years.

The Dutch monitoring program does not fully comply with the recommendations of the European Union, mainly concerning the measurement of drinking water, milk and food.

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Appendix A

Table A1: Weekly results of gross α- and gross β-activity concentrations in air dust sampled with a HVS at RIVM in 2003.

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]	0.048	0.96	± 0.06	27	0.038	0.42	± 0.03
2	0.09	0.35	± 0.02	28	0.044	0.34	± 0.02
3	0.034	0.277	± 0.019	29	0.035	0.34	± 0.02
4	0.026	0.176	± 0.013	30	0.037	0.31	± 0.02
5	0.031	0.176	± 0.013	31	0.07	0.47	± 0.03
6	0.12	0.56	± 0.04	32	0.10	0.84	± 0.05
7	0.042	0.56	± 0.04	33	0.055	0.42	± 0.03
8	0.10	1.02	± 0.07	34	0.022	0.28	± 0.02
9	0.035	0.262	± 0.018	35	0.032	0.222	± 0.016
10	0.054	0.34	± 0.02	36	0.06	0.55	± 0.04
11	0.038	0.49	± 0.03	37	0.07	0.66	± 0.04
12	0.08	0.88	± 0.06	38 [2]	0.22	1.77	± 0.11
13	0.049	0.54	± 0.04	39 [2]	0.038	0.48	± 0.03
14	0.042	0.39	± 0.03	40	0.057	0.29	± 0.02
15	0.07	0.80	± 0.05	41	0.028	0.35	± 0.02
16	0.09	0.81	± 0.05	42	0.032	0.42	± 0.03
17	0.07	0.50	± 0.03	43	0.050	0.37	± 0.03
18	0.042	0.30	± 0.02	44	0.041	0.30	± 0.02
19	0.043	0.210	± 0.015	45	0.07	0.76	± 0.05
20	0.046	0.29	± 0.02	46	0.038	0.219	± 0.015
21	0.054	0.32	± 0.02	47	0.09	0.60	± 0.04
22	0.049	0.57	± 0.04	48	0.07	0.55	± 0.04
23	0.07	0.267	± 0.018	49	0.043	0.53	± 0.03
24	0.044	0.285	± 0.019	50	0.035	0.30	± 0.02
25	0.030	0.265	± 0.018	51	0.050	0.37	± 0.03
26	0.047	0.31	± 0.02	52	0.052	0.220	± 0.016
				Average	0.06 [3]	0.467	± 0.005 [4]
				SD [5]	0.03		0.3

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

[2] Due to problems with the high volume sampler sampling didn't occur for 4.5, 4, 2.5 days during week 1, 38 and 39 respectively.

[3] Due to large uncertainties caused by variations in dust thickness on the filters, gross α-activity concentrations in air dust are given as indicative values [5].

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

[5] SD is the standard deviation of the weekly results. Errors are given as 1σ.

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 2003. 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 in previous years [52] due to a different detector set-up.

Nuclide	Detection limit	Nuclide	Detection limit
^{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 results of ^{7}Be-, ^{137}Cs- and ^{210}Pb-activity concentrations in air dust sampled with a HVS at RIVM in 2003. 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	03/01-10/01	4600	±	400		1040	±	100
2	10/01-17/01	2900	±	300		330	±	30
3	17/01-24/01	2210	±	190		290	±	30
4	24/01-31/01	2400	±	200		180	±	30
5	31/01-07/02	2060	±	180		171	±	18
6	07/02-14/02	2800	±	200		800	±	80
7	14/02-21/02	4100	±	400		590	±	60
8	21/02-28/02	5000	±	400		1100	±	100
9	28/02-07/03	2800	±	200		145	±	15
10	07/03-14/03	4100	±	400		290	±	30
11	14/03-21/03	3500	±	300		540	±	50
12	21/03-28/03	6400	±	600		930	±	80
13	28/03-04/04	4400	±	400		490	±	50
14	04/04-11/04	4000	±	400		460	±	60
15	11/04-18/04	6300	±	500		720	±	60
16	18/04-25/04	5000	±	400		950	±	90
17	25/04-02/05	3900	±	300		490	±	50
18	02/05-09/05	3400	±	300		280	±	30
19	09/05-16/05	2900	±	300		180	±	30
20	16/05-23/05	3000	±	300		290	±	30
21	23/05-28/05	4400	±	400		260	±	30
22	28/05-06/06	4400	±	400		620	±	60
23	06/06-13/06	3000	±	300		300	±	40
24	13/06-20/06	3200	±	300		250	±	30
25	20/06-27/06	2900	±	300		280	±	30
26	27/06-04/07	3400	±	300		290	±	30

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Table A3: Continued

Week number	Period	^{7}Be µBq·m^{-3}			^{137}Cs µBq·m^{-3}	^{210}Pb µBq·m^{-3}		
27	04/07-11/07	3700	±	300		440	±	40
28	11/07-18/07	3300	±	300		330	±	30
29	18/07-25/07	2800	±	200		360	±	40
30	25/07-01/08	2900	±	300		290	±	30
31	01/08-08/08	4500	±	400		490	±	40
32	08/08-15/08	5000	±	400		990	±	90
33	15/08-22/08	4400	±	400		400	±	40
34	22/08-29/08	3100	±	300		270	±	30
35	29/08-05/09	2800	±	200		200	±	20
36	05/09-12/09	4000	±	300		550	±	50
37	12/09-19/09	4500	±	400		810	±	80
38	19/09-22/09	8700	±	800		1920	±	170
39	29/09-03/10	2700	±	200		630	±	60
40	03/10-10/10	2700	±	200		300	±	30
41	10/10-17/10	3200	±	300		340	±	30
42	17/10-24/10	3100	±	300		510	±	50
43	24/10-30/10	2140	±	190		420	±	40
44	30/10-07/11	2150	±	190		340	±	30
45	07/11-14/11	2200	±	200		1040	±	100
46	14/11-21/11	1960	±	170		310	±	30
47	21/11-28/11	2300	±	200		660	±	60
48	28/11-05/12	1560	±	140		730	±	70
49	05/12-11/12	2300	±	200		570	±	50
50	11/12-19/12	1970	±	170		320	±	30
51	19/12-24/12	2900	±	300		520	±	50
52	24/12-31/12	1760	±	150		290	±	30
	Average	3460	±	50 [(1)]		506	±	8 [(1)]
	SD [(2)]			1300				300

[(1)] 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.

[(2)] SD is the standard deviation of the weekly results. Errors are given as 1σ.

Table A4: Precipitation per month and ^{3}H-, long-lived gross α- and gross β-activity in deposition sampled at RIVM in 2003.

Month	Precipitation mm	^{3}H [(1)] Bq·m^{-2}			Gross α Bq·m^{-2}			Gross β Bq·m^{-2}		
January	39.8	<68			0.62	±	0.13	3.4	±	0.3
February	26.7	<45			<0.6			2.16	±	0.18
March	47.0	<80			1.3	±	0.2	4.7	±	0.4
April	32.0	<52			1.1	±	0.2	6.1	±	0.5
May	93.3	150	±	50	2.6	±	0.4	10.3	±	0.8
June	59.7	120	±	30	2.3	±	0.4	11.0	±	0.9
July	17.6	33	±	9	0.83	±	0.15	3.8	±	0.3
August	4.8	8	±	2	1.5	±	0.3	4.5	±	0.4
September	61.6	<101			1.6	±	0.3	5.5	±	0.4
October	77.7	<127			1.1	±	0.3	5.3	±	0.4
November	39.8	<65			<0.7			5.3	±	0.4
December	105.1	<172			1.5	±	0.3	7.8	±	0.6
Total	605	<1020			15.8	±	0.9 [(2)]	70	±	2 [(2)]

[(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 (1,7 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.

Table A5: Yearly totals [(1)] for long-lived gross α-, gross β- and ^{3}H-activity in deposition for 1983-2003.

Year	Precipitation mm	Gross α Bq·m^{-2}			Gross β Bq·m^{-2}			^{3}H Bq·m^{-2}		
1983	869	40			120			2100		
1984	868	25			130			2610		
1985	767	30			140			3800		
1986	825	45			18000			2400		
1987	975	24 [(2)]	±	1	85 [(2)]	±	3	2630		
1988	887	36	±	2	103	±	3	1700	±	40
1989	706	43	±	1	89	±	3	1560	±	130
1990	756	68	±	1	121	±	4	1360	±	120
1991	699	48	±	1	85	±	1	1060	±	50
1992	946	44	±	1	87	±	1	1440	±	50
1993	886	54.3	±	0.7	87.9	±	0.8	1310	±	30
1994	1039	52.0	±	0.7	91.2	±	1.0	1210	±	30
1995	724	39	±	4	95	±	8	970	±	40
1996	626	16.4	±	1.5	67	±	5	970	±	50
1997	760	23.1	±	1.3	87	±	3	1160	±	60
1998	1238	31.1	±	1.3	106	±	3	1200	±	110
1999	916	25.5	±	1.0	84	±	2	1530	±	110
2000	935	35.2	±	1.3	104	±	3	<1390		
2001	1053	23.9	±	1.0	97	±	3	<2420		
2002	965	20.6	±	0.9	97	±	2	<1630		
2003	605	15.8	±	0.9	70	±	2	<1020		

[(1)] Errors are given as 1σ.
[(2)] Introduction of new method.

Table A6: Monthly values of ^{210}Po-activity [1] in deposition sampled at RIVM in 2003.

Month	^{210}Po Bq·m^{-2}		
January	0.06	±	0.12
February	0.24	±	0.09
March	0.04	±	0.16
April	0.40	±	0.15
May	1.0	±	0.4
June	0.5	±	0.2
July	0.90	±	0.12
August	<0.22		
September	0.70	±	0.08
October	0.36	±	0.10
November	0.47	±	0.06
December	0.20	±	0.12
Total	5.1	±	0.6 [2]

[1] *Measurements are carried out using α-spectroscopy. Errors are given as 1σ.*

[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.*

Table A7: Yearly totals [1] for ^{7}Be, ^{137}Cs, ^{210}Pb- and ^{210}Po-activity in deposition for 1985-2003.

Year	^{7}Be [2] Bq·m^{-2}		^{137}Cs [2] Bq·m^{-2}		^{210}Pb [2] Bq·m^{-2}		^{210}Pb [3] Bq·m^{-2}		^{210}Po [3] Bq·m^{-2}	
1985	980		<5		-		-		-	
1986	>1040		3360		-		15		3	
1987	1330	± 50	12.3		-		52		6	
1988	1200	± 50	<6		-		110	± 3	25	± 1
1989	740	± 40	<3.05		-		94	± 7	24	± 4
1990	810	± 36	<5.5		-		85	± 4	16	± 2
1991	760	± 1	1.35	± 0.03	93	± 1	56	± 1	10	± 1
1992	1050	± 30	0.69	± 0.16	-		83	± 5	11	± 1
1993	1090	± 20	0.80	± 0.03	105	± 2	78	± 3	6.0	± 0.6
1994	1320	± 30	0.38	± 0.02	118	± 3	82	± 3	12.7	± 0.7
1995	993	± 16	0.28	± 0.02	96	± 2	- [4]		- [4]	
1996	920	± 20	0.55	± 0.03	65	± 2	57	± 3	9	± 2
1997	1090	± 30	0.121	± 0.014	67	± 2	80	± 3	<10	
1998	1840	± 50	0.60	± 0.03	163	± 4	91	± 4	<16	
1999	1580	± 30	1.22	± 0.06	158	± 4	- [5]		<5.1	
2000	1500	± 30	-		177	± 6	-		<7.8	
2001	1480	± 30	-		88	± 4	-		9.0	± 0.4
2002	1510	± 30	-		125	± 5	-		7.5	± 1.0
2003	1020	± 20	-		93	± 4	-		5.1	± 0.6

[1] *Errors are given as 1σ.*

[2] *Data from γ-spectroscopy.*

[3] *Data from α-spectroscopy.*

[4] *Result rejected [53].*

[5] *α-spectroscopy analysis of ^{210}Pb stopped in 1999.*

(-) No analysis.

Table A8: Weekly values of ^{7}Be- and ^{210}Pb-activity (1) deposition sampled at RIVM in 2003. Empty fields indicate that the value was below the detection limit (0.7 and 0.9 Bq·m^{-2} for ^{7}Be and ^{210}Pb respectively) .

Week Number	Period	Precipitation mm	^{7}Be Bq·m^{-2}		^{210}Pb Bq·m^{-2}	
1	03/01-10/01	1.4	5.8	± 1.2	1.8	± 0.5
2	10/01-17/01	4.6	10.8	± 1.6	2.2	± 0.8
3	17/01-24/01	13.8	21	± 3	0.8	± 0.5
4	24/01-31/01	20.0	28	± 3	1.3	± 0.7
5	31/01-07/02	26.0	25	± 3	2.4	± 0.6
6	07/02-14/02	0.6	2.2	± 0.6		
7	14/02-21/02	0.0	1.2	± 0.6		
8	21/02-28/02	0.0				
9	28/02-07/03	8.8	9.6	± 1.5	1.1	± 0.6
10	07/03-14/03	17.8	42	± 5	2.0	± 0.7
11	14/03-21/03	0.0	3.7	± 0.7	1.6	± 0.5
12	21/03-28/03	0.0	2.4	± 0.6	1.8	± 0.7
13	28/03-21/03	20.5	24	± 3	3.1	± 0.9
14	21/03-11/04	1.3	5.8	± 1.3	1.4	± 0.6
15	11/04-18/04	0.0	2.5	± 0.6	2.7	± 0.9
16	18/04-25/04	4.3	17	± 2	4.2	± 0.7
17	25/04-02/05	26.4	35	± 4	4.4	± 1.2
18	02/05-09/05	23.5	93	± 12	6.9	± 1.1
19	09/05-16/05	20.5	40	± 5	1.2	± 0.5
20	16/05-23/05	37.9	52	± 6	3.6	± 0.7
21	23/05-28/05	11.4	21	± 3	2.0	± 0.5
22	28/05-06/06	16.8	43	± 5	7.2	± 1.0
23	06/06-13/06	13.0	36	± 4	3.3	± 0.7
24	13/06-20/06	4.2	21	± 3	3.3	± 0.6
25	20/06-27/06	0.0	10.8	± 1.6	2.5	± 0.6
26	27/06-04/07	25.8	21	± 3	2.3	± 0.7

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Table A8: Continued.

Week Number	Period	Precipitation mm	^{7}Be Bq·m^{-2}		^{210}Pb Bq·m^{-2}	
27	04/07-11/07	1.4	13.8	± 1.8		
28	11/07-18/07	8.2	6.1	± 0.8	2.4	± 0.7
29	18/07-25/07	0.9	12.1	± 1.6	1.5	± 0.5
30	25/07-01/08	7.1	15.1	± 1.8	0.8	± 0.2
31	01/08-08/08	0.6	15.2	± 1.9	2.0	± 0.5
32	08/08-15/08	0.0	5.4	± 1.1		
33	15/08-22/08	0.6	8.4	± 1.6		
34	22/08-29/08	3.7	10	± 2		
35	29/08-05/09	8.3	9.5	± 1.4		
36	05/09-12/09	19.3	27	± 3		
37	12/09-19/09	0.0	2.0	± 0.7		
38	19/09-26/09	26.0	37	± 4	3.7	± 0.8
39	26/09-03/10	8.0	28	± 4	1.9	± 0.7
40	03/10-10/10	58.5	81	± 10	4.4	± 0.8
41	10/10-17/10	0.7	2.4	± 0.6		
42	17/10-24/10	1.0	4.4	± 0.8		
43	24/10-31/10	17.5	15	± 2		
44	31/10-07/11	7.4	16	± 2		
45	07/11-14/11	0.9	1.6	± 0.7		
46	14/11-21/11	7.3	11.9	± 1.6		
47	21/11-28/11	24.3	27	± 3	4.4	± 0.8
48	28/11-05/12	9.0	5.8	± 1.1		
49	05/12-12/12	5.6	9.1	± 1.2		
50	12/12-19/12	37.0	40	± 5	2.5	± 0.6
51	19/12-24/12	24.0	29	± 4	3.9	± 1.0
52	24/12-31/12	29.5	18	± 2	2.1	± 0.7
	Total	605	1020	± 20 [(2)]	93	± 4 [(2)]

[(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.*

Table A9: Yearly averaged results in 2003 for α-activity concentration in air and ambient dose equivalent rate, as measured by the NMR stations equipped with aerosol monitors.

Station	No. [1]	α-Activity concentration Bq.m^{-3}	Ambient dose equivalent rate nSv.h^{-1}
Kollumerwaard [2]	972	3.7	-
Valthermond [3]	974	3.5	71
Vlaardingen [2]	976	3.5	-
Braakman [2]	978	3.5	-
Huijbergen	980	3.9	72
Houtakker	982	4.0	68
Wijnandsrade	984	9.1	85
Eibergen	986	4.4	71
De Zilk	988	2.1	75
Wieringerwerf [2]	990	3.4	-
Vredepeel	992	4.6	71
Biddinghuizen [2]	994	4.6	-
Wageningen	996	5.5	93
Bilthoven	998	3.7	71

[1] The number of the station has changed in respect to previous years. The location remains the same.
[2] Ambient dose equivalent rate monitor not operational or unreliable.
[3] The station formerly known as Witteveen.

Table A10: The yearly average results for ambient dose equivalent rate for the NMR stations in 2003.

Station	No.	Ambient dose equivalent rate nSv.h^{-1}	Station	No.	Ambient dose equivalent rate nSv.h^{-1}
Den Burg	1001	69	Hooglanderveen	1046	81
Den Oever	1003	71	Harderwijk	1050	67
Julianadorp	1004	62	Wijk bij Duurstede	1056	79
Petten	1006	63	Rhenen [2]	1061	76
Kolhorn	1007	82	Nieuwegein	1062	82
Egmond aan Zee	1009	62	Apeldoorn	1066	74
Heerhugowaard	1011	73	Heerenveen	1071	63
Haarlem-Noord	1014	72	Oosterwolde [1]	1072	-
Nederhorst den Berg	1015	61	Bergum	1074	69
Enkhuizen	1018	71	Witmarsum	1076	89
Oosthuizen	1019	67	Sneek	1077	72
Zaandam	1021	69	St. Jacobiparochie	1081	76
Gouda	1024	75	Holwerd	1082	80
Dordrecht	1027	58	Leeuwarden	1085	66
Zuid-Beijerland	1028	76	Zwolle-Zuid	1087	73
Pijnacker	1032	78	Ommen	1093	63
Rotterdam Crooswijk	1033	74	Hardenberg	1095	63
Rotterdam Waalhaven	1034	78	Assen	1097	63
Maasvlakte	1035	71	Rutten	1099	75
Maassluis	1037	96	Lelystad	1103	74
Hellevoetsluis	1038	95	Urk	1105	74
Ouddorp	1039	62	Eemshaven	1106	74
Wekerom	1041	71	Uithuizen	1107	81
Wageningen [1]	1043	-	Wagenborgen	1109	71

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Table A10: Continued.

Station	No.	Ambient dose equivalent rate nSv.h^{-1}	Station	No.	Ambient dose equivalent rate nSv.h^{-1}
Winschoten	1110	69	Reuver	1188	73
Ter Apel	1111	65	Nederweert	1189	72
Stadskanaal	1112	67	Heythuisen	1190	74
Nieuweschans	1113	71	Mariahoop	1191	67
Bellingwolde	1114	61	Stramproy	1192	64
Groningen	1116	71	Arnhem-Oosterbeek	1193	74
Leens	1117	77	Leiden	1196	80
Grijpskerk	1118	75	Hulst	1197	69
Meppel	1125	63	Terneuzen	1199	78
Hoogeveen	1126	61	Sluis	1201	69
Steenwijksmoer	1129	67	Vlissingen	1202	77
Nieuw Amsterdam	1130	69	Halsteren	1204	65
Nw. Schoonebeek/ Weiteveen	1131	63	Oud-Gastel	1206	65
Emmen	1132	68	Goes	1207	75
Borne	1135	69	Bruinisse (1)	1209	-
Hengelo (Gld)	1136	70	Burgh-Haamstede	1211	59
Enschede	1139	66	Vrouwenpolder	1212	63
Losser	1140	61	Wemeldinge	1214	78
Oldenzaal	1141	64	Middelburg	1215	73
Westerhaar	1142	65	Westkapelle	1216	69
Rijssen	1143	73	Noordwijk-Binnen	1217	78
's Heerenberg	1144	71	Stein	1219	83
Dinxperlo	1145	78	Maastricht	1220	90
Varsseveld	1146	68	Ravensbos	1221	89
Groenlo	1147	81	Vaals	1222	88
Deventer	1148	76	Gulpen	1223	76
Etten-Leur	1154	67	Kerkrade	1224	89
Den Bosch	1157	66	Hoensbroek	1225	88
Raamsdonkveer	1159	81	Wijchen (2)	1226	74
Ulvenhout	1160	71	Gennep	1228	71
Baarle-Nassau	1161	106	Elst (Gld) (1)	1229	-
Uden	1162	67	Zevenaar	1230	72
Mill	1163	61	Nijmegen	1231	66
Oss	1167	67	Amstelveen	1233	82
Nuenen	1172	68	Amsterdam Oost	1234	72
Bergeyk (1)	1174	-	Aalsmeer	1236	84
Waalre	1175	65	Nispen (1)	1237	-
Someren (dorp)	1176	64	Groesbeek	1240	70
Oisterwijk	1178	74	Tubbergen	1243	69
Riel	1179	67	Haaksbergen	1244	64
Oostelbeers	1180	91	Scheveningen	1247	74
Hilvarenbeek	1181	63	Zaltbommel	1251	71
Venray	1183	61	IJzendijke	1252	78
Nieuw-Bergen	1184	60	Ritthem	1253	101
Sevenum	1185	68	Vlissingen-Haven	1254	74

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Table A10: Continued.

Station	No.	Ambient dose equivalent rate nSv.h^{-1}	Station	No.	Ambient dose equivalent rate nSv.h^{-1}
Nieuwdorp	1255	84	Slijk Ewijk [2]	1268	112
's Heerenhoek	1256	82	Doorwerth [2]	1269	67
Driewegen	1257	90	Randwijk	1270	96
Arnemuiden	1258	72	Beneden Leeuwen	1272	75
Heinkeszand	1259	85	Appeltern [1, 2]	1273	-
Baarland	1260	86	Puiflijk [2]	1274	78
Biervliet	1261	64	Bergharen [2]	1275	77
Slijkplaat	1262	77	Beuningen [2]	1276	81
Rilland	1263	84	Denekamp	1278	62
Putte	1264	57	Winterswijk	1279	67
Nieuw Namen [3]	1265	78	Bilthoven	1280	59
Ochten [1, 2]	1266	-	Maarheze/Gastel	1281	66
Opheusden [1, 2]	1267	-			

[1] Station was not operational in 2003.
[2] Station is part of the so-called ring around the nuclear powerplant Dodewaard. The powerplant stopped operation in March 1997. The last of the nuclear fuel was removed in April 2003. Therefore these stations are dismantled or will be dismantled in the near future.
[3] For the calculation of the yearly average only 42 days were available for this station.

Table A11: ^{3}H- and residual β-activity concentrations ($mBq \cdot L^{-1}$) in surface water in 2003 as measured by RIZA.

Date	^{3}H	Residual β
Location: Eijsden (Meuse)		
21/01/03	1800	19
18/02/03	5200	23
18/03/03	5600	13
15/04/03	19700	3
13/05/03	27900	17
10/06/03	1200	11
08/07/03	45000	26
05/08/03	59000	7
02/09/03	31000	18
30/09/03	30000	10
28/10/03	38000	10
25/11/03	18000	< 1
23/12/03	5400	20
Average	**22100**	**14**
Location: Lobith (Rhine)		
22/01/03	4300	27
19/02/03	1000	38
19/03/03	9600	28
16/04/03	6100	37
14/05/03	5100	46
11/06/03	2500	36
09/07/03	2800	27
06/08/03	2800	25
03/09/03	3300	47
01/10/03	5100	48
29/10/03	6200	25
26/11/03	10000	29
22/12/03	5700	25
Average	**5000**	**34**
Location: Schaar van Ouden Doel (Scheldt)		
14/01/03	4600	78
11/02/03		110
10/03/03	9600	120
07/04/03		64
06/05/03	6800	63
03/06/03		62
01/07/03	12000	62
30/07/03		77
27/08/03	9600	34
22/09/03		110
20/10/03	8600	82
17/11/03		84
15/12/03	20000	96
Average	**10200**	**80**

Table A12: ^{137}Cs-activity concentrations in suspended solids (Bq·kg^{-1}) in surface water in 2003 as measured by RIZA.

Date	^{137}Cs	Date	^{137}Cs
Location: Eijsden (Meuse)		**Location: Ketelmeer-West**	
07/01/03	14	08/01/03	23
14/01/03	14	06/03/03	17
21/01/03	14	02/05/03	14
29/01/03	13	26/06/03	18
04/02/03	10	21/08/03	21
11/02/03	14	16/10/03	21
18/02/03	10	11/12/03	20
25/02/03	11	**Average**	**19**
04/03/03	16	**Location: Lobith (Rhine)**	
11/03/03	13	22/01/03	16
18/03/03	11	19/02/03	17
25/03/03	8	19/03/03	16
01/04/03	8	16/04/03	11
08/04/03	6	14/05/03	12
15/04/03	5	11/06/03	20
22/04/03	6	09/07/03	19
29/04/03	7	06/08/03	14
06/05/03	10	03/09/03	16
13/05/03	9	01/10/03	18
20/05/03	14	29/10/03	18
27/05/03	12	26/11/03	17
03/06/03	10	22/12/03	17
10/06/03	5	24/12/03	17
17/06/03	5	**Average**	**16**
24/06/03	5	**Location: Schaar van Ouden Doel (Scheldt)**	
01/07/03	7	14/01/03	12
08/07/03	8	11/02/03	15
15/07/03	7	10/03/03	15
22/07/03	< 1	07/04/03	11
29/07/03	7	06/05/03	11
05/08/03	7	03/06/03	11
12/08/03	5	01/07/03	15
19/08/03	7	30/07/03	12
26/08/03	7	27/08/03	11
02/09/03	8	22/09/03	14
09/09/03	8	20/10/03	13
16/09/03	7	17/11/03	11
23/09/03	7	15/12/03	12
30/09/03	8	**Average**	**13**
07/10/03	12		
14/10/03	9		
21/10/03	8		
28/10/03	9		
04/11/03	11		
11/11/03	8		
18/11/03	10		
25/11/03	9		
02/12/03	11		
09/12/03	14		
16/12/03	16		
23/12/03	12		
30/12/03	12		
Average	**9**		

Table A13: Gross α-, residual β-, ^{3}H- and ^{90}Sr-activity concentrations ($mBq \cdot L^{-1}$) in seawater in 2003 as measured by RIZA.

Date	Gross α	Residual β	^{3}H	^{90}Sr
Location:	**Coastal area**			
13/02/03	370	88	3400	
07/05/03	380	56	3900	
14/08/03	750	46	3300	
13/11/03	620	53	3500	
Average	**530**	**61**	**3500**	
Location:	**Southern North Sea**			
12/02/03	360	100	1500	1
08/05/03	370	25	2700	4
13/08/03	250	44	4000	< 1
12/11/03	770	51	5200	< 1
Average	**438**	**55**	**3400**	**1.5**
Location:	**Central North Sea**			
11/02/03	580	80	< 100	6
14/05/03	310	51	560	5
12/08/03	760	32	460	5
11/11/03	640	51	360	6
Average	**573**	**54**	**460**	**5.5**
Location:	**Delta Coastal Waters**			
09/01/03	290	120		
12/02/03	400	100	4000	6
10/03/03	460	88		
14/04/03	330	74		
06/05/03	310	53	3900	< 1
17/06/03	290	16		
22/07/03	400	67		
19/08/03	410	32	4300	3
24/09/03	530	55		
23/10/03	900	31		
12/11/03	1040	51	5000	4
17/12/03	660	79		
Average	**502**	**64**	**4300**	**3.4**
Location:	**Westerscheldt**			
14/01/03	450	92	4300	< 1
11/02/03	460	74	5300	4
11/03/03	450	150	4600	8
08/04/03	560	93	5200	< 1
06/05/03	650	140	5800	1
02/06/03	480	65	4700	< 1
01/07/03	310	40	4600	6
29/07/03	330	73	4400	4
26/08/03	490	68	5300	< 1
22/09/03	430	35	5000	< 1
21/10/03	540	61	5300	< 1
19/11/03	600	47	5500	2
17/12/03	710	57	5700	3
Average	**497**	**77**	**5100**	**2.0**

To be continued on the next page.

Table A13: Continued.

Date Location:	Gross α Eems-Dollard	Residual β	^{3}H	^{90}Sr
14/02/03	420	110	3700	
16/05/03	150	47	4300	
20/08/03	670	79	5000	
20/11/03	560	66	3200	
Average	**450**	**76**	**4100**	
Location:	**Wadden Sea West**			
13/02/03	330	93	3300	
15/05/03	230	44	3600	
11/08/03	660	34	2200	
17/11/03	350	41	4800	
Average	**393**	**53**	**3500**	
Location:	**Wadden Sea East**			
12/02/03	820	150	4200	
13/05/03	450	75	3100	
12/08/03	380	60	3600	
11/11/03	590	190	3700	
Average	**560**	**119**	**3700**	

Table A14: ^{137}Cs- and ^{210}Po-activity concentrations in suspended solids ($Bq \cdot kg^{-1}$) in seawater in 2003 as measured by RIZA.

Date	**^{137}Cs**	**^{210}Po**
Location:	**Coastal area**	
14/02/03	15	120
12/05/03	n/a	n/a
11/08/03	8	86
10/11/03	n/a	n/a
Average	**12**	**103**
Location:	**Westerscheldt**	
10/02/03	7	86
07/05/03	5	62
25/08/03	6	66
19/11/03	n/a	n/a
Average	**6**	**71**
Location:	**Eems-Dollard**	
07/02/03	11	110
19/05/03	8	87
20/08/03	8	83
24/11/03	9	98
Average	**9**	**94**
Location:	**Wadden Sea West**	
12/02/03	n/a	n/a
14/05/03	n/a	n/a
08/08/03	n/a	n/a
12/11/03	n/a	n/a
Average		
Location:	**Wadden Sea East**	
12/02/03	8	130
16/05/03	n/a	n/a
11/08/03	5	84
11/11/03	9	110
Average	**7**	**108**

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