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**Monitoring of radiation in the environment in the Netherlands
Results in 2002**

G.J. Knetsch, editor



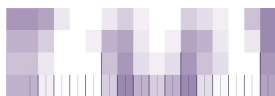
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Abstract

The Dutch government is compelled to measure radioactivity in the environment under terms of the Euratom Treaty of 1957. This report presents the results of radioactivity measurements in the Dutch environment in 2002. The measurements were carried out by RIVM, RIZA, RIKZ and Inspectorate for Health Protection and Veterinary Public Health. Radioactivity measurements were carried out on airborne particles, deposition, surface water, seawater, drinking water and food (honey, powdered milk, game, poultry, blueberry and chanterelle). No measurements were performed on milk since 1998. Results for ambient dose equivalent rates have been obtained from the National Radioactivity Monitoring Network.

In 2002 two unusual levels of radioactivity were found in the Dutch environment. The activity concentration of ^{210}Pb in air dust during week 45 ($3000 \pm 300 \mu\text{Bq}\cdot\text{m}^{-3}$) is the highest concentration since 1991. A deposited ^7Be -activity as high as that of week 43 ($158 \pm 19 \text{ Bq}\cdot\text{m}^{-2}$) has not occurred since 1998.

Furthermore, the ^3H -activity in the Meuse exceeded the target value ($10 \text{ Bq}\cdot\text{L}^{-1}$) in ten out of thirteen samples taken. However the yearly average ($15 \text{ Bq}\cdot\text{L}^{-1}$) is within range of previous years.

The Dutch monitoring program deviates from the recommendations of the European union, mainly concerning the measurement of drinking water, milk and food.

Preface

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Samenvatting

In het kader van het Euratom Verdrag uit 1957 is de Nederlandse overheid verplicht om radioactiviteitsgehalten te meten in de compartimenten lucht, water en bodem. In 2000 heeft de Europese Unie dit nauwkeuriger gespecificeerd middels aanbevelingen. Hierin wordt in detail beschreven wat moet worden gemeten (luchtstof, de omgevingsdosis, oppervlaktewater, drinkwater, melk en voedsel) en met welke frequentie. De resultaten dienen jaarlijks te worden gerapporteerd. In dit rapport worden de resultaten gegeven van radioactiviteitsmetingen in het Nederlandse milieu in 2002. De metingen zijn verricht door RIVM, RIZA, RIKZ en Keuringsdienst van Waren.

In luchtstof werd de jaargemiddelde activiteitsconcentratie bepaald van totaal- α , totaal- β , ^7Be , ^{137}Cs en ^{210}Pb . In depositie werd de totale jaarlijkse activiteit bepaald van totaal- α , totaal- β , ^3H , ^7Be , ^{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 afkomstig van menselijk handelen). Het verschil tussen de NMR-metingen en bovenstaande metingen wordt vooral veroorzaakt door de bijdrage van kortlevende natuurlijke radionucliden (radon en dochterproducten). Het jaargemiddelde voor de totaal- α -activiteitsconcentratie in luchtstof (inclusief radondochters) was $3,1 \text{ Bq}\cdot\text{m}^{-3}$. 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 $73 \text{ nSv}\cdot\text{h}^{-1}$. Gebaseerd op eerder onderzoek wordt aangenomen dat deze waarde een overschatting is met 5 tot $10 \text{ nSv}\cdot\text{h}^{-1}$.

In oppervlaktewater werd de jaargemiddelde activiteitsconcentratie bepaald van ^3H 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 , ^3H 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*.

Gangbare waarden die in ruw water voor de drinkwaterproductie gevonden worden, zijn $1\text{-}10 \text{ Bq}\cdot\text{L}^{-1}$ voor ^3H -activiteit en $0,1\text{-}1 \text{ Bq}\cdot\text{L}^{-1}$ voor zowel totaal- β als rest- β -activiteit. In dit water is weinig kalium, en dus ^{40}K , aanwezig.

Radioactiviteitsmetingen zijn verricht aan een aantal voedingsproducten. De resultaten zijn weergegeven in *Tabel S1*. Radioactiviteit werd niet gedetecteerd in enkele bemonsterde producten, waaronder bosbes en cantharel. Sinds 1998 zijn er geen metingen verricht aan melk.

In 2002 zijn er in het Nederlandse milieu enkele ongebruikelijke niveaus van radioactiviteit gevonden. De activiteitsconcentratie van ^{210}Pb in luchtstof gedurende week 45 ($3000 \pm 300 \mu\text{Bq}\cdot\text{m}^{-3}$) is de hoogste concentratie sinds 1991. Sinds 1998 is de gedeponeerde ^7Be -activiteit niet meer zo hoog geweest als die van week 43 ($158 \pm 19 \text{Bq}\cdot\text{m}^{-2}$). Daarnaast overschreed de ^3H -activiteit in de Maas in tien van de dertien in 2002 genomen monsters de streefwaarde van $10 \text{Bq}\cdot\text{L}^{-1}$. Het jaargemiddelde ($15 \text{Bq}\cdot\text{L}^{-1}$) ligt 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.

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 2002. The measurements were carried out by RIVM, RIZA, RIKZ and the Inspectorate for Health Protection and Veterinary Public Health.

The yearly averaged activity concentration in air dust was determined for gross α , gross β , ^7Be , ^{137}Cs and ^{210}Pb . The yearly total activity in deposition was determined for gross α , gross β , ^3H , ^7Be , ^{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 and its daughters). The yearly averaged gross α -activity concentration in air dust was $3.1 \text{ Bq}\cdot\text{m}^{-3}$. 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 $73 \text{ nSv}\cdot\text{h}^{-1}$. Based upon earlier research it is assumed that this value is an overestimate of 5 to $10 \text{ nSv}\cdot\text{h}^{-1}$.

The yearly averaged activity concentrations of ^3H 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 , ^3H 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*.

Typical activities found in raw input water for drinking water production were $1\text{-}10 \text{ Bq}\cdot\text{L}^{-1}$ for ^3H -activity and $0.1\text{-}1 \text{ Bq}\cdot\text{L}^{-1}$ for gross β - and residual β -activity. There is little potassium, and thus ^{40}K , present in this water.

Radioactivity was determined in some food products. The results are presented in *Table S1*. Radioactivity was not detected in several products sampled, amongst which blueberry and chanterelle.

No measurements were performed on milk since 1998. In 2002 two unusual levels of radioactivity were found in the Dutch environment. The activity concentration of ^{210}Pb in air dust during week 45 ($3000 \pm 300 \text{ }\mu\text{Bq}\cdot\text{m}^{-3}$) is the highest concentration found since 1991. A

deposited ^7Be -activity as high as that of week 43 ($158 \pm 19 \text{ Bq}\cdot\text{m}^{-2}$) has not occurred since 1998.

Furthermore, the ^3H -activity in the Meuse exceeded the target value ($10 \text{ Bq}\cdot\text{L}^{-1}$) in ten out of thirteen samples taken. However the yearly average ($15 \text{ Bq}\cdot\text{L}^{-1}$) is within range of previous years.

The Dutch monitoring program deviates from the recommendations of the European union, mainly concerning the measurement of drinking water, milk and food.

*Tabel S1: Overzicht van de resultaten in 2002.**Table S1: Summary of the results in 2002.*

Matrix	Parameter	Location	Values	Frequency (per year)
Air dust ⁽¹⁾	Gross α	1	0.05 mBq·m ⁻³	53
	Gross β	1	0.432 mBq·m ⁻³	53
	⁷ Be	1	3.210 mBq·m ⁻³	53
	¹³⁷ Cs	1	<0.002 mBq·m ⁻³ ⁽²⁾	53
	²¹⁰ Pb	1	0.486 mBq·m ⁻³	53
Deposition ⁽³⁾	Gross α	1	20.6 Bq·m ⁻²	12
	Gross β	1	97 Bq·m ⁻²	12
	³ H	1	<1630 Bq·m ⁻² ⁽⁴⁾	12
	⁷ Be	1	1510 Bq·m ⁻²	53
	¹³⁴ Cs	1	<0.1 Bq·m ⁻² ⁽²⁾	53
	¹³⁷ Cs	1	<0.1 Bq·m ⁻² ⁽²⁾	53
	²¹⁰ Pb	1	125 Bq·m ⁻²	53
	²¹⁰ Po	1	7.5 Bq·m ⁻²	12
Surface water ⁽¹⁾	Residual β	3	0.030-0.114 Bq·L ⁻¹	13
	³ H	3	4.5-15.4 Bq·L ⁻¹	6 or 13 ⁽⁵⁾
	¹³⁷ Cs	4	10-22 Bq·kg ⁻¹	6, 13 or 53 ⁽⁵⁾
Seawater ⁽¹⁾	Gross α	8	0.211-0.438 Bq·L ⁻¹	4, 11 or 13 ⁽⁵⁾
	Residual β	8	0.063-0.148 Bq·L ⁻¹	4, 11 or 13 ⁽⁵⁾
	³ H	8	0.8-5.0 Bq·L ⁻¹	4 or 13 ⁽⁵⁾
	⁹⁰ Sr	4	<0.001-0.004 Bq·L ⁻¹	4 or 13 ⁽⁵⁾
	¹³⁷ Cs	5	6-10 Bq·kg ⁻¹	1, 3 or 4 ⁽⁵⁾
	²¹⁰ Po	5	80-110 Bq·kg ⁻¹	1, 3 or 4 ⁽⁵⁾
Food ^(6, 7)				
Various kinds of honey	¹³⁷ Cs	-	n.d. ⁽⁸⁾	97 (0) ⁽⁹⁾
Heather honey	¹³⁷ Cs	-	28-327 Bq·kg ⁻¹	19 (19) ⁽⁹⁾
Powdered milk	¹³⁷ Cs	-	6-33 Bq·kg ⁻¹	80 (9) ⁽⁹⁾
Game and poultry	¹³⁷ Cs	-	28 and 69 Bq·kg ⁻¹	95 (2) ⁽⁹⁾

⁽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 ¹³⁴Cs as well, but it was not detectable.⁽⁸⁾ = Not detectable.⁽⁹⁾ = 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 2002. 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 .

The results will, in general, be presented in graphs and tables with a minimum amount of text. 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 2002 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 2002 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 m³ 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 ²²²Rn and ²²⁰Rn. This is to ensure that these naturally occurring decay-products do not contribute to the measured α - and β -activity concentrations.

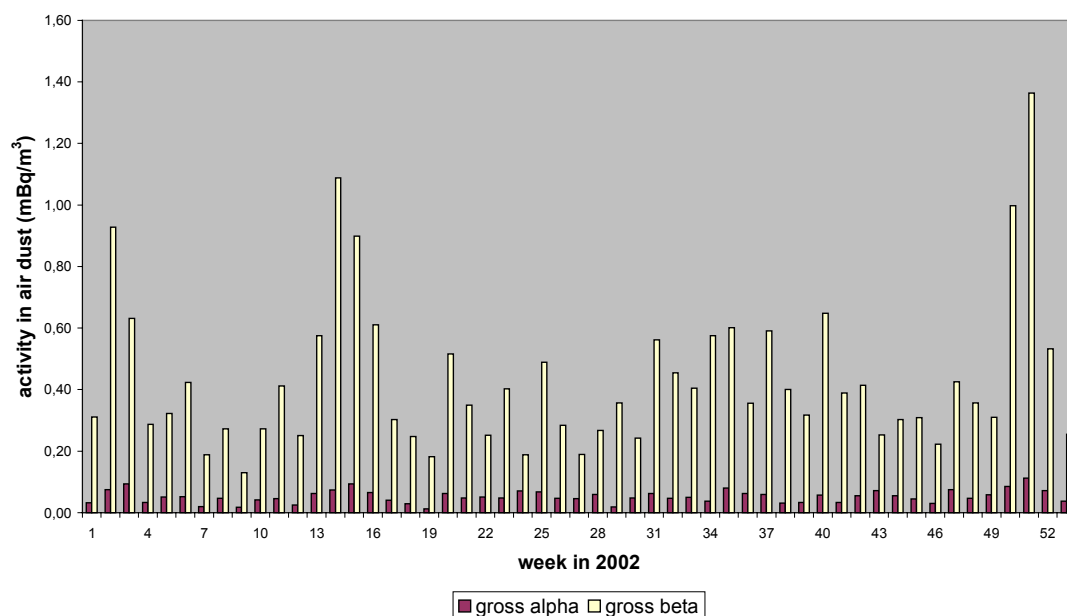


Figure 2.1: Weekly results of gross α - and β -activity concentrations of long-lived nuclides in air dust sampled at RIVM in 2002.

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.

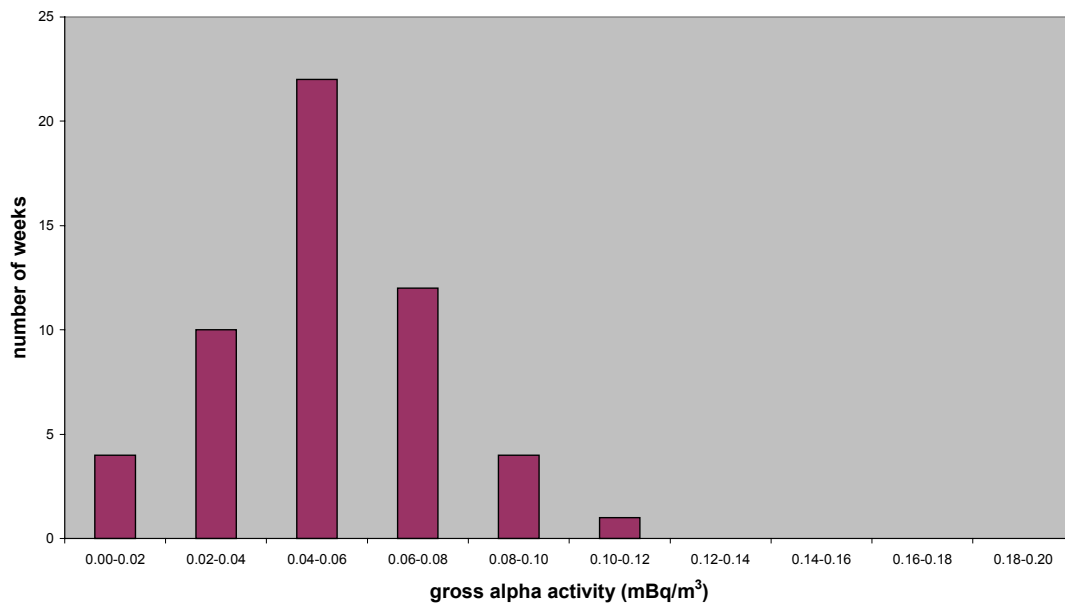


Figure 2.2: Frequency distribution of gross α -activity concentration of long-lived nuclides in air dust collected weekly at RIVM in 2002. Mean concentration is 0.05 ($SD=0.02$) $\text{mBq}\cdot\text{m}^{-3}$. SD is the standard deviation and illustrates the variation in weekly averages during the year.

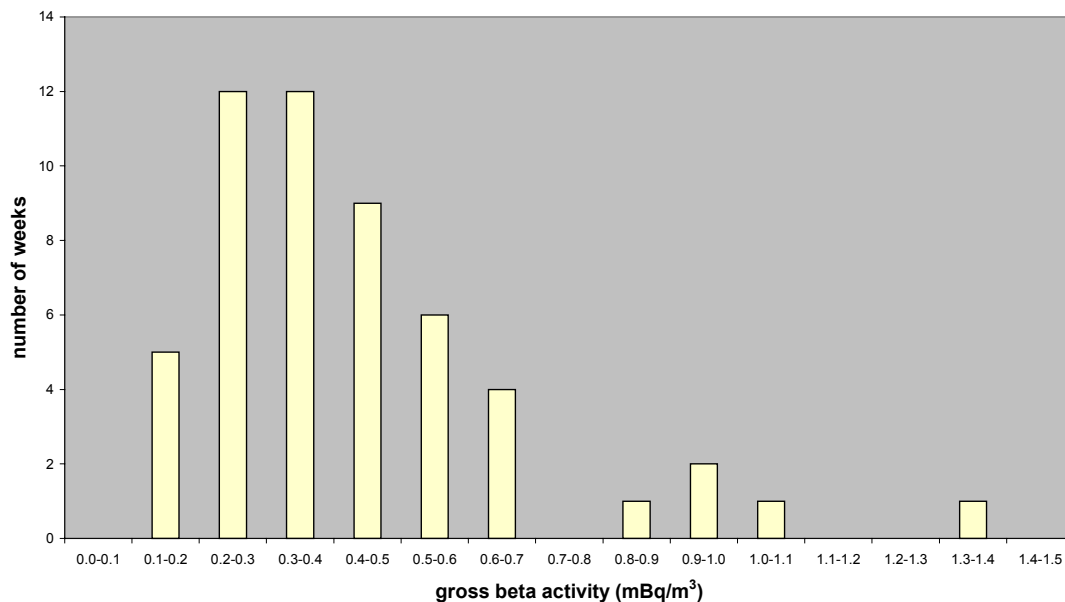


Figure 2.3: Frequency distribution of gross β -activity concentration of long-lived nuclides in air dust collected weekly at RIVM in 2002. Mean concentration is 0.432 ± 0.004 ($SD=0.2$) $\text{mBq}\cdot\text{m}^{-3}$.

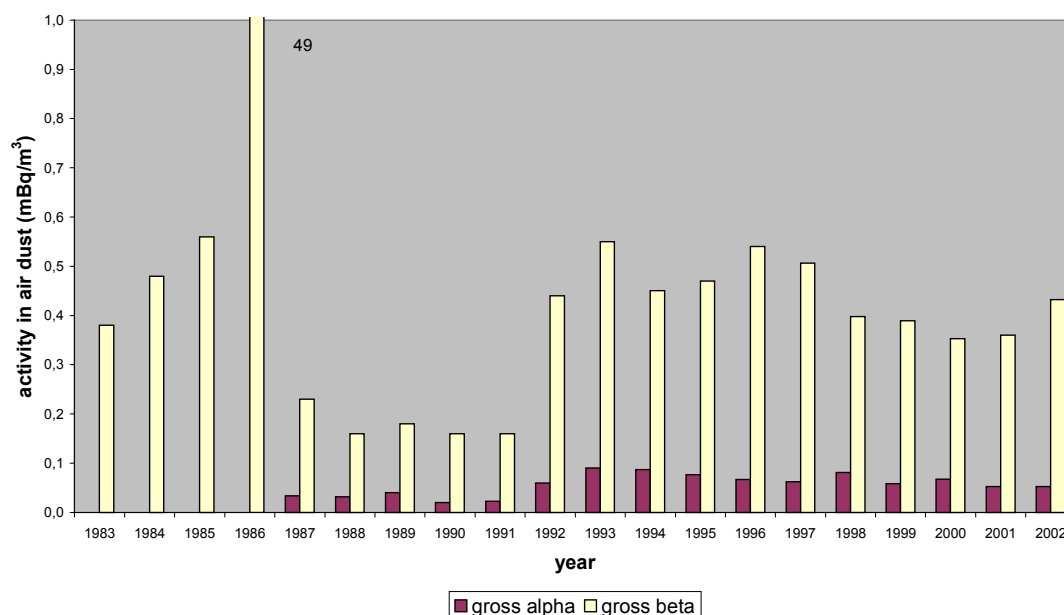


Figure 2.4: Yearly averages of gross α - and gross β -activity concentration of long-lived nuclides in air dust from the outset of the respective monitoring campaigns. The high level in 1986 was caused by the accident at the Chernobyl nuclear power plant.

The yearly averages of the gross α - and β -activity concentrations of long-lived nuclides in 2002 are within the range of the results from the period 1992-2001 [6].

Figure 2.4 shows a 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 activity concentrations [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 ^7Be and ^{210}Pb (Table A3, Figure 2.5, 2.6 and 2.7). Since late 1999 the detection limit of ^{137}Cs is higher ($2.0 \mu\text{Bq}\cdot\text{m}^{-3}$) than during 1991-1999 ($0.1 \mu\text{Bq}\cdot\text{m}^{-3}$), due to a different detector set-up.

The behaviour of ^7Be in the atmosphere has been studied world-wide [9, 10, 11, 12, 13, 14, 15]. Natural ^7Be (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 $\text{Be}(\text{OH})_2$ molecules. Approximately 70% of ^7Be is produced in the stratosphere, with the remaining 30% being produced in the troposphere. A residence time is estimated at about a year in the stratosphere and about six weeks in the troposphere. Most of the ^7Be 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 ^7Be 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 ^7Be 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 ^7Be -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 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 ^7Be -activity concentration can be explained by the decrease in cosmogenic radiation.

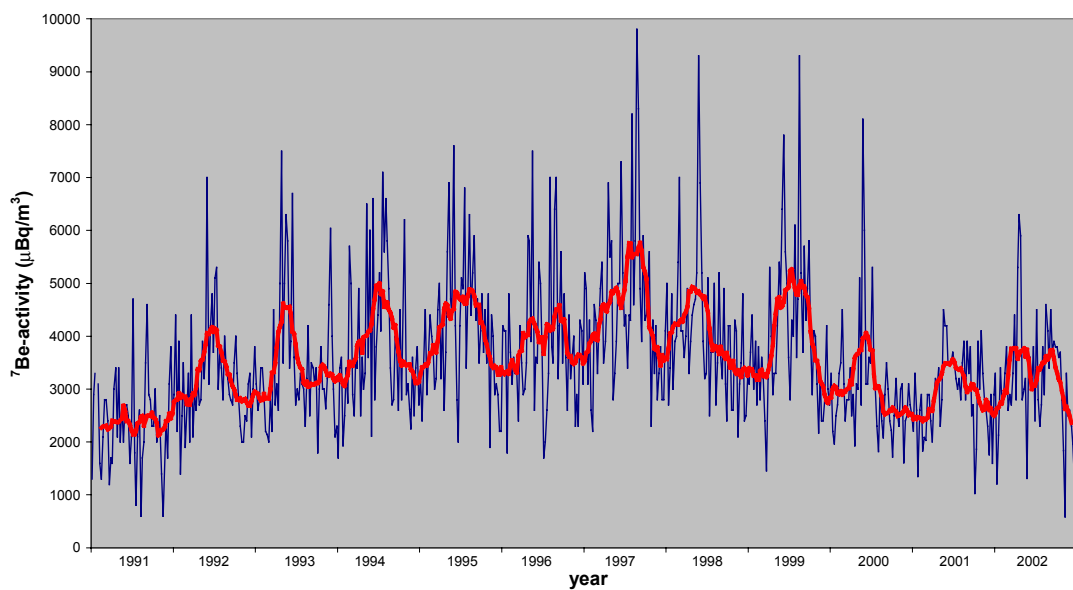


Figure 2.5: Weekly averaged activity concentrations (blue) of ^7Be in air dust at RIVM in 1991-2002. The red line represents a moving average of 13 weeks. Yearly average for 2002 is 3210 ± 40 ($SD=1100$) $\mu\text{Bq}\cdot\text{m}^{-3}$.

The concentrations found for ^7Be in 2002 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].

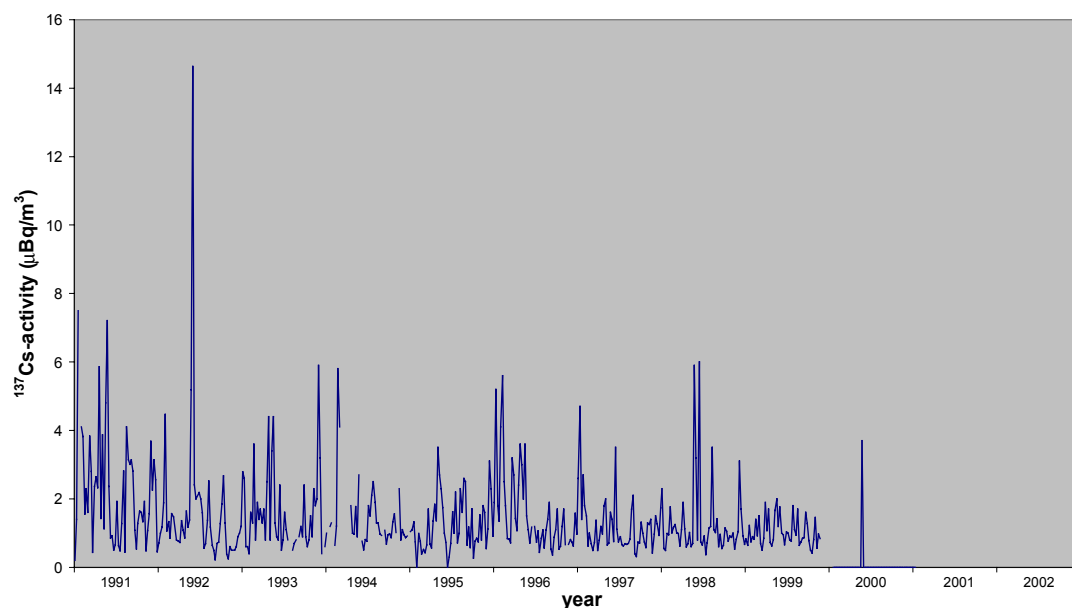


Figure 2.6: Weekly averaged activity concentrations of ^{137}Cs in air dust at RIVM in 1991-2002. In 2002 all measurements were below the detection limit. The detection limit was higher than during 1991-1999, due to a different detector set-up.

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 $500 \mu\text{Bq}\cdot\text{m}^{-3}$ [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]. Industrial emissions are discharged by power plants using fossil fuels, fertiliser and phosphorus industries, and as 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 $60 \text{ TBq}\cdot\text{year}^{-1}$ 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.

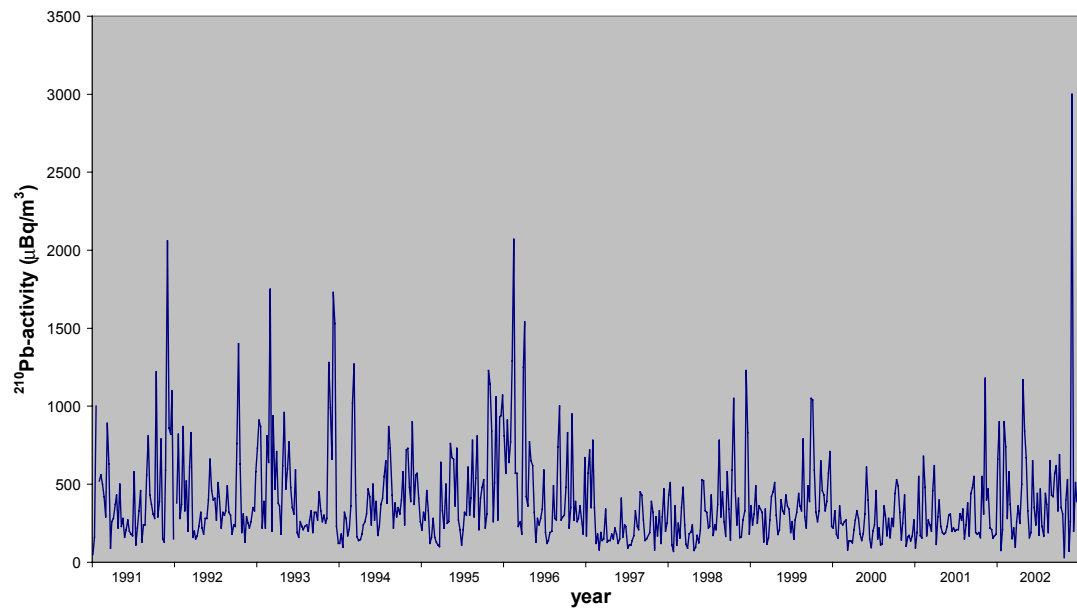


Figure 2.7: Weekly averaged activity concentrations of ^{210}Pb in air dust at RIVM in 1991-2002. Yearly average for 2002 is 486 ± 9 ($SD=500$) $\mu\text{Bq}\cdot\text{m}^{-3}$.

Except for the higher concentration of ^{210}Pb during week 45 (31st of October until 8th of November) the results do not differ significantly from those found in 1991-2001.

Unusual values might be explained by natural phenomena like an explosive volcanic eruption, Saharan dust and resuspension of (local) dust. The unusual value of week 45 (3000 ± 300 $\mu\text{Bq}\cdot\text{m}^{-3}$) can not be explained by these natural sources as is shown below.

On the 26th of October the Etna started with the biggest explosive eruption in all of Europe of the last hundreds years [30, 31, 32]. Considering the direction of the plume (mainly south or east) during that period it is unlikely for the emitted ^{210}Pb to have been transported to the Netherlands.

On the 27th of October the most violent storm in twelve years passed over the Netherlands. With wind speeds up to $148 \text{ km}\cdot\text{h}^{-1}$ [33] loose soil could be resuspended in the air, which might contribute to the ^{210}Pb concentration in air. However, no elevated levels of submicron-sized aerosols (PM10) were measured during that period by the LML (Landelijk Meetnet Luchtkwaliteit) [34] which suggests that no significant resuspension of soil occurred.

Another possible source of ^{210}Pb is Saharan dust, as reported elsewhere [35, 36, 37]. Considering the absence of elevated levels of submicron-sized aerosols (as measured by the LML) it seems unlikely that a considerable amount of Sahara dust was present in the air during week 45.

3. Deposition

The 2002 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 , ^3H and ^{210}Po .

Table 3.1: The 2002 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	^3H	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 20.6 ± 0.9 and $97 \pm 2 \text{ Bq}\cdot\text{m}^{-2}$, respectively. These values do not differ significantly from those measured since 1987, as illustrated in *Figure 3.2* and *Table A5*. The measuring technique for gross α and gross β was changed around mid 1986 [38], which makes it difficult to compare data before 1986 with data after 1986 [39].

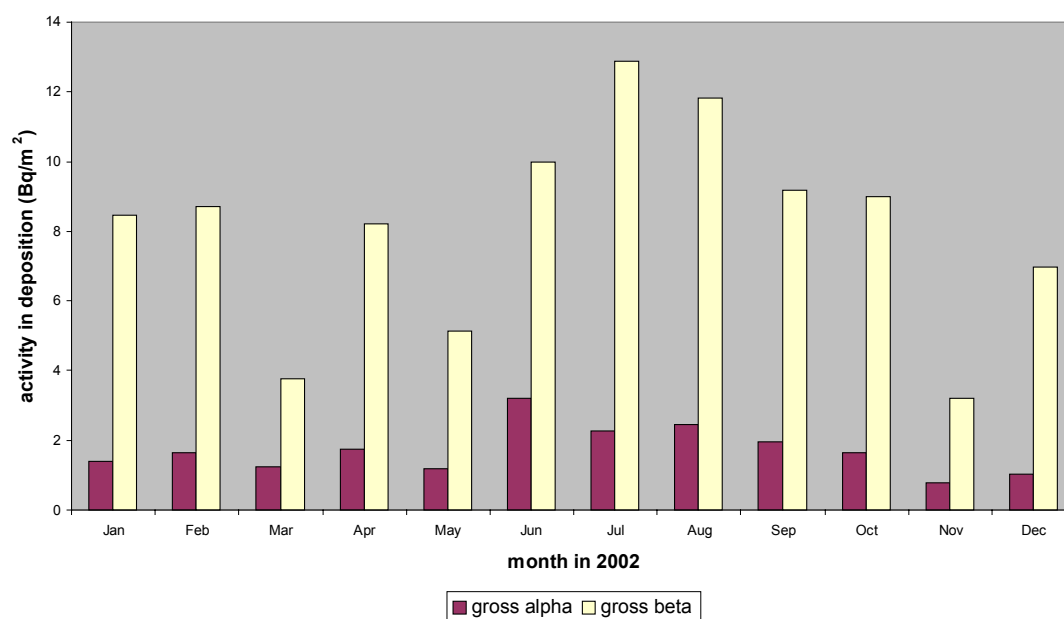


Figure 3.1: Monthly deposited gross α - and gross β -activity of long-lived nuclides at RIVM in 2002.

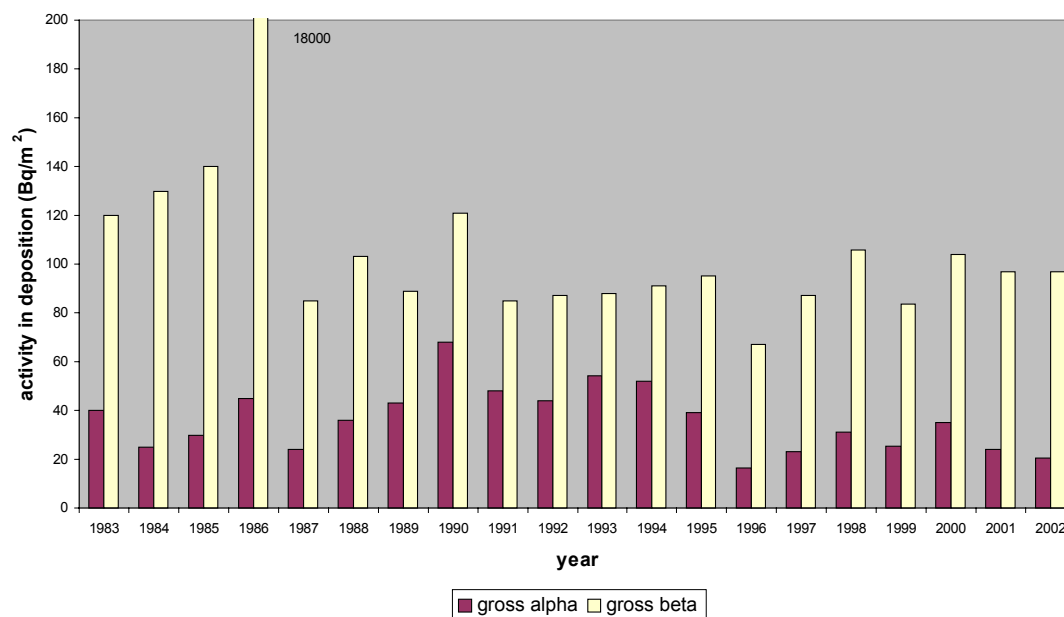


Figure 3.2: Yearly gross α - and gross β -activity of long-lived nuclides deposited at RIVM from 1983 to 2002 (see Table A5). The 1986 level resulted from the accident at the Chernobyl nuclear power plant.

The monthly deposition of ^3H is given in Table A4. In 2002 less than $1630 \text{ Bq}\cdot\text{m}^{-2}$ of ^3H was deposited. Ten 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 ^3H 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 ^3H after the end of the atmospheric nuclear weapons tests in the seventies.

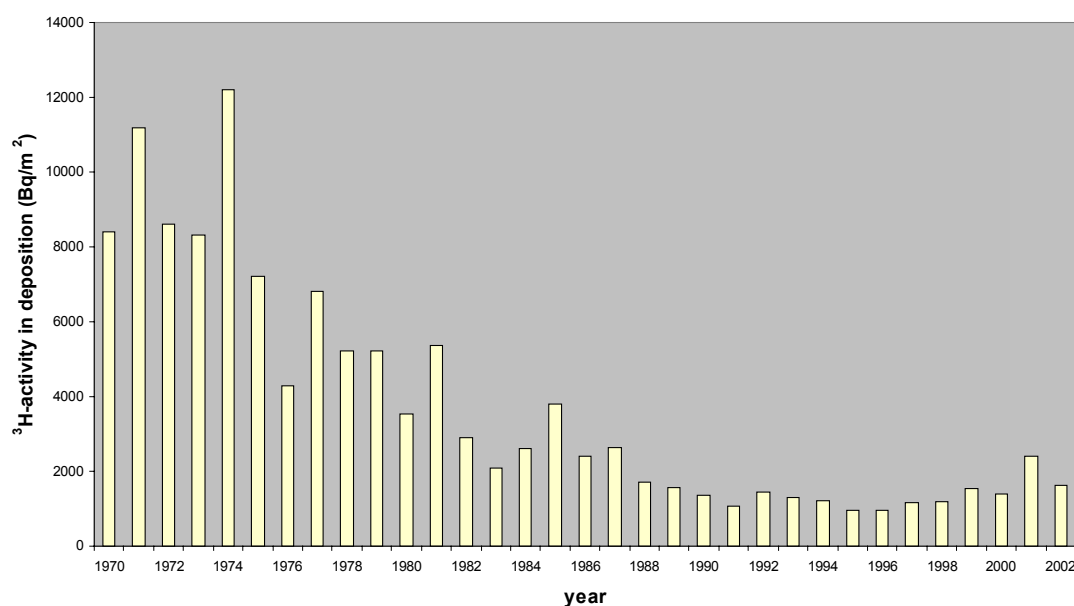


Figure 3.3: Yearly deposition of ^3H at RIVM in the period 1970-2002.

The monthly α -spectroscopy results for ^{210}Po are given in *Table A6*. The results for previous years are given in *Table A7*. In 2002 $7.5 \pm 1.0 \text{ Bq}\cdot\text{m}^{-2}$ of ^{210}Po was deposited. Because no ^{210}Po was detected in the October deposition, the detection limit was used for the October contribution to the year total.

3.2 γ -Emitting nuclides

Detectable quantities of the naturally occurring nuclides ^7Be and ^{210}Pb were found, with yearly total depositions of 1510 ± 30 and $125 \pm 5 \text{ Bq}\cdot\text{m}^{-2}$, respectively. The nuclides ^{134}Cs and ^{137}Cs were not found (detection limit is $0.1 \text{ Bq}\cdot\text{m}^{-2}$ for both nuclides). The weekly results for deposition of ^7Be 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 ^7Be (*Figure 3.4*) is less clear than in previous years [6]. A deposited ^7Be -activity as high as found in week 43 ($158 \pm 19 \text{ Bq}\cdot\text{m}^{-2}$) has not occurred since 1998 [40]. However, during 1998 the ^7Be -activities correlated with a large amount of precipitation (78–125.5 mm), where in 2002 the precipitation was relatively low (17.3 mm).

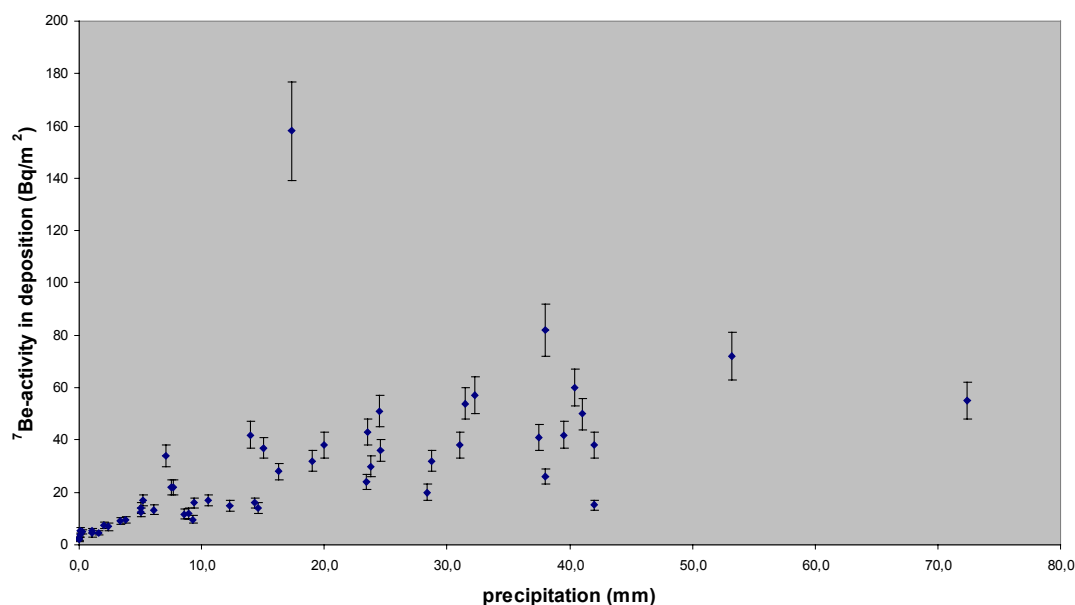


Figure 3.4: The weekly deposition of ^7Be at RIVM in 2002 versus precipitation.

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

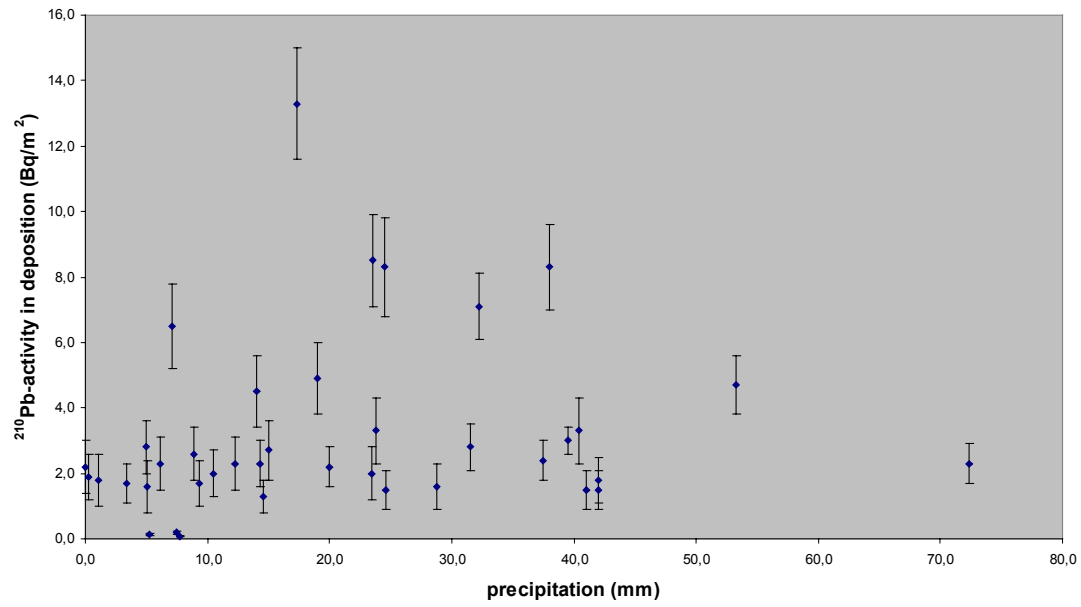


Figure 3.5: The weekly deposition of ^{210}Pb at RIVM in 2002 versus precipitation.

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 [41]. 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 [42]. 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.

The 14 aerosol FAG FHT59S monitors were replaced by 14 new Berthold BAI 9128 monitors during the second half of 2002. 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 reports about 20% higher values than the FAG monitor [43]. The estimated uncertainty for both monitors is about 20%. Hence, the difference is within the estimated uncertainty. 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 [42, 44] 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.

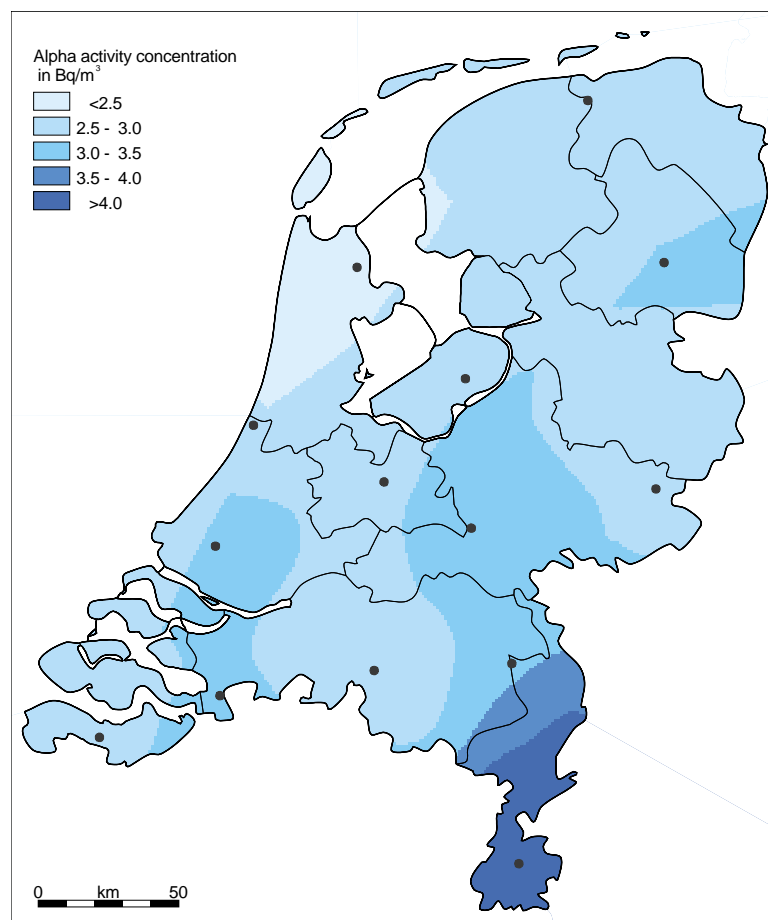


Figure 4.1: Spatial variation in the average gross α -activity concentration in air dust in 2002. The dots represent the locations of the aerosol monitors.

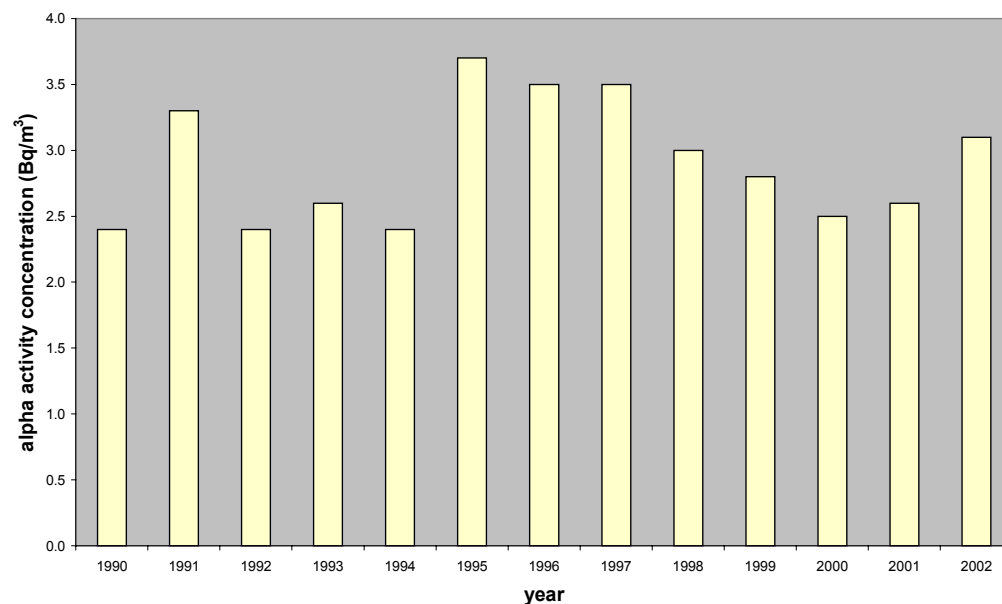


Figure 4.2: Yearly averages for gross α -activity concentration.

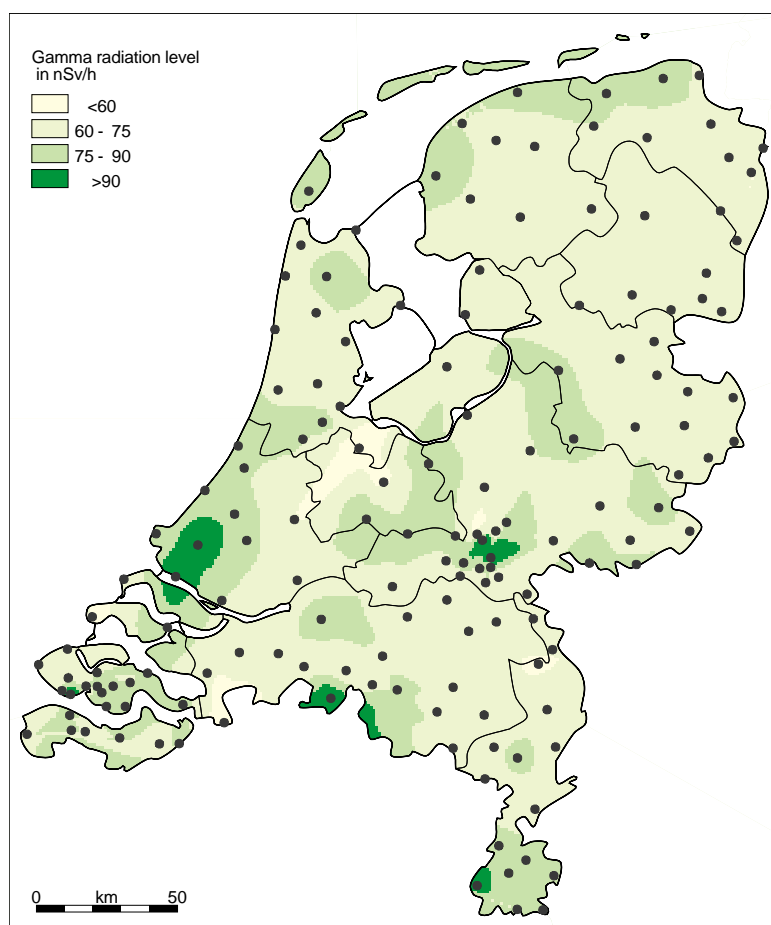


Figure 4.3: Spatial variation in the average ambient dose equivalent rate in 2002. The dots represent the locations of the dose equivalent rate monitors.

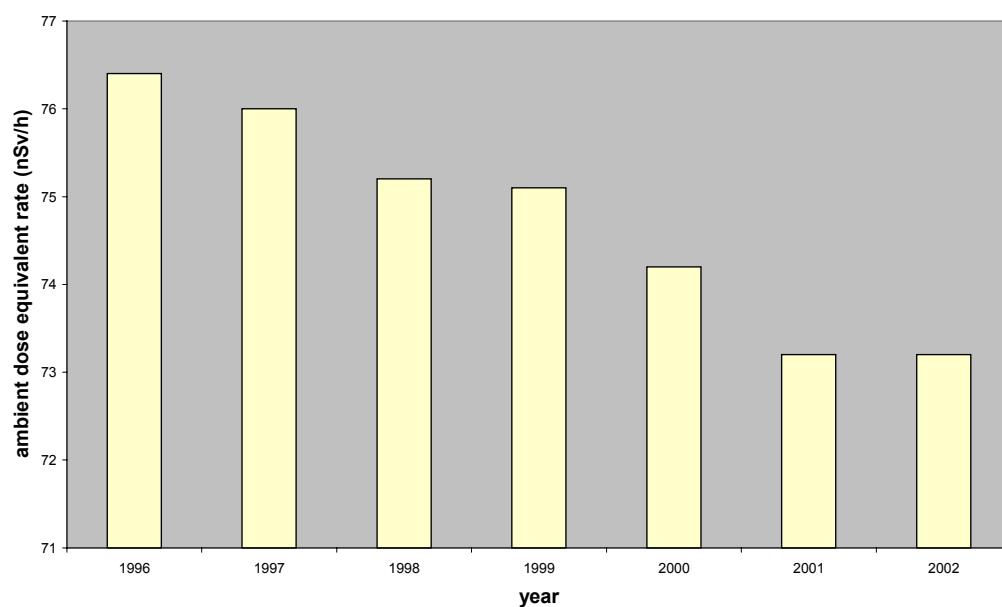


Figure 4.4: Yearly averages of the ambient dose equivalent rate.

Figures 4.2 and 4.4 present the yearly averages of gross α -activity concentration and ambient dose equivalent rate from 1990 to 2002, respectively. The yearly averaged gross α -activity concentration in air dust was $3.1 \text{ Bq}\cdot\text{m}^{-3}$ (based on the yearly averages of the 14 measurement locations). This value does not differ significantly from 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 2002 is calculated using 156 stations. The remaining 7 stations were not operational. For the ambient dose equivalent rate the yearly averaged measured value was $73 \text{ nSv}\cdot\text{h}^{-1}$. It is assumed that this value is an overestimate of 5 to $10 \text{ nSv}\cdot\text{h}^{-1}$. 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 2002 (Figure 4.4) might be related to the decrease in the cosmogenic contribution.

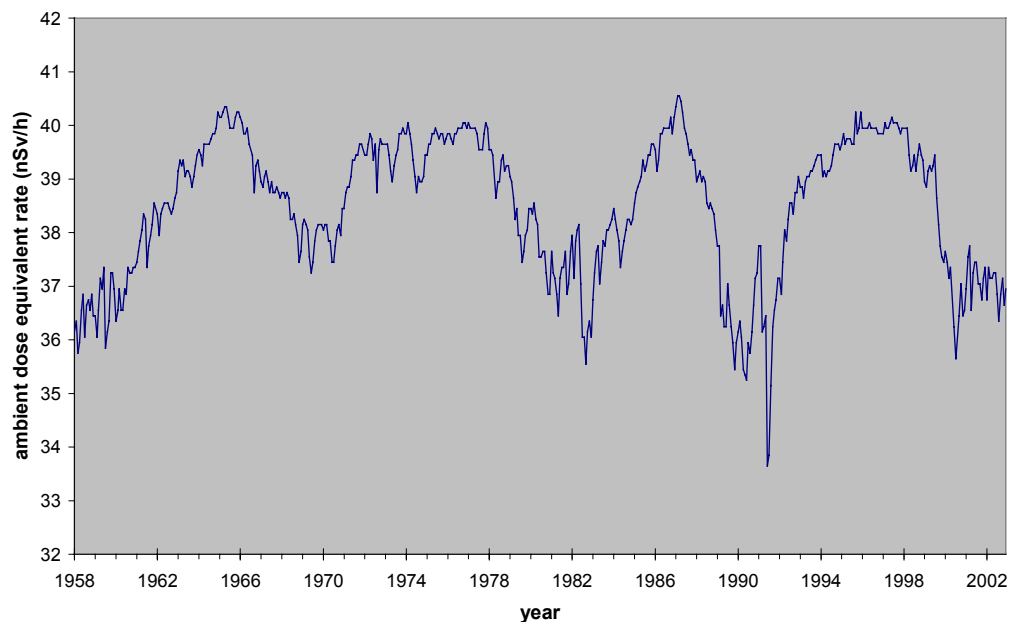


Figure 4.5: Cosmogenic contribution to the ambient dose equivalent rate (at sea level), influenced by the solar cycle. Location $51^{\circ}26'$ north latitude and $3^{\circ}43'$ eastern longitude, air pressure 1019 hPa. Figure derived from data supplied by Office of Aerospace Medicine [45].

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 [46, 47, 48].

The locations presented in this report have been chosen to represent the major inland waters and seawater. The 2002 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 2002.

Location	Parameter	Compartment	Monitoring frequency (per year)
Meuse (Eijsden)	Residual β	Water	13
	^3H	Water	13
	^{137}Cs	Suspended solids	53 ⁽¹⁾
Rhine (Lobith)	Residual β	Water	13
	^3H	Water	13
	^{137}Cs	Suspended solids	13
Scheldt (Schaar van Ouden Doel)	Residual β	Water	13
	^3H	Water	6
	^{137}Cs	Suspended solids	13
Ketelmeer West	^{137}Cs	Suspended solids	6

⁽¹⁾ Data were available for 52 out of 53 samples taken.

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 [47] and [49]. 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”) [50]. The yearly averages are compared with these target values.

Table 5.2: Monitoring program for the determination of radioactive nuclides in seawater in 2002.

Area	Location	Parameter	Compartment	Monitoring frequency (per year)
Coastal area (KZ)	Noordwijk 2 ⁽¹⁾	Gross α	Water	4
		Residual β	Water	4
		^3H	Water	4
		^{137}Cs	Suspended solids	1 ⁽²⁾
		^{210}Po	Suspended solids	1 ⁽²⁾
Southern North Sea (ZN)	Noordwijk 70 ⁽¹⁾	Gross α	Water	4
		Residual β	Water	4
		^3H	Water	4
		^{90}Sr	Water	4
Central North Sea (CN)	Terschelling 235 ⁽¹⁾	Gross α	Water	4
		Residual β	Water	4
		^3H	Water	4
		^{90}Sr	Water	4
Delta Coastal Waters (VD)	Schouwen 10 ⁽¹⁾	Gross α	Water	11 ⁽³⁾
		Residual β	Water	11 ⁽³⁾
		^3H	Water	4
		^{90}Sr	Water	4
Westerscheldt (WS)	Vlissingen Boei	Gross α	Water	13 ⁽⁴⁾
		Residual β	Water	13 ⁽⁴⁾
		^3H	Water	13 ⁽⁴⁾
		^{90}Sr	Water	13 ⁽⁴⁾
		^{137}Cs	Suspended solids	4
		^{210}Po	Suspended solids	4
Eems-Dollard (ED)	Huibergat Oost	Gross α	Water	4
		Residual β	Water	4
		^3H	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
		^3H	Water	4
	Doove Balg West	^{137}Cs	Suspended solids	1 ⁽²⁾
		^{210}Po	Suspended solids	1 ⁽²⁾
Wadden Sea East (WO)	Dantziggat	Gross α	Water	4
		Residual β	Water	4
		^3H	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. One sample was not taken.

(4) Normally 12 times per year.

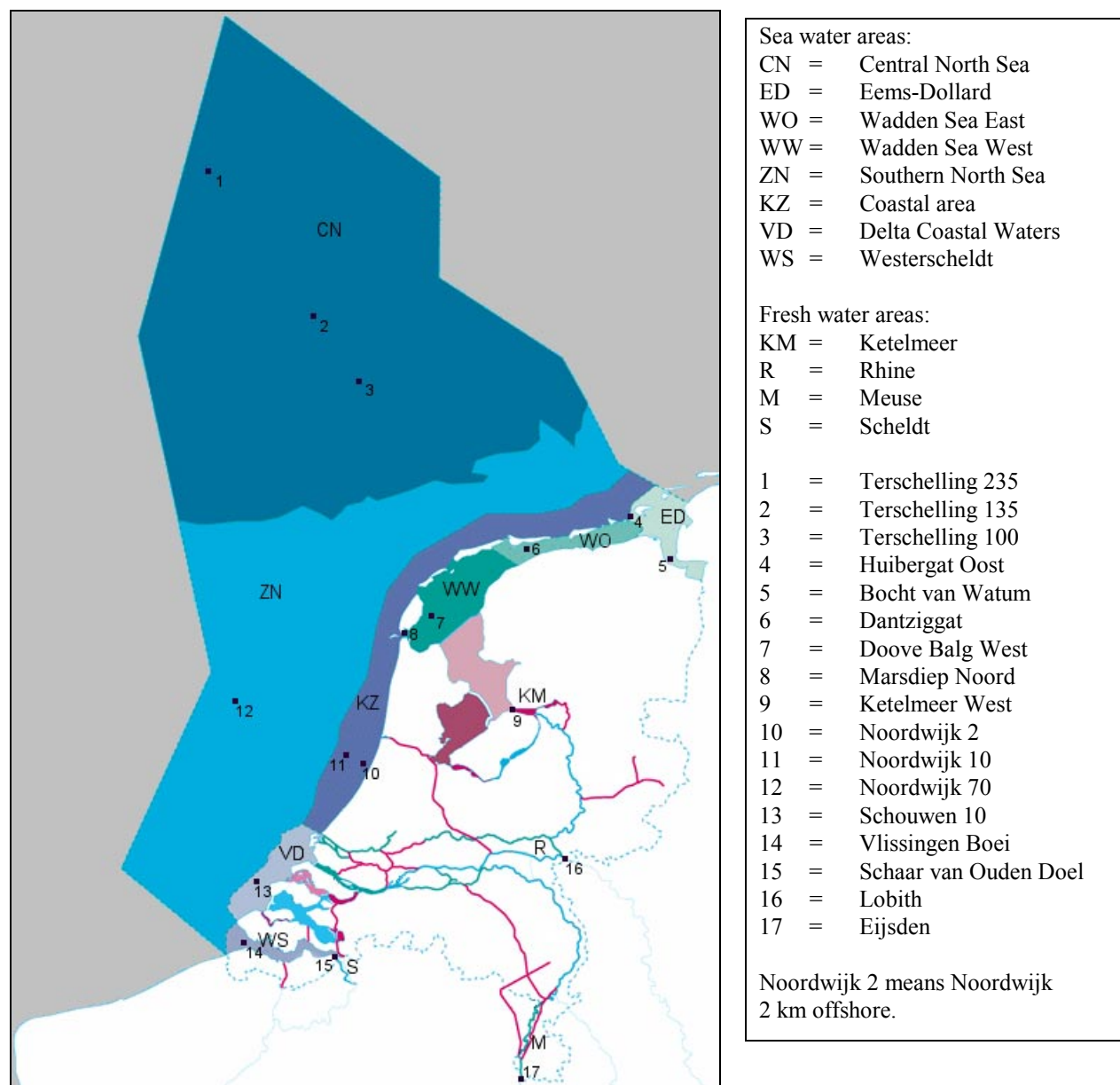


Figure 5.1: Overview of monitoring locations for the monitoring program in surface water and in seawater. Terschelling 135 km offshore and Terschelling 100 km offshore were the old monitoring locations for the Central North Sea during 1989 and 1988-1994 (except 1989), respectively. Terschelling 235 km 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 [47].

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.

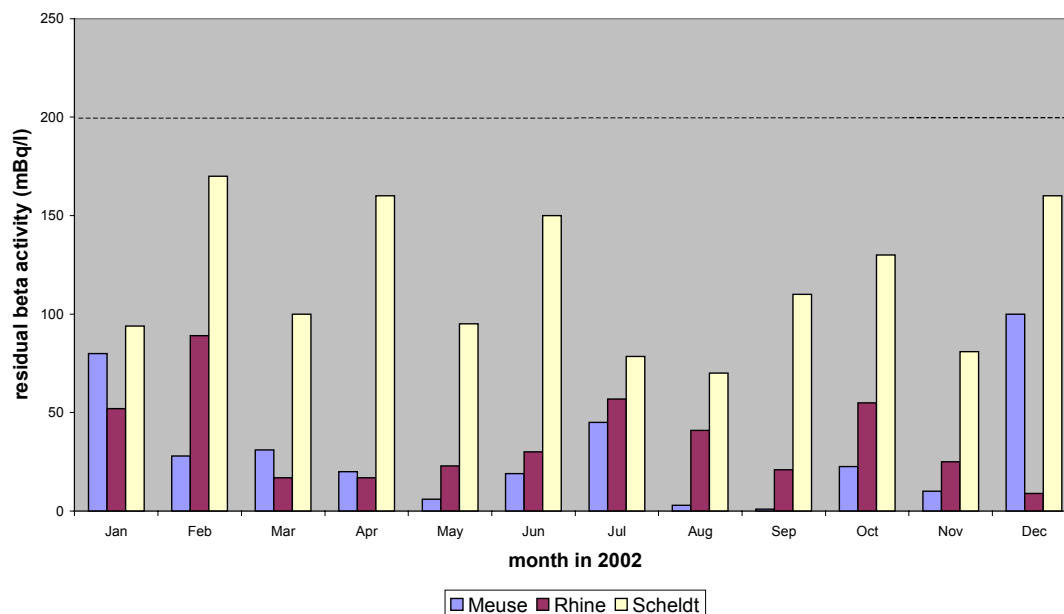


Figure 5.2: The residual β -activity concentration in 2002 for the Meuse, Rhine and Scheldt, with yearly averages of 30, 38 and 114 $\text{mBq}\cdot\text{L}^{-1}$, respectively. Averaged values are shown in case of multiple measurements per month. The dotted line represents the target value [50].

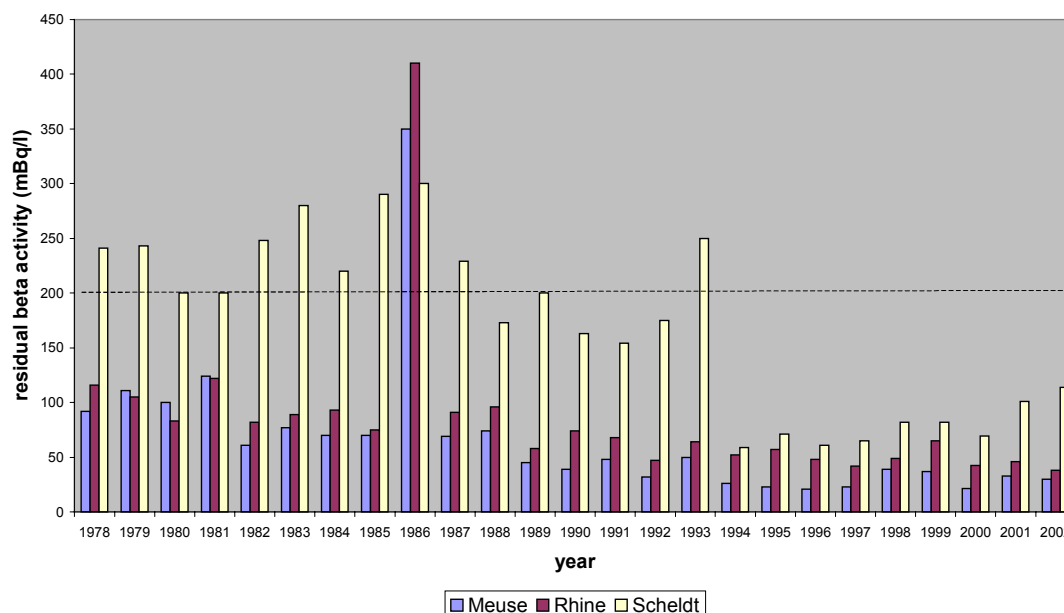


Figure 5.3: Yearly averaged residual β -activity concentrations.

The yearly averaged concentrations of residual β in 2002 are within the range of those in previous years. The averaged residual β -concentrations are below the target value of $200 \text{ mBq}\cdot\text{L}^{-1}$. 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 [47]. Therefore, no change in trend is shown for the Meuse and the Rhine.

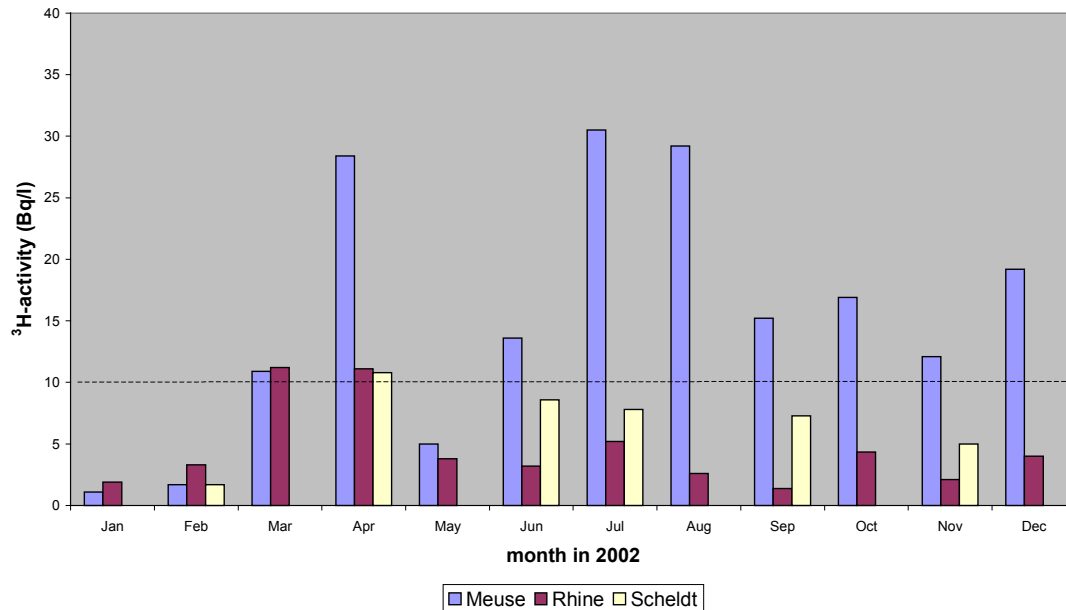


Figure 5.4: The ^3H -activity concentration in 2002 for Meuse, Rhine and Scheldt, with yearly averages of 15.4, 4.5 and 6.9 $\text{Bq}\cdot\text{L}^{-1}$, respectively. Averaged values are shown in case of multiple measurements per month.

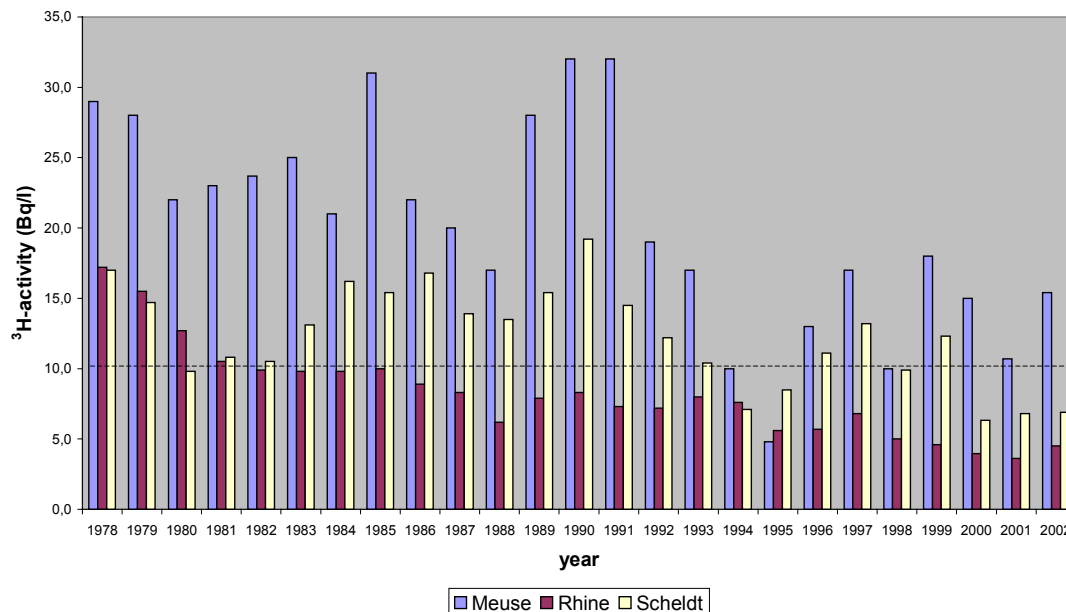


Figure 5.5: Yearly averaged ^3H -activity concentrations.

The ^3H -activity in the Meuse exceeded the target value ($10 \text{ Bq}\cdot\text{L}^{-1}$) 10 out of 13 times. The elevated levels of ^3H in the Meuse (Figure 5.4) could originate from the nuclear power plants Tihange (Belgium) or Chooz (France). The yearly averaged concentrations of tritium in 2002 are within the range of those in previous years. In 2002 the averaged tritium concentration in the Meuse ($15 \text{ Bq}\cdot\text{L}^{-1}$) is above the target value of $10 \text{ Bq}\cdot\text{L}^{-1}$.

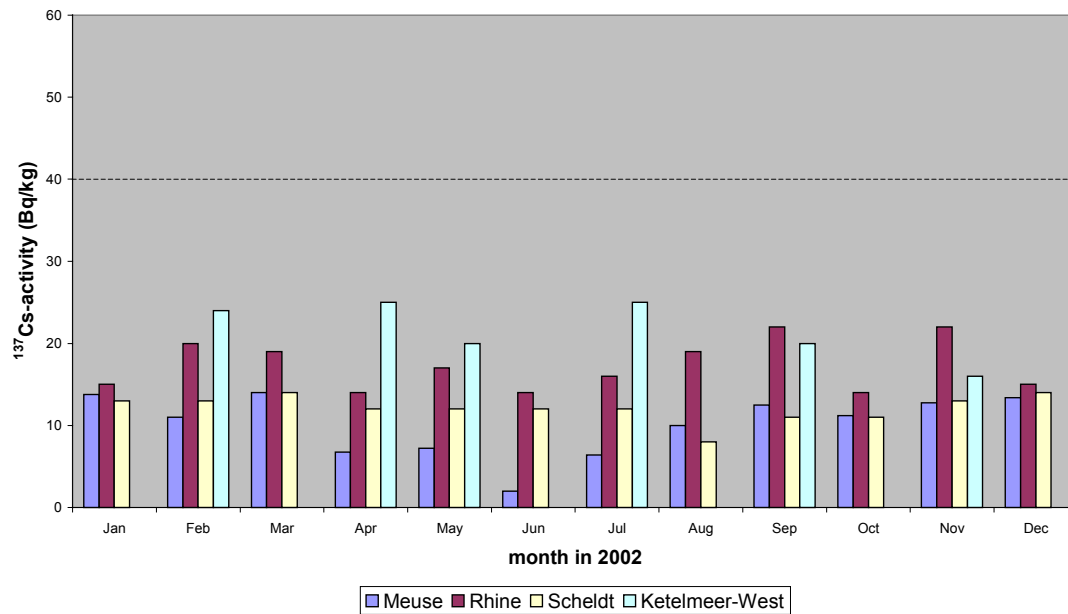


Figure 5.6: The ^{137}Cs -activity concentration in suspended solids in 2002 for the Meuse, Rhine, Scheldt and Ketelmeer-West with yearly averages of 10, 18, 12 and 22 $\text{Bq}\cdot\text{kg}^{-1}$, respectively. Averaged values are shown in case of multiple measurements per month.

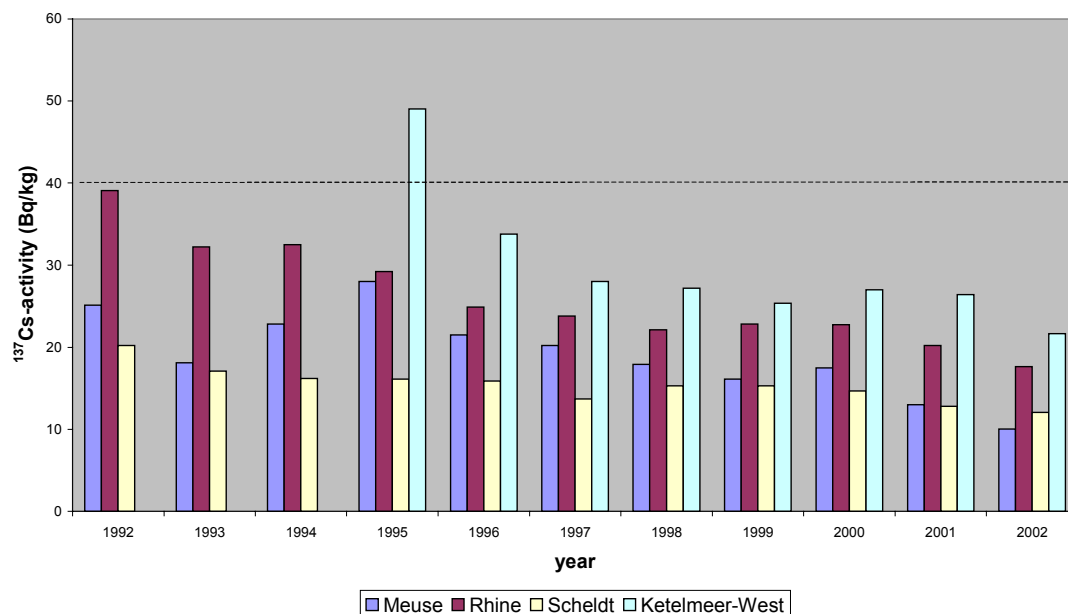


Figure 5.7: Yearly averaged ^{137}Cs -activity concentrations in suspended solids. Data on Ketelmeer-West are available since 1995.

The yearly averaged concentrations of ^{137}Cs in 2002 are within the range of those in previous years. The averaged ^{137}Cs -concentrations are below the target value of $40 \text{ Bq}\cdot\text{kg}^{-1}$.

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 [51].

5.3 The results for seawater

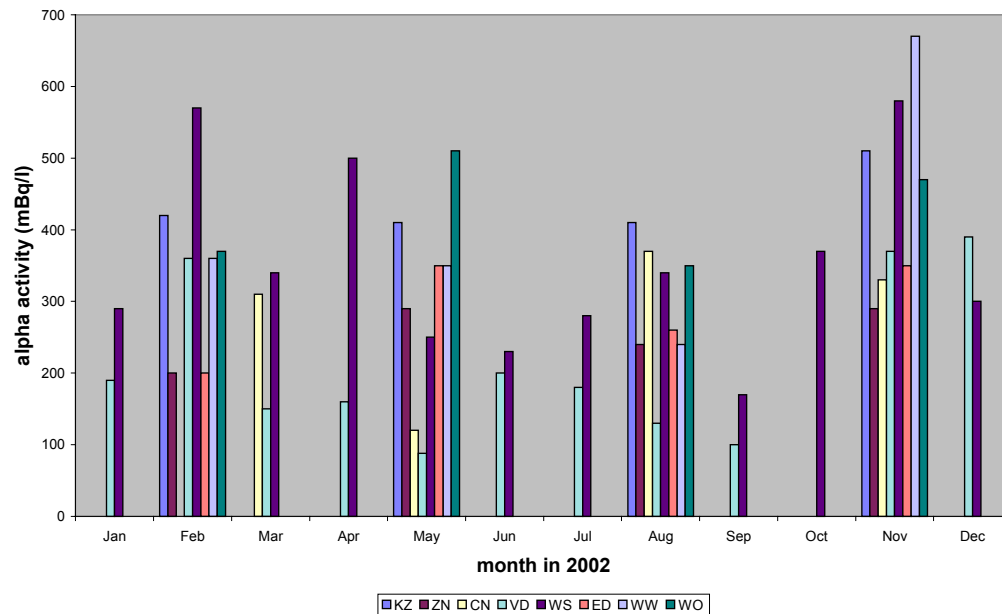


Figure 5.8: The gross α -activity concentration in seawater in 2002. The yearly averages for the Coastal area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Westerscheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO) are 438, 255, 283, 211, 346, 290, 405 and 425 $\text{mBq}\cdot\text{L}^{-1}$, respectively.

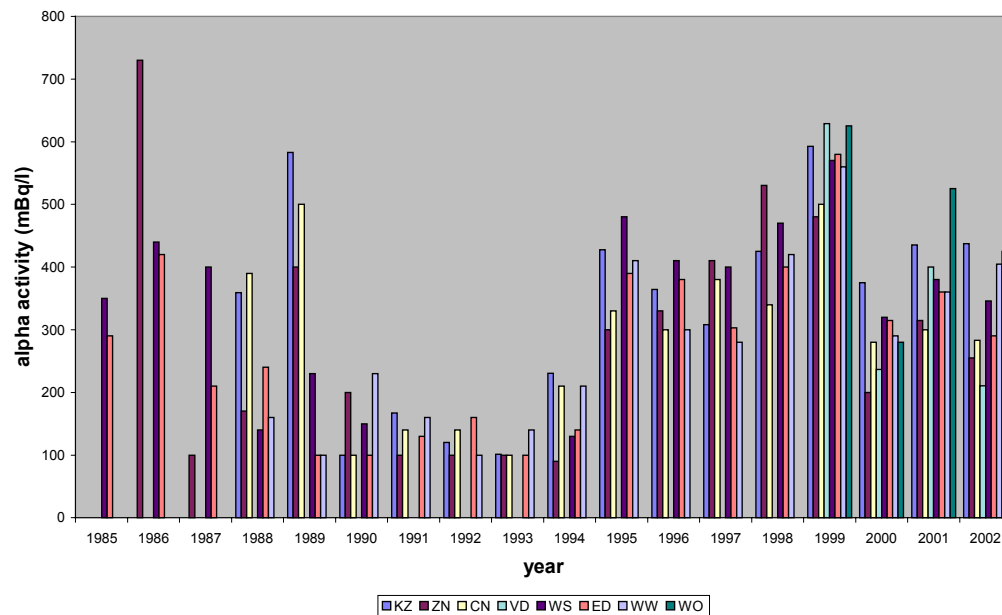


Figure 5.9: Yearly averaged gross α -activity concentrations.

Gross α and residual β are indicative parameters [47]. 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 [47]. The results of 2002 are within the range of those in the period 1995-2001.

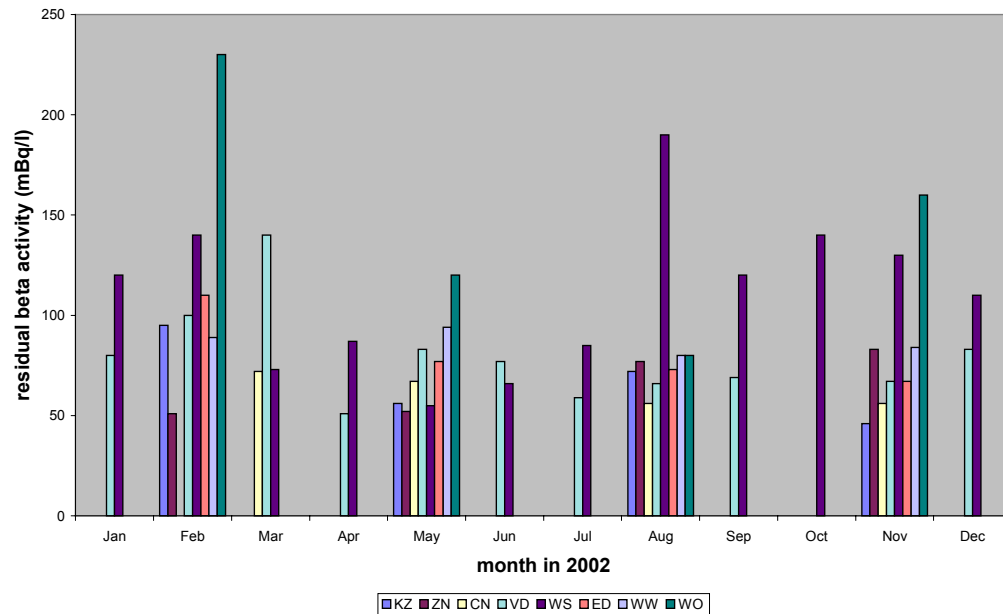


Figure 5.10: The residual β -activity concentration in seawater in 2002. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 67, 66, 63, 80, 108, 82, 87 and 148 $\text{mBq}\cdot\text{L}^{-1}$, respectively.

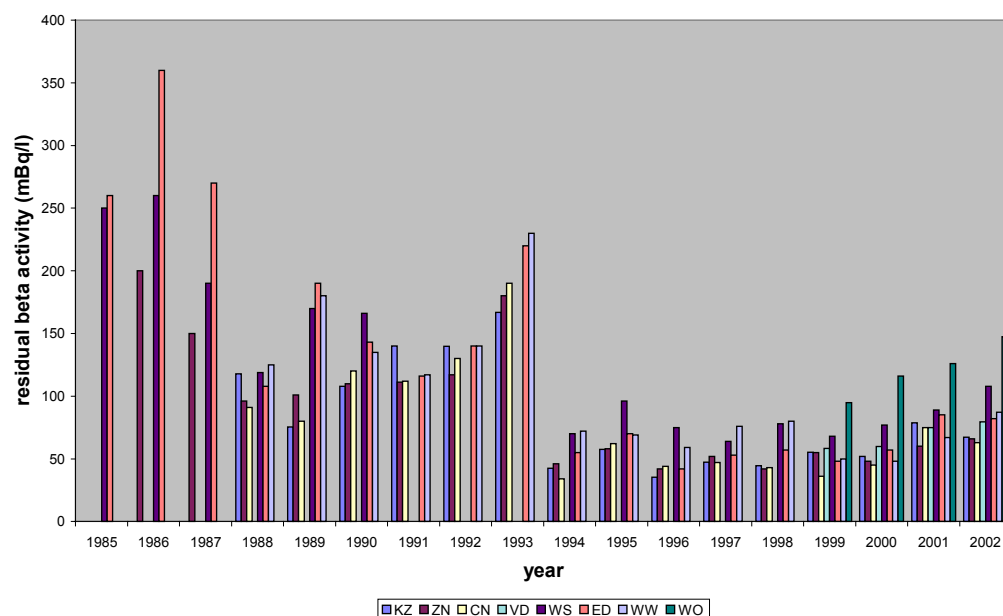


Figure 5.11: Yearly averaged residual β -activity concentrations.

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 [47]. The yearly averaged concentrations of residual β in 2002 are within the range of those in the period 1994-2001.

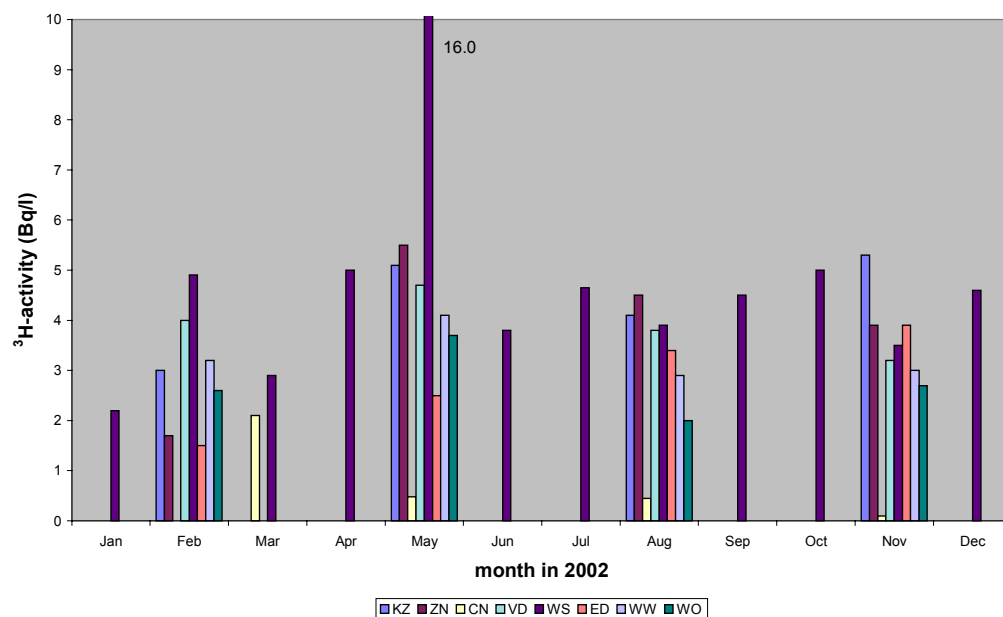


Figure 5.12: The ^3H -activity concentration in seawater in 2002. The yearly averages for the Coastal area, Southern North Sea, Central North Sea, Delta Coastal Waters, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 4.4, 3.9, 0.8, 3.9, 5.0, 2.8, 3.3 and $2.8 \text{ Bq} \cdot \text{L}^{-1}$, respectively.

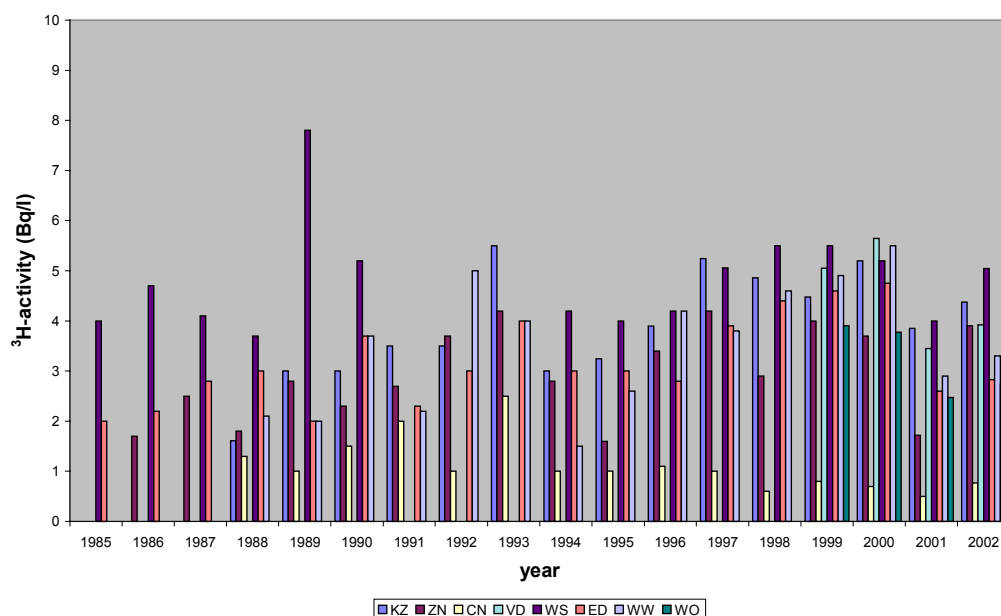


Figure 5.13: Yearly averaged ^3H -activity concentrations.

Nuclear power plants discharge the nuclides ^3H and ^{137}Cs . Nuclear fuel reprocessing plants discharge the nuclides ^3H 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 [47]. The impact of both sources (nuclear power and reprocessing plants) is monitored indirectly in the Delta Coastal Waters (VD). The yearly averaged concentrations of ^3H in 2002 are within the range of those in previous years.

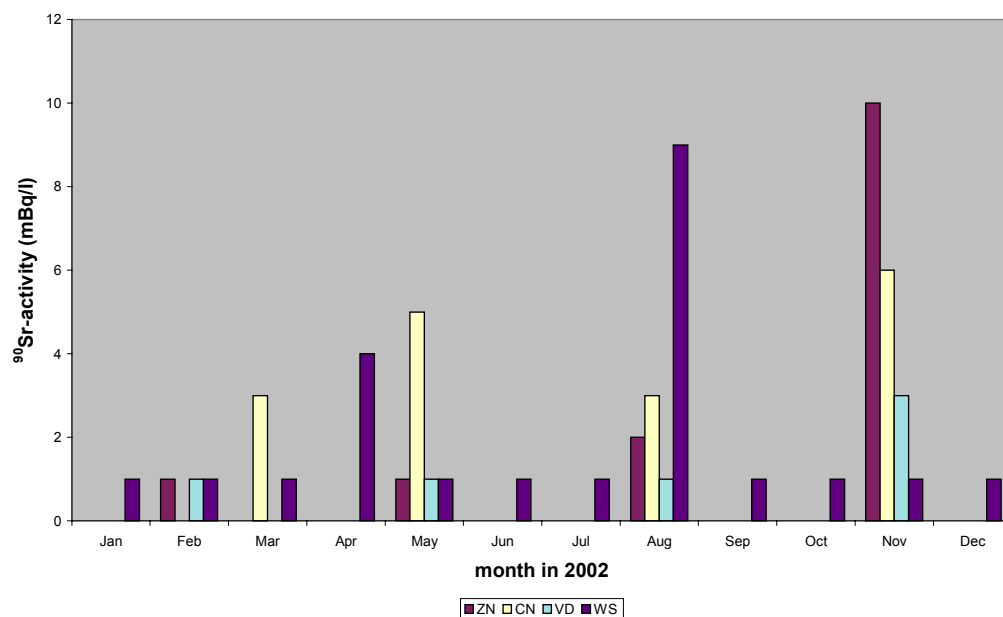


Figure 5.14: The ^{90}Sr -activity concentration in seawater in 2002. The yearly averages for the Southern North Sea, Central North Sea, Delta Coastal Waters and Westerscheldt are 3, 4, <1 and 1 mBq·L⁻¹, respectively.

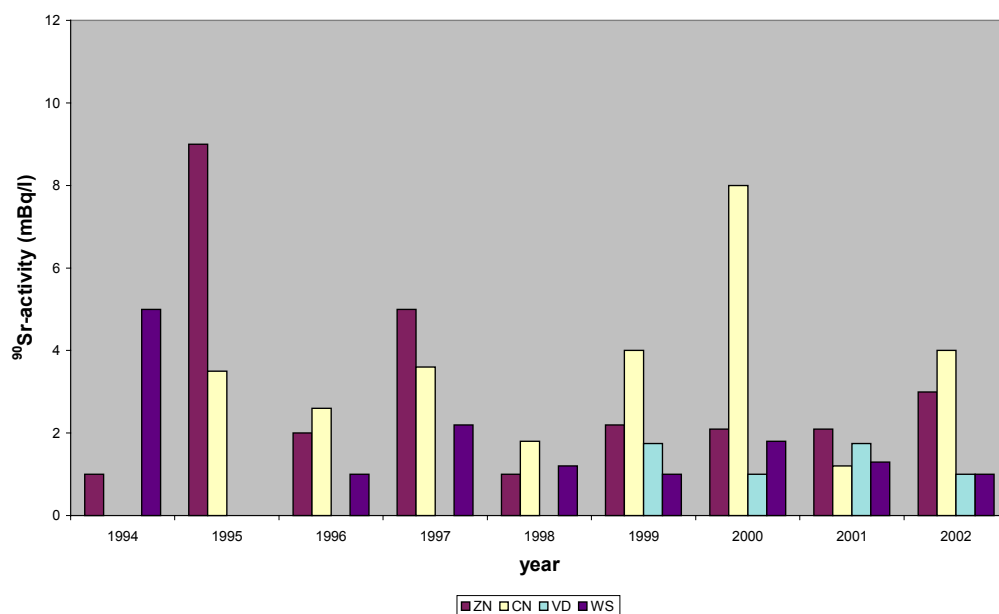


Figure 5.15: Yearly averaged ^{90}Sr -activity concentrations.

The yearly averaged concentrations of ^{90}Sr in 2002 are within the range of those in previous years.

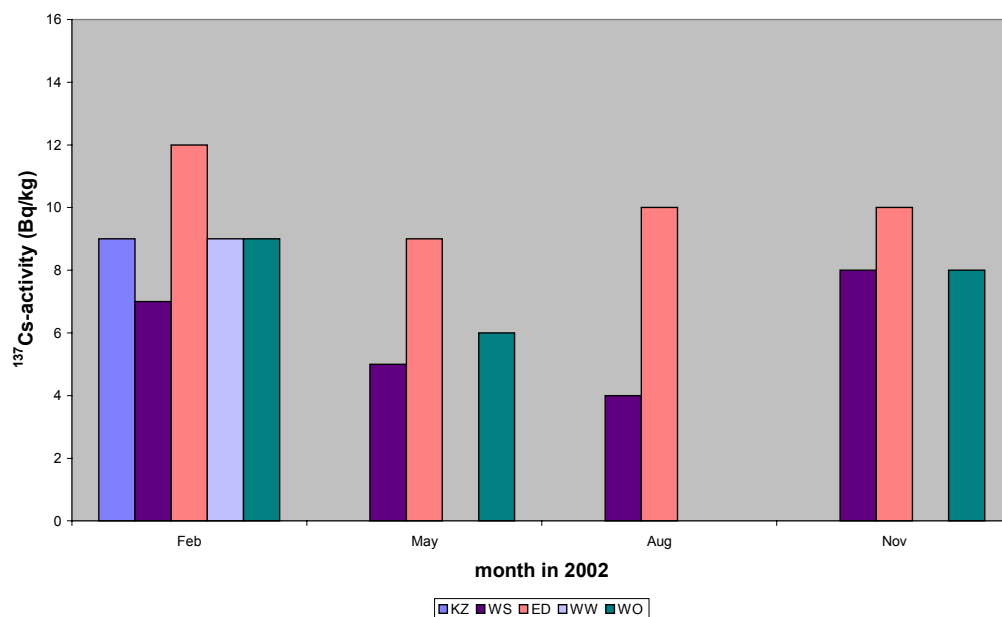


Figure 5.16: The ^{137}Cs -activity concentration in suspended solids in seawater in 2002. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 9, 6, 10, 9 and 8 Bq·kg⁻¹, respectively. Data were not available in May (KZ and WW), August (KZ, WW and WO) and November (KZ and WW) due to insufficient amount of collected suspended solids.

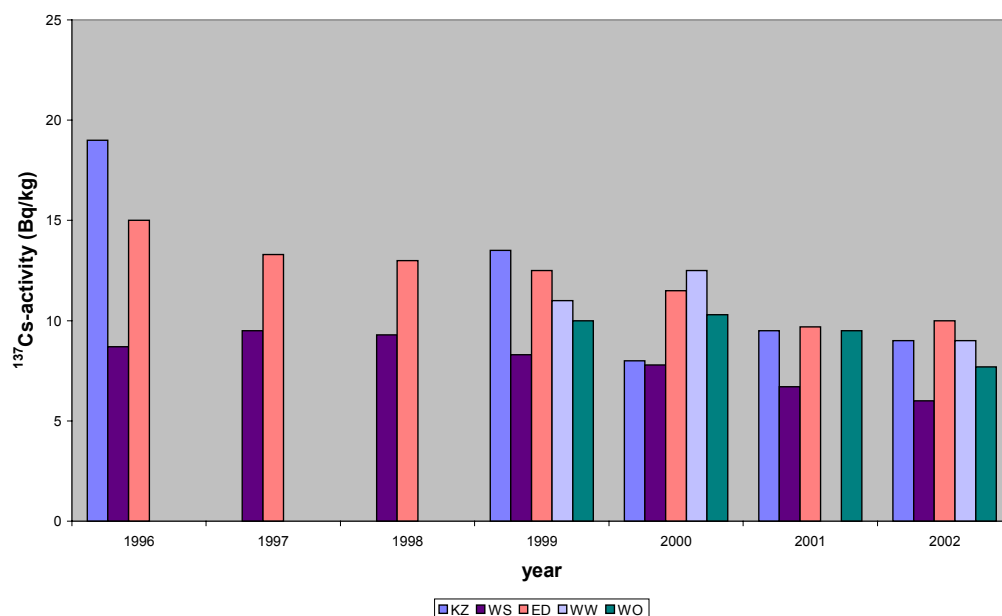


Figure 5.17: Yearly averaged ^{137}Cs -activity concentrations in suspended solids.

The yearly averaged concentrations of ^{137}Cs in 2002 are within the range of those in previous years. In 2001 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 [47]. 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.

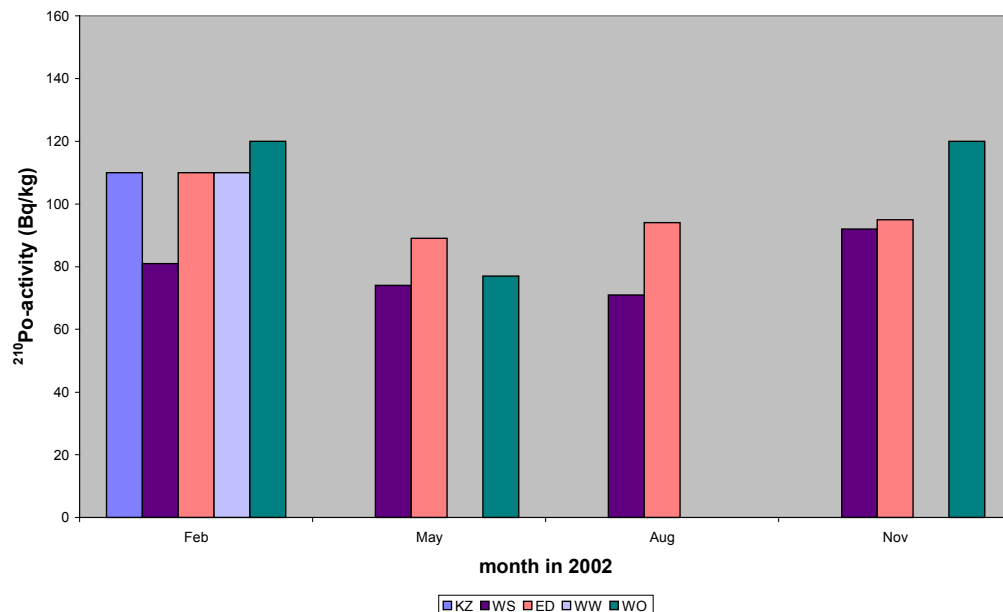


Figure 5.18: The ^{210}Po -activity concentration in suspended solids in seawater in 2002. The yearly averages for the Coastal area, Westerscheldt, Eems-Dollard, Wadden Sea West and Wadden Sea East are 110, 80, 97, 110 and 106 $\text{Bq}\cdot\text{kg}^{-1}$, respectively. Data were not available in May (KZ and WW), August (KZ, WW and WO) and November (KZ and WW) due to insufficient amount of collected suspended solids.

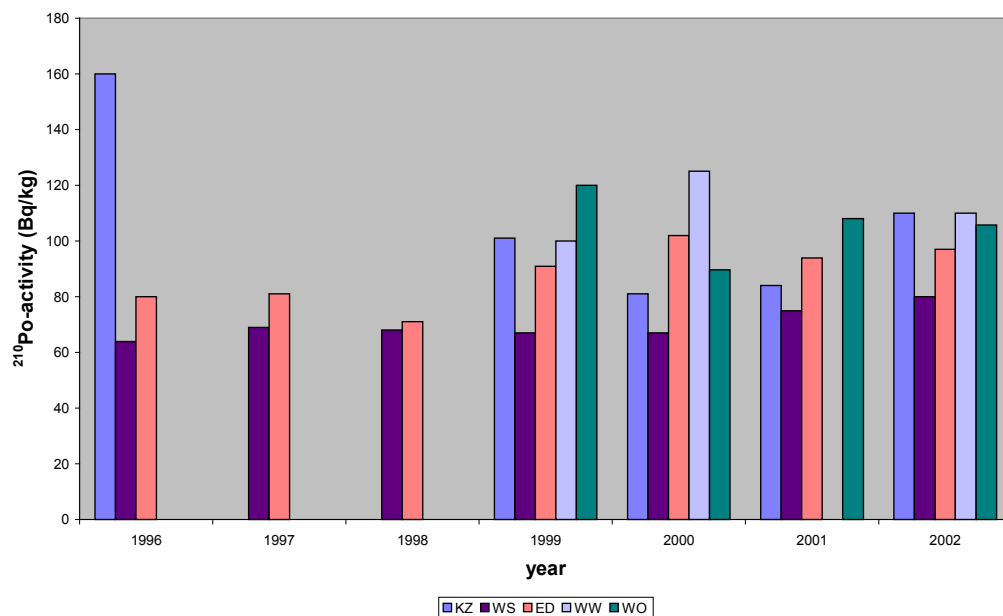


Figure 5.19: Yearly averaged ^{210}Po -activity concentrations in suspended solids.

The yearly averaged concentrations of ^{210}Po in 2002 are within the range of those in previous years. In 2001 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 ^3H -, gross β - and residual β -activity. The monitoring frequency is from once to twenty times per year depending on the volume of water produced. Typical activities for ^3H are $1\text{--}10\text{ Bq}\cdot\text{L}^{-1}$. Typical activities for both gross β - and residual β -activity are $0.1\text{--}1\text{ Bq}\cdot\text{L}^{-1}$. Since there is almost no ^{40}K present, gross β - and residual β -activities are equal.

The activity of natural nuclides, such as ^{226}Ra and ^{222}Rn , in Dutch drinking water is very low. In 1994 a survey was carried out to determine the radon activity of Dutch water [52]. The average concentration found was $2.2\text{ Bq}\cdot\text{L}^{-1}$ 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. 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.

8. Food

Radioactivity is measured in food suspected to contain more than the normal activity concentrations. The measurements are performed by the Inspectorate for Health Protection and Veterinary Public Health. Measurements were carried out according to standard procedures [53]. The results are presented in *Table 8.1*.

8.1 Honey

In total 116 samples of honey were analysed [54]. The activity (sum of ^{134}Cs and ^{137}Cs) was found to be below the set limit of $600 \text{ Bq}\cdot\text{kg}^{-1}$ [55]. All samples of heather honey contained ^{137}Cs . The activity varied from 28 up to $327 \text{ Bq}\cdot\text{kg}^{-1}$.

8.2 Powdered Milk

Via the import team 80 samples of powdered milk were offered for analysis. The samples originated from Eastern Europe. Measurable quantities of activity were found in 9 samples, varying from 6 up to $33 \text{ Bq}\cdot\text{kg}^{-1}$. The samples containing activity originated from Poland. The activity found was below the limit of $370 \text{ Bq}\cdot\text{kg}^{-1}$.

8.3 Game and poultry

In total 95 samples of game and poultry were analysed. Measurable quantities of activity were found in some samples of game. A sample of deer contained $69 \text{ Bq}\cdot\text{kg}^{-1}$ and a sample of roe contained $28 \text{ Bq}\cdot\text{kg}^{-1}$.

8.4 Other products

Some products, amongst which blueberry and chanterelle, were sampled within the scope of *Customs Import Surveillance*. Radioactivity was not detected in these products.

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

Product	Number of samples	Number of positive samples	^{134}Cs ($\text{Bq}\cdot\text{kg}^{-1}$)	^{137}Cs ($\text{Bq}\cdot\text{kg}^{-1}$)
Various kinds of honey	97	0	n.d.	n.d.
Heather honey	19	19	n.d.	28-327
Powdered milk	80	9	n.d.	6-33
Game and poultry	95	2	n.d.	28 and 69

n.d. = not detectable

9. Conclusions

In 2002 two unusual levels of radioactivity were found in the Dutch environment. The activity concentration of ^{210}Pb in air dust during week 45 ($3000 \pm 300 \mu\text{Bq}\cdot\text{m}^{-3}$) is the highest concentration since 1991. A deposited ^7Be -activity as high as that of week 43 ($158 \pm 19 \text{Bq}\cdot\text{m}^{-2}$) hasn't occurred since 1998.

Furthermore, the ^3H -activity in the Meuse (yearly average $15 \text{Bq}\cdot\text{L}^{-1}$) exceeded the target value ($10 \text{Bq}\cdot\text{L}^{-1}$) in ten out of thirteen samples taken. No measurements were performed on milk since 1998. This does not comply to the Recommendation on the Application of Article 36 of the Euratom Treaty.

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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 2002.

Week number	Gross α mBq.m ⁻³	Gross β mBq.m ⁻³		Week number	Gross α mBq.m ⁻³	Gross β mBq.m ⁻³	
1	0.032	0.311	± 0.017	28	0.060	0.267	± 0.018
2	0.08	0.93	± 0.05	29	0.019	0.36	± 0.02
3	0.09	0.63	± 0.05	30	0.048	0.242	± 0.017
4	0.034	0.29	± 0.02	31	0.06	0.56	± 0.04
5	0.052	0.32	± 0.02	32	0.047	0.45	± 0.03
6	0.052	0.42	± 0.03	33	0.050	0.40	± 0.03
7	0.020	0.188	± 0.014	34	0.037	0.57	± 0.04
8	0.048	0.272	± 0.019	35	0.08	0.60	± 0.04
9	0.018	0.130	± 0.010	36	0.06	0.36	± 0.02
10	0.042	0.273	± 0.019	37	0.059	0.59	± 0.04
11	0.045	0.41	± 0.03	38	0.031	0.40	± 0.03
12	0.025	0.252	± 0.017	39	0.033	0.32	± 0.02
13	0.06	0.57	± 0.04	40	0.058	0.65	± 0.04
14	0.07	1.09	± 0.07	41	0.034	0.39	± 0.03
15	0.09	0.90	± 0.06	42	0.056	0.41	± 0.03
16	0.07	0.61	± 0.04	43	0.07	0.253	± 0.018
17	0.041	0.30	± 0.02	44	0.055	0.30	± 0.02
18	0.030	0.247	± 0.017	45	0.045	0.31	± 0.02
19	<0.013	0.183	± 0.015	46	0.030	0.223	± 0.016
20	0.06	0.52	± 0.03	47	0.08	0.43	± 0.03
21	0.048	0.35	± 0.02	48	0.048	0.36	± 0.02
22	0.051	0.252	± 0.017	49	0.058	0.310	± 0.014
23	0.049	0.40	± 0.03	50	0.08	1.00	± 0.06
24	0.07	0.189	± 0.014	51	0.11	1.36	± 0.07
25	0.07	0.49	± 0.03	52	0.07	0.53	± 0.04
26	0.047	0.284	± 0.019	53	0.037	0.254	± 0.018
27	0.046	0.190	± 0.014				
				Average	0.05 ⁽¹⁾	0.432	± 0.004 ⁽²⁾
				SD ⁽³⁾	0.02		0.2

⁽¹⁾ 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].

⁽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. Errors are given as 1σ .

Table A2: Detection limits ($\mu\text{Bq}\cdot\text{m}^{-3}$) in the residue measurement of air dust sampled during a seven days sampling period with a HVS at RIVM in 2002. 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 $50,000\text{ m}^3$. The detection limits are higher than in previous years [56] due to a different detector set-up.

Nuclide	Detection limit	Nuclide	Detection limit
^7Be	9	^{113}Sn	1.1
^{22}Na	0.9	$^{115\text{m}}\text{Cd}$	45
^{24}Na	600 ⁽¹⁾	^{115}Cd	44
^{40}K	17	$^{123\text{m}}\text{Te}$	1.2
^{51}Cr	11	^{124}Sb	1.1
^{54}Mn	0.6	^{125}Sb	2
^{57}Co	0.4	$^{129\text{m}}\text{Te}$	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
$^{110\text{m}}\text{Ag}$	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 ^7Be -, ^{137}Cs - and ^{210}Pb -activity concentrations in air dust sampled with a HVS at RIVM in 2002. Empty fields indicate that the value was below the detection limit given in Table A2.

Week number	Period	^7Be $\mu\text{Bq}\cdot\text{m}^{-3}$			^{137}Cs $\mu\text{Bq}\cdot\text{m}^{-3}$			^{210}Pb $\mu\text{Bq}\cdot\text{m}^{-3}$		
1	27/12-04/01	2130	±	190				210	±	20
2	04/01-11/01	3400	±	300				900	±	80
3	11/01-18/01	2800	±	200				740	±	70
4	18/01-25/01	2800	±	200				280	±	30
5	25/01-01/02	3300	±	300				580	±	60
6	01/02-08/02	3800	±	300				370	±	30
7	08/02-15/02	2600	±	200				152	±	17
8	15/02-22/02	2900	±	300				220	±	20
9	22/02-01/03	2700	±	200				96	±	12
10	01/03-08/03	3300	±	300				260	±	20
11	08/03-15/03	4400	±	400				360	±	30
12	15/03-22/03	2800	±	200				250	±	20
13	22/03-29/03	5300	±	500				500	±	50
14	29/03-05/04	6300	±	500				1170	±	110
15	05/04-12/04	5900	±	500				840	±	80
16	12/04-19/04	2800	±	200				670	±	60
17	19/04-26/04	3000	±	300				330	±	30
18	26/04-03/05	3200	±	300				159	±	17
19	03/05-08/05	1310	±	120				190	±	20
20	08/05-17/05	3600	±	300				650	±	60
21	17/05-24/05	3600	±	300				350	±	40
22	24/05-31/05	3000	±	300				240	±	30
23	31/05-07/06	3800	±	300				440	±	40
24	07/06-14/06	2400	±	200				174	±	18
25	14/06-21/06	4500	±	400				470	±	40
26	21/06-28/06	2800	±	200				230	±	20

To be continued on the next page

Table A3: Continued

Week number	Period	^7Be $\mu\text{Bq}\cdot\text{m}^{-3}$	^{137}Cs $\mu\text{Bq}\cdot\text{m}^{-3}$	^{210}Pb $\mu\text{Bq}\cdot\text{m}^{-3}$
27	28/06-05/07	2300 ± 200		169 ± 18
28	05/07-12/07	2700 ± 200		440 ± 40
29	12/07-19/07	3800 ± 300		370 ± 40
30	19/07-26/07	2900 ± 300		190 ± 20
31	26/07-02/08	4600 ± 400		650 ± 60
32	02/08-09/08	4100 ± 400		430 ± 40
33	09/08-16/08	3400 ± 300		420 ± 40
34	16/08-23/08	4500 ± 400		570 ± 50
35	23/08-30/08	3700 ± 300		620 ± 60
36	30/08-06/09	3900 ± 300		330 ± 30
37	06/09-13/09	3800 ± 300		690 ± 60
38	13/09-20/09	3800 ± 300		350 ± 30
39	20/09-27/09	3600 ± 300		310 ± 30
40	27/09-04/10	3700 ± 300		31 ± 3
41	04/10-11/10	2800 ± 200		400 ± 40
42	11/10-18/10	1840 ± 160		530 ± 50
43	18/10-25/10	590 ± 50		72 ± 11
44	25/10-31/10	3300 ± 300		260 ± 30
45	31/10-08/11	2500 ± 200		3000 ± 300
46	08/11-15/11	2600 ± 200		200 ± 20
47	15/11-22/11	2300 ± 200		510 ± 50
48	22/11-29/11	1970 ± 170		390 ± 40
49	29/11-06/12	1290 ± 110		420 ± 40
50	06/12-13/12	4400 ± 400		1210 ± 110
51	13/12-20/12	2800 ± 200		1410 ± 130
52	20/12-27/12	2400 ± 200		640 ± 60
53	27/12-03/01	1880 ± 200		290 ± 60
Average		3210 ± 40 ⁽¹⁾		486 ± 9 ⁽¹⁾
SD ⁽²⁾		1100		500

⁽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 ^3H -, long-lived gross α - and gross β -activity in deposition sampled at RIVM in 2002.

Month	Precipitation mm	^3H $\text{Bq}\cdot\text{m}^{-2}$	Gross α $\text{Bq}\cdot\text{m}^{-2}$			Gross β $\text{Bq}\cdot\text{m}^{-2}$		
January	90.6	<140	1.4	±	0.2	8.4	±	0.7
February	139.1	<215	1.7	±	0.2	8.7	±	0.7
March	33.9	<52	1.26	±	0.19	3.8	±	0.3
April	60.8	<94	1.7	±	0.2	8.2	±	0.6
May	27.2	<46	1.2	±	0.2	5.1	±	0.4
June	86.0	<147	3.2	±	0.3	10.0	±	0.8
July	102.3	210 ± 50	2.3	±	0.3	12.9	±	1.0
August	96.6	160 ± 50	2.5	±	0.3	11.8	±	0.9
September	37.9	<65	1.9	±	0.3	9.2	±	0.7
October	73.4	<126	1.6	±	0.3	9.0	±	0.7
November	84.7	<146	0.8	±	0.2	3.2	±	0.3
December	132.3	<228	1.03	±	0.18	7.0	±	0.5
Total	965	<1630	20.6	±	0.9 ⁽¹⁾	97	±	2 ⁽¹⁾

⁽¹⁾ 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 ^3H -activity in deposition for 1983-2002.

Year	Precipitation mm	Gross α $\text{Bq}\cdot\text{m}^{-2}$		Gross β $\text{Bq}\cdot\text{m}^{-2}$		^3H $\text{Bq}\cdot\text{m}^{-2}$	
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	

⁽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 2002.

Month	^{210}Po $\text{Bq}\cdot\text{m}^{-2}$		
January	0.10	±	0.14
February	2.0	±	0.8
March	0.65	±	0.11
April	0.28	±	0.19
May	0.91	±	0.15
June	0.6	±	0.2
July	0.6	±	0.2
August	0.3	±	0.3
September	0.25	±	0.15
October	<0.49		
November	0.61	±	0.05
December	0.65	±	0.13
Total	7.5	±	1.0

⁽¹⁾ Measurements are carried out using α -spectroscopy. Errors are given as 1σ .

Table A7: Yearly totals ⁽¹⁾ for ^7Be , ^{137}Cs , ^{210}Pb - and ^{210}Po -activity in deposition for 1985-2002.

Year	^7Be ⁽²⁾ $\text{Bq}\cdot\text{m}^{-2}$	^{137}Cs ⁽²⁾ $\text{Bq}\cdot\text{m}^{-2}$	^{210}Pb ⁽²⁾ $\text{Bq}\cdot\text{m}^{-2}$	^{210}Pb ⁽³⁾ $\text{Bq}\cdot\text{m}^{-2}$	^{210}Po ⁽³⁾ $\text{Bq}\cdot\text{m}^{-2}$
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

⁽¹⁾ Errors are given as 1σ .

⁽²⁾ Data from γ -spectroscopy.

⁽³⁾ Data from α -spectroscopy.

⁽⁴⁾ Result rejected [57].

⁽⁵⁾ α -spectroscopy analysis of ^{210}Pb stopped in 1999.

(-) No analysis.

Table A8: Weekly values of ^7Be - and ^{210}Pb -activity ⁽¹⁾ deposition sampled at RIVM in 2002.

Week Number	Period	Precipitation mm	^7Be Bq·m ⁻²	^{210}Pb Bq·m ⁻²
1	28/12-04/01	12.3	15 ± 2	2.3 ± 0.8
2	04/01-11/01	1.1	4.5 ± 1.6	
3	11/01-18/01	14.3	16 ± 2	2.3 ± 0.7
4	18/01-25/01	23.5	24 ± 3	2.0 ± 0.8
5	25/01-01/02	39.5	42 ± 5	3.0 ± 0.4
6	01/02-08/02	24.6	36 ± 4	1.5 ± 0.6
7	08/02-15/02	31.5	54 ± 6	2.8 ± 0.7
8	15/02-22/02	42.0	38 ± 5	1.5 ± 0.6
9	22/02-01/03	41.0	50 ± 6	1.5 ± 0.6
10	01/03-08/03	2.4	6.9 ± 1.5	
11	08/03-15/03	7.7	22 ± 3	0.07 ± 0.02
12	15/03-22/03	23.8	30 ± 4	3.3 ± 1.0
13	22/03-29/03	0.1	3.6 ± 0.8	
14	29/03-05/04	0.0	2.3 ± 0.5	2.2 ± 0.8
15	05/04-12/04	0.3	5.1 ± 0.9	1.9 ± 0.7
16	12/04-19/04	19.0	32 ± 4	4.9 ± 1.1
17	19/04-26/04	1.1	5.4 ± 0.8	1.8 ± 0.8
18	26/04-03/05	40.4	60 ± 7	3.3 ± 1.0
19	03/05-08/05	7.5	22 ± 3	0.19 ± 0.05
20	08/05-17/05	5.3	17 ± 2	0.12 ± 0.03
21	17/05-24/05	5.1	12.5 ± 1.7	1.6 ± 0.8
22	24/05-31/05	9.4	16 ± 2	
23	31/05-07/06	7.1	34 ± 4	6.5 ± 1.3
24	07/06-14/06	37.5	41 ± 5	2.4 ± 0.6
25	14/06-21/06	38.0	82 ± 10	8.3 ± 1.3
26	21/06-28/06	3.4	9.2 ± 1.2	1.7 ± 0.6

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Table A8: Continued.

Week Number	Period	Precipitation mm	^7Be $\text{Bq}\cdot\text{m}^{-2}$	^{210}Pb $\text{Bq}\cdot\text{m}^{-2}$
27	28/06-05/07	28.8	32 ± 4	1.6 ± 0.7
28	05/07-12/07	15.0	37 ± 4	2.7 ± 0.9
29	12/07-19/07	14.0	42 ± 5	4.5 ± 1.1
30	19/07-26/07	20.0	38 ± 5	2.2 ± 0.6
31	26/07-02/08	24.5	51 ± 6	8.3 ± 1.5
32	02/08-06/08	53.3	72 ± 9	4.7 ± 0.9
33	09/08-16/08	6.1	13.4 ± 1.9	2.3 ± 0.8
34	16/08-23/08	32.3	57 ± 7	7.1 ± 1.0
35	23/08-30/08	5.0	14 ± 2	2.8 ± 0.8
36	30/08-06/09	3.8	9.6 ± 1.3	
37	06/09-13/09	23.5	43 ± 5	8.5 ± 1.4
38	13/09-20/09	0.1	5.3 ± 1.2	
39	20/09-27/09	8.9	12 ± 2	2.6 ± 0.8
40	27/09-04/10	1.6	4.5 ± 0.7	
41	04/10-11/10	10.5	17 ± 2	2.0 ± 0.7
42	11/10-18/10	14.6	14 ± 2	1.3 ± 0.5
43	18/10-25/10	17.3	158 ± 19	13.3 ± 1.7
44	25/10-01/11	31.0	38 ± 5	
45	01/11-08/11	38.0	26 ± 3	
46	08/11-15/11	28.4	20 ± 3	
47	15/11-22/11	2.0	7.4 ± 1.1	
48	22/11-29/11	16.3	28 ± 3	
49	29/11-06/12	8.6	11.8 ± 1.7	
50	06/12-13/12	0.0	2.1 ± 0.9	
51	13/12-20/12	9.3	9.7 ± 1.5	1.7 ± 0.7
52	20/12-27/12	42.0	15.2 ± 1.9	1.8 ± 0.7
53	27/12-03/01	72.4	55 ± 7	2.3 ± 0.6
	Sum	965	1510 ± 30 ⁽²⁾	125 ± 5 ⁽²⁾
	SD ⁽³⁾		30	3

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

Table A9: Yearly averaged results in 2002 for α -activity concentration in air and ambient dose equivalent rate, as measured by the NMR stations equipped with aerosol monitors.

Station	No.	α -Activity concentration Bq.m ⁻³	Ambient dose equivalent rate nSv.h ⁻¹
Vredepeel	131	3.4	69
Wijnandsrade	133	5.2	84
Houtakker	230	2.6	69
Huijbergen	235	3.1	71
Braakman ⁽¹⁾	318	2.7	-
Vlaardingen ⁽¹⁾	433	3.2	-
De Zilk	444	2.5	75
Wieringerwerf	538	2.3	81
Bilthoven	627	2.9	71
Biddinghuizen	631	2.9	85
Eibergen	722	2.8	72
Wageningen	724	3.4	100
Witteveen	928	3.0	70
Kollumerwaard ⁽¹⁾	934	2.7	-

⁽¹⁾ Ambient dose equivalent rate monitor not operational.

Table A10: The yearly average results for ambient dose equivalent rate for the NMR stations in 2002.

Station	No.	Ambient dose equivalent rate nSv.h ⁻¹	Station	No.	Ambient dose equivalent rate nSv.h ⁻¹
Den Burg	1001	78	Hooglanderveen	1046	81
Den Oever	1003	71	Harderwijk	1050	69
Julianadorp	1004	64	Wijk bij Duurstede	1056	80
Petten	1006	63	Rhenen	1061	75
Kolhorn	1007	81	Nieuwegein	1062	82
Egmond aan Zee	1009	64	Apeldoorn	1066	75
Heerhugowaard	1011	70	Heerenveen	1071	63
Haarlem-Noord	1014	72	Oosterwolde	1072	67
Nederhorst den Berg	1015	56	Bergum	1074	68
Enkhuizen	1018	72	Witmarsum	1076	90
Oosthuizen	1019	70	Sneek	1077	71
Zaandam	1021	68	St. Jacobiparochie	1081	75
Gouda	1024	61	Holwerd	1082	80
Dordrecht	1027	66	Leeuwarden	1085	68
Zuid-Beijerland	1028	75	Zwolle-Zuid	1087	76
Pijnacker	1032	85	Ommen	1093	67
Rotterdam Crooswijk	1033	80	Hardenberg	1095	68
Rotterdam Waalhaven ⁽¹⁾	1034	-	Assen	1097	63
Maasvlakte	1035	79	Rutten	1099	75
Maassluis	1037	96	Lelystad	1103	74
Hellevoetsluis	1038	95	Urk	1105	74
Ouddorp	1039	64	Eemshaven	1106	74
Wekerom	1041	72	Uithuizen	1107	79
Wageningen	1043	69	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	70	Reuver	1188	70
Ter Apel	1111	65	Nederweert	1189	72
Stadskanaal	1112	66	Heythuisen	1190	77
Nieuweschans	1113	70	Mariahoop	1191	67
Bellingwolde	1114	60	Stramproy	1192	64
Groningen	1116	71	Arnhem-Oosterbeek	1193	77
Leens	1117	77	Leiden	1196	78
Grijpskerk	1118	75	Hulst	1197	69
Meppel	1125	66	Terneuzen	1199	75
Hoogeveen	1126	62	Sluis	1201	73
Steenwijksmoer	1129	67	Vlissingen	1202	77
Nieuw Amsterdam	1130	69	Halsteren	1204	62
Nw. Schoonebeek/ Weiteveen	1131	62	Oud-Gastel	1206	65
Emmen	1132	68	Goes	1207	75
Borne	1135	69	Bruinisse	1209	85
Hengelo (Gld)	1136	70	Burgh-Haamstede	1211	58
Enschede	1139	66	Vrouwenpolder	1212	62
Losser	1140	60	Wemeldinge	1214	78
Oldenzaal ⁽²⁾	1141	66	Middelburg	1215	74
Westerhaar	1142	65	Westkapelle	1216	67
Rijssen	1143	72	Noordwijk-Binnen	1217	84
's Heerenberg	1144	84	Stein	1219	81
Dinxperlo	1145	79	Maastricht	1220	93
Varsseveld	1146	68	Ravensbos	1221	87
Groenlo	1147	82	Vaals	1222	86
Deventer	1148	76	Gulpen	1223	74
Etten-Leur	1154	67	Kerkrade	1224	87
Den Bosch	1157	68	Hoensbroek	1225	85
Raamsdonkveer	1159	80	Wijchen	1226	74
Ulvenhout	1160	67	Gennep	1228	71
Baarle-Nassau	1161	98	Elst (Gld) ⁽¹⁾	1229	-
Uden	1162	66	Zevenaar	1230	71
Mill	1163	68	Nijmegen	1231	67
Oss	1167	67	Amstelveen	1233	77
Nuenen	1172	68	Amsterdam Oost	1234	71
Bergeyk ⁽¹⁾	1174	-	Aalsmeer	1236	76
Waalre	1175	66	Nispen	1237	62
Someren (dorp)	1176	66	Groesbeek	1240	70
Oisterwijk	1178	74	Tubbergen	1243	69
Riel	1179	66	Haaksbergen	1244	64
Oostelbeers	1180	78	Scheveningen	1247	82
Hilvarenbeek	1181	63	Zaltbommel	1251	71
Venray	1183	60	IJzendijke	1252	86
Nieuw-Bergen	1184	61	Ritthem	1253	104
Sevenum	1185	67	Vlissingen-Haven	1254	73

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Table A10: Continued.

Station	No.	Ambient dose equivalent rate nSv.h⁻¹	Station	No.	Ambient dose equivalent rate nSv.h⁻¹
Nieuwdorp	1255	84	Slijk Ewijk	1268	101
's Heerenhoek	1256	78	Doorwerth	1269	65
Driewegen	1257	84	Randwijk	1270	109
Arnhem	1258	75	Beneden Leeuwen	1272	74
Heinkesand	1259	83	Appeltern	1273	70
Baarland	1260	88	Puiflijk	1274	84
Biervliet	1261	67	Bergharen	1275	76
Slijkplaat	1262	77	Beuningen	1276	82
Rilland	1263	78	Denekamp	1278	62
Putte	1264	55	Winterswijk	1279	67
Nieuw Namen	1265	79	Bilthoven	1280	59
Ochten ⁽¹⁾	1266	-	Maarheze/Gastel	1281	66
Opheusden ⁽¹⁾	1267	-			

⁽¹⁾ Station was not operational in 2002.

⁽²⁾ For the calculation of the average over the year (with averages over the day) only 25 days were available for this station.

Table A11: ^3H - and residual β -activity concentrations ($\text{mBq}\cdot\text{L}^{-1}$) in surface water in 2002 as measured by RIZA.

Date	^3H	Residual β
Location: Eijsden (Meuse)		
22/01/02	1100	80
19/02/02	1700	28
19/03/02	10900	31
16/04/02	28400	20
14/05/02	5000	6
11/06/02	13600	19
09/07/02	30500	45
06/08/02	29200	3
03/09/02	15200	1
01/10/02	14600	19
29/10/02	19200	26
26/11/02	12100	10
23/12/02	19200	100
Average	15400	30
Location: Lobith (Rhine)		
23/01/02	1900	52
20/02/02	3300	89
20/03/02	11200	17
17/04/02	11100	17
15/05/02	3800	23
12/06/02	3200	30
10/07/02	5200	57
07/08/02	2600	41
04/09/02	1400	21
02/10/02	3300	41
30/10/02	5400	69
27/11/02	2100	25
23/12/02	4000	9
Average	4500	38
Location: Schaar van Ouden Doel (Scheldt)		
16/01/02		94
13/02/02	1700	170
13/03/02		100
10/04/02	10800	160
07/05/02		95
03/06/02	8600	150
01/07/02		110
31/07/02	7800	47
28/08/02		70
25/09/02	7300	110
23/10/02		130
20/11/02	5000	81
16/12/02		160
Average	6900	114

Table A12: ^{137}Cs -activity concentrations in suspended solids ($\text{Bq}\cdot\text{kg}^{-1}$) in surface water in 2002 as measured by RIZA.

Date	^{137}Cs	Date	^{137}Cs
Location: Eijsden (Meuse)		Location: Ketelmeer-West	
02/01/02	14	07/02/02	24
08/01/02	14	05/04/02	25
14/01/02	12	30/05/02	20
22/01/02	15	25/07/02	25
05/02/02	12	20/09/02	20
12/02/02	11	14/11/02	16
19/02/02	11	Average	22
26/02/02	10	Location: Lobith (Rhine)	
06/03/02	17	23/01/02	15
12/03/02	14	20/02/02	20
20/03/02	11	20/03/02	19
26/03/02	14	17/04/02	14
02/04/02	10	15/05/02	17
09/04/02	4	12/06/02	14
16/04/02	9	10/07/02	16
23/04/02	4	07/08/02	19
01/05/02	10	04/09/02	22
07/05/02	14	02/10/02	14
14/05/02	10	01/11/02	22
21/05/02	< 1	27/11/02	22
28/05/02	< 1	23/12/02	15
04/06/02	< 1	Average	18
11/06/02	< 1	Location: Schaar van Ouden	
19/06/02	3	16/01/02	13
25/06/02	3	13/02/02	13
02/07/02	11	13/03/02	14
09/07/02	4	10/04/02	12
16/07/02	7	07/05/02	12
23/07/02	5	03/06/02	12
30/07/02	5	01/07/02	12
06/08/02	9	31/07/02	12
13/08/02	5	28/08/02	8
20/08/02	14	25/09/02	11
27/08/02	12	23/10/02	11
03/09/02	11	20/11/02	13
10/09/02	17	16/12/02	14
17/09/02	11	Average	12
25/09/02	11		
01/10/02	9		
08/10/02	10		
15/10/02	10		
23/10/02	13		
30/10/02	14		
05/11/02	13		
12/11/02	9		
19/11/02	12		
26/11/02	17		
03/12/02	13		
10/12/02	16		
17/12/02	13		
23/12/02	12		
30/12/02	13		
Average	10		

Table A13: Gross α -, residual β -, ^3H - and ^{90}Sr -activity concentrations ($\text{mBq}\cdot\text{L}^{-1}$) in seawater in 2002 as measured by RIZA.

Date	Gross α	Residual β	^3H	^{90}Sr
Location:	Coastal area			
14/02/02	420	95	3000	
07/05/02	410	56	5100	
15/08/02	410	72	4100	
19/11/02	510	46	5300	
Average	438	67	4400	
Location:	Southern North Sea			
14/02/02	200	51	1700	< 1
22/05/02	290	52	5500	< 1
13/08/02	240	77	4500	2
11/11/02	290	83	3900	10
Average	255	66	3900	3
Location:	Central North Sea			
14/03/02	310	72	2100	3
16/05/02	120	67	480	5
21/08/02	370	56	450	3
12/11/02	330	56	< 100	6
Average	283	63	770	4
Location:	Delta Coastal Waters			
03/01/02	190	80		
13/02/02	360	100	4000	< 1
11/03/02	150	140		
07/04/02	160	51		
21/05/02	88	83	4700	< 1
11/06/02	200	77		
23/07/02	180	59		
14/08/02	130	66	3800	< 1
19/09/02	100	69		
18/11/02	370	67	3200	3
23/12/02	390	83		
Average	211	80	3900	< 1
Location:	Westerscheldt			
15/01/02	290	120	2200	1
11/02/02	570	140	4900	1
12/03/02	340	73	2900	< 1
09/04/02	500	87	5000	4
07/05/02	250	55	16000	< 1
04/06/02	230	66	3800	< 1
02/07/02	320	100	5400	< 1
30/07/02	240	70	3900	< 1
27/08/02	340	190	3900	9
24/09/02	170	120	4500	< 1
22/10/02	370	140	5000	< 1
19/11/02	580	130	3500	< 1
17/12/02	300	110	4600	1
Average	346	108	5000	1

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Table A13: Continued.

Date	Gross α	Residual β	^3H	^{90}Sr
Location:	Eems-Dollard			
08/02/02	200	110	1500	
24/05/02	350	77	2500	
19/08/02	260	73	3400	
18/11/02	350	67	3900	
Average	290	82	2800	
Location:	Wadden Sea West			
13/02/02	360	89	3200	
16/05/02	350	94	4100	
26/08/02	240	80	2900	
14/11/02	670	84	3000	
Average	405	87	3300	
Location:	Wadden Sea East			
06/02/02	370	230	2600	
22/05/02	510	120	3700	
15/08/02	350	80	2000	
13/11/02	470	160	2700	
Average	425	148	2800	

Table A14: ^{137}Cs - and ^{210}Po -activity concentrations in suspended solids ($\text{Bq}\cdot\text{kg}^{-1}$) in seawater in 2002 as measured by RIZA.

Date	^{137}Cs	^{210}Po
Location:	Coastal area	
15/02/02	9	110
	n/a	n/a
	n/a	n/a
	n/a	n/a
Average	9	110
Location:	Westerscheldt	
11/02/02	7	81
08/05/02	5	74
26/08/02	4	71
18/11/02	8	92
Average	6	80
Location:	Eems-Dollard	
18/02/02	12	110
16/05/02	9	89
12/08/02	10	94
08/11/02	10	95
Average	10	97
Location:	Wadden Sea West	
14/02/02	9	110
	n/a	n/a
	n/a	n/a
	n/a	n/a
Average	9	110
Location:	Wadden Sea East	
06/02/02	9	120
22/05/02	6	77
	n/a	n/a
13/11/02	8	120
Average	8	106

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

Appendix B Mailing list

1	-	10	Directeur VROM/DGM/SAS
11	-	19	Regionaal Inspecteur VROM-Inspectie Regio Zuid-West
20			Hoofd afdeling Handhaving Algemeen van de VROM-Inspectie
21			plv. Directeur-Generaal Milieubeheer
22	-	36	Rijksinstituut voor Integraal Zoetwaterbeheer en Afvalwaterbehandeling
37	-	51	Rijksinstituut voor Kust en Zee
52			Dr. Ir. G. Kleter, Veterinair Inspecteur Algemene Directie Keuringsdienst van Waren
53	-	57	Algemene Directie Keuringsdienst van Waren
58			Directeur Keuringsdienst van Waren Zutphen
59			Hoofd Signalering Veterinaire Producten Keuringsdienst van Waren Zutphen
60	-	62	Keuringsdienst van Waren Zutphen
63			European commission, D.G. ENV.C.1 - Radiation Protection Unit
64			Depot van Nederlandse publicaties en Nederlandse bibliografie
65			ir. W. Cramer, VROM/DGM/BWL
66			Directie RIVM
67			Directeur Sector Milieurisico's en Externe Veiligheid
68			Hoofd van het Laboratorium voor Stralingsonderzoek
69			Hoofd van de afdeling Monitoring en Meetmethoden van het Laboratorium voor Stralingsonderzoek
70			Auteur
71			Mw. ir. J.F.M. Versteegh, RIVM/IEM
72			SBC/Communicatie
73			Bureau Rapportenregistratie
74			Bibliotheek RIVM
75			Bibliotheek LSO
76	-	80	Bureau Rapportenbeheer
81	-	110	Reserve exemplaren ten behoeve van het Laboratorium voor Stralingsonderzoek