National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Monitoring of **radioactivity** in the Netherlands

Surface water and seawater – results 2020 and 2021

RIVM letter report 2023-0072
C.P. Tanzi

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C.P. Tanzi (editor), RIVM

Contact:
Cristina Tanzi, Centre for Environmental Safety and Security
cristina.tanzi@rivm.nl

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Synopsis

Monitoring of radioactivity in the Netherlands

Surface water and seawater – results 2020 and 2021

In 2020 and 2021 the Netherlands fulfilled its annual European obligation to measure how much radioactivity is present in the environment. Radioactivity levels in surface water and seawater were similar to previous years.

All countries of the European Union are required to perform these measurements each year under the terms of the Euratom Treaty of 1957. The Netherlands performs these measurements following the guidance issued in 2000.

The measurements represent the background values for radioactivity that are present under normal circumstances. They can be used as reference values, for instance, during a nuclear emergency.

The results on radioactivity in the environment are reported to the European Commission by the National Institute for Public Health and the Environment (RIVM) on behalf of the competent authority in the Netherlands.

Keywords: radioactivity, surface water, seawater

Publiekssamenvatting

Monitoring van radioactiviteit in Nederland

Oppervlaktewater en zeewater – resultaten 2020 en 2021

In 2020 en 2021 voldeed Nederland aan de Europese verplichting om elk jaar te meten hoeveel radioactiviteit in het milieu zit. De niveaus radioactiviteit in oppervlaktewater en zeewater zijn vergelijkbaar met die van eerdere jaren.

Alle landen van de Europese Unie zijn volgens het Euratom-verdrag uit 1957 verplicht om deze metingen te doen. Nederland volgt daarbij de aanbevelingen uit 2000 op om de metingen op een bepaalde manier uit te voeren.

De metingen leveren achtergrondwaarden op, ofwel radioactiviteitsniveaus die er onder normale omstandigheden zijn. Deze waarden kunnen bij bijvoorbeeld calamiteiten of rampen als referentie dienen.

Het RIVM brengt namens de Autoriteit Nucleaire Veiligheid en Stralingsbescherming (ANVS) verslag uit aan de Europese Unie over radioactiviteit in het milieu.

Kernwoorden: radioactiviteit, oppervlaktewater, zeewater

Contents

Summary

Radioactivity levels in surface water and seawater were determined for gross α, residual β (gross β minus naturally occurring ^{40}K), ^{3}H and ^{90}Sr, and additionally for ^{226}Ra in surface water only. Radioactivity levels in suspended solids in surface water and seawater were determined for ^{137}Cs and ^{210}Pb, and additionally for ^{60}Co and ^{131}I in surface water only.

This report presents results for the years 2020 and 2021. The yearly averaged radioactivity levels for both years were within the range of those found in previous years.

1 Introduction

Rijkswaterstaat (RWS) regularly monitors the concentration of a large number of radionuclides in surface water and seawater. A representative part of the RWS's monitoring programme is presented here. The monitoring data are publicly available on the website of RWS, or can be requested for specific locations. A more detailed description of the monitoring programme and its underlying strategy are reported elsewhere [1, 2, 3, 4].

The general monitoring strategy used for surface water is to monitor the inland and transborder water bodies of the Netherlands. Therefore, about 20 sampling locations shown in Figure 1 are used for monitoring, as they represent the major inland, incoming and outgoing waters of the Netherlands. The locations for seawater presented in this report were chosen to represent the major areas of seawater. Radionuclides were measured in water and in suspended solids. The samples were collected at equidistant times with frequencies ranging from weekly to quarterly, depending on location and radionuclide. The sampling frequencies of the selected locations are presented in Table 1 to Table 4 for the years 2020 and 2021. Small changes in sampling frequency may occur from year to year, for example due to operational constraints. Measurements in sediment and biota are also part of the RWS monitoring programme, but the results are not presented in this report. The radionuclides were measured according to standard procedures [3].

Table 1 Yearly frequency of the monitoring programme for the determination of the activity concentrations (mBq·L^{-1}) of radionuclides in surface water in the years 2020 and 2021.

Location	Gross α		Residual β		^{3}H		^{90}Sr		^{226}Ra	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
IJsselmeer	13	13	13	13	7	6	-	-	-	-
North Sea Canal (Noordzeekanaal)	13	13	13	13	13	13	-	-	-	-
Nieuwe Waterweg	13	-	13	-	6	-	6	-	6	-
Rhine	13	13	13	13	13	13	6	7	6	7
Scheldt	13	13	13	13	7	6	-	-	7	6
Meuse	14	13	14	13	14	13	7	7	7	7
Ghent-Terneuzen Canal	13	13	13	13	6	7	-	-	-	-
Haringvliet	13	12	13	12	7	6	-	-	-	-

[1] E.J. de Jong and O.C. Swertz, 2000. Radioactieve stoffen in de zoute wateren. RIKZ, The Hague, Report no. RIKZ/2000.041
[2] L.J. Gilde, K.H. Prins, C.A.M. van Helmond, 1999. Monitoring zoete rijkswateren. RIZA Lelystad, Report no. 99.004.
[3] MWTL Meetplan 2016, Monitoring Waterstaatkundige Toestand des Lands, Milieumeetnet Rijkswateren chemie en biologie, 19 augustus 2015.
[4] Web page: https://waterinfo-extra.rws.nl/monitoring/chemie/ (August 2022).

Table 2 Yearly frequency of the monitoring programme for the determination of radionuclides in suspended solids (Bq·kg^{-1}) in surface water in the years 2020 and 2021.

Location	^{60}Co		^{131}I		^{137}Cs		^{210}Pb	
	2020	2021	2020	2021	2020	2021	2020	2021
IJsselmeer	13	13	13	13	13	13	-	-
North Sea Canal (Noordzeekanaal)	6	7	6	7	6	7	-	-
Nieuwe Waterweg	13	13	13	13	13	13	5	7
Rhine	26	26	26	26	26	26	6	7
Scheldt	13	13	13	13	13	13	7	6
Meuse	52	48	52	48	52	48	7	5
Ghent-Terneuzen Canal	4	4	4	4	4	4	-	-
Haringvliet	4	4	4	4	4	4	-	-

Table 3 Yearly frequency of the monitoring programme for the determination of the activity concentrations (mBq·L^{-1}) of radionuclides in seawater in the years 2020 and 2021.

Location	Gross α		Residual β		^{3}H		^{90}Sr	
	2020	2021	2020	2021	2020	2021	2020	2021
Coastal Area	4	4	4	4	4	4	-	-
Southern North Sea	4	4	4	4	4	4	4	4
Central North Sea	4	4	4	4	4	4	4	4
Delta Coastal Waters	12	11	12	11	12	11	4	4
Western Scheldt	13	13	13	13	13	13	13	13
Eems Dollard	4	4	4	4	4	4	-	-
Wadden Sea West	4	4	4	4	4	4	-	-
Wadden Sea East	4	4	4	4	4	4	-	-

Table 4 Yearly frequency of the monitoring programme for the determination of radionuclides in suspended solids (Bq·kg^{-1}) in seawater in the years 2020 and 2021.

Location	^{137}Cs		^{210}Pb	
	2020	2021	2020	2021
Western Scheldt	4	4	4	4

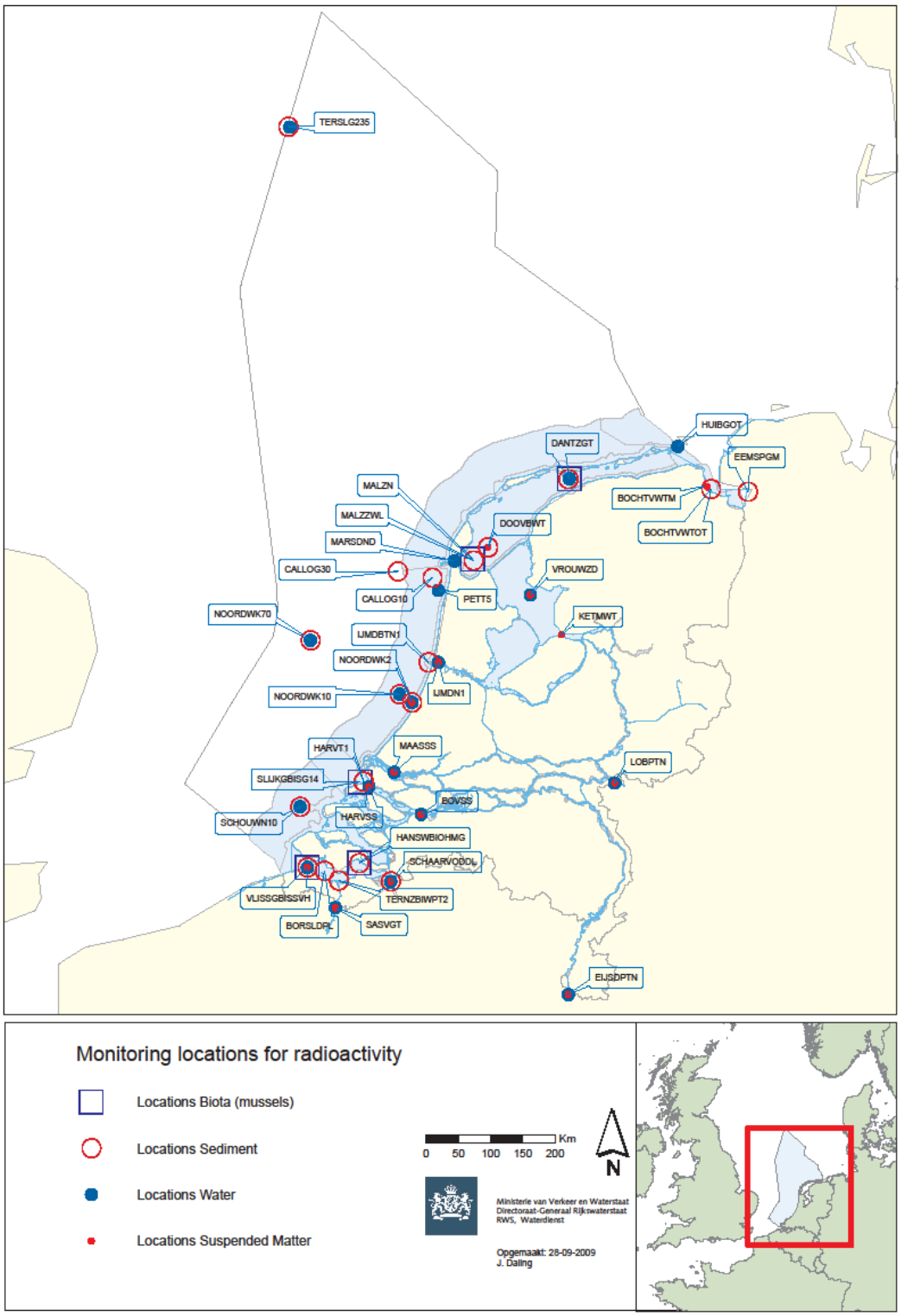

Figure 1 Overview of monitoring locations for the entire monitoring programme for surface water and seawater, as given by Rijkswaterstaat. The location IJMDN1 has been temporarily moved in 2021 a few hundred meters to location IJMDNT1 because of the construction of a new sea lock.

2 Results

The yearly averages of the radioactivity measurements for the selected locations are presented in Table 5 to Table 8 for the year 2020, in Table 9 and Table 12 for the year 2021, and Figure 2 to Figure 16. The results of the complete monitoring programme conducted by RWS is presented elsewhere [5].

Table 5 Yearly averaged gross α, residual β, ^{3}H, ^{90}Sr and ^{226}Ra activity concentrations (mBq·L^{-1}) in surface water in 2020.

Location	Gross α	Residual β	^{3}H	^{90}Sr	^{226}Ra
IJsselmeer	49	16	2,291	-	-
North Sea Canal (Noordzeekanaal)	237	33	2,548	-	-
Nieuwe Waterweg	269	40	3,512	< 1.7	4.4
Rhine	51	26	3,155	< 1.8	2.9
Scheldt	358	122	11,341	-	6.7
Meuse	42	21	15,697	< 0.9	1.7
Ghent-Terneuzen Canal	126	39	1,698	-	-
Haringvliet	43	13	4,160	-	-

Table 6 Yearly averaged ^{60}Co, ^{131}I, ^{137}Cs and ^{210}Pb activity concentrations in suspended solids (Bq·kg^{-1}) in surface water in 2020.

Location	^{60}Co	^{131}I	^{137}Cs	^{210}Pb
IJsselmeer	< 1	< 1	3.1	-
North Sea Canal (Noordzeekanaal)	< 1	22	3.4	-
Nieuwe Waterweg	< 1	< 1.3	6.7	101
Rhine	< 1	< 1.6	8.7	152
Scheldt	< 1	< 0.6	4.7	82
Meuse	6.7	< 8	7.3	169
Ghent-Terneuzen Canal	< 1	8	4.4	-
Haringvliet	< 1	< 1	10.4	-

Table 7 Gross α, residual β, ^{3}H and ^{90}Sr activity concentrations (mBq·L^{-1}) in seawater in 2020.

Location	Gross α	Residual β	^{3}H	^{90}Sr
Coastal Area	467	50	4,093	-
Southern North Sea	518	33	2,345	< 1.3
Central North Sea	722	36	280	< 2.0
Delta Coastal Waters	651	46	3,958	< 1.6
Western Scheldt	727	70	4,605	< 2.0
Eems Dollard	614	48	4,340	-
Wadden Sea West	395	58	4,048	-
Wadden Sea East	498	76	3,890	-

[5] Web page: https://www.rijkswaterstaat.nl/water/waterdata-en-waterberichtgeving/waterdata (July 2023).

Table 8 ^{137}Cs and ^{210}Pb activity concentrations in suspended solids ($Bq \cdot kg^{-1}$) in seawater in 2020.

Location	^{137}Cs	^{210}Pb
Western Scheldt	3.5	37

For the location Nieuwe Waterweg there has been a time interval, from 2021 (see Table 9) to the first half of 2022, when no measurements were performed of gross α, residual β, ^{3}H, ^{90}Sr and ^{226}Ra due to the choice of the moment of sampling.

Table 9 Yearly averaged gross α, residual β, ^{3}H, ^{90}Sr and ^{226}Ra activity concentrations ($mBq \cdot L^{-1}$) in surface water in 2021.

Location	Gross α	Residual β	^{3}H	^{90}Sr	^{226}Ra
IJsselmeer	42	28	2,067	-	-
North Sea Canal (Noordzeekanaal)	175	28	2,273	-	-
Nieuwe Waterweg	-	-	-	-	-
Rhine	69	52	2,575	< 3.2	3.5
Scheldt	307	104	10,517	-	7.4
Meuse	44	29	6,451	< 1.3	3.7
Ghent-Terneuzen Canal	108	23	1,327	-	-
Haringvliet	43	25	2,678	-	-

Table 10 Yearly averaged ^{60}Co, ^{131}I, ^{137}Cs and ^{210}Pb activity concentrations in suspended solids ($Bq \cdot kg^{-1}$) in surface water in 2021.

Location	^{60}Co	^{131}I	^{137}Cs	^{210}Pb
IJsselmeer	< 1	< 1	3.0	-
North Sea Canal (Noordzeekanaal)	< 1	31	4.7	-
Nieuwe Waterweg	< 1	< 2.5	6.5	100
Rhine	< 1	< 1.5	7.6	129
Scheldt	< 1	< 0.7	5.1	82
Meuse	6.9	15	8.8	132
Ghent-Terneuzen Canal	< 1	2	3.6	-
Haringvliet	< 1	< 1	10.3	

Table 11 Gross α, residual β, ^{3}H and ^{90}Sr activity concentrations ($mBq \cdot L^{-1}$) in seawater in 2021.

Location	Gross α	Residual β	^{3}H	^{90}Sr
Coastal Area	706	39	4,173	-
Southern North Sea	345	29	2,503	2.6
Central North Sea	790	24	400	3.1
Delta Coastal Waters	563	32	4,218	< 1.1
Western Scheldt	681	96	4,540	< 2.2
Eems Dollard	376	24	2,780	-
Wadden Sea West	392	54	3,415	-
Wadden Sea East	619	114	2,750	-

Table 12 ^{137}Cs and ^{210}Pb activity concentrations in suspended solids (Bq·kg^{-1}) in seawater in 2021.

Location	^{137}Cs	^{210}Pb
Western Scheldt	3.0	56

2.1 Surface water, activity concentrations (Bq·L^{-1})

Gross α and residual β are indicative parameters. In general, gross α and β analysis is used as a screening method to determine the total radioactivity present in the form of α and β radiation, without regard to the identity of specific radionuclides.

The yearly averages of gross α and residual β activity concentrations in surface water are presented in Table 5, Table 9, and in Figure 2 and Figure 3. The yearly average activity concentrations of gross α in 2020 and 2021 were within the range of those in previous years. Residual β in the North Sea Canal (Noordzeekanaal), Nieuwe Waterweg and Scheldt has shown a change in trend since 1994, caused by a change in the measuring technique applying only to salt and brackish water [6]. This change in trend was therefore not seen for residual β in the IJsselmeer, Rhine or Meuse. The yearly average activity concentrations of residual β in 2020 and 2021 were within the range of those in previous years.

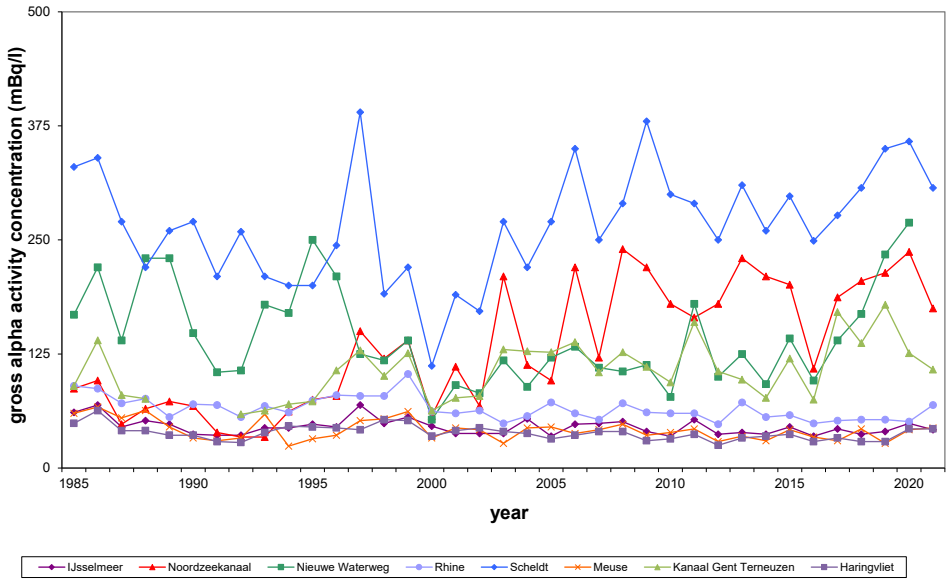

Figure 2 Yearly average gross α activity concentrations (mBq·L^{-1}). Data are not available for the Nieuwe Waterweg in 2021 as detailed in Section 2.

[6] E.J. de Jong and O.C. Swertz, 2000. Radioactieve stoffen in de zoute wateren. RIKZ, The Hague, Report no. RIKZ/2000.041

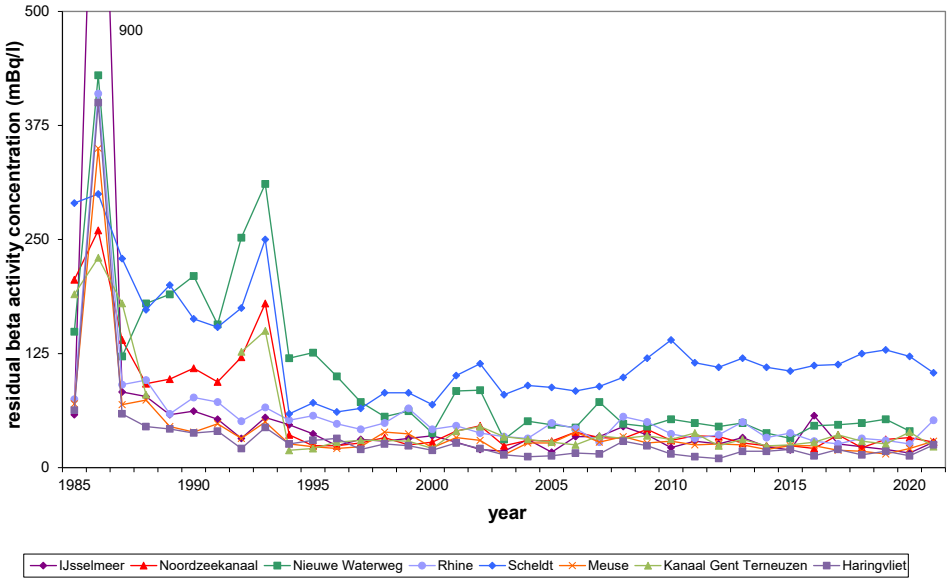

Figure 3 Yearly average residual β activity concentrations (mBq·L^{-1}).

The yearly averages of ^{3}H activity concentrations are presented in Table 5, Table 9 and Figure 4 and were in 2020 and 2021 within the range of those in previous years. In general, elevated levels of ^{3}H in the Rhine may originate from several nuclear power plants or research reactors in Germany, France or Switzerland. Elevated levels of ^{3}H in the Meuse could have originated from the nuclear power plants at Tihange (Belgium) or Chooz (France). Elevated levels of ^{3}H in the Scheldt could have originated from the nuclear power plant at Doel (Belgium).

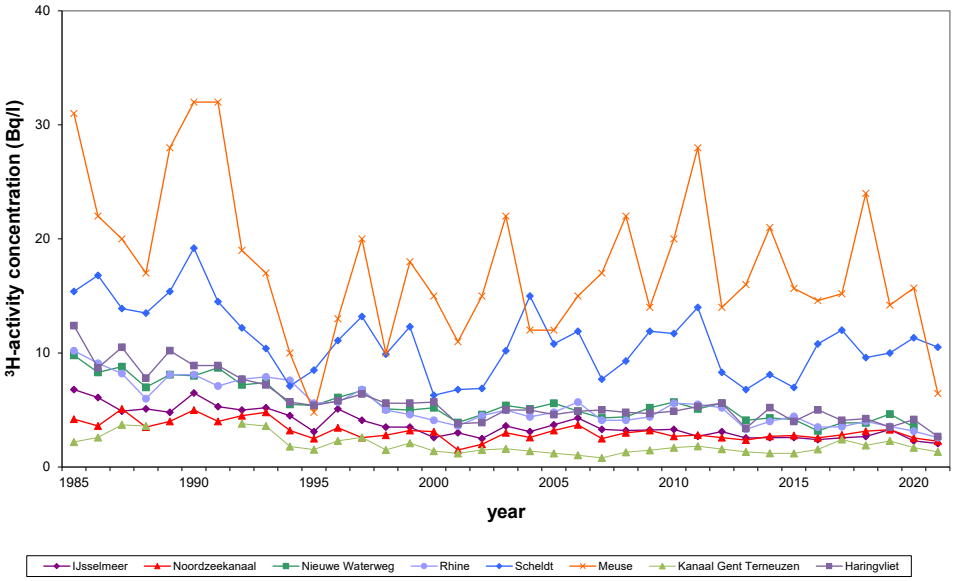

Figure 4 Yearly average ^{3}H activity concentrations (Bq·L^{-1}).

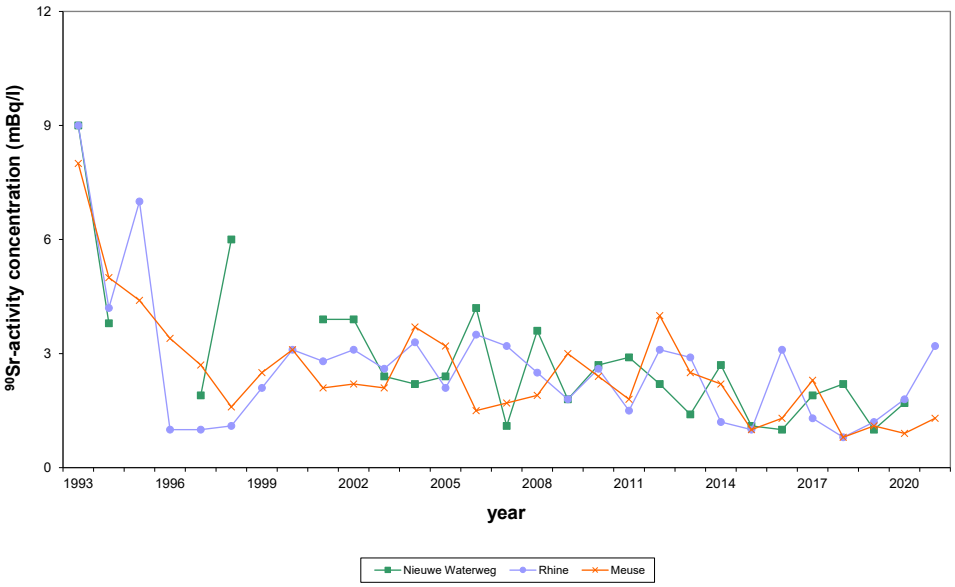

Figure 5 Yearly average ^{90}Sr activity concentrations (mBq·L^{-1}). Data are not available for the Nieuwe Waterweg in 1995, 1996, 1999, 2000 and 2021.

The radionuclide ^{90}Sr is released into the environment by nuclear power plants and nuclear reprocessing plants. The yearly averages of ^{90}Sr activity concentrations are presented in Table 5, Table 9 and Figure 5 and were within the range of those in previous years.

The nuclide ^{226}Ra is released into the environment by the ore-processing industry and transhipment. ^{226}Ra in the Nieuwe Waterweg and Scheldt might originate from these industries in the port areas of Rotterdam-Rijnmond and Antwerp, respectively. The yearly averages of ^{226}Ra activity concentrations are presented in Table 5, Table 9, and Figure 6 and were within the range of those in previous years.

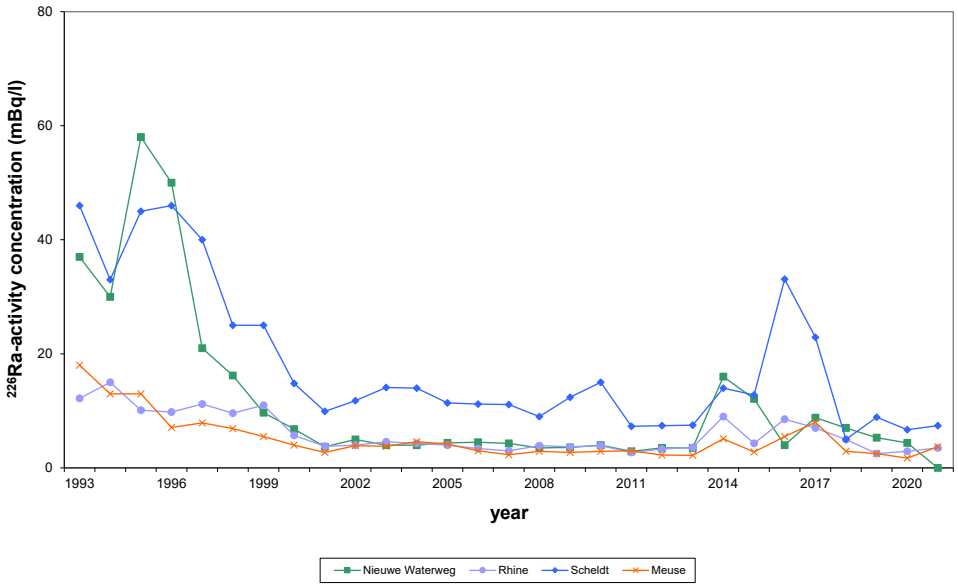

Figure 6 Yearly average ^{226}Ra activity concentrations (mBq·L^{-1}).

2.2 Surface water, activity in suspended solids (Bq·kg^{-1})

The radionuclides ^{60}Co and ^{137}Cs are released into the environment by nuclear power plants. The yearly averages of ^{60}Co and ^{137}Cs activity concentrations in 2020 and 2021 are presented in Table 6, Table 10, Figure 7 and Figure 8 and were within the range of those in previous years.

The radionuclide ^{131}I is released into the environment primarily by medical facilities. The yearly averages of ^{131}I activity concentrations in 2020 and 2021 are presented in Table 6, Table 10 and Figure 9 and were within the range of those in previous years. ^{131}I activity concentrations are higher in the North Sea Canal (Noordzeekanaal, at location IJmuiden) and Meuse than elsewhere. ^{131}I in the Meuse might originate from medical facilities in Belgium, and^{131}I in the North Sea Canal might originate from a sewage treatment plant in the port area of Westpoort. One of the contributions to the sewage waters is discharge from medical facilities. Without further investigation we can't correlate changes of activity concentrations over the years, as may be observed in Figure 9, to changes in discharges over time.

The radionuclides ^{210}Po and ^{210}Pb originate from the uranium decay chain and are released by the ore-processing industry. Since ^{210}Po is usually in equilibrium with ^{210}Pb in suspended solids, RWS reports only ^{210}Pb. ^{210}Pb in the Nieuwe Waterweg and Scheldt might originate from these types of industries in the port areas of Rijnmond and Antwerp, respectively. The yearly averages of ^{210}Pb activity concentrations in 2020 and 2021 are presented in Table 6, Table 10 and Figure 10 and were within the range of those in previous years.

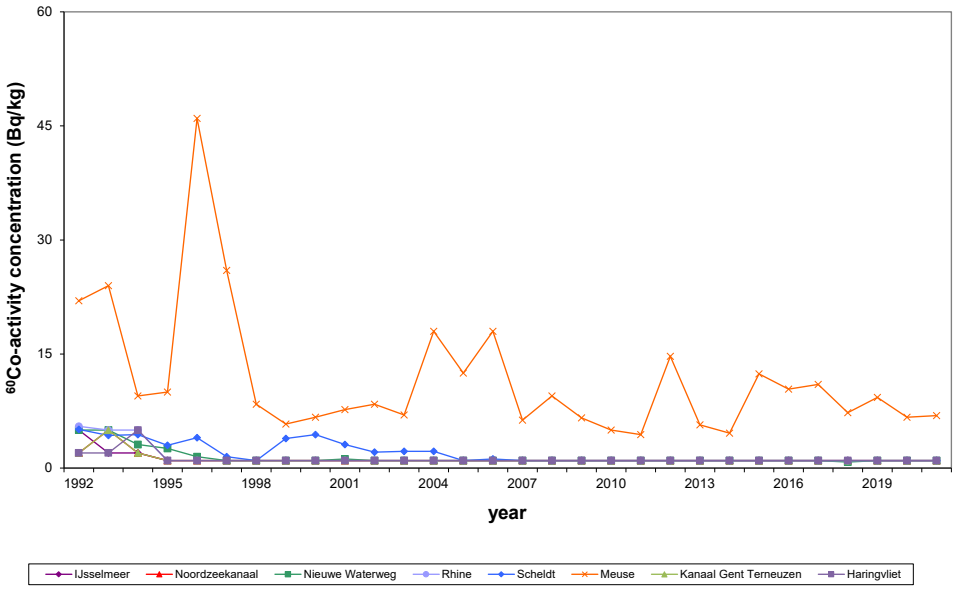

Figure 7 Yearly average ^{60}Co activity concentrations (Bq·kg^{-1}) in suspended solids.

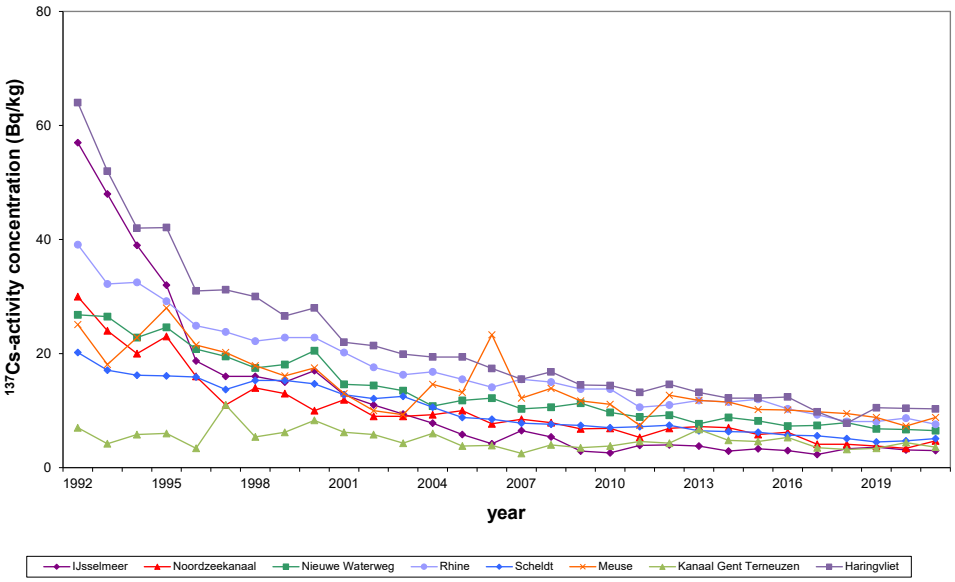

Figure 8 Yearly average ^{137}Cs activity concentrations in suspended solids ($Bq \cdot kg^{-1}$).

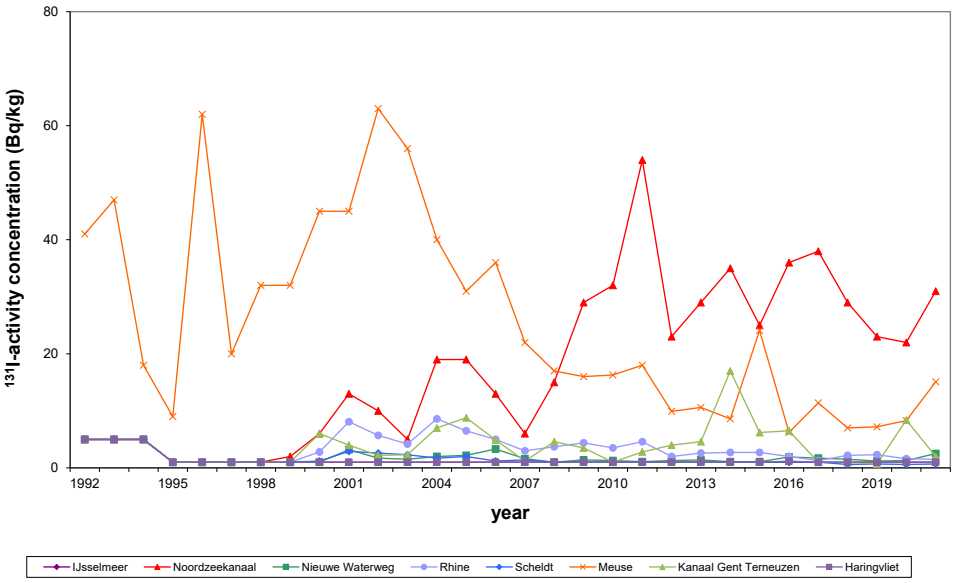

Figure 9 Yearly average ^{131}I activity concentrations in suspended solids ($Bq \cdot kg^{-1}$).

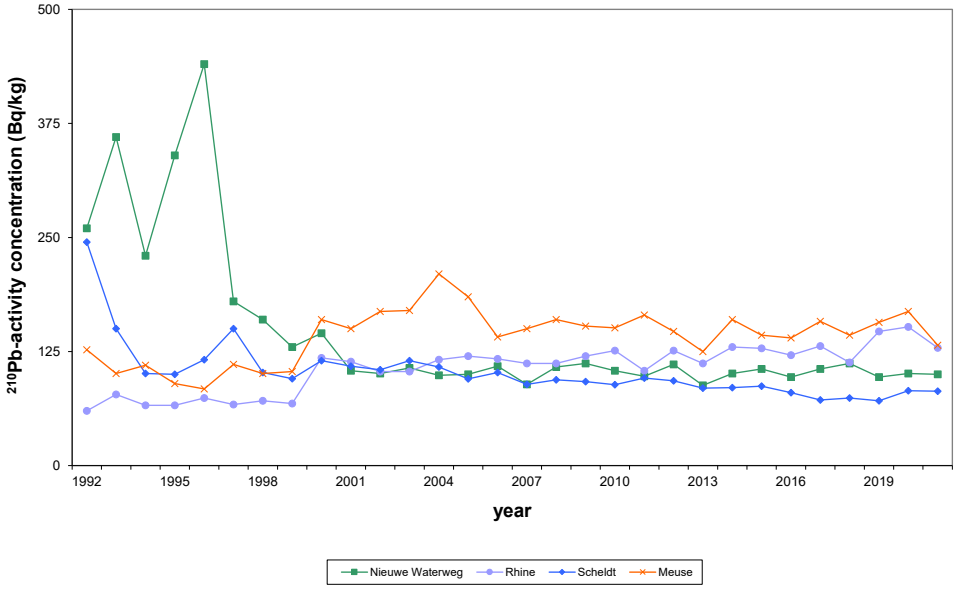

Figure 10 Yearly average ^{210}Pb activity concentrations in suspended solids (Bq·kg^{-1}).

2.3 Seawater, activity concentrations (Bq·L^{-1})

Gross α and residual β are indicative parameters. The yearly averages of gross α and residual β are presented in Table 7, Table 11, Figure 11 and Figure 12. The yearly average activity concentrations of gross α and residual β in 2020 and 2021 were within the range of those in previous years. Residual β shows an apparent change in trend since 1994. This was caused by a change in measuring technique that applies to salt and brackish water [6].

Nuclear power plants discharge the radionuclides ^{3}H and ^{137}Cs, among others. Nuclear fuel reprocessing plants discharge the radionuclides ^{3}H and ^{90}Sr, among others. Discharges from the nuclear power plants at Doel (Belgium) and Borssele (Netherlands) are monitored in the Western Scheldt (WS) area. 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) areas, respectively [6]. The impact of both sources (nuclear power and reprocessing plants) is monitored indirectly in the Delta Coastal Waters (VD) area.

The yearly averages of ^{3}H and ^{90}Sr activity concentrations are presented in Table 7, Table 11, Figure 13 and Figure 14 and were within the range of those in previous years.

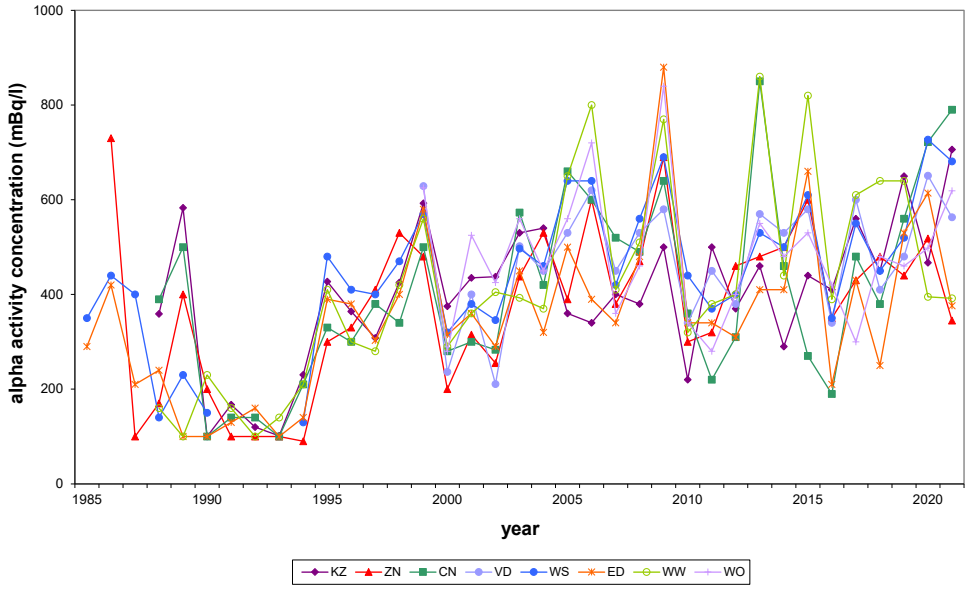

Figure 11 Yearly average gross α activity concentrations in seawater (mBq·L^{-1}) for the Coastal Area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Western Scheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO).

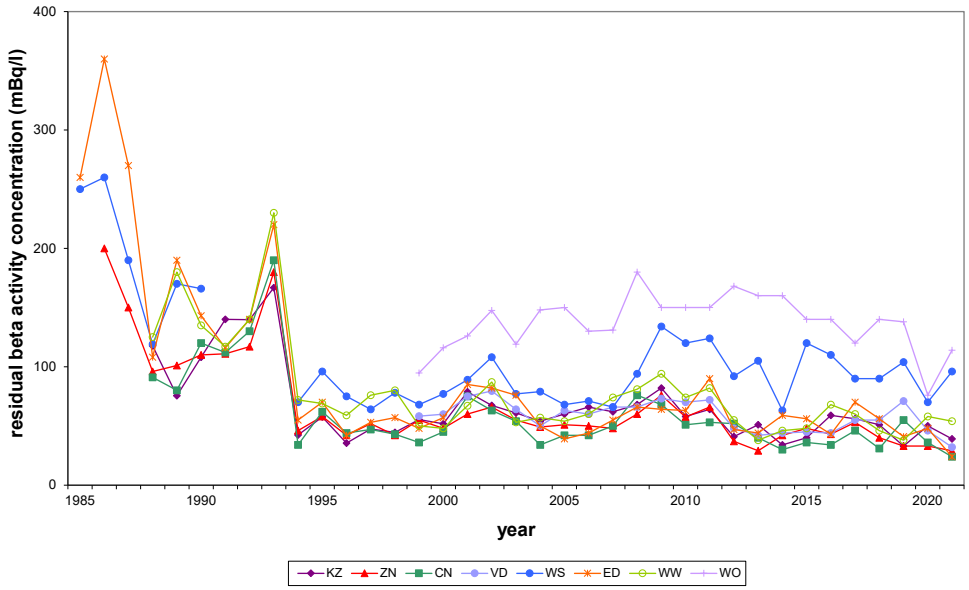

Figure 12 Yearly average residual β activity concentrations in seawater (mBq·L^{-1}) for the Coastal Area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Western Scheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO).

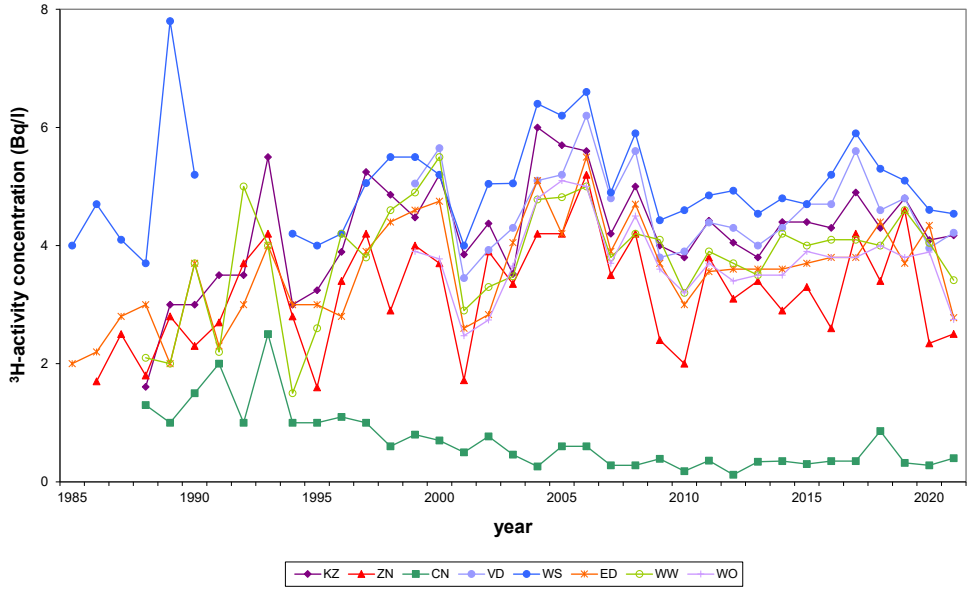

Figure 13 Yearly average ^{3}H activity concentrations in seawater ($Bq \cdot L^{-1}$) for the Coastal Area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Western Scheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO).

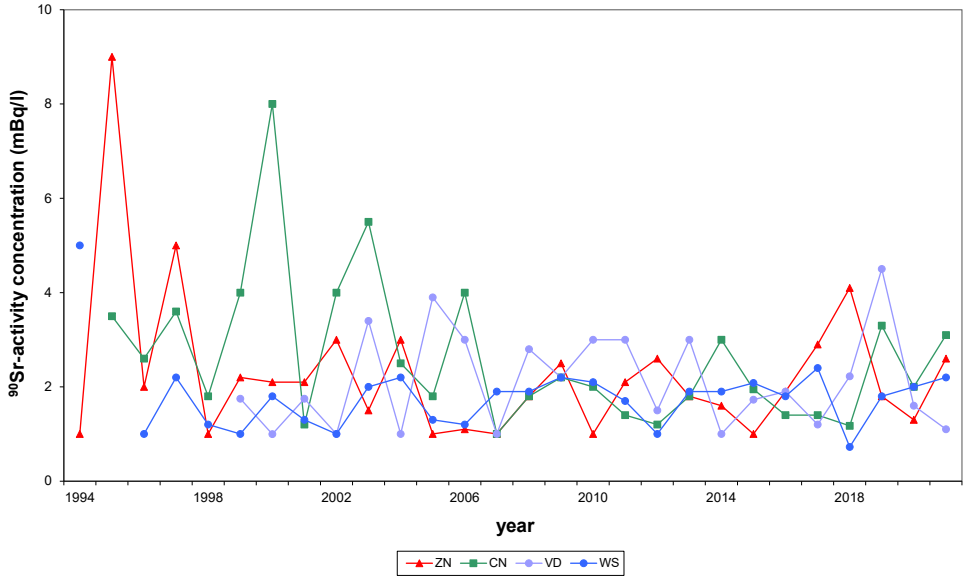

Figure 14 Yearly average ^{90}Sr activity concentrations in seawater ($mBq \cdot L^{-1}$) for the Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD) and Western Scheldt (WS).

2.4 Sea water, activity in suspended solids ($Bq \cdot kg^{-1}$)

The radionuclides ^{210}Pb and ^{210}Po originate from the uranium decay chain and are released, for example, by the phosphate-processing industry and production platforms for oil and gas [6]. The phosphate-processing industry has not been operational in the Netherlands since 2012. Since ^{210}Po is usually in equilibrium with ^{210}Pb in suspended solids, RWS reports only on ^{210}Pb (as in surface water). In cases in which a strong increase in the gross α value is noticed, however, ^{210}Po is

determined as well. This is because the increase in the gross α value might be possibly caused by discharges of ^{210}Po. Discharges via the main rivers are monitored in the Coastal Area (KZ). Discharges from the ore- and phosphate-processing industries in Belgium and the Netherlands are monitored in the Western Scheldt (WS) area. Discharges from Delfzijl, Eemshaven and plants in Germany are monitored in the Eems-Dollard (ED) area. The impact of these discharges, together with activity originating from the North Sea, is monitored indirectly in the Wadden Sea (WW and WO) area. Since 2009, Wadden Sea West replaced Wadden Sea East as a monitoring location. Since 2014, the monitoring of suspended solids has been discontinued in the Coastal Area, Eems-Dollard and Wadden Sea West. The yearly averages of ^{137}Cs and ^{210}Pb activity concentrations for 2020 and 2021 are presented in Table 8, Table 12, Figure 15 and Figure 16. They were within the range of those in previous years, with the exception of Pb-210 in 2020 where one of the four measurements was below the minimum detectable activity of 1 Bq·kg^{-1}.

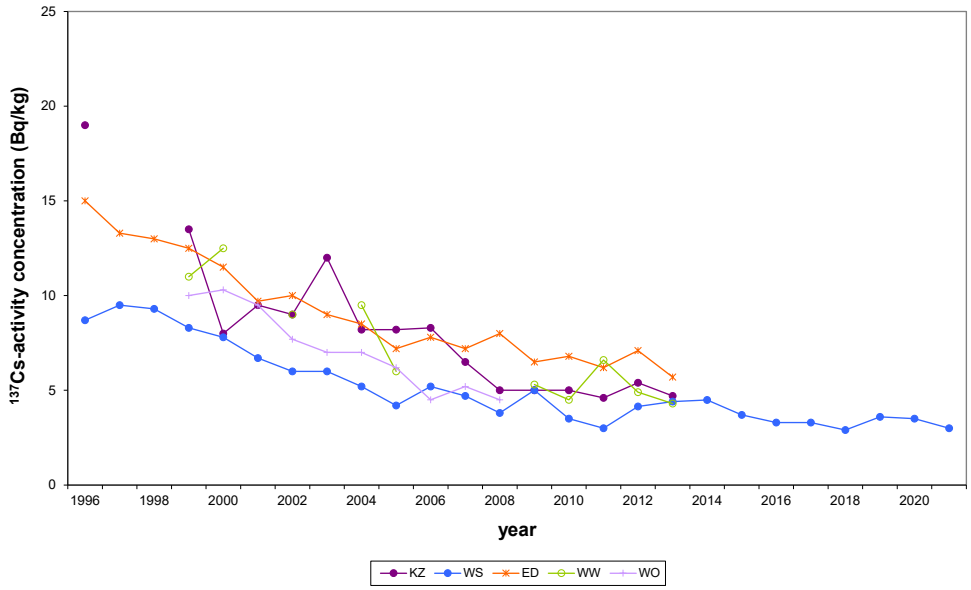

Figure 15 Yearly average ^{137}Cs activity concentrations in suspended solids (Bq·kg^{-1}). Since 2009, Wadden Sea West (WW) replaced Wadden Sea East (WO) as a monitoring location. Since 2014, the monitoring of suspended solids has been discontinued in the Coastal Area (KZ), Eems-Dollard (ED) and Wadden Sea West (WW). The monitoring continues for the Western Scheldt (WS).

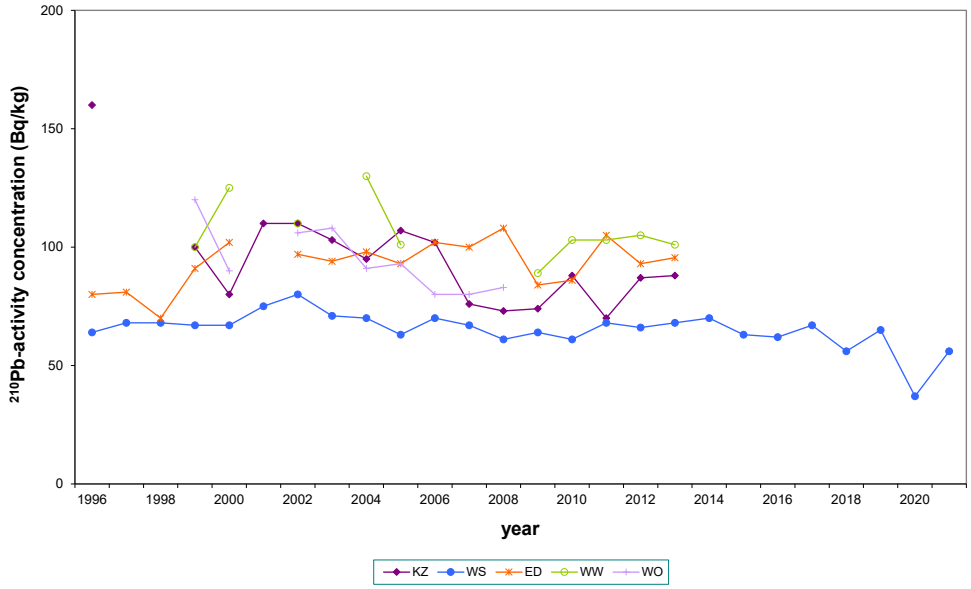

Figure 16 Yearly average ^{210}Pb activity concentrations in suspended solids ($Bq \cdot kg^{-1}$). Since 2009, Wadden Sea West (WW) replaced Wadden Sea East (WO) as a monitoring location. Since 2014, the monitoring of suspended solids has been discontinued in the Coastal Area (KZ), Eems-Dollard (ED) and Wadden Sea West (WW). The monitoring continues for the Western Scheldt (WS).

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