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

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Results 2019 and 2020

RIVM letter report 2021-0078
P.J.M. Kwakman

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Synopsis

Contra expertise on environmental monitoring in the vicinity of the Borssele nuclear power plant.
Results in 2019 and 2020.

Regularly, RIVM performs a contra expertise on parts of the measurements that were carried out in the vicinity of the Borssele nuclear power plant (NPP). Various samples taken in 2019 and 2020 were analysed by RIVM. The analytical results indicate that no radiological contamination from the nuclear power plant can be found. In most samples RIVM reports detection limits, a very low amount of natural activity, or in a sand sample a negligible activity of ^{137}Cs. This is a known surface contamination of ^{137}Cs in the Netherlands [8] and originates most likely from the Chernobyl accident.

The Nuclear Research and Consultancy Group (NRG) always carries out the measurements for NPP-Borssele. In 2019, NRG reported a significant gross-bèta activity for one sample (out of 48 samples in total) of suspended solids at sample point 3. The RIVM contra expertise a few months later did not show the same value, but a detection limit. The total analytical procedure of this sample was extensively reviewed by NRG with inconclusive results.

In 2020, all gross-bèta data in river Scheldt water and suspended solids were in good agreement. In 2019 and 2020, trace amounts of ^{54}Mn were found in sand, downstream as well as upstream of the NPP. The origin is not quite clear.

In 2019, a low amount of tritium is found in water from the river Scheldt. Due to the upstream location of the Doel nuclear power plant in Belgium, the origin of this trace activity of tritium is hard to determine. In 2020, ^{3}H was not determined by both RIVM and NRG.

The NPP assigned the NRG to carry out monthly sampling of water, air dust, sediment, seaweed, and yearly sampling of sand. NRG analysed these samples for ^{3}H, gamma-emitters, gross alpha and gross beta activity.

Keywords: nuclear power plant Borssele, environment, radioactivity, contra expertise

Publiekssamenvatting

Contra-expertise op milieumetingen in de omgeving van kerncentrale Borssele.

Resultaten in 2019 en 2020

Het RIVM voert regelmatig een contra-expertise uit op de metingen die de kerncentrale Borssele in de directe omgeving van de centrale laat uitvoeren. Hiervoor zijn de monsters geanalyseerd die in 2019 en 2020 op verschillende plekken zijn genomen. Er is geen radioactiviteit van de kerncentrale gevonden.

In de meeste gevallen rapporteert het RIVM een detectiegrens, een lage hoeveelheid van natuurlijke activiteit, of sporen van ^{137}Cs in een grondmonster. Dit is een bekende oppervlaktebesmetting voor ^{137}Cs en komt hoogstwaarschijnlijk van het kernongeval bij Chernobyl in 1986.

De Nuclear Research and Consultancy Group (NRG) voert altijd de metingen uit voor Borssele. NRG rapporteerde in 2019 in één monster (van de 48 monsters) een significante hoeveelheid totaal-bèta activiteit in zwevend slib bij monsterlocatie 3. Het RIVM vond enkele maanden later in dat monster geen activiteit boven de detectiegrens. NRG heeft de hele analytische behandeling van dit monster uitgebreid bekeken, zonder een oorzaak te kunnen vinden.

In 2020 was er een goede overeenstemming tussen de RIVM- en NRG-data voor totaal-bèta in Schelde water en zwevend slib. In 2019 en 2020 zijn enkele sporen van ^{54}Mn in zandmonsters gevonden, zowel stroomopwaarts als stroomafwaarts. De oorsprong van ^{54}Mn is niet duidelijk.

Het RIVM heeft in 2019 in enkele watermonsters van de Westerschelde een zeer lage hoeveelheid van ^{3}H aangetroffen. ^{3}H afkomstig van kerncentrale Doel stroomt eveneens langs kerncentrale Borssele, waardoor de oorsprong ervan onbekend is. In 2020 hebben het RIVM en NRG geen ^{3}H gevonden.

NRG neemt sinds de jaren negentig van de vorige eeuw elke maand monsters van gras, water, luchtstof, sediment, en zeewier. Elk jaar neemt het een grondmonster. NRG analyseerde deze monsters op gammastralers, totaal-alfa en totaal-bèta activiteit.

Kernwoorden: kerncentrale Borssele, milieumetingen, radioactiviteit, contra expertise

Contents

Summary

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Results in 2019 and 2020.

Regularly RIVM performs a contra expertise on parts of the measurements that were carried out in the vicinity of the Borssele nuclear power plant (NPP). The NPP assigned the Nuclear Research and Consultancy Group (NRG) to carry out monthly sampling of water, air dust, sediment, seaweed, and yearly sampling of sand. NRG analysed these samples for gamma-emitters, ^{3}H, gross alpha and gross beta activity.
Various samples taken in 2019 and 2020 were also analysed by RIVM. The analytical results indicate that no radiological contamination from the nuclear power plant can be found.

In general, the RIVM measurement data confirm the findings that have been reported by NRG. In most samples, RIVM reports detection limits, a very low amount of natural activity, or in a sand sample a negligible activity of ^{137}Cs. This is a known surface contamination of about 90 – 100 Bq/m^2 ^{137}Cs in the Netherlands [8] and originates most likely from the Chernobyl accident.

In 2019, NRG reported a gross-bèta activity of (86.9 ± 0.6 kBq.kg^{-1}) for one sample (out of 48 samples in total) of suspended solids at sample point 3. This is almost two orders of magnitude higher than all other samples in 2019. The RIVM contra expertise, carried out a few months later, did not show the same value, but a detection limit. The total analytical procedure of this sample was extensively reviewed by NRG with inconclusive results.

In 2020, all gross-bèta data from RIVM and NRG in river Scheldt water and suspended solids were in good agreement. In 2019 and 2020, trace amounts of ^{54}Mn were found in sand, downstream as well as upstream of the NPP. The origin is not quite clear.

In 2019, a low amount of tritium is found in water from the river Scheldt, but due to the upstream location of the Doel nuclear power plant in Belgium, the origin of this trace activity of tritium is hard to determine.

The detection limit of ^{131}I in air filters and grass is strongly dependent on the delay between sampling and measurement. In 2019 and 2020 this period was long and as a result, the detection limit of ^{131}I was very high for the RIVM results. This is not consistent with NRG results where detection limits for ^{131}I were at least two orders of magnitude lower.

1 Introduction

The Dutch nuclear power plant at Borssele is operated by the Electriciteits Productiemaatschappij Zuid-Nederland (EPZ). Where in this report "EPZ" is mentioned, it is in fact the nuclear power plant Borssele.

1.1 Brief history

EPZ has an obligation to carry out an environmental monitoring programme in the vicinity of the Borssele NPP. This environmental programme was described in 1994 in ref. [1] by the former contractor KEMA (now NRG, Nuclear Research and consultancy Group). The programme consists of monthly sampling of air dust, sediment, grass, water, suspended solids and seaweed; sand is sampled once a year. The measurements results are reported by EPZ and parts of the data are published in the yearly RIVM report on Environmental Radioactivity in the Netherlands [2].

1.2 Goal – Independent verification of environmental monitoring

In 2014, a team of the Integrated Regulatory Review Service (IRRS) visited the Netherlands on request of the Dutch Government. The team members reviewed the regulatory framework with regard to the Dutch nuclear and radiological facilities and activities.
In the IRRS report [3], one of the recommendations (R25) deals with an independent verification of the environmental monitoring reported by the regulated facilities. The independent verification was described in detail in the 2018 report [4].

1.3 Evaluation of the environmental monitoring programme

In 2019, NRG performed a review of the environmental monitoring programme around the nuclear power plant Borssele [5]. In short, the environmental compartments air, sand, surface water and river water, and direct gamma radiation are evaluated. Especially the amount of samples taken in those compartments. Next, the environmental programmes of Belgium and Finland are compared with the environmental programme carried out around NPP Borssele. In conclusion, there was no need to change this programme. Only minor improvements were suggested.

2 Sampling Programme by EPZ

2.1 The sampling programme by EPZ, carried out by contractor NRG.

The sampling programme, which is carried out by the Nuclear Research and Consultancy Group (NRG), Petten, has been described in an earlier report [4].
This programme has been routinely carried out by NRG with a monthly frequency for a large number of years.
Samples are taken in order to monitor radionuclides in air dust, grass, sand, water, suspended solids, seaweed and sediment [1]. The monitoring programme for environmental samples is outlined in Table 1 and Figure 2.

Table 1 Monitoring programme for environmental samples taken near the Borssele nuclear power plant in 2019 and 2020

Matrix	Location (Fig 2)	Parameter	Monitoring frequency (per year)
Air dust	21, 22, 23, 27 and 29	gross α, gross β	12
		γ-emitters (1)	12 (2)
Grass	21, 22, 23, 27 and 29	γ-emitters (3)	12 (2)
Sand	O1, O2, O3 and O4 (4)	γ-emitters (5)	1
Water	1, 2, 3 and 4	residual β, ^{3}H	12
Suspended solids	1, 2, 3 and 4	gross β	12
Seaweed	1, 2, 3 and 4	γ-emitters (3)	12 (2)
Sediment	1, 2, 3 and 4	γ-emitters (3)	12 (2)

The location numbers correspond to the location numbers given in Figure 2.
(1) γ-spectroscopic analysis of specific γ-emitting radionuclides: ^{60}Co, ^{137}Cs, naturally occurring radionuclides and elemental and organically bound ^{131}I.
(2) Analysis was performed on a combined sample of monthly samples taken from all four or five locations.
(3) γ-spectroscopic analysis of specific γ-emitting radionuclides: ^{60}Co, ^{131}I and ^{137}Cs.
(4) The four locations where samples were taken near the outlet are not shown in Figure 2.
(5) γ-spectroscopic analysis of specific γ-emitting radionuclides: ^{54}Mn, ^{60}Co, ^{134}Cs and ^{137}Cs.

The map in Fig 2 shows the vicinity and larger area around the Borssele nuclear power plant. The NPP is situated in the red circle in the centre of the map. The circles represent distances of 2, 4, 6, 8 and 10 km.
The Westerscheldt is basically the estuary of the river Scheldt ("Schelde" in Dutch). Just some 30 km upstream, in Belgium, the Doel nuclear power plant is situated, containing 4 reactors, this NPP also discharges waste water to the river Scheldt.

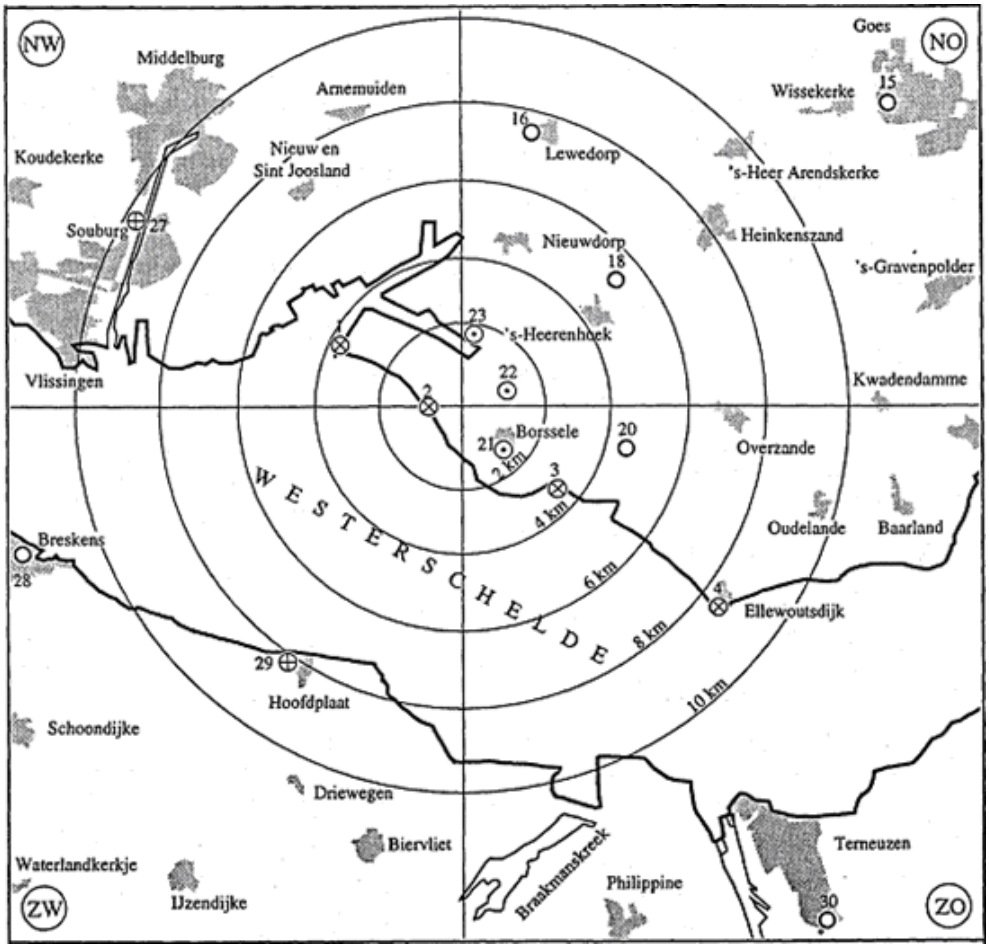

Fig. 1 Surroundings of the Borssele nuclear power plant (in red circle). The numbers on the map refer to sampling locations.

2.2 Contra expertise by RIVM

The contra expertise analyses were carried out on a selection of monthly samples taken in 2019 and 2020. RIVM did not carry out the sampling procedure. Instead, parts of the samples which were taken by the contractor NRG were accepted as representative subsamples.

Some samples, such as air filters, are unique and cannot be split for analyses by both laboratories of NRG and RIVM. Such samples, after having been measured by NRG, were transferred to RIVM, where the measurement was repeated.

In Table 2, an overview is given on sample handling and the proposed analyses.

Table 2 Overview of contra expertise by RIVM in 2019 and 2020

Sample matrix	subsamples	Parameter	Remarks
Air dust	Glass fibre Carbon filter Carbon cartridge	Gross alpha/beta Gamma spec	Unique samples Return to NRG after analysis
Grass	3 bags of grass. Third bag for RIVM	Gamma spec	Destroyed after ~1 month
Seaweed	300-400 g seaweed from NRG	Gamma spec	Destroyed after ~1 week
sediment	Half of sample from NRG	Gamma spec	Kept in freezer until next sample
Sand	Sample of 0,5 kg from NRG	Gamma spec	Yearly sample close to discharge pipe from NPP
Water	2 L of NRG-filtrate for RIVM	Gross alpha/beta, ^{3}H (LSC)	
Suspended solids	Precipitate in filtrate after NH_4OH addition	Gross alpha/beta	4 filters with suspended solids from NRG, also analysed by RIVM

2.3 Comparison of RIVM and NRG data

For the reasons described below a statistical comparison of RIVM and NRG data, based on data with uncertainties, is not carried out.

1. Measurements carried out on the same sample by two laboratories can be compared by using their measurement data and uncertainty. In a large number of cases data are 'lower than detection limit' and in those cases a comparison can not be carried out.
2. Low amounts of radioactivity in air is mainly caused by natural radiation, such as ^{222}Rn and consecutive radon daughters. This leads eventually to the radionuclide ^{210}Pb and ingrowth of ^{210}Bi (β-emitter), and finally slow ingrowth of ^{210}Po (α-emitter). Due to the large time delay between NRG and RIVM measurements, the gross-bèta and gross-alpha activity is not the same and can not be compared.
3. In the cases of stacked aerosol filters, and dried sediments RIVM analysed individual samples and NRG analysed a mixed sample. A comparison of data is not possible in this case.
4. A comparison based on uncertainties is only valid if both laboratories have a well documented uncertainty budget for all data.

3 RIVM results and discussion

The NRG data of sampling period 2019 and 2020 were reported to EPZ in February 2020 and February 2021 [6, 7]. See Tables 3 and 4 for a summary of all results.

3.1 Overview of analytical data by RIVM and NRG in 2019

In the Table below, a summary of all analytical data of the RIVM measurements on the samples of September 2019, and sand samples from May 2019, are given next to the NRG data on the same samples. In Annex A, all data are presented in separate tables A1 – A10.

Table 3 Summary of RIVM measurement results; samples from September 2019, yearly sand sample from May 2019.

Matrix	Parameter	Locations	Values [(1)] RIVM; Sept 2019	Values EPZ [6]; in Sept 2019
Air (aerosol) ($mBq \cdot m^{-3}$)	Gross α	5	< 0.01 – 0.12	0.003 – 0.04
	Gross β	5	0.08 ± 0.02 – 0.38 ± 0.03	0.06 ± 0.12 – 0.60 ± 0.08
Air (aerosol) ($mBq \cdot m^{-3}$)	^{60}Co	5 [(2)]	< 0.1 – < 0.9	< 0.055
	$^{131}I_{el}$ [(3)]	5 [(2)]	n.d.	< 0.3
	$^{131}I_{org}$	5	n.d.	< 0.5
	^{137}Cs	5 [(2)]	< 0.1 – < 0.7	< 0.034
	Nat. [(4)]	5 [(2)]	<0.2 – < 1.7	1.64 ± 0.14
Grass ($Bq \cdot kg^{-1}$)	^{60}Co	5 [(2)]	< 0.9	< 3
	^{131}I	5 [(2)]	n.d.	< 2
	^{137}Cs	5 [(2)]	< 8	< 2
Sand ($Bq \cdot kg^{-1}$) *May 2019*	^{54}Mn	4	< 0.6	0.28 ± 0.03 - < 0.3
	^{60}Co	4	< 0.4 – < 0.5	< 0.2 - < 0.3
	^{134}Cs	4	< 0.6	< 0.2
	^{137}Cs	4	0.3 ± 0.1 – 0.7 ± 0.1	0.56 ± 0.04– 1.25±0.06
Water ($kBq \cdot m^{-3}$)	Gross β[(5)]	4	0.17 – 0.58	0.06 – 0.24
	^{3}H	4	(4.1 – 8.1) ± 1.4	< 3
Suspended solids ($kBq \cdot kg^{-1}$)	Gross β	1 en 2	< 0.7 – 0.53 ± 0.08	1.0 ± 0.16 – 4.9 ± 0.5
		3 en 4	< 0.6 – 0.83 ± 0.12	4.6 ± 0.3 – 86.9 ± 0.6
Seaweed ($Bq \cdot kg^{-1}$)	^{60}Co	4 [(2)]	< 8	< 2
	^{131}I	4 [(2)]	n.d.	< 2
	^{137}Cs	4 [(2)]	< 6	< 1
Sediment ($Bq \cdot kg^{-1}$)	^{60}Co	4 [(2)]	< 0.6 – < 0.9	< 0.2
	^{131}I	4 [(2)]	n.d.	< 0.5
	^{137}Cs	4 [(2)]	< 0.3 – 1.6 ± 0.2	0.82 ± 0.04

[(1)] Given range represents values of individual samples; see Annex A for individual data.
[(2)] Analysis was performed on a combined sample of the monthly samples in all four or five locations.
[(3)] Elemental ^{131}I. Basically HI and I_2.
[(4)] Naturally occurring γ-emitters (Pb-214 and Bi-214)
[(5)] This has been erroneously reported as "residual β".
n.d. Not detected; due to the short half-life of I-131 and the long time between sampling and analysis it is not possible to detect low concentrations of I-131.

3.2 Overview of analytical data by RIVM and NRG in 2020

In the Table below, a summary of all analytical data of the RIVM measurements on the samples of 2020, and sand samples from May 2020, are given next to the NRG data on the same samples. In Annex B, all data are presented in separate tables B1 – B10.

Table 4 Summary of RIVM measurement results; samples from September-November 2020, yearly sand sample from May 2020.

Matrix	Parameter	Locations	Values (1) RIVM; in Sept-nov 2020	Values EPZ [6]; in Sept-nov 2020
Air (aerosol) ($mBq \cdot m^{-3}$)	Gross α	5	< 0.01 – 0.18	< 0.2 – 0.018 ± 0.012
	Gross β	5	< 0.2 – 0.44 ± 0.03	< 0.5 – 0.115 ± 0.015
Air (aerosol) ($mBq \cdot m^{-3}$)	^{60}Co	5 (2)	< 0.1 – < 1.7	< 0.052
	$^{131}I_{el}$ (3)	5 (2)	n.d.	< 0.2
	$^{131}I_{org}$	5	n.d.	< 0.4
	^{137}Cs	5 (2)	< 0.1 – < 1.4	< 0.038
	Nat. (4)	5 (2)		< 2
Grass ($Bq \cdot kg^{-1}$)	^{60}Co	5 (2)	< 20	< 2
	^{131}I	5 (2)	n.d.	< 2
	^{137}Cs	5 (2)	< 19	< 2
Sand ($Bq \cdot kg^{-1}$) *May 2020*	^{54}Mn	4	< 0.4 - < 0.7	0.26 ± 0.05 - < 0.3
	^{60}Co	4	< 0.5 – < 0.6	< 0.2 - < 0.3
	^{134}Cs	4	< 0.4 - < 0.7	< 0.2 - < 0.3
	^{137}Cs	4	< 0.4 – 1.4 ± 0.2	0.26 ± 0.07– 1.36±0.07
Water	Gross β(5)	4	0.15 ± 0.03 – 0.25 ± 0.04	0.022 ± 0.009 0.045 ± 0.010
($kBq \cdot m^{-3}$)	^{3}H	4	< 5	< 3
Suspended solids ($kBq \cdot kg^{-1}$)	Gross β	1 en 2 3 en 4	(0.75-0.90) ± 0.11 (0.55-0.67) ± 0.03	(0.96-1.32) ± 0.18 (0.91-0.96) ± 0.04
Seaweed ($Bq \cdot kg^{-1}$)	^{60}Co	4 (2)	< 6	< 2
	^{131}I	4 (2)	n.d.	< 2
	^{137}Cs	4 (2)	< 5	< 2
Sediment ($Bq \cdot kg^{-1}$)	^{60}Co	4 (2)	< 0.5 - < 0.8	< 0.3
	^{131}I	4 (2)	n.d.	< 0.3
	^{137}Cs	4 (2)	< 0.5 – 1.6 ± 0.2	0.70 ± 0.04

(1) Given range represents values of individual samples; see Annex A for individual data.
(2) Analysis was performed on a combined sample of the monthly samples in all four or five locations.
(3) Elemental ^{131}I. Basically HI and I_2.
(4) Naturally occurring γ-emitters (Pb-214 and Bi-214)
(5) This has been erroneously reported as "residual β".

n.d. Not detected; due to the short half-life of I-131 and the long time between sampling and analysis it is not possible to detect low concentrations of I-131.

3.3 Discussion of the results

In general, the RIVM and NRG data in Table 3 (2019) and Table 4 (2020) are in good agreement. Most activity concentrations are below the detection limit or very low, mostly due to natural radioactivity or ^{137}Cs originating from the Chernobyl accident. The only exceptions are all data for ^{131}I and a sample of suspended solids on sample point 3 in

the Westerscheldt in 2019.
The detection limit of ^{131}I in air filters and grass is strongly dependent on the period before the measurement takes place. In the summer of 2019, this delay period was long and as a result, the detection limit of ^{131}I was very high. This is not in line with NRG results, where detection limits for ^{131}I were at least two to three orders of magnitude lower.

In 2019, the gross-bèta activity of one sample (out of 48 samples in total) of suspended solids at sample point 3 (86.9 ± 0.6 kBq.kg^{-1}) is almost two orders of magnitude higher than all other samples. The RIVM contra expertise, carried out a few months later, did not show the same value, but a detection limit. The total analytical procedure of this sample was extensively reviewed by NRG with inconclusive results.
In 2020, all gross-bèta data in river Scheldt water and suspended solids were in good agreement.

The origin of traces of ^{3}H in water from the Westerscheldt, sampled in 2019, is not clear. ^{3}H may originate from discharges of the Borssele nuclear power plant or the Doel nuclear power plant further upstream, just over the Belgian border. In the same period, May-December 2019, Rijkswaterstaat sampled water from the river Scheldt at sampling point Vlissingen Boei. The activity concentration of ^{3}H ranged from 4.3 – 6.2 Bq.l^{-1}. This is practically the same range as the data found in samples from river Scheldt in Table 3.

Low levels of ^{137}Cs are found in sand. This is not unusual in Dutch soil as a result of the Chernobyl accident [8]. In 2019 and 2020, a very low amount of ^{54}Mn was also found in sand, downstream as well as upstream of the NPP. The origin is not quite clear.

For some samples there is a difference in the sample handling between NRG and RIVM. For convenience, NRG stacks five filters from five locations, where RIVM does not. This will not lead to exactly the same activity concentration. Nevertheless, both NRG and RIVM confirm the absence of ^{131}I in all samples.
Carbon cartridge material of samples of five locations is combined by NRG in order to compose one sample. The filter stack and the mixed carbon sample are measured just once in order to optimize gamma spectrometry detection time. In case an enhanced activity is observed in the stack, the original samples will be analysed separately.
RIVM determines the activity of one filter package, consisting of an aerosol filter, a coal filter and a carbon cartridge. In case an enhanced activity is observed, the components of the filter package are analysed individually.

4 Conclusions

In general, the RIVM and NRG data in Table 3 (2019) and Table 4 (2020) are in good agreement. In most samples, RIVM reports detection limits, a very low amount of natural activity, or in a sand sample a negligible activity of ^{137}Cs. This is a known surface contamination of about 90 – 100 Bq/m^2 ^{137}Cs in the Netherlands [8] and originates most likely from the Chernobyl accident.

NRG reported a gross-bèta activity of (86.9 $\pm$ 0.6 kBq.kg^{-1}) for one sample (out of 48 samples in total) of suspended solids at sample point 3, taken in 2019. This is almost two orders of magnitude higher than all other samples in 2019. The RIVM contra expertise did not show the same value, but a detection limit. The total analytical procedure of this sample was extensively reviewed by NRG with inconclusive results.

In 2020, all gross-bèta data in river Scheldt water and suspended solids were in good agreement. In 2019 and 2020, a very low amount of ^{54}Mn was found in sand, downstream as well as upstream of the NPP. The origin is not quite clear.

A low amount of tritium is found in water from the river Scheldt, but due to the upstream location of the Doel nuclear power plant in Belgium, the origin of this trace activity of tritium is hard to determine.

The detection limit of ^{131}I in air filters and grass is strongly dependent on the delay between sampling and measurement. In the summer of 2019 this period was long and as a result, the detection limit of ^{131}I was very high for the RIVM results. This is not consistent with NRG results where detection limits for ^{131}I were at least two orders of magnitude lower.

For some samples there is a difference in the sample handling between NRG and RIVM. For convenience, NRG stacks five air filters from five locations, where RIVM does not. This will not lead to exactly the same activity concentration. Nevertheless, both NRG and RIVM confirm the absence of ^{131}I in all samples from 2019 and 2020.

5 Annex A Data tables 2019

Table A1 Gross alpha activity in airdust (aerosol filter), contra expertise on sample of September 2019 (mBq.m^{-3})

NRG sample location nr	RIVM gross-α	NRG gross-α
21	0.087 ± 0.013	0.003 ± 0.013
22	< 0.013	0.027 ± 0.008
23	0.117 ± 0.017	0.039 ± 0.019
27	< 0.05	0.02 ± 0.03
29	0.046 ± 0.005	0.008 ± 0.004

Table A2 Gross beta activity in airdust (aerosol filter), contra expertise on sample of September 2019 (mBq.m^{-3})

NRG sample location nr	RIVM gross-β	NRG gross-β
21	0.38 ± 0.03	0.21 ± 0.06
22	0.075 ± 0.015	0.09 ± 0.04
23	0.28 ± 0.03	0.60 ± 0.08
27	0.28 ± 0.05	0.06 ± 0.12
29	0.133 ± 0.009	0.169 ± 0.018

Table A3 Gamma activity in air (aerosol filter, coal filter, carbon cartridge), contra expertise on sample of September 2019 (mBq.m^{-3})

Sample*	Nuclide	RIVM#	NRG§
Aerosol filter	^{60}Co	< 0.1 - < 0.9	< 0.055
	^{137}Cs	< 0.1 - < 0.7	< 0.034
	^{214}Bi	< 0.2 - < 1.7	
	^{214}Pb	< 0.2 - < 1.4	1.64 ± 0.14
Aerosol + coal filter	^{131}I (HI, I_2)	n.d.	< 0.3
Carbon Cartridge	^{131}I (organic)	n.d.	< 0.5

* The sampling locations are nr. 21, 22, 23, 27 and 29 (see Fig 2). n.d. = not detected due to short half-life of I-131
# RIVM analysed the filters and carbon cartridges separately. RIVM data shown in the Table are a 'min-max' range of all 5 locations
§ NRG analysed a filter stack or a carbon cartridge mix sample of all 5 sampling locations.

Table A4 Gamma activity in grass, contra expertise on sample of September 2019 (Bq.kg^{1})

Sample*	Nuclide	RIVM#	NRG#
Grass	^{60}Co	< 0.9	< 3
	^{137}Cs	< 8	< 2
	^{131}I	n.d.	< 2

* The sampling locations are nr. 21, 22, 23, 27 and 29 (see Fig 2).
n.d. = not detected due to short half-life of I-131
# NRG and RIVM both analysed a mix sample of all 5 sampling locations.

Table A5 Gamma activity in sand, contra expertise on sample of May 2019 (Bq.kg[1])

Sample location*	Nuclide	RIVM#	NRG#
1, 2, 3, 4	^{54}Mn	< 0.6	< 0.3 – 0.28 ± 0.03
	^{60}Co	< 0.4 - < 0.5	< 0.2 - < 0.3
	^{134}Cs	< 0.6	< 0.2
	^{137}Cs	0.3 – 0.7 ± 0.1	0.56 ± 0.04 – 1.25 ± 0.06

* The sampling locations are shown in Fig 2.

Table A6 Gross beta activity in water from river Scheldt, contra expertise on sample of September 2019 (kBq.m^{-3})

NRG sample location nr	RIVM gross-β	NRG gross-β
1 (West)	0.58 ± 0.07	0.06 ± 0.008
2 (Centr.)	0.38 ± 0.05	0.074 ± 0.008
3 (East)	0.17 ± 0.03	0.058 ± 0.008
4 (El.dijk)*	0.49 ± 0.06	0.237 ± 0.01

* El. Dijk = Ellewoutsdijk

Table A7 Gross beta activity in suspended solids from river Scheldt water, contra expertise on sample of September 2019 (kBq.kg^{-1})

NRG sample location nr	RIVM gross-β	NRG gross-β
1 (West)	0.53 ± 0.08	4.9 ± 0.5
2 (Centr.)	< 0.7	1.00 ± 0.16
3 (East)	< 0.6	86.9 ± 0.6
4 (El.dijk)*	0.83 ± 0.12	4.6 ± 0.3

* El. Dijk = Ellewoutsdijk

Table A8 Tritium activity in water from river Scheldt water, contra expertise on sample of September 2019 (kBq.m^{-3})

NRG sample location nr	RIVM ^{3}H	NRG ^{3}H
1 (West)	7.1 ± 1.3	< 3
2 (Centr.)	5.1 ± 1.4	< 3
3 (East)	8.1 ± 1.4	< 3
4 (El.dijk)*	4.1 ± 1.3	< 3

* El. Dijk = Ellewoutsdijk

Table A9 Gamma activity in seaweed, contra expertise on sample of September 2019 (Bq.kg[1])

NRG sample mix (4 loc.)#	RIVM Bq.kg^{-1}	NRG Bq.kg^{-1}
^{60}Co	< 8	< 2
^{137}Cs	< 6	< 1
^{131}I	n.d.	< 2

# NRG and RIVM both analysed a mix sample of all 4 sampling locations: West, Centrale, East, Ellewoutsdijk.
n.d. = not detected due to short half-life of I-131

Table A10 Gamma activity in dried sediments, contra expertise on sample of September 2019 (Bq.kg^{-1})

Sample mix (4 loc.)	**RIVM#**	**NRG**
^{60}Co	< 0.6 - < 0.9	< 0.2
^{131}I	n.d.	< 0.5
^{137}Cs	< 0.3 – 1.6 ± 0.2	0.82 ± 0.04

* The sampling locations are shown in Fig 2.
n.d. = not detected due to short half-life of I-131
# RIVM analysed all 4 samples separately. The data shown are a 'min – max' range. Nuclide ^{131}I could not be determined (n.d.) due to the long delay between sampling and analysis.
NRG analysed a mixed sample of all 4 samples.

6 Annex B Data tables in 2020

Table B1 Gross alpha activity in airdust (aerosol filter), contra expertise on sample of September 2020 (mBq.m^{-3})

NRG sample location nr	RIVM gross-α	NRG gross-α
21	< 0.017	0.018 ± 0.012
22	0.13 ± 0.04	< 0.21
23	0.183 ± 0.019	0.07 ± 0.02
27	< 0.08	0.09 ± 0.05
29	0.031 ± 0.004	0.010 ± 0.004

Table B2 Gross beta activity in airdust (aerosol filter), contra expertise on sample of September 2020 (mBq.m^{-3})

NRG sample location nr	RIVM gross-β	NRG gross-β
21	< 0.05	0.04 ± 0.04
22	< 0.3	< 0.7
23	0.44 ± 0.03	< 1.2
27	< 0.2	< 0.54
29	0.078 ± 0.006	0.115 ± 0.015

Table B3 Gamma activity in air (aerosol filter, coal filter, carbon cartridge), contra expertise on sample of September 2020 (mBq.m^{-3})

Sample*	Nuclide	RIVM#	NRG§
Aerosol filter	^{60}Co	< 0.1 - < 1.7	< 0.052
	^{137}Cs	< 0.1 - < 1.4	< 0.038
	^{214}Bi		
	^{214}Pb		< 2
Aerosol + coal filter	^{131}I (HI, I_2)	n.d.	< 0.2
Carbon Cartridge	^{131}I (organic)	n.d.	< 0.4

* The sampling locations are nr. 21, 22, 23, 27 and 29 (see Fig 2). n.d. = not detected due to short half-life of I-131
# RIVM analysed the filters and carbon cartridges separately. RIVM data shown in the Table are a 'min-max' range of all 5 locations
§ NRG analysed a filter stack or a carbon cartridge mix sample of all 5 sampling locations.

Table B4 Gamma activity in dried grass, contra expertise on sample of November 2020 (Bq.kg^{1})

Sample*	Nuclide	RIVM#	NRG#
Grass	^{60}Co	< 20	< 2
	^{137}Cs	< 19	< 2
	^{131}I	n.d.	< 2

* The sampling locations are nr. 21, 22, 23, 27 and 29 (see Fig 2).
n.d. = not detected due to short half-life of I-131
# NRG and RIVM both analysed a mix sample of all 5 sampling locations.

Table B5 Gamma activity in sand, contra expertise on sample of May 2020 (Bq.kg[1])

Sample location*	Nuclide	RIVM#	NRG#
1, 2, 3, 4	^{54}Mn	< 0.4 - < 0.7	< 0.3 – 0.26 ± 0.05
	^{60}Co	< 0.5 - < 0.6	< 0.2 - < 0.3
	^{134}Cs	< 0.4 - < 0.7	< 0.2 - < 0.3
	^{137}Cs	< 0.4 – 1.4 ± 0.2	0.26 ± 0.07 – 1.36 ± 0.07

* The sampling locations are shown in Fig 2.

Table B6 Gross beta activity in water from river Scheldt, contra expertise on sample of October 2020 (kBq.m^{-3})

NRG sample location nr	RIVM gross-β	NRG gross-β
1 (West)	0.20 ± 0.06	0.022 ± 0.009
2 (Centr.)	0.15 ± 0.03	0.043 ± 0.016
3 (East)	0.17 ± 0.05	0.045 ± 0.010
4 (El.dijk)*	0.25 ± 0.04	0.04 ± 0.02

* El. Dijk = Ellewoutsdijk

Table B7 Gross beta activity in suspended solids from river Scheldt water, contra expertise on sample of October 2020 (kBq.kg^{-1})

NRG sample location nr	RIVM gross-β	NRG gross-β
1 (West)	0.90 ± 0.11	0.96 ± 0.18
2 (Centr.)	0.75 ± 0.11	1.32 ± 0.17
3 (East)	0.55 ± 0.03	0.91 ± 0.03
4 (El.dijk)*	0.67 ± 0.03	0.96 ± 0.04

* El. Dijk = Ellewoutsdijk

Table B8 Tritium activity in water from river Scheldt water, contra expertise on sample of November 2020 (kBq.m^{-3})

NRG sample location nr	RIVM ^{3}H	NRG ^{3}H
1 (West)	< 5	< 3
2 (Centr.)	< 5	< 3
3 (East)	< 5	< 3
4 (El.dijk)*	< 5	< 3

* El. Dijk = Ellewoutsdijk

Table B9 Gamma activity in seaweed, contra expertise on sample of November 2020 (Bq.kg[1])

NRG sample mix (4 loc.)	RIVM Bq.kg^{-1}	NRG Bq.kg^{-1}
^{60}Co	< 6	< 2
^{137}Cs	< 5	< 2
^{131}I	n.d.	< 2

# NRG and RIVM both analysed a mix sample of all 4 sampling locations: West, Centrale, East, Ellewoutsdijk.
n.d. = not detected due to short half-life of I-131

Table B10 Gamma activity in dried sediments, contra expertise on sample of November 2020 (Bq.kg^{-1})

NRG sample mix (4 loc.)	**RIVM# Bq.kg^{-1}**	**NRG Bq.kg^{-1}**
^{60}Co	< 0.5 - < 0.6	< 0.3
^{131}I	n.d.	< 0.3
^{137}Cs	< 0.5 – 1.6 ± 0.2	0.70 ± 0.04

* The sampling locations are shown in Fig 2.
# RIVM analysed all 4 samples separately. The data shown are a 'min – max' range.
NRG analysed a mixed sample of all 4 sample locations: West, Centrale, East, Ellewoutsdijk.
n.d. = not detected due to short half-life of I-131

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