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

Environmental monitoring in the vicinity of the Borssele nuclear power plant

Results 2018

RIVM Letter report 2018-0145
P.J.M. Kwakman

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Colophon

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Synopsis

Environmental monitoring in the vicinity of the Borssele nuclear power plant.
Results in 2018.

In 2018, RIVM performed a check on the measurements that were carried out in the vicinity of and by the Borssele nuclear power plant. Of the several types of samples taken, the analytical results indicate that no radiological contamination from the nuclear power plant (NPP) can be found.

The NPP assigned the Nuclear Research Group (NRG) to carry out monthly sampling of water, air dust, sediment, seaweed, and yearly sampling of soil. In these samples, NRG has determined gamma-emitters, gross alpha and gross beta activity. The tritium activity was determined in water samples only. In 2018, RIVM carried out a counter expertise on remaining sampling material taken by NRG in June 2018. In general, the RIVM data compare well with the data from NRG. In the samples, RIVM did not find any radioactivity above the detection limit, with two exceptions only.
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.
Low levels of ^{137}Cs are found in soil. This is not unusual in Dutch soil as a result of the Chernobyl accident.

Keywords: nuclear power plant Borssele, environment, radioactivity

Publiekssamenvatting

Milieumetingen in de omgeving van kerncentrale Borssele.
Resultaten in 2018

Het RIVM heeft in 2018 de metingen gecontroleerd die de kerncentrale Borssele zelf in de directe omgeving van de centrale uitvoert. Hiervoor zijn de monsters geanalyseerd die in de maand mei op diverse plekken zijn genomen. In de diverse soorten monsters is geen radioactiviteit afkomstig van de kerncentrale aangetroffen.

De kerncentrale Borssele heeft opdracht gegeven aan Nuclear Research and Consultancy Group (NRG) om maandelijks monsters te nemen van gras, water, luchtstof, sediment, en zeewier, en jaarlijks een grondmonster. In deze monsters stelt NRG vast of er door de kerncentrale radioactiviteit geloosd is.

In het algemeen is de vergelijking tussen de data van het RIVM en NRG goed. Het RIVM heeft in enkele monsters in de Westerschelde een zeer lage hoeveelheid van ^{3}H in de Westerschelde aangetroffen; door de locatie van kerncentrale Doel bovenstrooms van kerncentrale Borssele is de oorsprong van ^{3}H onbekend. Zeer lage sporen van ^{137}Cs zijn aangetroffen in zand. Dit is niet ongebruikelijk in de Nederlandse bodem als gevolg van de Chernobyl ramp.

Kernwoorden: kerncentrale Borssele, milieumetingen, radioactiviteit

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The NPP assigned the Nuclear Research Group (NRG) to carry out monthly sampling of water, air dust, sediment, seaweed, and yearly sampling of soil. In these samples, NRG has determined gamma-emitters, gross alpha and gross beta activity. The tritium activity was determined in water samples only.

In 2017, RIVM witnessed a full sampling day as contractor NRG usually performed it. This time, RIVM did not repeat the time consuming sampling procedure.

In 2018, RIVM carried out a counter expertise on remaining sampling material taken by NRG in June 2018.
In most cases, NRG supplied remaining sampling material to RIVM. In the case of air filters, the sample is unique and therefore, the same filter was measured both by NRG and RIVM.
In general, the RIVM data compare well with the data from NRG. In the samples, RIVM did not find any radioactivity above the detection limit, with two exceptions only.
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.
Low levels of ^{137}Cs are found in soil. This is not unusual in Dutch soil as a result of the Chernobyl accident.

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). The programme consists of monthly sampling of air dust, sediment, grass, water, suspended solids and seaweed; soil is sampled once a year.
The measurements results are reported by epz to rivm and later published in the yearly RIVM report on Environmental Radioactivity in the Netherlands [2].

1.2 Observation by IRRS - 2014

In 2014, a team of the Integrated Regulatory Review Service (IRRS) visited the Netherlands at the 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, recommendation R25 deals with an independent verification of the environmental monitoring reported by the regulated facilities. This independent verification is not undertaken by the Netherlands. See Fig.1.

Recommendation 25 from the IRRS FU report for the Netherlands. August 2018, par 11.2, p. 83 [3].

R25 Recommendation
The regulatory body should undertake independent verification of the environmental monitoring reported by regulated facilities.
Observation
The regulatory body in the Netherlands does not undertake an independent verification of environmental radioactivity reported by the regulated entities.

Taking this observation and GSR Part 3 Requirement 32 (see below) into account, the ANVS assigned RIVM to carry out an independent verification of the environmental monitoring of EPZ (Fig 2).
This verification was incorporated in the yearly monitoring plan of RIVM. By the end of 2018, the first results will be available for the ANVS.

Requirements in GSR part 3 (IAEA)
GSR PART 3 Requirement 32 states "The regulatory body and relevant parties shall ensure that programmes for source monitoring and environmental monitoring are in place and that the results from the monitoring are recorded and are made available".

GSR PART3 paragraph 3.135. states “The regulatory body shall be responsible, as appropriate, for:
(c) Making provision for an independent monitoring programme.
(d) Assessment of the total public exposure due to authorized sources and practices in the State on the basis of monitoring data provided by registrants and licensees and with the use of data from independent monitoring and assessments.”

The work in 2018 will be evaluated and this evaluation will be input for the yearly plans in the coming years. Depending on the outcome, the ANVS will decide in the future if it needs to extend the program to perform the verification more frequently, on a broader range of sampling types and for the sites of different facilities.

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 Group (NRG) at Petten, is described in table 1. In the column “Values” a range is given of minimum and maximum values found in the given period. Most of the reported values are detection limits.

Table 1 Summary of the EPZ-monitoring programme in the vicinity of the Borssele nuclear power plant. Results from 2015 [5].

Matrix	Parameter	Locations	Values (1)	Frequency (per year)
Air (dust)	Gross α	5	0.003–0.08 mBq·m^{-3}	12
	Gross β	5	0.02–0.89 mBq·m^{-3}	12
	^{60}Co	5 (2)	< 0.04–< 0.07 mBq·m^{-3}	12
	$^{131}I_{el}$ (3)	5 (2)	< 0.1–< 0.2 mBq·m^{-3}	12
	$^{131}I_{or}$ (4)	5 (2)	< 0.3–< 1 mBq·m^{-3}	12
	^{137}Cs	5 (2)	< 0.03–< 0.05 mBq·m^{-3}	12
	Nat. (5)	5 (2)	<1.6– 2.5 mBq·m^{-3}	12
Grass	^{60}Co	5 (2)	< 1–< 2 Bq·kg^{-1}	12
	^{131}I	5 (2)	< 1–< 2 Bq·kg^{-1}	12
	^{137}Cs	5 (2)	< 1–< 2 Bq·kg^{-1}	12
Soil	^{54}Mn	4	< 0.2–< 0.4 Bq·kg^{-1}	1
	^{60}Co	4	< 0.2–< 0.4 Bq·kg^{-1}	1
	^{134}Cs	4	< 0.3–< 0.4 Bq·kg^{-1}	1
	^{137}Cs	4	0.99–1.66 Bq·kg^{-1}	1
Water	Residual β	4	0.011–0.082 Bq·L^{-1}	12
	^{3}H	4	1.3–6.7 Bq·L^{-1}	12
Suspended solids	Gross β	4	0.50–3.60 kBq·kg^{-1}	12
Seaweed	^{60}Co	4 (2)	< 1–< 3 Bq·kg^{-1}	12
	^{131}I	4 (2)	< 0.8–< 3 Bq·kg^{-1}	12
	^{137}Cs	4 (2)	< 0.9–< 2 Bq·kg^{-1}	12
Sediment	^{60}Co	4 (2)	< 0.2–< 0.4 Bq·kg^{-1}	12
	^{131}I	4 (2)	< 0.2–< 0.4 Bq·kg^{-1}	12
	^{137}Cs	4 (2)	< 0.3–1.35 Bq·kg^{-1}	12

(1) Given range represents values of individual samples.
(2) Analysis was performed on a combined sample of the monthly samples in all four or five locations.
(3) Elemental ^{131}I.
(4) Organically bound ^{131}I.
(5) Naturally occurring γ-emitters.

This programme has been routinely carried out by NRG with a monthly frequency for a large number of years. Soil samples are taken just once a year.

2.2 Witnessing the EPZ-environmental sampling programme in 2017

Yearly, contra expertise of source monitoring in The Netherlands is performed by the National Institute for Public Health and the Environment (RIVM) on behalf of ANVS. In addition to this counter expertise, which has been carried out for many years, independent verification of the environmental monitoring of EPZ (Operator of the Borssele NPP) and COVRA (Dutch central organization for interim storage of nuclear waste) was prepared in 2017. In that year, RIVM witnessed the sample taking by NRG, the contractor of EPZ; see Fig 1. Samples are taken of air dust, soil, sediment, grass, water, suspended solids and seaweed.

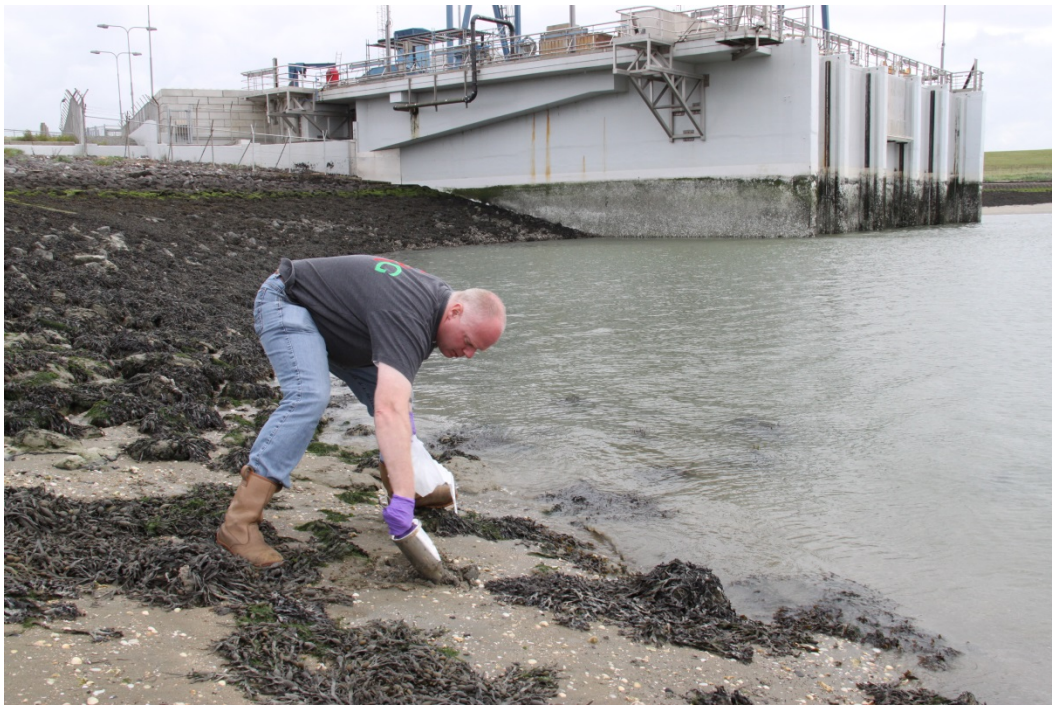

Fig 1 Sampling seaweed and sediment by NRG close to the Borssele nuclear power plant.

The map in Fig 2 shows the vicinity and larger area around the Borssele nuclear power plant. The NPP is situated near the centre of the map. The circles represent distances of 2, 4, 6, 8 and 10 km.
The Westerschelde 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.

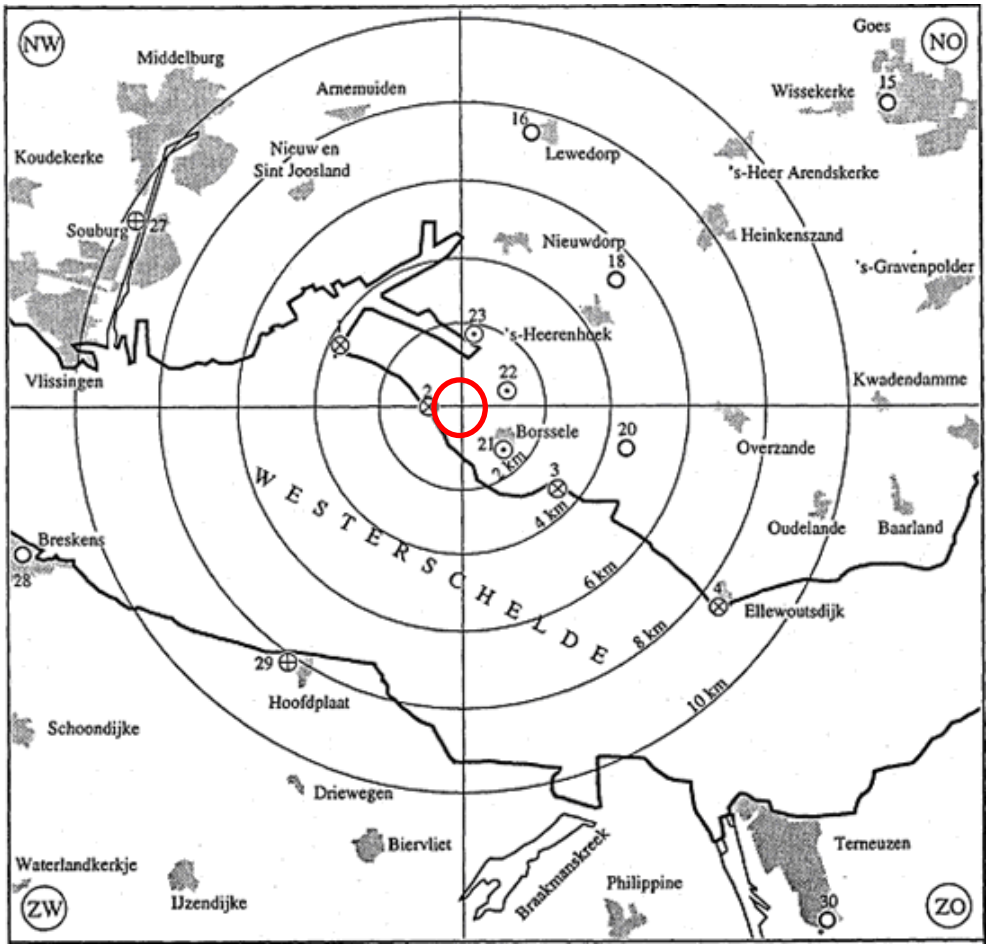

Fig. 2 Surroundings of the Borssele nuclear power plant (in red circle). The numbers on the map refer to sampling locations.

2.3 Logistics of sampling and taking sub-samples by RIVM

RIVM did not carry out the sampling procedure in 2018. Instead, parts of the samples that were taken by the contractor NRG were accepted as representative samples. Some samples, such as air filters, are unique and cannot be split for analyses in both the 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 counter expertise by RIVM in 2018

Sample matrix	subsamples	Parameter	Samples
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
Soil	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	Alfa/beta, ^{3}H (LSC)	
Suspended solids	Precipitate in filtrate after NH_4OH addition	Alfa/beta	4 filters with suspended solids from NRG, also analyzed by RIVM

In 2018, preparation for this counter expertise programme took considerable extra work in sample preparation, administration in the LIMS[1] system, sample preparation for unknown sample types (seaweed and grass), data handling in Excel and reporting. Therefore, it was decided to carry out this sequence just once in 2018, for the samples taken during the month of May of that year.

[1] LIMS : Laboratory Information Mangement System. A software system for sample registration, sample handling, all relevant measrurement information. All laboratory PC's are connected to this LIMS.

3 RIVM results and discussion

The NRG data from the first half of sampling period 2018 were reported to EPZ in October of 2018. Therefore, the RIVM data in this report can be compared with EPZ data. See Table 3 for all results.

3.1 Analytical data by RIVM and NRG in first half of 2018

In the Tables below, the analytical data of the RIVM measurements on the samples of May 2018 are given next to the NRG data on the samples of the first half of 2018.

Table 3 Summary of RIVM measurement results; samples from May 2018

Matrix	Parameter	Locations	Values [(1)] RIVM; May 2018	Values EPZ [[6]]; first half 2018
Air (aerosol) ($mBq \cdot m^{-3}$)	Gross α	5	< 0.03 – 0.19	0.01 – 0.06
	Gross β	5	0.11 – 0.77	0.16 – 0.83
Air (coal filt) ($mBq \cdot m^{-3}$)	Gross α	5	0.014 – 0.049	
	Gross β	5	0.037 – 0.096	
Air (aerosol) ($mBq \cdot m^{-3}$)	^{60}Co	5 [(2)]	< 0.1 – < 0.4	< 0.05 - < 0.06
	$^{131}I_{el}$ [(3)]	5 [(2)]	< 20E3 – < 70E3	< 0.1 - < 0.4
	^{137}Cs	5 [(2)]	< 0.06 – < 0.28	< 0.03 - < 0.05
	Nat. [(4)]	5 [(2)]	<0.17 – < 1.2	< 1.4 - < 2
Grass ($Bq \cdot kg^{-1}$)	^{60}Co	5 [(2)]	< 10	< 0.9 - < 2
	^{131}I	5 [(2)]	< 85	< 0.9 - < 2
	^{137}Cs	5 [(2)]	< 12	< 0.9 - < 2
Soil ($Bq \cdot kg^{-1}$)	^{54}Mn	4	< 0.2 – < 0.3	< 0.2 - < 0.3
	^{60}Co	4	< 0.3 – < 0.7	< 0.2 - < 0.3
	^{134}Cs	4	< 0.2 – < 0.8	< 0.2
	^{137}Cs	4	0.4 – 1.23	1.11 – 1.13
Water ($Bq \cdot L^{-1}$)	Gross β[(5)]	4	0.2 – 0.3	0.07 – 0.16
	^{3}H	4	6 – 7	4.2 – 4.9
Suspended solids ($kBq \cdot kg^{-1}$)	Gross β	4	1.2 – 9	5.9 – 12.7
Seaweed ($Bq \cdot kg^{-1}$)	^{60}Co	4 [(2)]	< 2.9	< 1 - < 2
	^{131}I	4 [(2)]	< 9.5	< 1 - < 2
	^{137}Cs	4 [(2)]	< 2.5	< 0.8 - < 2
Sediment ($Bq \cdot kg^{-1}$)	^{60}Co	4 [(2)]	< 0.4 – < 0.4	< 0.2 - < 0.3
	^{131}I	4 [(2)]	< 0.3 – < 0.6	< 0.2 - < 0.3
	^{137}Cs	4 [(2)]	< 0.2 – 1.0	0.4 – 1.0

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

In general, the RIVM data in Table 3 compare well with the data from NRG. The only exceptions are some data for ^{131}I. This is easily explained as the short half-life of ^{131}I (8 days) leads to high detection limits when samples are not analysed directly. The detection limit of ^{131}I in air filters and grass is strongly dependent on the waiting period before the measurement takes place. In the summer of 2018, this waiting period was long and as a result, the detection limit of ^{131}I was very high. This is not consistent with NRG results, where detection limits for ^{131}I were at least two orders of magnitude lower.

Next, there is a difference in the sample handling between NRG and RIVM. For convenience, NRG stacks five filters from five locations. Carbon cartridge material of samples of five locations is mixed 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 elevated activity is observed, the original samples are analysed separately.
RIVM determines the activity of one filter stack, consisting of an aerosol filter, a coal filter and a carbon cartridge. When an elevated activity is observed, the components of the filter stack are analysed individually.

The sample handling methods applied by NRG and RIVM do not lead to the exactly the same result. Nevertheless, both NRG and RIVM confirm the absence of ^{131}I in all samples.

The origin of traces of ^{3}H in water from the Westerschelde is not clear. ^{3}H may originate from discharges of the Borssele nuclear power plant or the Doel nuclear power plant further upstream. Low levels of ^{137}Cs are found in soil. This is not unusual in Dutch soil as a result of the Chernobyl accident.

4 Conclusions

In general, the RIVM measurement data confirm the findings that have been reported by NRG in the past. In most samples, RIVM reports detection limits, or in a soil 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 [5] and originates most likely from the Chernobyl accident.

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.
Low levels of ^{137}Cs are found in soil. This is not unusual in Dutch soil as a result of the Chernobyl accident.

The detection limit of ^{131}I in air filters and grass is strongly dependent on the waiting period before the measurement takes place. In the summer of 2018 this waiting 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.

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