DTU Library

Radioactivity in the Risø District July- December 2016

Nielsen, Sven Poul; Andersson, Kasper Grann; Miller, Arne

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Radioactivity in the Risø District July-December 2016

DTU Nutech Report

Sven P. Nielsen, Kasper G. Andersson and Arne Miller
DTU-Nutech-15(EN)
June 2017

DTU Nutech
Center for Nuclear Technologies

Author: Sven P. Nielsen, Kasper G. Andersson and Arne Miller
Title: Radioactivity in the Risø District July-December 2016
Center for Nuclear Technologies

Abstract (max. 2000 char.): The environmental surveillance of the Risø environment was continued in July-December 2016. The mean concentrations in air were: 0.18±0.13 μBq m^{-3} of ^{137}Cs, 2.30±0.68 mBq m^{-3} of ^{7}Be and 0.21±0.12mBq m^{-3} of ^{210}Pb (±1 standard uncertainty). The depositions by precipitation at Risø in the second half of 2016 were: 0.046±0.006 Bq m^{-2} of ^{137}Cs, 494±50 Bq m^{-2} of ^{7}Be, 24.9±2.2 Bq m^{-2} of ^{210}Pb and <1.2 kBq m^{-2} of ^{3}H. The average background dose rate (TLD) at Risø (Zone I) was measured as 45 ± 2 nSv h^{-1} compared with 45 ± 6 nSv h^{-1} (±1 standard uncertainty) in the four zones around Risø.

DTU-Nutech-15(EN)
June 2017

ISBN 978-87-997857-5-9

Contract no.:

Group's own reg. no.:
59514 E-1

Sponsorship:

Cover :

Pages: 26
Tables: 14
References:

Center for Nuclear Technologies
Technical University of Denmark
Frederiksborgvej 399
DK-4000 Roskilde
Denmark
Telephone +45 46774173
kgan@dtu.dk
www.nutech.dtu.dk

Contents

INTRODUCTION

A specific monitoring programme in the vicinity of the nuclear installations at the Risø site is carried out by DTU Nutech on behalf of and as a contractor to Danish Decommissioning (DD). This report presents the analytical results of the monitoring and sampling carried out in the period July-December 2016. The materials and methods used in connection with the monitoring programme are described in pages 23-24.

Table 1. Radionuclides in ground level air collected at Risø (cf. Figs. 1, 1.1 and 1.2), July-December 2016 (Unit: $\mu Bq\ m^{-3}$)

Date			^{7}Be	^{137}Cs	^{210}Pb
04-Jul-16	–	11-Jul-16	2605(10%)	0.073(20%)	148(10%)
11-Jul-16	–	19-Jul-16	1641(10%)	0.035(28%)	73(10%)
19-Jul-16	–	25-Jul-16	2934(10%)	0.105(27%)	306(10%)
25-Jul-16	–	01-Aug-16	2164(10%)	0.076(46%)	190(10%)
01-Aug-16	–	08-Aug-16	2253(10%)	0.052(31%)	117(10%)
08-Aug-16	–	15-Aug-16	1367(10%)	0.050(40%)	67(10%)
15-Aug-16	–	22-Aug-16	1668(10%)	0.124(20%)	168(10%)
22-Aug-16	–	29-Aug-16	2477(10%)	0.076(36%)	188(10%)
29-Aug-16	–	05-Sep-16	2620(10%)	0.046(25%)	130(10%)
05-Sep-16	–	13-Sep-16	1931(10%)	0.098(17%)	248(10%)
13-Sep-16	–	19-Sep-16	2245(10%)	0.117(16%)	274(10%)
19-Sep-16	–	26-Sep-16	4114(10%)	0.171(25%)	457(10%)
26-Sep-16	–	03-Oct-16	2717(10%)	0.091(21%)	203(10%)
03-Oct-16	–	10-Oct-16	1689(10%)	0.264(15%)	196(10%)
10-Oct-16	–	17-Oct-16	2267(10%)	0.400(13%)	315(10%)
17-Oct-16	–	24-Oct-16	1679(10%)	0.589(13%)	544(10%)
24-Oct-16	–	31-Oct-16	1974(10%)	0.247(16%)	134(10%)
31-Oct-16	–	07-Nov-16	1601(10%)	0.261(17%)	229(10%)
07-Nov-16	–	14-Nov-16	1804(10%)	0.428(11%)	421(10%)
14-Nov-16	–	21-Nov-16	2406(10%)	0.113(22%)	123(10%)
21-Nov-16	–	28-Nov-16	2782(10%)	0.257(15%)	205(10%)
28-Nov-16	–	05-Dec-16	1970(10%)	0.199(19%)	67(10%)
05-Dec-16	–	12-Dec-16	2567(10%)	0.169(15%)	67(10%)
12-Dec-16	–	19-Dec-16	1496(10%)	0.253(16%)	66(10%)
19-Dec-16	–	29-Dec-16	3250(10%)	0.201(14%)	280(10%)
29-Dec-16	–	03-Jan-17	3681(10%)	0.225(16%)	175(10%)
Mean			2304	0.181	207
SD			676	0.133	124

∗Figures in brackets are relative standard uncertainties

Table 2.1. Radionuclides in precipitation in the 10 m^2 rain collector at Risø (cf. Fig. 8.1), July - December 2016. (Unit: Bq m^{-3})

Month	^{7}Be	^{137}Cs	^{210}Pb
July	1500(10%)*	0.105(13%)	59(10%)
August	2000(10%)	0.103(21%)	130(10%)
September	589(10%)	0.134(10%)	10(11%)
October	1093(10%)	0.103(14%)	44(10%)
November	1525(10%)	0.262(15%)	107(10%)
December	1546(10%)	0.101(28%)	80(10%)

*Figures in brackets are relative standard uncertainties

Table 2.2. Radionuclides in precipitation in the 10 m^2 rain collector at Risø (cf. Fig. 8.1), July - December 2016. (Unit: Bq m^{-2})

Month	Precipitation (m)	^{7}Be	^{137}Cs	^{210}Pb
July	0.103(10%)*	154.0(14%)	0.0108(16%)	6.1(14%)
August	0.050(10%)	99.7(14%)	0.0051(23%)	6.4(14%)
September	0.028(10%)	16.2(14%)	0.0037(14%)	0.3(15%)
October	0.080(10%)	87.2(14%)	0.0082(17%)	3.5(14%)
November	0.055(10%)	83.5(14%)	0.0144(18%)	5.9(14%)
December	0.034(10%)	53.1(14%)	0.0035(30%)	2.7(14%)
Sum	0.350(5%)	493.7(10%)	0.0457(13%)	24.9(9%)

*Figures in brackets are relative standard uncertainties

Table 2.3. Tritium in precipitation collected at Risø (cf. Figs. 1, 2.3.1 and 2.3.2). July - December 2016. (Unit: kBq m^{-3})

Month	10 m^2 rain collector*
July	< 3.1[a]
August	< 3.1
September	< 3.1
October	< 2.2
November	3.8(26%)
December	3.8(21%)
Double determinations*.	

[a] Figures in brackets are relative standard uncertainties

Table 2.4. Tritium in precipitation collected at Risø (cf. Fig. 1). July - December 2016. (Unit: kBq m^{-2})

Month	Precipitation (m)	10 m^2 rain collector
July	0.103(10%)[a]	< 0.319
August	0.050(10%)	< 0.155
September	0.028(10%)	< 0.087
October	0.080(10%)	< 0.176
November	0.055(10%)	0.209(28%)
December	0.034(10%)	0.129(23%)
Sum	0.350(5%)	<1.163

[a] Figures in brackets are relative standard uncertainties

Table 3.1. Radionuclides in sediment samples collected at Bolund in Roskilde Fjord.(cf. Fig. 3.1) July - December 2016. (Unit: Bq kg^{-1} dry)

Date	^{137}Cs	K*
1 July	2.0(12%)[a]	25.1(10%)
*Unit: g kg^{-1} dry		

[a] Figures in brackets are relative standard uncertainties

Table 4.1. Radionuclides in seawater collected in Roskilde Fjord (cf. Fig. 4.1) July - December 2016. (Unit: Bq m^{-3})

Date	^{137}Cs
1 July	6.4(12%)

Table 4.2. Tritium in seawater collected in Roskilde Fjord (Risø pier) (cf. Fig. 4.2) July - December 2016.*

Month	kBq m^{-3}
September	4.72(29%)[a]
December	4.28(30%)
* Double determinations	

[a] Figures in brackets are relative standard uncertainties

Table 5.1. Radionuclides in grass (snow) collected at Risø near the Waste Treatment Station, location I P3, Fig. 1, July - December 2016. (**Measured on bulked ash samples)*

Week no. or month	Date	K (g kg^{-1} fresh)	^{137}Cs (Bq kg^{-1} fresh)	^{137}Cs (Bq m^{-2})
27	4 July	4.5(11%) [a]	<0.2	
29	19 July	5.2(10%)	<0.5	
31	1 August	4.1(11%)	<0.6	
33	15 August	5.6(10%)	<0.3	
35	29 August	4.6(11%)	<0.6	
37	13 September	5.6(10%)	<0.5	
39	26 September	6.5(10%)	<0.5	
41	10 October	4.7(11%)	<0.6	
43	24 October	3.6(10%)	<0.7	
45	7 November	3.6(10%)	<0.3	
47	21 November	3.1(10%)	<0.3	
49	5 December	1.9(12%)	<0.4	
51	19 December	1.4(15%)	<0.7	
**July		5.1(10%)	0.116(22%)	0.039(24%)
**August		4.2(10%)	0.083(29%)	0.018(26%)
**September		7.1(10%)	0.052(30%)	0.023(28%)
**October		4.1(10%)	0.489(14%)	0.016(31%)
**November		3.8(10%)	0.085(25%)	0.030(27%)
**December		2.2(10%)	0.136(18%)	0.081(20%)

[a] Figures in brackets are relative standard uncertainties

Table 5.2. Radionuclides in Fucus vesiculosus collected at Bolund in Roskilde Fjord. July - December 2016. (Unit: Bq kg^{-1} dry)

Date	^{137}Cs	K*	% dry matter
1 July	2.0(12%)[a]	25(10%)	23(10%)
*Unit: g kg^{-1} dry			

[a] Figures in brackets are relative standard uncertainties

Table 7.1. Waste water collected at Risø (cf. Fig. 1), July - December 2016.

Week number	Total beta (eqv. mg KCl l^{-1})	^{137}Cs (Bq m^{-3})	^{131}I (Bq m^{-3})	^{226}Ra (Bq m^{-3})
27	123(10%)	<108	<124	<265
28	68(11%)	<78	<81	<180
29	95(10%)	<116	<124	<270
30	95(10%)	<133	<144	<329
31	134(10%)	<136	<149	<316
32	116(10%)	<126	<126	<294
33	110(10%)	<90	<98	<218
34	112(12%)	<130	<139	<306
35	116(10%)	<123	<129	<309
36	114(10%)	<132	<139	<311
37	121(10%)	<133	<135	<314
38	158(10%)	<122	<121	<301
39	140(11%)	<142	<144	<344
40	119(10%)	<131	<131	<316
41	129(10%)	<107	<148	<300
42	82(11%)	<119	<126	<293
43	111(10%)	<120	<132	<288
44	132(11%)	<123	<127	<303
45	109(11%)	<128	<131	<305
46	94(12%)	<117	<120	<281
47	89(12%)	<119	<126	<295
48	87(10%)	<117	<117	<282
49	100(10%)	<111	<115	<269
50	87(11%)	<142	<136	<322
51	94(11%)	<137	<150	<336
52	85(11%)	<114	<169	<277
Mean	108.5	<121	<130	<293
SD	20.8			

[a] Figures in brackets are relative standard uncertainties

.

Table 8.1. Background dose rates around the border of Risø (cf. Fig. 8.1) measured with thermoluminescence dosimeters (TLD) in the period May 2016 – October 2016. (Results are normalized to nSv h^{-1})

Location	nSv h^{-1} ¤
1	29(10%)[a]
2	40(10%)
3	41(10%)
4	47(10%)
5	48(10%)
6	79(10%)
Mean	47(5%)

[a] Figures in brackets are relative standard uncertainties

Table 8.2. Background dose rates around Risø (cf. Fig. 8.2 and Fig. 1) measured with thermoluminescence dosimeters (TLD) in the period May 2016– October 2016. (Results are normalized to nSv h^{-1})

Risø zone	Location	nSv h^{-1}
I	1	39(10%)[a]
I	2	37(10%)
I	3	64(10%)
I	4	39(10%)
I	5	45(10%)
Mean		45(5%)
II	P1	42(10%)
II	P2	-[c]
II	P3	35(10%)
II	P4	43(10%)
Mean		40(6%)
III	P1	53(10%)
III	P2	40(10%)
III	P3	43(10%)
Mean		45(6%)
IV	P1	33(10%)
IV	P2	36(10%)
IV	P3	43(10%)
IV	P4	40(10%)
IV	P5	38(10%)
IV	P6	41(10%)
IV	P7	54(10%)
Mean		41(4%)
V	P1	48(10%)
V	P2	127(10%)[b]
V	P3	57(10%)
V	P4	40(10%)
V	P5	42(10%)
V	P6	34(10%)
V	P7	-[c]
V	P8	55(10%)
V	P9	39(10%)
V	P10	46(10%)
Mean		54(4%)

a Figures in brackets are relative standard uncertainties

b It is believed that the measurement result is correct, but it is unknown what caused the deviation from the normally observed value.

c This denotes that the TLD dosimeter has been lost during the exposure period

Table 8.3. Terrestrial dose rates at the Risø zones (cf. Fig. 8.2 and Fig. 1) July – December 2016. Measured with a NaI(Tl) detector. (Unit: nSv h^{-1})

Risø zone	Location	October
I	P1	40(10%)[a]
I	P2	54(10%)
I	P3	309(10%)
I	P4	47(10%)
I	P5	53(10%)
Mean		101(5%)
II	P1	43(10%)
II	P2	46(10%)
II	P3	43(10%)
II	P4	43(10%)
Mean		44(5%)
III	P1	50(10%)
III	P2	50(10%)
III	P3	47(10%)
Mean		49(6%)
IV	P1	40(10%)
IV	P2	51(10%)
IV	P3	46(10%)
IV	P4	42(10%)
IV	P5	39(10%)
IV	P6	45(10%)
IV	P7	50(10%)
Mean		45(4%)
V	P1	62(10%)
V	P2	59(10%)
V	P3	50(10%)
V	P4	49(10%)
V	P5	55(10%)
V	P6	54(10%)
V	P7	47(10%)
V	P7a	41(10%)
V	P8	48(10%)
V	P9	59(10%)
V	P10	44(10%)
Mean		52(4%)

[a] Figures in brackets are relative standard uncertainties

Fig. 1. Locations for measurements of gamma-background radiation Zone I and II (cf. Tables 8.2 and 8.3)

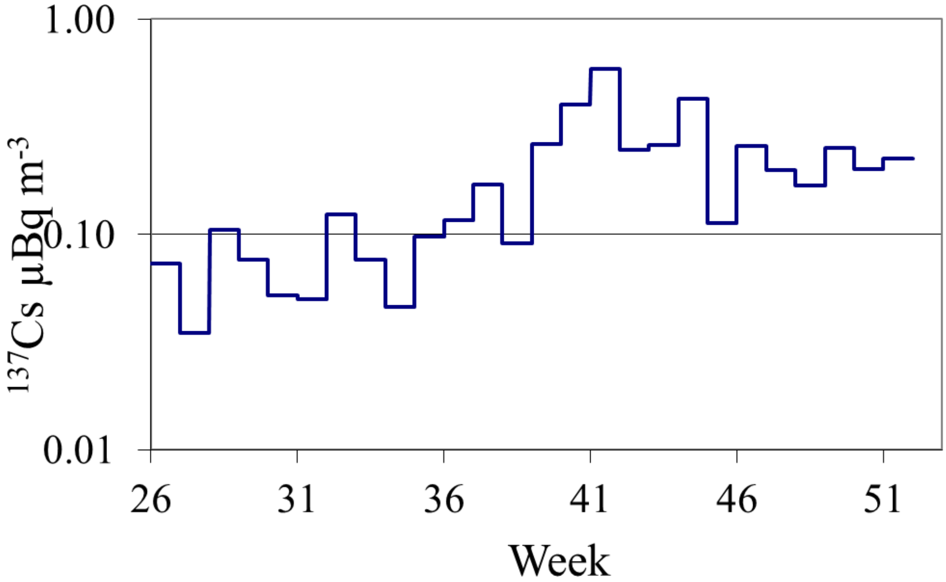

Fig. 1.1. Caesium-137 in ground level air collected at Risø in July-December 2016. (Unit: µBq m^{-3})

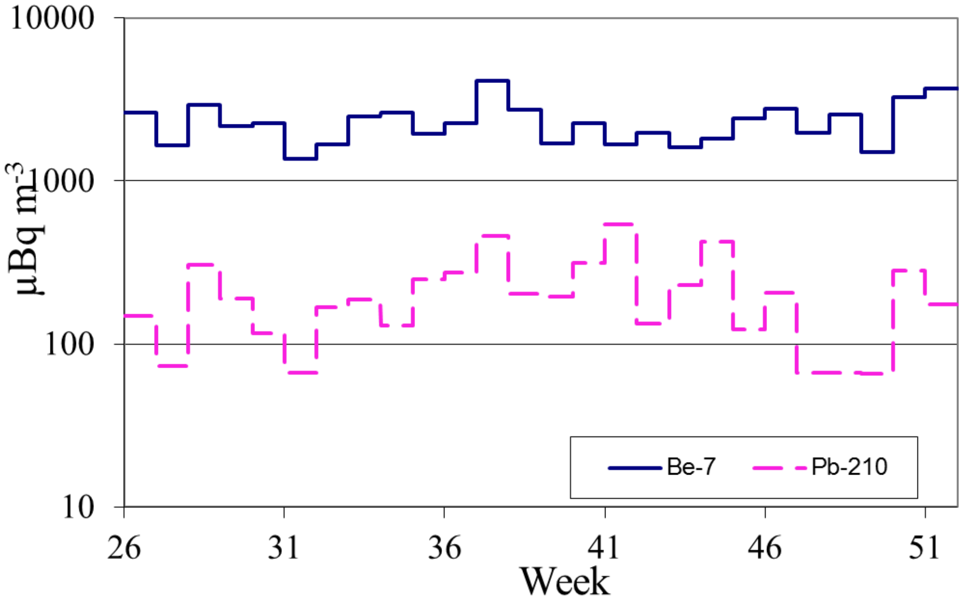

Fig. 1.2. Beryllium-7 and Lead-210 in ground level air collected at Risø in July-December 2016. (Unit: µBq m^{-3})

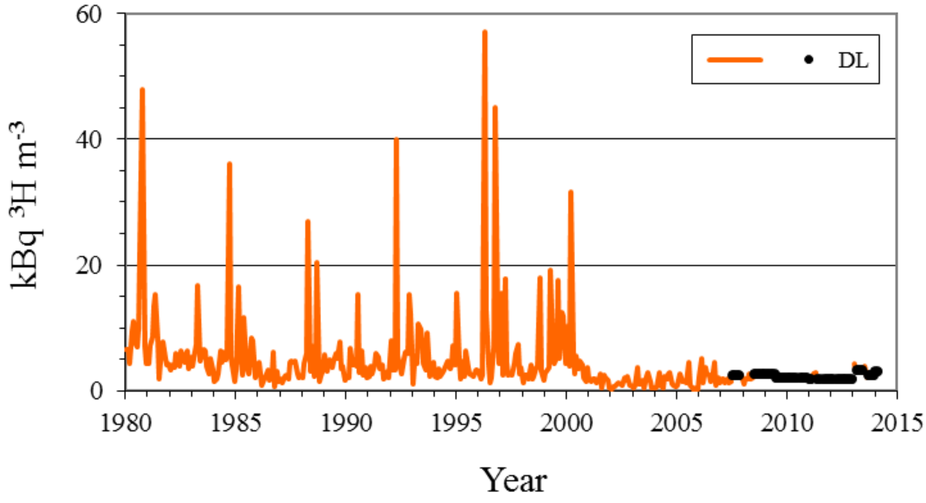

Fig. 2.3.1. Tritium in precipitation collected at Risø (1 m^2 rain collector) 1980 - 2013. (Unit: kBq m^{-3}; DL = detection limit . This rain collector was taken out of operation in 2013.

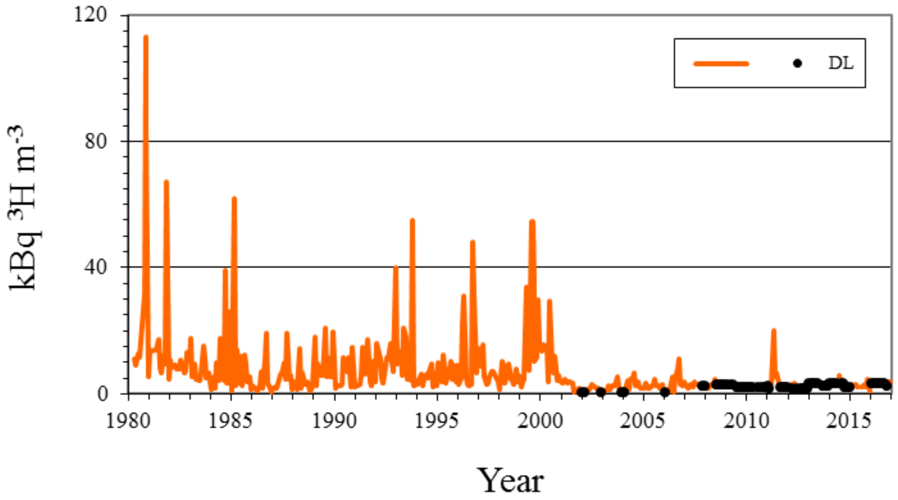

Fig. 2.3.2. Tritium in precipitation collected at Risø (10 m^2 rain collector) 1980 - 2016. (Unit: kBq m^{-3}; DL = detection limit)

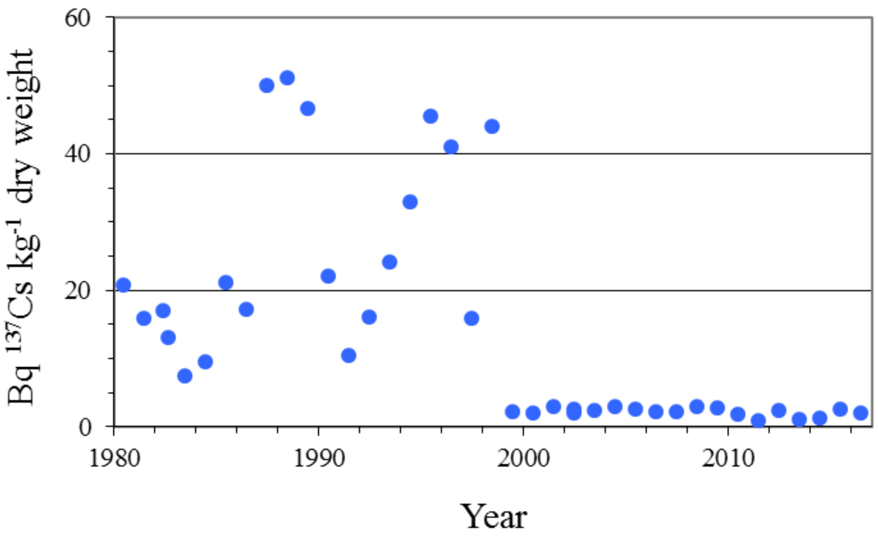

Fig. 3.1. Caesium–137 in sediment samples collected at Bolund in Roskilde Fjord. 1980 – 2016. (Unit: Bq kg^{-1} dry matter)

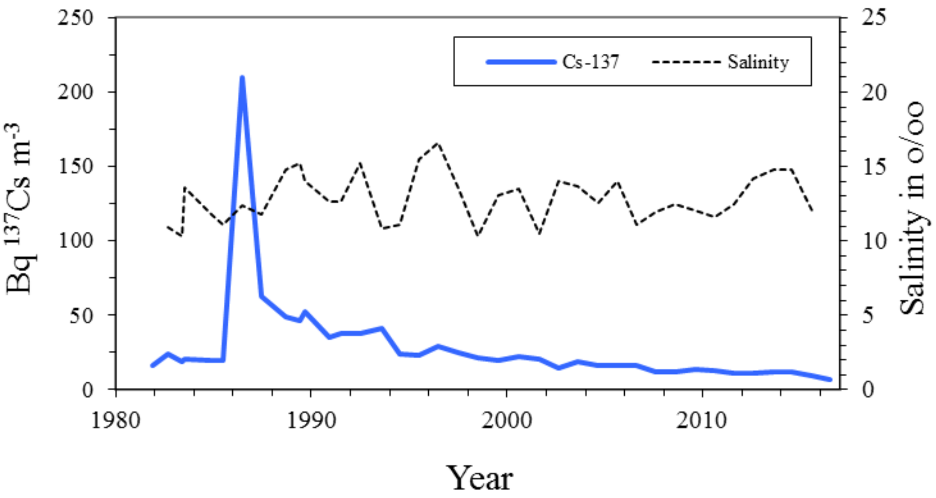

Fig. 4.1. Caesium–137 in seawater collected in Roskilde Fjord 1980 - 2016. (Unit: Bq m^{-3})

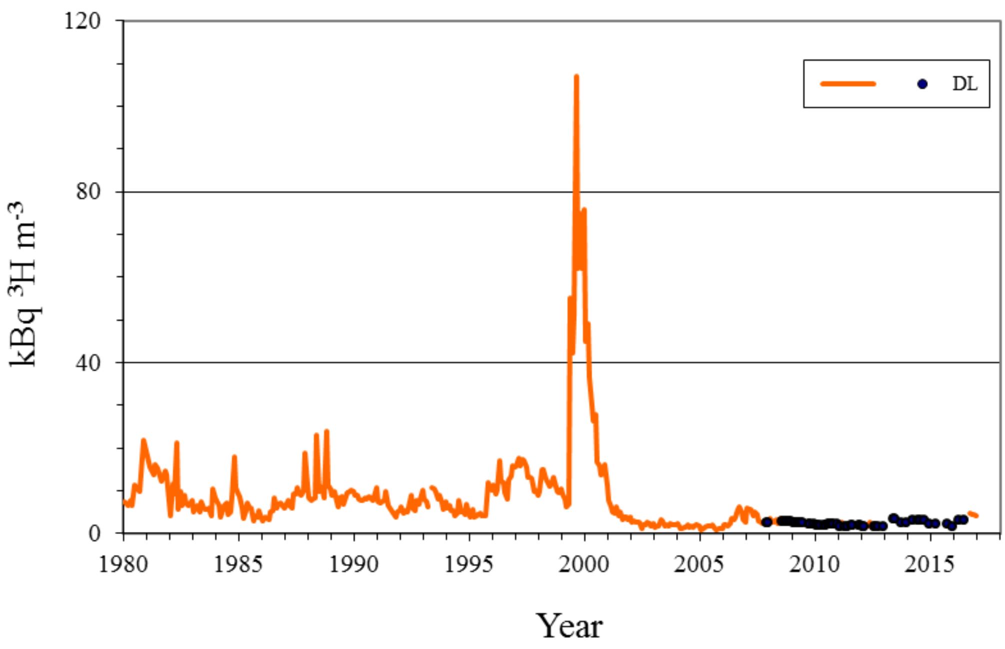

Fig. 4.2. Tritium in seawater collected in Roskilde Fjord 1980 - 2016. (Unit: kBq m^{-3}; DL = detection limit)

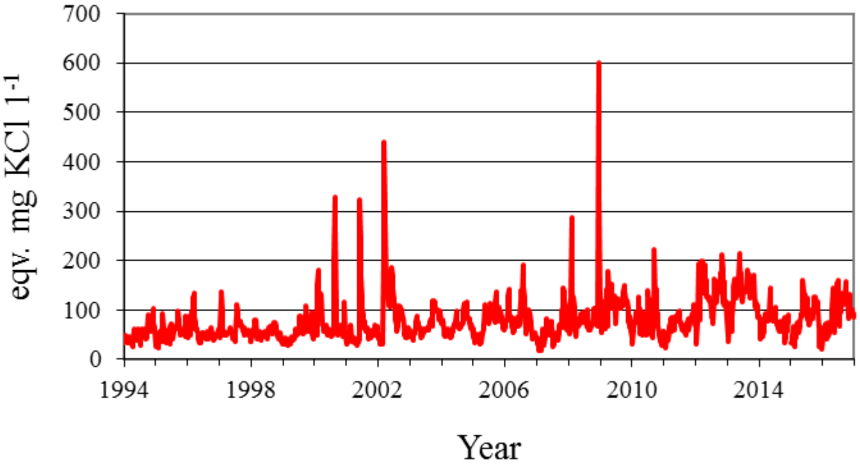

Fig. 7.1. Total-beta radioactivity in waste water collected at Risø 1994 - 2016. (Unit: eqv. mg KCl l^{-1})

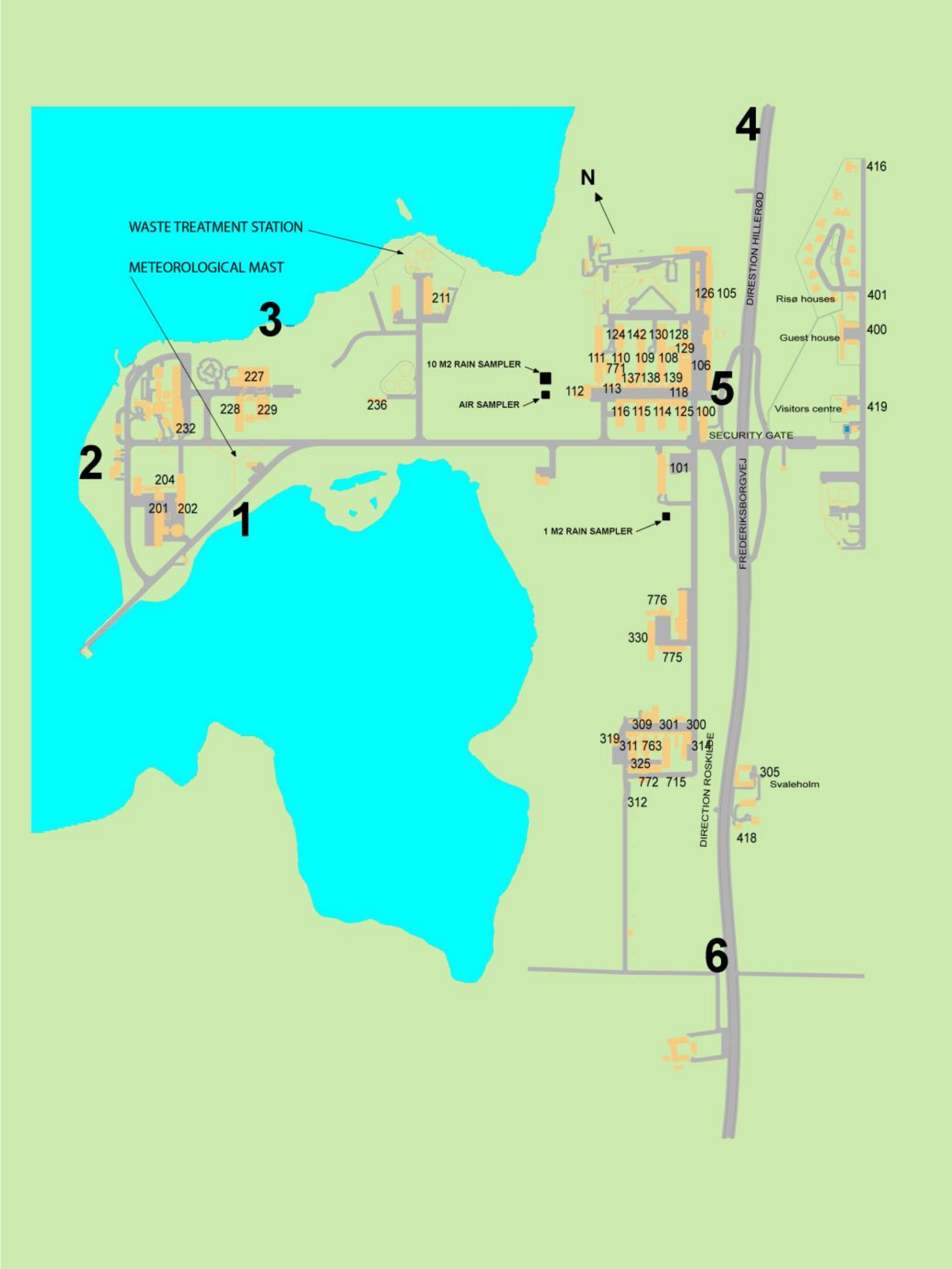

Fig. 8.1. Locations (1-6) for TLD measurements around the border of Risø (cf. Table 8.1).

Fig. 8.2. Locations for measurements of background radiation around Risø in Zones III, IV and V.

MATERIALS AND METHODS

External gamma dose rate monitoring

Monitoring of external gamma dose rate is carried out with the following devices

- Thermolumiscence dosimeters TLD: LiF, measurement frequency annually from May to April. TLD equipment manufacturer: ALNOR/RADOS
- NaI detector: 3x3 inch, SAM 935 Surveillance and Measurement System, Berkeley Nucleonics Cooperation, USA, visual read-out

Calibration of TLD is carried out by irradiation of dosimeters at a calibration irradiator. Traceability of delivered doses is ensured through calibration of the dose rate of the calibration irradiator by the National Institute of Radiation Protection (SIS). Calibration has been verified by measurement with ionisation chamber from NPL, UK. The NaI detector is calibrated periodically vs. a Reuter Stokes high-pressure ionisation chamber.

Air sampler

The sampler at Risø is manufactured by DTU. Air is drawn through a polypropylene filter at a rate of about 2000 m^3/h. The filter is normally changed weekly. The flow rate is monitored by a gas meter connected to a shunt. The gas meter reading is compared to that of a reference gas meter intermittently.

DTU analyse the filters by gamma spectrometry shortly after filter change to check for the presence of short-lived man-made radionuclides. The air filters are subsequently stored for a minimum of one week to allow for decay of short-lived naturally occurring radionuclides before repeated gamma analysis. Filters are analysed for ^{137}Cs, ^{7}Be and ^{210}Pb and other gamma emitters.

Deposition collector

The Risø site operates a large rain collector of 10 m^2. The collector is heated and water is passed through an ion exchange column to a large tank. The 10 m^2 collector provides monthly samples of rain water analysed for tritium and ion exchange resin which is analysed by gamma spectrometry for ^{7}Be, ^{137}Cs and ^{210}Pb and other gamma emitters.

Water and sediment

A waste water sample from the Waste Treatment Station is collected weekly and analysed for total beta radioactivity and the radionuclides ^{131}I, ^{137}Cs and ^{226}Ra. Water samples from Roskilde Fjord are collected each quarter and analysed for tritium, annually for ^{137}Cs. A sediment sample is collected annually from Roskilde Fjord and analysed for ^{137}Cs.

Terrestrial and aquatic biota and flora

Grass samples are collected weekly at the Risø site and analysed by gamma spectrometry. Samples are bulked to monthly samples which are analysed for ^{137}Cs.

Seaweed samples are collected annually from Roskilde Fjord at Risø and analysed for ^{137}Cs.

Sample reception and preparation

Sample identification numbers are entered in log books. Sample preparation methods include drying, freeze drying, ashing, sorting and sieving. Selected samples are archived.

Sample measurements

Radioactivity in samples is measured by total beta counting and gamma spectrometry.

Measurement devices

- Ge detectors for gamma spectrometry. Calibration of detectors is based on mixed-nuclide standards used occasionally. Monthly checks are made of detector efficiency and energy resolution. Background measurements of gamma systems are made a few times per year.
- Low-level Geiger-Müller counters for total beta counting, manufactured by DTU. Calibration based on standards of KCl. Counting efficiency and background are checked monthly.
- Liquid scintillation spectrometer for analysis of tritium in water. Samples are analysed with a calibration standard.

Analytical results, data handling and reporting tools

Analytical results are printed on paper, recorded in log books and stored in a data base on intranet. Results below detection limits recorded as such. Spreadsheets are used for calculating results from raw data.

Quality assurance, laboratory accreditation and intercomparison exercises

Analytical results are checked by experienced staff and discussed with senior scientists if questions arise.

DTU is accredited to testing for radioactivity by DANAK according to the international standard ISO 17025. The accreditation covers testing for certain non-gamma emitting radionuclides but not for radionuclides occurring in the environment and food in general.

DTU participate regularly in international intercomparisons on laboratory analyses of radionuclides.

CONCLUSIONS

This report shows the results of the environmental surveillance monitoring programme carried out at and around the Risø site in July-December 2016. The mean concentrations in air were: 0.18±0.13 μBq m^{-3} of ^{137}Cs, 2.30±0.68 mBq m^{-3} of ^{7}Be and 0.21±0.12 mBq m^{-3} of ^{210}Pb (±1 standard uncertainty). The depositions by precipitation at Risø in the second half of 2015 were: 0.046±0.006 Bq m^{-2} of ^{137}Cs, 494±50 Bq m^{-2} of ^{7}Be, 24.9±2.2 Bq m^{-2} of ^{210}Pb and <1.2 kBq m^{-2} of ^{3}H. The average background dose rate (TLD) at Risø (Zone I) was measured as 45 ± 2 nSv h^{-1} compared with 45 ± 6 nSv h^{-1} (±1 standard uncertainty) in the four zones around Risø. None of the recorded levels of radioactivity and radiation have given rise to concern.

Center for Nuclear Technologies is Denmark's national competency center for nuclear technology.   With roots in research in the peaceful use of nuclear power, DTU Nutech works with the applications of ionizing radiation and radioactive substances for the benefit of society.

DTU
Center for Nuclear Technologies
Technical University of Denmark

Frederiksborgvej 399
PO Box 49
DK-4000 Roskilde
Denmark
Phone +45 4677 4677
Fax +45 4677 5688

www.dtu.dk