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Russian-Norwegian monitoring of radioactive contamination of ground-level air in the border areas

– monitoring programs, methods and results

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Møller Bredo, Chaus Oksana, Ustinova Alyona, Pavlova Tatiana, Shkola Kiril, Berglen Tore, Jensen Louise Kiel. Russisk og norsk luftovervåking av radioaktiv forurensing i grenseområdet – overvåkingsprogrammer, metoder og resultater.

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Resymé
Rapporten beskriver nasjonale metoder for luftovervåking av radioaktiv forurensing og hvilke overvåkingsprogrammer som er implementert i de grensenære områder mellom Norge og Russland.

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Key words
Air monitoring, Norwegian-Russian cooperation

Abstract
The report describes the methods used for air monitoring of radioactive contamination in Northern Norway and Northwest Russia and the monitoring programmes implemented on each side of the border.

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Russian-Norwegian monitoring of radioactive contamination of ground-level air in the border areas – monitoring programs, methods and results

Preface

In the border area in the Barents region, both Russia and Norway have an interest in managing the adjoining terrestrial and marine ecosystems in a sustainable way. Cooperation on monitoring of the ecosystems will provide assembled knowledge for national management.

The Norwegian-Russian Expert Group on Investigation of Radioactive Contamination of the Northern Regions was established in 1992 and is coordinated by Roshydromet on the Russian side and the Norwegian Radiation and Nuclear Safety Authority (DSA) on the Norwegian side. This expert group is working under the Joint Norwegian-Russian Commission on Environmental Protection co-ordinated by the Ministry for Climate and the Environment on the Norwegian side and the Ministry of Natural Resources and Environment on the Russian side.

Among other projects, the expert group coordinates a project on environmental monitoring of radioactive substances in the northern areas. The group has decided to strengthen the environmental monitoring programme by including cooperation on air monitoring. In May 2016, it was agreed to compose a joint report describing the Russian and the Norwegian efforts for monitoring the radioactive contamination in air in the northern areas as a foundation for further cooperation.

Contributors to the report are Federal State Budgetary Institution Murmansk Administration for Hydrometeorology and Environmental Monitoring (FSBI Murmansk UGMS) (O. Chaus, A. Ustinova, T. Pavlova and K. Shkola), Norwegian Institute for Air Research – NILU (T.F. Berglen) and Norwegian Radiation and Nuclear Safety Authority – DSA (B. Møller and L.K. Jensen)

NILU

Innholdsfortegnelse

1 Introduction

Many countries have established networks to monitor radioactive substances in air. Radionuclides are often released to air in case of accidents and air-borne radionuclides are the fastest traveling parts of the release. Thus, air monitoring systems is considered important within the emergency response and preparedness as they provide the first warning of releases. In general, air monitoring systems are either passive devises continuously measuring the total dose of radioactivity in the area or active devises collecting integrated samples over time which are analyzed for the activity of specific radionuclides.

When comparing and sharing of data from air monitoring systems between nations, it is essential to be acquainted with the instrumentation and procedures followed by the respective countries. Such knowledge will enable an evaluation of the comparability of the national results. Further, differences in instrumentation and procedures may explain inconsistencies between results.

This report is compiled to compare the monitoring programs, applied procedures and results achieved by the responsible Norwegian and Russian authorities. Geographically, the report covers the Norwegian counties Nordland, Troms and Finnmark and the Russian county of Murmansk.

The two parties have provided the descriptions of the national systems and results independently, while the final conclusion is a joint product.

2 Description of the monitoring systems

This section gives specific descriptions of the Russian and the Norwegian systems of air monitoring in the Barents region and the assessment criteria applied when evaluation the results.

2.1 Russian monitoring

2.1.1 Background

The radiological situation in Murmansk Region is determined by the activities of the enterprises nuclear technological complex: Kola Nuclear Power Plant (JSC Concern Energoatom) in the town of Poliarnye Zori, Zasheyek settlement, the main supplier of electric power to the industrial complex, and the facilities of State Corporation for nuclear energy Rosatom FSUE Atomflot, NWC SevRAO – Branch FSUE RosRAO, the city of Murmansk.

2.1.2 Monitoring systems

Radiological monitoring in the territory of Murmansk Region is performed at 30 hydro-meteorological stations and monitoring stations of Murmansk UGMS which are part of the Roshydromet monitoring network.

Since 2000, Murmansk territorial automated system of radiological control has been operational – MT ASKRO established under the regional target programme Environmental Protection in Murmansk Region. FSBI Murmansk UGMS has been defined as the center of collection, storage, analysis of the information on the radiological situation. In the framework of MT ASKRO development, additional 45 territorial stations for radiological control with automatic sensors type UDRG-50 (NTC RION), BDMG (NPP DOZA) have been established. The ASKRO system allows continuous automated control of radiological and meteorological situation, alert notification of exceeding of the established threshold values for the gamma dose rate, collection and prompt transfer of data, and diagnostics of the system's components' condition.

MT ASKRO is part of the Integrated State Automated System for Radiological Control (EGASKRO) that comprises a network of monitoring stations across the whole country. The EGASKRO Center in real time receives data from Rosgidromet, results of meteorological parameters measurements from Rosgidromet meteorological stations, and results of radiological monitoring from the Rosgidromet network.

In the regular mode, measurements are performed every 15 minutes and the average hourly values are provided to the server of Murmansk UGMS. In case of radiological contingency measurements are performed every 2 minutes. Information of the radiological situation in Murmansk Region is provided daily at the website of Murmansk UGMS   http://www.kolgimet.ru.

Updated information in a remote user mode is provided to EMERCOM Russia for Murmansk Region, Civil Defense Directorate for Murmansk Region, Rosatom, and TIAC EGASMRO.

For the purpose of developing the radiological contamination monitoring, Murmansk UGMS has received an automobile-based radiological survey laboratory (ALLR) designed for prompt measurement of radiological parameters; a modern gamma-spectrum complex monitor based on sensor GEM-20P4 and a digital analyzer for radionuclide composition of air spray and fallout samples; in 2012 at the meteorological station Zasheyek a permanent station for ground-air radiation monitoring was installed (air-filter device for air spray sampling UVF); in 2015 at the Murmansk station specialists from FSBI NPO Typhoon performed installation and commissioning of a radiological monitoring station comprising an air-filtering device for air spray sampling UVF-2 with an interface of a remote PC for transmitting the data of continuous measurement of surface beta-activity.

2.1.3 Monitoring networks

Monitoring of radiological contamination in the territory of the Kola Peninsula is performed at 30 hydrometeorological stations and monitoring stations of FSBI Murmansk UGMS included in the main monitoring network. See figure 1 for details.

Radioactive contamination of an area is determined at 30 main stations measuring the rate of ambient dose equivalent (RAD) of gamma-irradiation. According to the daily measurements by radiation monitors the rate of ambient equivalent dose (RAD) in the territory of Murmansk Region varies within the limits of natural radiation background (0.04-0.23 mcSv/h); the RAD values did not exceed the background figures.

Radioactive contamination of the ground air is performed at seven stations for sampling of daily atmospheric fallout with the use of a tablet and exposed canvas (Murmansk, Pechenga, Poliarny, Teriberka, Kandalaksha, Monchegorsk, Zasheyek), and two stations for sampling of daily radioactive sprays (Zasheyek, Murmansk). The Murmansk station is shown in Figure 2.

Radioactive atmospheric fallout is activity by radionuclides which are part of atmospheric sprays that sediment from the atmosphere on the underlying terrain of an area of 1 m^2 per unit of time (daily – Bq/m^2 – day ; monthly – Bq/m^2 - month; yearly – Bq/m^2 - year).

Radioactive atmospheric sprays are solid and liquid colloid particles suspended in the ambient air, which disperse particles include radionuclides.

The concentration of the total β-active and separate radionuclides of industrial and natural origin is identified in the collected samples of atmospheric fallout and sprays;

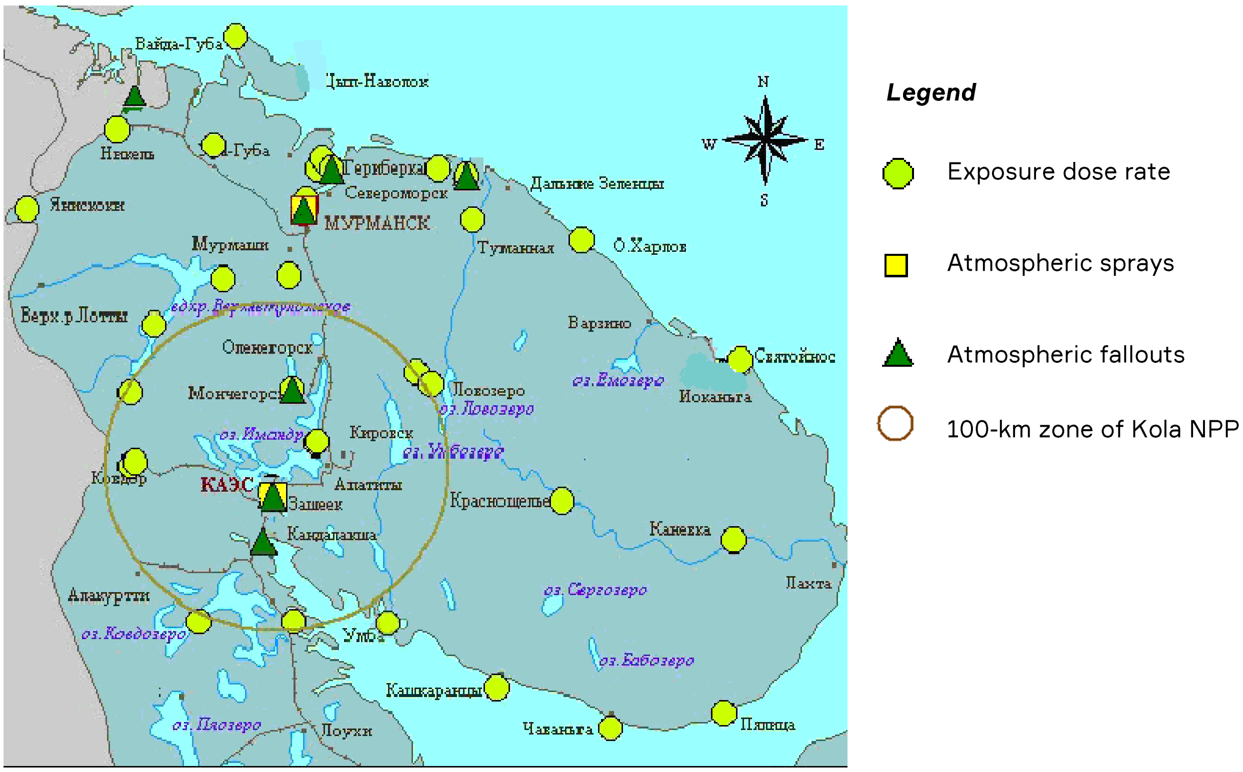

Figure 1: Sketch map of radiological monitoring network of Murmansk UGMS.

Sampling of atmospheric sprays at the stations Murmansk and Zasheyek is performed round the clock with the help of air-filter devices (VFU), for analytical absorption-filtering material. The filters once in place are fixed with a frame along their edges, the VFU is then switched on and the velocity, date and time of sampling commencement is recorded. The sampling is uninterrupted for 24 hours with a pause for filter replacement at 08:30 Moscow Standard Time. On completion of sampling the velocity, date, and time of the sample exposure is recorded in the log, as well as the amount of air pumped through the filter, and the rate of ambient dose equivalent (RAD) at a height ca. 2 meters above the ground is measured by a dose monitor. The spray filter is then sealed and forwarded further for processing in the radiological laboratory where the sample is compressed and measurement of short-lived radionuclides of natural origin and radionuclides of industrial origin is performed at spectrometer of gamma irradiation energy GAMMA-1P. The samples are then charred, incinerated in a muffle-type furnace until homogeneous gray ash is made, a load is made for 24 hours, a week, a month, and the radionuclide composition of air spray samples is identified at a spectrometer, as well as activity of radionuclides of industrial origin.

Regular route monitoring in the zones of radiation-hazardous facilities and Kola Nuclear Power Plant by the automobile-based laboratory for radiological survey (ALLR) considerably improves the quality of radiological monitoring in the territory of Murmansk Region.

During the year route surveys are performed with sampling of snow, vegetation, soil in the close vicinity of Kola Nuclear Power Plant, and FSUE Atomflot (Murmansk). The radionuclide composition of soil and vegetation samples is analyzed at spectrometer of gamma irradiation energy GAMMA-1P.

According to observations by FSBI Murmansk UGMS, in the locations of potentially hazardous radiological facilities the situation has been stable. The concentrations of radionuclides detectable in the ground air and atmospheric fallouts are below the concentrations stipulated by the norms of radiation safety.

Figure 2: The Murmansk sampling station for radioactive contamination of the ground air. The shelter and the air sampling instrument inside. Photo: Murmansk Hydromet

2.1.4 Russian criteria for assessment of radiological situation

According to the Rosgidromet's Order dated 31.10.2000 No. 156 On Introduction of Procedure for Processing and Presentation of General Purpose Information on Environment Pollution [1], the criteria of increased radioactive air contamination and dose rate of gamma-irradiation are as follows:

- → The EHC criterion is observed in the event of any of the following conditions:
  - → concentration of volumetric total beta-activity of radionuclides in the ambient air based on the data of primary measurements (24 hours after sampling) exceeding $3700x10^{-5}$ Bq/m^3;
  - → total beta-activity of fallout according to primary measurements (24 hours after sampling) exceeding 110 Bq/m^2 per day;
  - → the rate of ambient dose equivalent (RAD) measured at a height of 1 meter above the ground surface exceeded the background value by 0,6 μSv/h (60 μR/h) or more, which means that RAD may exceed the limit value of 5 mSv/year for the population under SanPin (sanitary norm) 2.6.1.2523-09 (НРБ-99/2009)[2].

- → The HC criterion is observed in the event of any of the following conditions:
  - → 5-time increase of the daily mean volumetric total beta-activity of radionuclides in the air according to secondary measurements (on the fifth day after sampling) as compared to the reference values from the previous month;
  - → 10-time increase of the total beta-activity, fallout according to the secondary measurements data as compared to the reference values from the previous month;
  - → the RAD value exceeded the background value in the last month for an individual monitoring station by 0,11μSv/h (13 μR/h) or more, which means RAD has been exceeded that will make the limit of dose rate for the population of 1 mSv/year under SanPin (sanitary norm) 2.6.1.2523-09 (НРБ-99/2009) [2].

2.2 Norwegian monitoring

2.2.1 Background

In Norway there are two different monitoring networks aimed at full time detection of radioactivity in air and air borne elements;

- → Radnett: early warning network monitoring dose rates in near real-time.
- → Air filter stations: high volume samplers for radioactive isotopes.

For further surveys, a precipitation collector is located at DSA Svanhovd, Pasvik valley, Finnmark. This office is also equipped with a car-borne monitoring unit. In addition, The Norwegian Civil Defence routinely conducts measurements of ambient dose rates at fixed stations for a national monitoring program to document levels of background radioactivity. These systems are not described in this report.

2.2.2 Monitoring systems and network: Radnett

The main purpose of the Radnett network is to detect and alert in case a large unknown radioactive atmospheric release hits Norway. There are 33 fixed stations evenly distributed all over Norway, whereof 14 are located in Northern Norway and the Barents region (Figure 3). The Radnett stations measures dose rates (μSv/h) and do not provide information on radionuclides. The ambient dose rates are presented to the public on the Radnett website in near real-time (http://radnett.dsa.no). In addition, the results are summarized annually in DSA reports (see ao [3]).

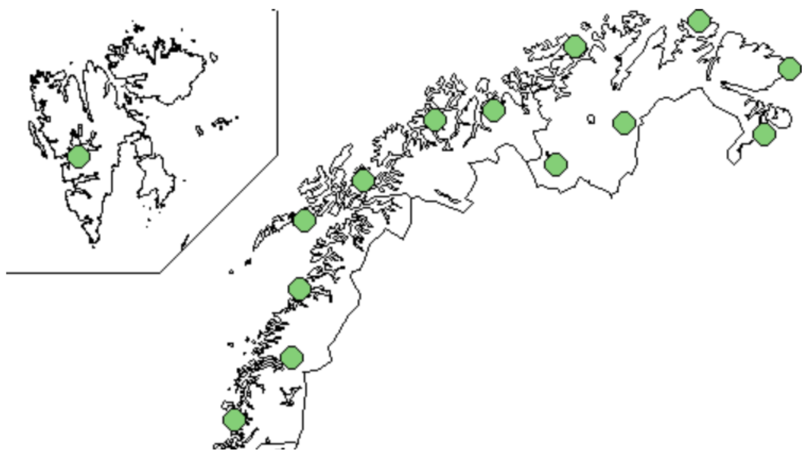

Figure 3: The 14 RADNETT stations located in Northern Norway and in the Barents region including Svalbard, Mehamn, Hammerfest, Vardø, Sørkjosen, Tromsø, Karasjok, Svanhovd, Kautokeino, Harstad, Svolvær, Bodø, Mo i Rana and Brønnøysund.

2.2.3 Monitoring systems and network: Air filter stations

There are four Norwegian high-volume samplers located in the Barents region, three on the mainland (Viksjøfjell, Svanhovd and Skibotn, operated by DSA) and one at Svalbard (operated by NORSAR). See Figure 4 for geographical location of these stations. The stations monitor the composition and amount of radionuclides in ground-level air on a weekly basis. The station at Svanhovd is equipped with both Radnett and air filter sampling instruments, as well at the above mentioned precipitation collector.

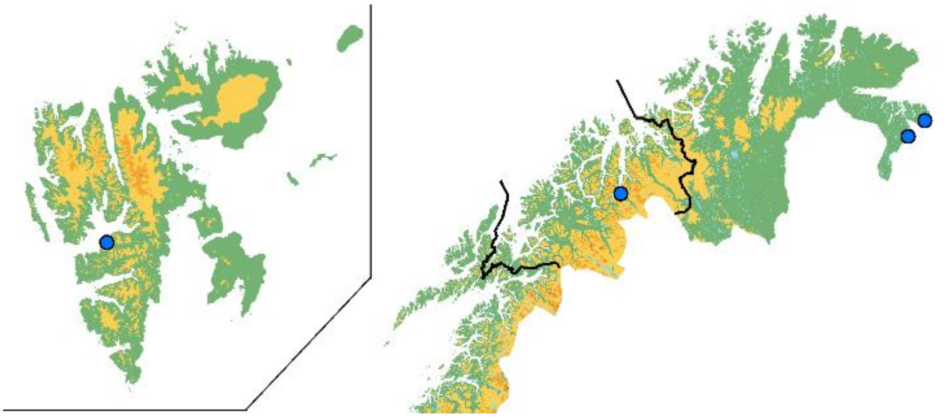

Figure 4: The four Norwegian air filter stations located in the Barents region including Svalbard.

The filter stations sample a high volume of ambient air which is pumped through a Whatman GF/A glass micro fiber filter and the aerosols are deposited. The filter is changed once a week and immediately prepared to be analysed for short lived gamma emitting radionuclides on a HPGe detector. Due to short half-life of some nuclides of interest it is important to analyzed the filters shortly after exposure. The filters are analyzed for a number of isotopes, including anthropogenic isotopes like caesium-137 (^{137}Cs) and iodine-131 (^{131}I) and the natural occurring radionuclide beryllium-7 (^{7}Be). The air filters often contain small traces of ^{137}Cs. This originates from both atmospheric testing of nuclear weapons during the 1950s and 1960s, as well as from the Chernobyl accident in 1986. In 2011 the Fukushima accident released ^{137}Cs (among other nuclides) to air which was detectable in northern part of Norway only days after accident. These levels – however – was minor compared to release of ^{137}Cs from Chernobyl accident and it is not assumed that the Fukushima derived ^{137}Cs contributes to the levels measured today.

The DSA laboratory at Svanhovd analyze samples from Skibotn, Viksjøfjell and Svanhovd. Under normal conditions, the filters are exposed for one week. However, in case of emergency situations the filters may be changed after a shorter time period to obtain more detailed results about the discharges and short time development.

Figure 5: The high volume air sampler at Svanhovd. Photo: DSA.

2.2.4 Norwegian limit values

Norwegian law defines a limit value concerning radiation stating that people should not be exposed to radiation so that effective dose exceed 1 mSv/y in addition to background radiation (Forskrift om strålevern og bruk av stråling (in Norwegian only), see reference list [4]).

The Norwegian Civil Defence has a limit value for 0.7 μSv/h for their Radiac network (equal to approximately 10 times the background level) to notify the DSA.

The RADNETT system triggers alarm to the officer on duty when exceeding 2 times the normal background in the area, measured as the average for the last 10 days.

2.3 Comparison of the Russian and the Norwegian air filter stations

A short table below compares the two different types of air filter stations in the two counties. Main differences are sampling time, counting time and software used in the laboratory. In addition, the Russian system monitor β-activity in filters, which Norway do not.

Table 1: Comparison of systems concerning sampling and analysis of radioactivity in the border areas.

	Russian monitoring	**Norwegian monitoring**
Sampling		
Monitoring established	1987	1993 (Svanvik)
Type filter	Filtering material Petrianov	Whatman GF/A
Sampling period	1 day	1 week
Air volume	Murmansk 800 m^3/h Zasheyek 1500 m^3/h	800 m^3/h
Option charcoal filter for uptake of gaseous iodine	Murmansk, Zasheyek	Svanvik
Analysis		
Instrument	Electrical cooled HPGE detector	Electrical cooled HPGE detector
Software	SpectraLine GP	Maestro and GAMMA10
Filter treatment	Burning and pressing	Fold-and-roll
Analysis time (quick measurement)	1 hrs	1 hrs
Analysis time (long measurement)	5 hrs	48 hrs
Sampling beaker (analysis)	46 x 10 mm (17 ml)	W1 (28 ml)
Monitoring of β-activity	Yes	No

3 Monitoring results

3.1 Russian monitoring results

Hourly mean dose rate for the Nikel monitoring station in 2017 is shown in Figure 6.

Figure 6: Hourly mean dose rate for the Nikel monitoring station in 2017. Unit: microroentgen per hour.

In 2017-2018 the radioactive contamination monitoring in the territory of the Kola Peninsula, in particular, sampling of air sprays was performed round the clock with air-filtering devices in the city of Murmansk and settlement of Zasheyek.

The concentration of the total β-active and separate radionuclides of industrial and natural origin was determined in the atmospheric fallout and spray samples.

1150 daily samples of air sprays were collected in 2017-2018. The monthly mean concentrations of β-active radionuclides in the air varied within: 35 –130 μBq/m³ at the Murmansk station and 20 – 118 μBq/m³ at the Zasheyek station. The maximum daily mean concentrations of radionuclides were observed: in Murmansk 345 μBq/m³ (May 2018), in Zasheyek 284 μBq/m³ (July 2018) (Table 1 in the Appendix).

No cases of five-time short-term exceeding of the daily concentrations for the total β-activity in sprays were observed in 2017-2018.

The radionuclide composition of the air spray samples was analyzed at a gamma-irradiation energy spectrometer Gamma-1П. The gamma-spectrometer analysis of air spray samples collected at the stations Murmansk and Zasheyek was performed for 24 hours, a week, a month, a quarter (Table 2 and 3 in the Appendix).

Under the joint Russian-Norwegian project Study of Radioactive Contamination of the Barents Marine Environment, the FSBI Murmansk UGMS has been exchanging the data obtained from the operational stations for air spray sampling in Murmansk and Zasheyek since April 2016.

3.2 Norwegian monitoring results

Radnett:

The results from Svanhovd show normal seasonal variation. The values are lower during winter when the ground is covered with snow. The sudden peaks are due to wash-out of radon and decay products of radon during precipitation events. The stations in Nordland, Troms and Finnmark counties show normal season variation with average values typically between 0,05 µSv/h in winter and 0,09 µSv/h in summer, see [3] for further information.

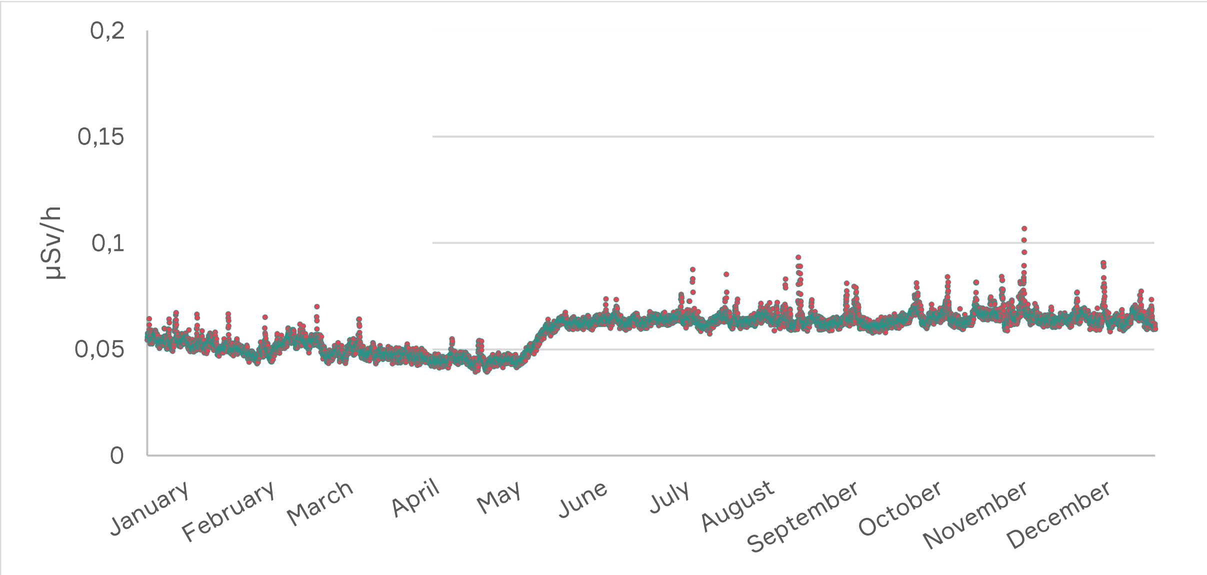

Figure 7: Hourly mean dose rate for the Svanhovd radnett monitoring station in 2017. The background radiation is typically around 0.06 µSv/h.

<u>Air filter stations:</u>

On the Norwegian air filter stations radionuclides with γ-activity are detected. Results for detection of radionuclides in 2017 and 2018 at the three monitoring stations in Norway are shown in Table 4 to Table 6 in the Appendix.

The values of ^{137}Cs are considered as normal throughout the year. The sporadic small elevated detections can be explained by "resuspension" of the radionuclide. This effect occurs when Cs-137 deposited on the ground is transported back to the air by wind and caught in the filter. This is most often seen in areas with higher levels of Chernobyl contamination.

In 2017, there were three episodes of ^{131}I in air at the stations in the border areas. In January, February and March (week 2, 8 and 10 at Svanhovd and week 8 at Viksjøfjell). In 2018, ^{131}I was detected in week 6, 10 and 33 at Svanhovd and week 6 and 10 at Viksjøfjell. At the station in Skibotn, no filters had ^{131}I levels above the detection limit in 2017, but ^{131}I was detected in week 3 and 10 in 2018. ^{131}I is a man-made radionuclide with a half-life of 8 days used i.e. for medical applications. The concentrations found are minimal and barely detectable, and far from any risk for the population. The sources of release are unknown.

Over a period of two weeks in October 2017, Ru-106 in air were detected at the monitoring station in Skibotn. Ru-106 is a manufactured radionuclide mainly used in brachytherapy for treatment of uveal melanoma. Many other countries in Europe also detected Ru-106 in this period of time and the occurrence of airborne Ru-106 over Europe is well documented. However, the origin of the release has still not been concluded [5].

3.3 Comparison of results

Both results from the dose rate measurements and some results from the air filter stations may be compared to evaluate the conformity between the analyses performed by the two nations.

The dose rate measurements from Nikel shown in Figure 6 are within the same range as the measurements from the Svanhovd station reported in Figure 7. However, please note that the units are different in the two countries. Russian results are given as μR/h, while the Norwegian results are given as μSv/h. There is approximately a factor 100 between the results given in μR/h and results given in μSv/h. The stations at Svanhovd and in Nikel are located only 8 km apart and the data indicate that these stations both detect close to background levels of radiation.

^{7}Be is one of the radionuclides detected by the air filter stations. This radionuclide originates only from cosmic radiation and is considered to be deposited at similar rates over large distances. In addition, with a relative short half-life there is limited built up of reservoirs that may act as a secondary source. ^{7}Be has been shown to fluctuate synchronically over larges distances [6] and may be used as a quality control indicator of measurements. Volumetric activity of ^{7}Be in the ground layer of the atmosphere at the Russian and Norwegian stations in 2017 and 2018 is shown in Figure 8. The values largely follow the same pattern and there is a large agreement between the measurements in the two countries.

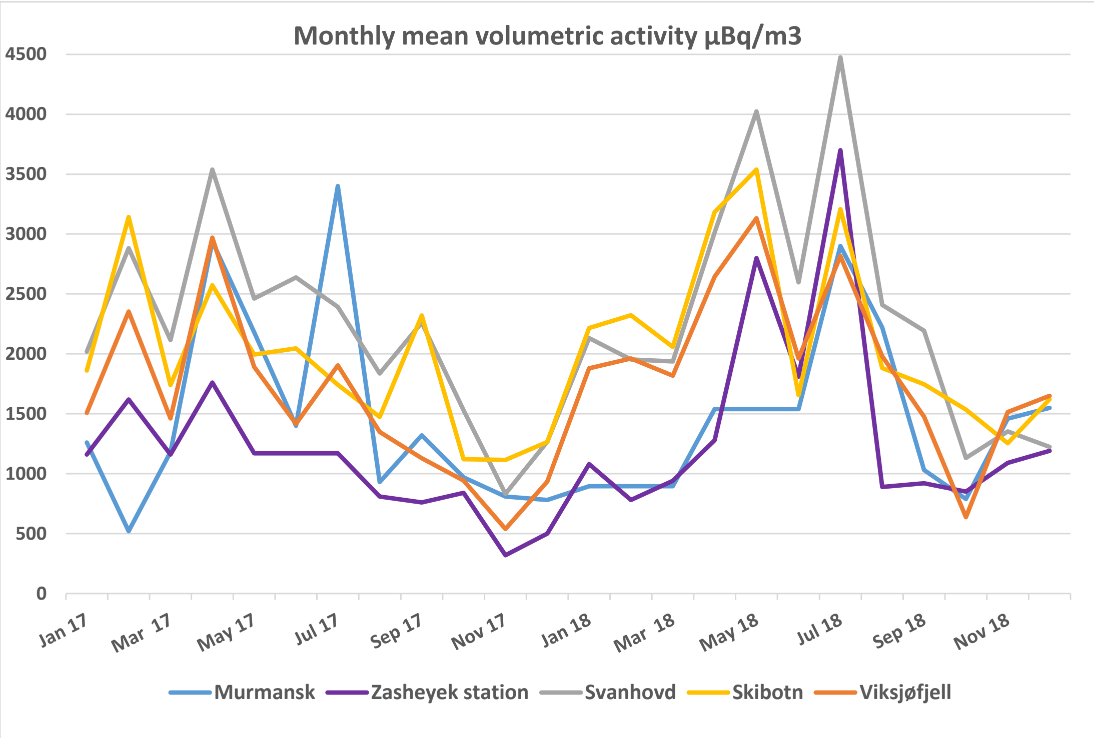

Figure 8: Volumetric activity of ^{7}Be radionuclides in the ground layer of the atmosphere at the Russian and Norwegian stations in 2017 and 2018.

4 Conclusion

Air monitoring of radioactive substances is well covered in Northern Norway and North West Russia. The respective national parties are equipped with high precision instruments with low detection levels. There are extensive networks of monitoring stations at both sides of the border. The equipment and methods are equivalent, and the results are scientifically robust and comparable.

This foundation lays the best grounds for a cooperation across the border. The cooperation has been initiated and exchange of data has been performed since 2016. In addition, there are regular meetings between the national responsible parties.

Figure 9: The Norwegian air filter station at Svanhovd is demonstrated for Russian colleagues. Photo: Hilde Elise Heldal.

According to the observations by Murmansk UGMS, the situation has been stable in the areas of potential hazardous radiation facilities.

In 2017 and 2018, no events of radioactive fallout with increased β-activity has been observed, nor any cases of total β-activity in air sprays above the reference background. The total β-activity of air spray samples and fallouts has not virtually changed compared to the previous years. On the Russian side, the concentrations of the detectable radionuclides in the ground air and atmospheric fallouts are lower than the values stipulated by the norms of radiation safety.

At the Norwegian air filter stations there were some registrations of ^{131}I, indicating a recent release of this man-made isotope. In addition, ^{106}Ru was detected in northern part of Norway in October 2017. The values were low and represented no risk to human health. There was no detection of man-made isotopes in fallout during the period.

The rate of ambient dose equivalent in the Region's territory has varied within the fluctuations of the natural radiation background including some elevated values during radon wash-out episodes.

The authors recommend continuous cooperation within the field of air monitoring near the Norwegian-Russian border. Long-term cooperation is important to build mutual trust and to be able to respond jointly in emergency situations for the benefit of the inhabitants in both countries. The cooperation falls naturally within the the work of the Joint Norwegian-Russian Expert Group on Investigation of Radioactive Contamination of the Northern Areas.

5 Abbreviations

DSA - Norwegian Radiation and Nuclear Safety Authority

FSBI Murmansk UGMS - Federal State Budgetary Institution Murmansk Administration for Hydrometeorology and Environmental Monitoring

NILU - Norwegian Institute for Air Research

JSC Concern Energoatom - Open Joint-Stock Company "Russian Concern for the Production of Electric and Heat Energy at Nuclear Power Plants"

NWC SevRAO – Branch FSUE RosRAO

M ASKRO - Murmansk territorial automated system of radiological control

UDRG-50 (NTC RION), BDMG (NPP DOZA) - Avtomatic sensor model UDRG-50 (scientific and technical center "RION"), Avtomatic sensor model BDMG (scientific production association «DOZA»)

EGASKRO - Integrated State Automated System for Radiological Control

EMERCOM - Ministry of the Russian Federation for Civil Defense, Emergencies and Disaster Relief

TIAC EGASMRO - Unified State Automated Monitoring System radiation situation on the territory of the Russian Federation

ALLR - Automotive Radiation Intelligence Laboratory

FSBI NPO Typhoon - Federal Service for Hydrometeorology and Environmental Monitoring Scientific Production Association "Typhoon"

RAD - Ambient Equivalent Dose

Bq/m^2/time - Activity of radioactive atmospheric on an area of 1 m2 per unit of time

NPP – Nuclear Power Plant

VFU - air-filter devices

GAMMA-1P - spectrometer of gamma irradiation energy

RADNETT – Radiation Network

NORSAR - Norwegian Seismic Array

HPGe – High Purity Germanium

EHC - Extremely high contamination

HC - High contamination

μR/h – microRoentgen per hour (100 uR/h = 1 uSv/h)

μSv/h – microSievert per hour (a measure of the health effect of low levels of ionizing radiation on the human body)

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7 Appendix

Table 1: Volumetric total β-activity of radionuclides in the ground layer of the atmosphere at the stations of Murmansk and Zasheyek in 2017-2018, μBq/m^3.

Murmansk station

year						**2017**						
month	1	2	3	4	5	6	7	8	9	10	11	12
Monthly mean volumetric activity	59	88	64	87	72	76	101	55	98	80	35	48
Maximum daily mean volumetric activity	120	165	146	190	131	193	252	111	220	304	74	113
year						**2018**						
month	1	2	3	4	5	6	7	8	9	10	11	12
Monthly mean volumetric activity	73	80	71	112	116	77	130	72	78	59	63	101
Maximum daily mean volumetric activity	216	194	168	259	345	190	282	179	264	153	243	221

Zasheyek station

year						**2017**						
month	1	2	3	4	5	6	7	8	9	10	11	12
Monthly mean volumetric activity	41	36	40	33	35	35	60	42	60	44	20	33
Maximum daily mean volumetric activity	137	113	109	104	76	115	149	119	196	148	49	94
year						**2018**						
month	1	2	3	4	5	6	7	8	9	10	11	12
Monthly mean volumetric activity	45	67	59	53	83	66	118	65	67	50	49	79
Maximum daily mean volumetric activity	161	212	147	184	204	171	284	250	254	210	140	205

Table 2: Results of measuring volumetric activity of radionuclides in the ground layer of the atmosphere at the Murmansk station in 2017 – 2018, μBq/m^3.

	Radionuclides					
	7Be	137Cs	40K	22Na	226Ra	232Th
2017						
January	1260	н	25	н	1,13	0,79
February	520	н	8,9	н	н	н
March	1180	н	33	н	1,22	н
April	2940	н	32	0,34	0,76	1
May	2180	н	42	Н	0,9	н
June	1400	н	н	0,74	н	н
July	3400	0,5	43	н	н	1,1
August	930	н	25	н	н	н
September	1320	н	42	н	н	н
October	970	4,6	н	н	16	н
November	810	4	н	н	н	н
December	780	н	н	н	н	н
2018						
1 Quarter	896	0,33	н	н	н	н
2 Quarter	1540	0,29	24,6	0,49	0,58	0,82
July	2900	н	н	1,4	н	н
August	2220	н	27	0,49	0,91	н
September	1030	н	н	н	0,58	0,6
October	790	н	н	н	0,59	0,83
November	1460	н	н	н	0,48	0,48
December	1550	н	н	н	0,78	0,57

н – below the detection threshold

Table 3: Results of measuring volumetric activity of radionuclides in the ground layer of the atmosphere at the Zasheyek station in 2017 – 2018, μBq/m³

	Radionuclides					
	^{7}Be	^{137}Cs	^{40}K	^{22}Na	^{226}Ra	^{232}Th
2017						
January	1160	0,31	17,9	н	0,41	0,34
February	1620	0,24	15,7	н	н	н
March	1160	н	16,3	н	0,41	н
April	1760	н	16,6	н	н	н
May	1170	н	н	н	н	1,8
June	1170	н	14,6	0,24	0,47	н
July	1170	0,39	23	н	н	н
August	810	0,27	18,2	н	н	н
September	760	2,4	н	н	н	20
October	840	2,4	н	н	н	н
November	320	0,23	н	н	н	н
December	500	Н	н	н	н	н
2018						
January	1080	0,27	н	н	н	н
February	780	0,38	н	н	н	н
March	940	н	н	н	н	н
April	1280	н	13,1	н	н	н
May	2800	н	21	0,48	н	н
June	1810	0,2	6,4	0,3	н	н
July	3700	0,31	31	0,55	0,77	н
August	890	н	н	н	н	н
September	920	н	н	н	н	н
October	850	н	н	н	0,26	0,29
November	1090	0,15	н	н	0,28	0,19
December	1190	0,22	н	н	0,18	н

н – below the detection threshold

Table 4: Results of measuring volumetric activity of radionuclides in the ground layer of the atmosphere at the Svanhovd station in 2017 – 2018, µBq/m³.

	Radionuclides		
	^{7}Be	^{131}I	^{137}Cs
2017			
January	2019	0.47 (one week only)	0.21
February	2881	0.37 (one week only)	0.12
March	2115	0.35 (one week only)	H
April	3539	H	H
May	2462	H	H
June	2638	H	0.21
July	2393	H	0.31
August	1837	H	0.19
September	2262	H	0.17
October	1530	H	H
November	833	H	0.08
December	1266	H	0.10
2018			
January	2131	H	0.15
February	1953	0.30 (one week only)	0.28
March	1938	0.50 (one week only)	0.10
April	3014	H	0.12
May	4025	H	0.14
June	2597	H	0.21
July	4475	H	0.40
August	2408	0.18 (one week only)	0.18
September	2194	H	0.33
October	1131	H	H
November	1352	H	0.17
December	1223	H	0.17

н – below the detection threshold

^{7}Be show monthly mean values, ^{131}I and ^{137}Cs show weekly values.

Table 5: Results of measuring volumetric activity of radionuclides in the ground layer of the atmosphere at the Viksjøfjell station in 2017 – 2018, μBq/m^3.

	Radionuclides		
	^{7}Be	^{131}I	^{137}Cs
2017			
January	1508	н	н
February	2352	0.50 (one week only)	н
March	1460	н	н
April	2970	н	0.15
May	1892	н	н
June	1417	н	н
July	1905	н	н
August	1348	н	0.21
September	1129	н	н
October	942	н	н
November	538	н	н
December	936	н	н
2018			
January	1880	н	0.18
February	1962	0.53 (one week only)	0.17
March	1817	0.28 (one week only)	H
April	2643	н	н
May	3131	н	0.15
June	1962	н	н
July	2817	н	0.33
August	1981	н	0.20
September	1476	н	0.26
October	638	н	н
November	1514	н	н
December	1650	н	0.25

н – below the detection threshold

^{7}Be show monthly mean values, ^{131}I and ^{137}Cs show weekly values.

Table 6:Results of measuring volumetric activity of radionuclides in the ground layer of the atmosphere at the Skibotn station in 2017 – 2018, μBq/m^3.

	Radionuclides		
	^{7}Be	^{131}I	^{137}Cs
2017			
January	1861	н	0.14
February	3142	н	0.05
March	1741	н	0.05
April	2573	н	н
May	1993	н	н
June	2046	н	0.14
July	1742	н	0.13
August	1475	н	0.17
September	2321	н	0.29
October	1120	н	н
November	1115	н	н
December	1264	н	н
2018			
January	2216	0.51	0.13
February	2323	н	0.13
March	2058	0.45	0.10
April	3184	н	H
May	3537	н	0.14
June	1656	н	0.09
July	3207	н	0.09
August	1882	н	0.13
September	1747	н	0.21
October	1536	н	0.06
November	1255	н	н
December	1622	н	0.08

н – below the detection threshold

^{7}Be show monthly mean values, ^{131}I and ^{137}Cs show weekly values.

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1 DSA-rapport 01-2020
Radioaktivitet i utmarksbeitende dyr 2018
Sommerovervåkning og soneinndeling for småfe

2 DSA-rapport 02-2020
Russian-Norwegian monitoring of radioactive contamination of ground-level air in the border areas – monitoring programs, methods and results

DSA

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Safety Authority